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THE DIET, GROWTH AND CONDITION OF COMMON BREAM, *ABRAMIS BRAMA* (L.) IN WŁOCŁAWEK RESERVOIR

POKARM, WZOST I KONDYCJA LESZCZA, *ABRAMIS BRAMA* (L.) W ZBIORNIKU WŁOCŁAWSKIM

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Within 1997–1999, studies were carried out in Włocławek Reservoir to determine diet composition, growth rate, and condition of common bream, *Abramis brama* (L.)—the dominant fish species there. An extraordinary abundance of bottom fauna in this reservoir is the reason that already in the first year, common bream begin to feed intensively on zoobenthos, they grow very rapidly (in length and weight), and are in good condition. Literature reports that at the beginning of the 1980s, when zoobenthos in the reservoir was considerably less abundant, bream growth was slower.

INTRODUCTION

The Włocławek Reservoir (WR) is the largest reservoir in Poland with respect to area (ca 70–75 km^2). It was formed in 1963–1970, after a water dam was build on the 675th km of the Vistula River (Grześ 1983). It is a eutrophic, shallow and strongly rheolimnic reservoir (run-off-river reservoir), of typically riverine, channel-like shape. The common bream, *Abramis brama* (L.) is a dominant fish species in this reservoir. According to official statistics, the average bream's share in the total commercial catch within 1980–1999 was ca 66% (Kakareko 2000). At the beginning of the 1980s a single complex investigation of the most numerous species of fish was carried out in WR. The parameters studied were, among others, diet, growth, and reproduction of common bream (Sych et al. 1986; Wielgosz and Tadajewska 1988; Wielgosz 1989). Results of that study do not significantly differ from those for most of other waters. In consequence of gradual saltation, a favourable structure of food and oxygen conditions was formed in the reservoir in the 1980s, several years after filling up, the result of which was an exceptionally high increase of macrozoobenthos. In just a few years, the biomass of Chironomidae larvae—an important food resource for common bream and other fish—increased, on the average, from several (Giziński et al.

1989) to over 70 $g \cdot m^{-2}$ (Żbikowski 1995) of muddy areas of the bottom. This increase turned out to be permanent. The abundance of the bottom fauna in the reservoir is still very high, often exceeding 100 thousand ind.$\cdot$ m^{-2} (Żbikowski 2000 and unpublished data). The influence of such an improvement of food conditions on the fish living in the reservoir—on their growth, condition, feeding behaviour—is yet unknown.

The aim of the present study is to investigate the diet composition, growth rate, and condition of common bream—the most numerous representative of ichthyofauna of the water area under discussion.

STUDY AREA

The morphometry and hydrology of WR have been described in the works of Glazik (1976), Banach (1981), and Grześ (1983). Among the more important features are the following: surface area of ca 70–75 km^2, length of ca 57 km, width of 500–2500 m (mean width 1210 m); mean depth of 5.5 m; maximal depth (at the dam) of 15 m; total initial (1970) capacity $408 \cdot 10^6$ m^3, capacity in 1999—$370 \cdot 10^6$ m^3; mean discharge—900 $m \cdot s^{-1}$. Grześ (1983) divides the reservoir into two zones: the upper one, rheolimnic (more river-like), where at the mean water level an average water flow rate is over 1 $m \cdot s^{-1}$, and the lower one, limnic (more reservoir-like), where an average water flow is within 0.1–0.4 $m \cdot s^{-1}$ (Fig. 1). The amount of water discharge in the reservoir is changeable in a long-term cycle and within one year (influence of the Vistula which accounts for 98% of water feeding the reservoir), as well as within one day (influence of hydroelectric power plant). The water level fluctuations do not exceed 1 m.

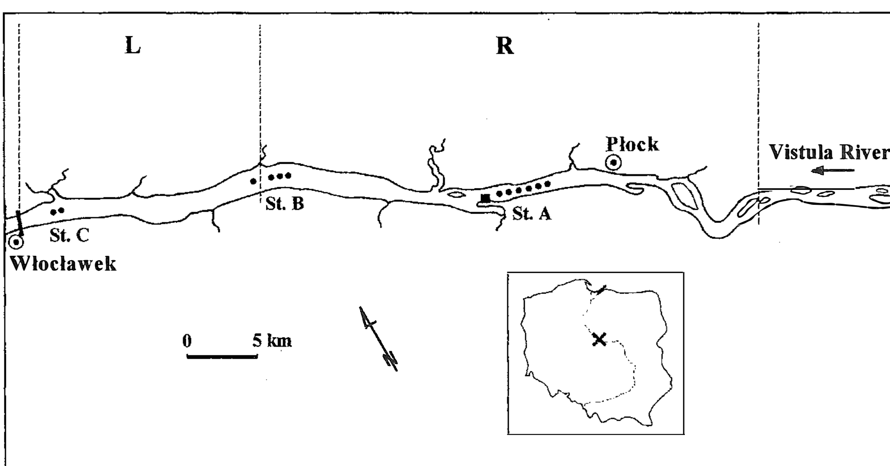

Fig. 1. Sketch of the Włocławek Reservoir. L, limnic part; R, rheolimnic part; St., sampling sites of fish aged 1+ to 10+ (● – netting areas); ■ – sampling site of fry

Descriptions of hydrochemistry and hydrobiology of WR are provided mainly by Giziński et al. (1989), Kentzer et al. (1999) and authors of papers published in *Acta Universitas Nicolai Copernici, Limnological Papers* 21. The reservoir is eutrophic, but strongly rheolimnic (the retention time is only 4–5 days). This is why many negative effects of high water trophy are minimized. The oxygen conditions are generally good. Blue-green algae blooms do not occur. The most recent analyses of plankton of WR are described in Dembowska and Napiórkowski (2000). Phytoplankton of WR has a typical river-like character, dominated by green algae and diatoms in the warm season and diatoms in the cool ones. The mean number of algae ranged from $2.5\cdot10^6$ to $6.0\cdot10^6$ ind.$\cdot$dm^{-3}, and the biomass from 5.0 to 14.6 mg$\cdot$dm^{-3}. Zooplankton has a rotifers-copepods-cladocerans structure; its mean number and the biomass are 533 ind.$\cdot$dm^{-3} and 114 μg$\cdot$dm^{-3} (dry weight). Zoobenthos of the reservoir was so far best studied in 1988–1992 (Żbikowski 1995, 2000), in its muddy areas of the bottom in the central part. Altogether 30 taxa, including 10 forms of Chironomidae, 11 species of Oligochaeta, and 9 species of Mollusca, were found. Among Chironomidae the following were dominating: *Chironomus* sp., *Procladius* spp.; among Oligochaeta: *Limnodrilus hoffmeisteri* Clap., *L. claparedeanus* Ratzel., *Potamothrix hamoniensis* Mich. and *Tubifex tubifex* Müll.; among Mollusca: small Sphaeriidae mussels. Abundance of the bottom fauna was very high. In the Vistula old-river-bed its mean number exceeded 100 thousand ind.$\cdot$m^{-2} and the mean biomass was ca 650 g$\cdot$m^{-2}. In the flood area those values were 70 thous. ind.$\cdot$m^{-2} and 300 g$\cdot$m^{-2} respectively. In both zones, Oligochaeta constituted over 80% of total number of the fauna, and Mollusca about 60% of biomass. In the ichtyofauna of WR, in the years 1980-1999, common bream dominated (66%) in the weight of total commercial catch. The catch of other fish was: roach, *Rutilus rutilus* (L.)—19%, white bream, *Blicca bjoerkna* (L.)—5%, zander, *Stizostedion lucioperca* (L.)—3%, ide, *Leuciscus idus* (L.)—2%, and other fish species—5%.

MATERIAL AND METHODS

Diet analysis

An analysis of the diet of bream focused on its composition in the growing season. The fry was sampled in shallow (up to ca 1.5–2.0 m depth) near-shore zone of the peninsula on the left, upper side of the reservoir (Fig. 1), rich in litoral emerged macrophytes. Those parts are vast spawning areas. The fry was caught by using shore seine with mesh size of 8 and 4 mm, and the wing length of 15 m. The catches were carried out in 40–50 m shore belt, in the afternoon or in the evening, in August and in September 1998, and in July 1999. The diet of 50 bream 0+ (Table 1) was examined.

Bigger fish were collected in the upper (Site A), central (Site B) and lower (Site C) parts of the reservoir (see Fig. 1). Gill nets were used almost exclusively, and only sporadically dragged tools. At each station fish were sampled at different times, different hours and various weather conditions, at different distances from the shore. In total, within 1997–1999, samples were collected in 26 periods of time of the growing season and diet of 162 common bream (length: 12.0–49.0 cm *SL*; Table 2.) were examined.

Table 1

Mean percentage by weight and frequency of occurrence (in %; numbers in parentheses) of particular components in the food of common bream 0+ in Włocławek Reservoir

Food components	Sampling dates		
	21 Jul 99	27 Aug 98	23 Sep 98
Chironomidae larvae	23 (70)	57 (100)	37 (100)
Oligochaeta	+ (5)	2 (88)	1 (54)
Ostracoda	13 (90)	+ (24)	12 (92)
Amphipoda	3 (15)	—	1 (15)
Trichoptera	—	+ (6)	+ (8)
Chydoridae	60 (100)	37 (100)	35 (100)
Daphnidae	—	—	1 (23)
Copepoda	1 (25)	3 (82)	13 (92)
Others	+ (80)	+ (88)	+ (77)
n	20	17	13
Mean standard length of fish (cm)	5.1 ±0.4	5.6 ±0.7	6.2 ±0.9
Mean total weight of fish (g)	2.6 ±0.7	3.9 ±1.6	4.3 ±1.9

+, less than 1%; "Others", Insecta n. det., Rotatoria, phytoplankton, sand.

Table 2

Characteristics of common bream > 10 cm *SL* with full intestines collected for diet analysis (results – see Table 3)

Length classes of fish	Site	*n*	Months	*SL* ±SD	*W* ±SD
10.1–30.0 cm	A	27	May–Jul, Sep	20.0 ±5.4	237 ±212
	B	49	May–Nov	23.8 ±4.6	353 ±185
	C	28	May, Jul–Oct	23.1 ±3.7	331 ±144
> 30.1 cm	A	40	May–Oct	37.1 ±5.0	1447 ±661
	B	18	May, Jun, Sep–Nov	33.8 ±3.0	991 ±271

SL, standard length; *W*, total weight.

The caught fish 0+ were preserved in a 10% formaldehyde solution and on being transported to the laboratory, they were measured (*SL*, standard length, *longitudo corporis*) exactly to the nearest 0.1 cm and weighed exactly to the nearest 0.1 g. Bigger fish were measured and weighed immediately after being caught, and then their guts were dissected out and preserved in a 4% formaldehyde solution. The percentage by weight (% of fresh weight) and frequency of occurrence (in %) of various prey taxa were determined according to Hyslop (1980). The proportion of calculable food items which included all animals excluding molluscs and oligochaets, was evaluated using length-weight relationship (Edmondson and Winberg 1971; Bottrell et al. 1976; Downing 1984; Kakareko, unpublished data). The proportions of other, non-calculable components were evaluated in various ways. The remains of eaten molluscs, isolated from the food, were dried in the temperature of 60°C, were weighed, and then the fresh weight value was calculated adopting Jasińska's (1994) assumption that hydration of molluscs (Sphaeriidae) is 75%. Sand was also isolated, dried, weighed and its share in total weight of ingested elements was calculated. The share of oligochaets was estimated assuming that mean biomass of 1 mm of those organisms was 0.14 mg (according to Szumiec, unpublished data). In case of presence in food of only setae of oligochaets, it was noticed that their share in food was lower than 1% and was marked +. Similar procedure was followed in cases of presence in food of small quantities of algae and fragments of macrophytes.

Participation and frequency of occurrence of Oligochaeta in food of common bream of various sizes at individual sites were compared using pairwise nonparametric Mann-Whitney U-tests with Bonferroni's corrections (Sokal and Rohlf 1995). The use of parametric statistics could not be applied because it was impossible to stabilise variance. Adopting Bonferroni's correction for 6 comparisons, the null hypothesis about the lack of differences between samples was rejected at $p < 0.0083$. During tests, frequencies of common bream with 0; >0–30.0; 30.1–60.0, and 60.1–100% share of oligochaets were compared in the mass of food.

Age and growth determination

Fish to be examined for age and growth rate were taken from the same catches as fish for the examination of diet. They were partly the same fish examined for food. A total of 150 bream of 13.7 to 49.0 cm *SL*, sampled in the reservoir within 1997–1999, were examined. Age estimation was based mainly on the annual ring structure of scales. Several scales were taken from every bream, from the left side of the body, from the first row above the lateral line and below the insertion of the dorsal fin. The scales were examined using a microfilm projector with 14.5; 24.5; 48.0 magnification, and under dissecting microscope. Additionally, to confirm the determinations made on scales, in 18 common bream of 15.0 to 45.0 cm *SL* caught in March 1999, results of independent readings of the age of scales were compared with readings of hard rays from dorsal fins which were clearly legible. In 16 cases, the results of readings were identical, so it was assumed that the determination of age on the basis of scales was reliable. The linear growth of the common bream was determined through back-calculations of length (L), by the radius of scale (S), using Fraser-Lee formula with the constant $c = 1.8$. The results of Heese (1992) methodological analyses indicate that this procedure is appropriate for common bream, since the *L–S* relationship is linear, which was confirmed in the case of WR (see Results). Measurements were made on caudal radius of scale exact to 0.04 mm. Von Bertalanffy's growth model was used (Ricker 1975) for the description of growth in length and weight.

Condition determination

Condition of common bream was examined on the material collected between October and December in 1997–1998. They were part of the fish which were also examined from the point of view of diet and growth. The total of 161 bream were examined of 13.0 to 42.5 cm *SL*. The condition of fish was determined on the basis of Fulton's condition factor and power relationship between standard length and total weight.

RESULTS

Diet composition

During summer the common bream 0+ fed mainly upon Chydoridae cladocerans and Chironomidae larvae. In subsequent months, these invertebrates constituted together from 72 to 94% of ingested food by weight (Table 1). *Leydigia* sp., *Alona* sp. and *Disparalona rostrata* Koch dominated among Chydoridae. Among Chironomidae larvae, forms of *Chironomus* sp. (73–95% of total weight of eaten larvae and 100% frequency of occurrence) were definitely eaten in greatest amounts and most frequently. Larvae of *Procladius* spp., *Cryptochironomus* sp., *Glyptotendipes* sp., and *Polypedilum* sp. were less significant in the diet. Apart from the dominating Chydoridae and Chironomidae larvae, lesser amounts (up to several % by weight) were also found in the diet of representatives of Ostracoda, Copepoda, Amphipoda, and Oligochaeta, and only vestigial amounts (≤ 1% of weight) of Daphnidae (*Bosmina longirostris* O.F. Müller, *Daphnia* sp.), Trichoptera, Rotatoria, algae, and sand.

Older common bream (aged 1+ to 10+), over 10 cm *SL*, fed, during growing seasons 1997–1999, almost exclusively on bottom fauna of the reservoir (Table 3). Zooplankton in the guts of the fish was found sporadically (3–6% frequency of occurrence), in amounts not exceeding 1% of weight. They were individual specimen of *Daphnia cucullata* Sars and *Keratella cochlearis* Gosse.

Common bream—relative to their size and the area of the reservoir—most often and in greatest amount fed on chironomid larvae or oligochaets. Chironomidae larvae dominated in the food of fish of various sizes in the central (site B) and lower (site C) parts of the reservoir and the fish > 30.1 cm *SL* in the upper part (site A).

Table 3

Mean percentage by weight and frequency of occurrence (in %; numbers in parentheses) of particular components in the food of common bream > 10 cm of *SL* in Włocławek Reservoir in the growing seasons (periods from May to Oct–Nov) 1997–1999

Food components	Site	Length classes of fish (cm)	
		10.1–30.0	30.1–50.0
Chironomidae larvae	A	7 (56)	55 (83)
	B	87 (100)	81 (100)
	C	77 (100)	×
Chironomidae pupae	A	+ (15)	2 (18)
	B	7 (57)	7 (44)
	C	1 (7)	×
Oligochaeta	A	71 (85)	6 (73)
	B	+ (49)	+ (56)
	C	+ (14)	×
Mollusca	A	11 (19)	28 (45)
	B	5 (14)	9 (17)
	C	20 (29)	×
Amphipoda	A	1 (7)	7 (45)
	B	—	2 (6)
	C	—	×
Ostracoda	A	—	—
	B	+ (12)	+ (17)
	C	2 (21)	×
Trichoptera	A	—	+ (3)
	B	+ (6)	—
	C	+ (4)	×
Cladocera, Copepoda, Rotatoria	A	+ (4)	+ (3)
	B	+ (6)	+ (6)
	C	—	×
Phytoplankton and plants	A	1 (23)	+ (98)
	B	+ (100)	+ (100)
	C	+ (100)	×
Sand*	A	8 (85)	2 (22)
	B	+ (27)	+ (11)
	C	+ (18)	×
Others	A	+ (11)	+ (3)
	B	+ (12)	+ (11)
	C	+ (4)	×

+, less than 1%; ×, lack of data; "Others", Arthropoda n. det., Insecta n. det., fish eggs.

* Sand is not a food component. It is only a fraction of intestines content.

They were mainly forms of *Chironomus* sp. (over 90% of weight of the total eaten larvae) and additionally *Cryptochironomus* sp., *Glyptotendipes* sp., *Procladius* spp., *Polypedilum* sp., *Stenochironomus* sp., *Stictochironomus* sp., *Microtedipes* e. g. *pedellus* de Geer. Oligochaets were a significant component of the diet of common bream only in the upper part of the reservoir (site A). They dominated there in the diet of fish of the length from 10.1 to 30.0 cm *SL* constituting on the average 71% by weight and 85% frequency of occurrence, and in bigger fish, > 30.1 cm *SL*, they were a supplementary food and constituted 6% and 73% respectively. In the central and lower parts of the reservoir the share of Oligochaeta did not exceed 1%, and the frequency of occurrence 56%; the lowest frequency was observed in the lower part of the reservoir. A statistical analysis confirmed that in the diet of fish from 10.1 to 30.0 cm, Oligochaeta have more significance in the upper part of the reservoir (*U*-test: $p < 0.001$), and lesser significance in its lower part (*U*-test: $p < 0.001$). This difference observed in fish > 30.1 cm, between site A and B, was not statistically significant (*U*-test: $p < 0.021$). In the upper part of the reservoir, the differences in the diet on Oligochaeta between fish of the two size classes under discussion were statistically significant (*U*-test: $p < 0.001$), and in the middle part they were not (*U*-test: $p < 0.143$). Regardless of the region of the reservoir, common bream supplemented their diet primarily with molluscs (on the average 5–28% by weight and 14–45% frequency of occurrence). They were almost exclusively composed of mussels Spheriidae. Sometimes snails (*Viviparus* sp., *Valvata naticina* Menke, *Valvata piscinalis* Müller) were found. Only in one out of 162 examined fish mussel *Dreissena polymorpha* Pallas was found. Small quantities (< 8%) of Chironomidae pupae, Amphipoda, sand, Ostracoda, algae, fragments of macrophytes, zooplankton and Trichoptera were also found in the guts of common bream. The amount of sand in the mass of food eaten by bream was positively correlated with the amount of Oligochaeta (*R* Spearman = 0.539; $p < 0.001$) and was biggest in the upper part of the reservoir (Table 3).

Growth rate and condition

Table 4

Back-calculated values of standard length of common bream from Włocławek Reservoir
The fish studied were caught in 1997–1999

Age groups	Standard length in successive years of life										n
	l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}	
1+	7.9										18
2+	8.7	16.1									12
3+	8.7	16.2	23.3								56
4+	7.9	15.6	21.0	25.9							20
5+	9.2	16.5	23.8	29.6	34.1						24
6+	8.4	17.1	23.8	30.2	35.1	38.6					5
7+	7.9	15.1	23.3	28.5	32.6	38.4	40.7				7
8+	6.7	13.6	20.2	25.4	30.8	35.5	38.3	40.5			3
9+	9.9	14.0	21.7	26.4	34.7	37.4	41.4	45.4	47.0		1
10+	8.0	15.3	21.8	26.4	31.5	35.4	39.6	42.5	44.0	45.4	4
Mean	8.5	16.0	22.9	28.0	33.7	37.4	40.0	42.1	44.6	45.4	
±SD	2.1	2.2	2.8	3.2	2.9	2.8	2.6	2.2	2.3	2.1	(*n* = 150)
V	2.4	1.4	1.2	1.1	0.9	0.7	0.7	0.5	0.5	0.5	
Increase	8.5	7.4	6.9	5.4	4.8	4.1	3.0	2.8	1.5	1.4	
±SD	2.1	2.4	1.8	1.6	1.3	1.3	1.2	0.9	0.4	0.3	(*n* = 150)
V	2.4	3.2	2.6	3.1	2.8	3.1	3.9	3.1	2.7	2.1	

V, coefficient of variance.

In examined common bream of WR, a linear relationship between the standard lengths (*L*) and the caudal radii of scales (*S*) was observed. The regression equation, calculated for the whole examined sample ($n = 150$), was $L = 5.5234 \cdot S - 0.18058$ ($r = 0.960$, $p < 0.001$). The growth rate of common bream is presented in Table 4. The values of parameters of von Bertalanffy's growth model are as follows: L_∞ = 54.64 cm; W_∞ = 4785.39 g; K = 0.185; t_0 = 0.015 years. The theoretical values of body length and weight calculated with Bertalanffy's equation, indicate a high correlation with the empirical data (r = 0.9977–0.9996, $p < 0.001$).

The relationship between total weight (W) and standard length (L) of common bream under study is represented by a power function: $W = 0.0103 \cdot L^{3,2616}$ (R^2 = 0.9964). The mean value of Fulton's condition factor is 2.44 . (range 1.67-3.15) – see Table 5.

Table 5

Values of Futon's condition factor (k) calculated for common bream caught in Włocławek Reservoir in the period from October to December 1997–1998

Length class (cm)	n	Mean	±SD	Range
13	4	2.23	0.17	1.99–2.37
14	22	2.09	0.07	1.93–2.17
15	27	2.06	0.11	1.90–2.43
16	7	2.01	0.11	2.17–2.26
17	1	1.97	—	—
18	2	2.22	—	2.17–2.26
19	1	2.13	—	—
20	5	2.29	0.14	2.09–2.45
21	2	2.32	—	2.17–2.41
22	5	2.50	0.04	2.42–2.53
23	11	2.35	0.07	2.19–2.45
24	1	2.58	—	—
25	13	2.35	0.12	2.10–2.50
26	8	2.24	0.24	1.67–2.41
27	2	2.61	—	2.49–2.74
28	4	2.33	0.23	2.14–2.62
29	1	2.95	—	—
30	1	2.15	—	—
31	3	2.51	0.16	2.34–2.65
32	8	2.59	0.16	2.21–2.75
33	5	2.66	0.12	2.53–2.78
34	10	2.56	0.19	2.32–2.95
35	4	2.71	0.26	2.33–2.92
36	3	2.63	0.14	2.46–2.72
37	4	2.71	0.16	2.55–2.88
38	5	2.61	0.14	2.47–2.81
39	1	2.73	—	—
42	1	3.15	—	—
Total	161	2.44	—	1.67–3.15

DISCUSSION

In the 1980s, after an increase of the amount of zoobenthos (Fig. 2) in Włocławek Reservoir, an acceleration of growth rate of common bream was noticed (Fig. 3). The structure of commercial catches does not indicate that the number of this fish has decreased in recent times in this reservoir (Fig. 4). We can assume then that the increase of their growth is a direct effect of abundance of food resources. Common bream grow now faster than at the beginning of the 1980s (Sych et al. 1986), also faster than in the Vistula (Brylińska 1969), in the majority of Polish lakes (Marciak 1974) and many other water bodies (Wright 1990; Kangur 1996; Pihu 1996; Specziár et al. 1997). On the basis of empirical data from 491 populations, Szczerbowski (1981) defined boundary values of body length and weight characteristic of very rapid, rapid, medium, and slow growth of common bream. In WR the growth rate in length of that fish is very rapid until the 5th year of life inclusive, then only rapid. The growth rate in weight is in all years very fast. Similar, or even faster growth of common bream is observed mainly at the southern ends of the range of that species as well as in lakes heated by warm water from the cooling systems of power plants (Ciepielewski 1994; Živkov and Raikova-Petrova 1996). The water temperature in WR is typical of Central Europe and its annual average is about 10.6°C. Kakareko (1998) gave an initial estimation, that common bream in this water region do not exert a strong feeding pressure upon the *Chironomus* sp. resources—the main source of food. We can safely assume that the fish under discussion have an excess of food in the reservoir and reach values of biological production close to maximal for these geographical conditions (the length of the growing season, water thermal conditions). Lammens (1982), referring to data from literature, indicates that if the chironomid standing stock exceeds 20 g·m^{-2} the growth of common bream is very good, i.e. they reach 1 kg after 9 years of life. In WR, with mean bio-

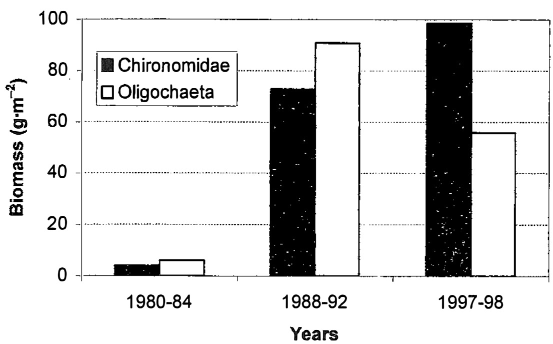

Fig. 2. Mean biomass of Chironomidae larvae (black bars) and Oligochaeta (white bars) in the muddy sediments of Włocławek Reservoir in various periods of time. The presented values are mean values calculated from site situated: 1980–84—in the whole reservoir (Giziński et al. 1989); 1988–92—in the central part of the reservoir (Żbikowski 1995); 1997–98—collectively in the central and lower parts of the reservoir (Żbikowski, unpublished data)

mass of Chironomidae larvae ca 100 g·m^{-2} (Fig. 2), common bream reach 1 kg of weight in the 5–6th year, and after 9 years, their weight is about 2.5 kg.

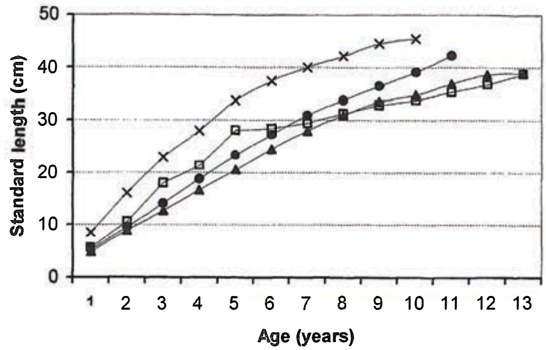

Fig. 3. The growth rate of common bream in Włocławek Reservoir in the 1990s, —×— (present study) and in the 1980s, —□— (Sych et al. 1986), in the Vistula —●— (Brylińska 1969) and in the majority of lakes in Poland —▲— (Marciak 1974)

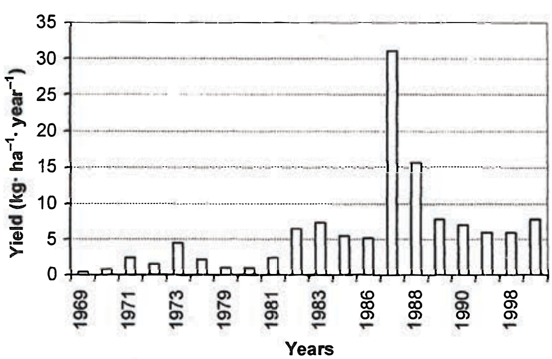

Fig. 4. The annual yield of common bream in Włocławek Reservoir in the years: 1969–1973, 1978–1984, 1986–1991, 1998–1999. According to commercial statistics, the surface area of catches is 7043 ha.

The rapid growth of fish under discussion is accompanied by their good condition. Kangur (1996) wrote that in Lake Peipsi in Estonia, the mean value of Fulton's condition factor (k) for common bream of 10–37 cm *SL* was 2.09. According to the above author this value is an evidence of "quite good" condition of fish, which is above the average in Estonian lakes. In WR the mean value of k coefficient calculated for common bream of the same sizes is 2.38, and is significantly higher than in Lake Peipsi (t-test: $p < 0.001$), thus their condition can be described as generally good. The mean value $k = 2.44$ (Table 5), calculated for all examined bream in WR, is higher than for fish of that species in many other water bodies (Musatov and Osokina 1968; Wright 1990).

According to the theory of optimal foraging, predators most frequently feed on those of prey which are most numerous in the environment, have biggest size, and are easiest to catch, i.e. they guarantee predators the highest energy gains (Werner and Hall 1974). Results of research on common bream diet in WR are consistent with this rule. The abundance of zoobenthos in the reservoir is the reason that very early, already in the first year, the fish begin to feed intensively on bottom invertebrates and eat them with near bottom living Chydoridae. In older age (> 0+) they base their diet almost exclusively on bottom fauna and practically they do not feed on zooplankton which is less abundant and therefore more energy consuming to catch. At the beginning of the 1980s, when zoobenthos in WR was significantly less abundant than now and its biomass (without molluscs) did not exceed several grams per square meter of the bottom (Giziński et al. 1989), zooplankton played a significant role in the diet of common bream of less than 20 cm *SL* in the central part of the reservoir, then under examination (Wielgosz and Tadajewska 1988). It is worth adding that common bream have a well developed and functional branchial sieve, which makes it possible for them, even big specimens, to efficiently feed on zooplankton (see Hoogenboezem 1991; van den Berg et al. 1992, 1993). In sufficient density, zooplankton can be the basic food of common bream of various sizes in reservoirs of poor zoobenthos (Lammens 1982; Lammens 1984; Kubečka et al. 1998).

In WR common bream feed largely upon Chironomidae larvae or Oligochaeta, and supplement their diet primarily with small mussels Sphaeriidae. The fact that chironomid larvae are an important, frequently fundamental, component of food of common bream is a well-known phenomenon, amply documented in literature (Wielgosz and Tadajewska 1988; Wielgosz 1989; Giles et al. 1990; Biró et al. 1991; Chlopnikov 1992; Tadajewska 1993; Kangur and Kangur 1995; Specziár et al. 1997; Specziár and Biró 1998). Common bream are adapted to effective feeding on muddy sediments (Brabrand 1984; Lammens 1984; Lammens and Hoogenboezem 1991). Pelophilous forms of chironomid larvae of the genus *Chironomus* play a particularly important role in their diet. In the central and lower part of WR, those forms constitute over 90% of biomass of the larvae of the total pelophilous Chironomidae (Żbikowski 1995, 2000); hence they were the most frequent and numerous food items.

The role of Oligochaeta in the diet of fish is not well known because of methodological difficulties in the estimation of their share in the food, difficulties caused by fast digestion (Žiteneva 1983; Krasnoper 1989). Only setae or small fragments of their bodies were found in the food of common bream in Polish waters (Prejs 1973; Terlecki et al. 1977;

Wielgosz and Tadajewska 1988). A substantial share of Oligochaeta was observed in the diet of common bream in dam reservoirs in Russia (Ermolin 1977; Žiteneva 1982, 1983). Domination of oligochaets in the diet of middle-size fish in the summer in the upper part of WR indicates that this typically river-like zone is different with respect to food conditions from the lower, less rheolimnic parts of the reservoir. Zoobenthos of the upper zone of the reservoir was not studied in the 1990s and it is difficult to explain the reasons of such a high significance of Oligochaeta in the diet of fish. Most probably, the upper part of the reservoir is generally poorer in chironomid larvae than its lower regions. The share of Oligochaeta in food was correlated with the amount of sand. Probably in the upper part of the reservoir, Oligochaeta are so numerous in the muddy-sandy areas of the bottom, that they are a good source of food for fish—especially in the periods of mass emergence of Chironomidae imago forms.

Common bream are not well adapted to eating molluscs. Nagelkerke and Sibbing (1996) demonstrated that with respect to the effectiveness of eating of *Dreissena polymorpha* mussels they are clearly inferior to co-occurring roach and white bream. In WR, molluscs—Sphaeriidae—were a significant component of food most probably because they occur in great quantities in the reservoir, are very small and have cylindrical shape, all of which makes eating them easy. Also in Zegrze Reservoir on the Bug and Narew rivers, which is as rich in Sphaeriidae as WR, they constituted a very important component of the diet of mature common bream (Tadajewska 1993).

The results of the study discussed in the present paper demonstrate that in the strongly rheolimnic Włocławek Reservoir on the Vistula River, there are exceptionally favourable food conditions for common bream. Exceptionally quantitatively rich zoobenthos is a fundamental diet for this fish and guarantees their very rapid growth and good condition. However, fishing yield of the reservoir is low and an average amounts to 10 $kg \cdot ha^{-1}$ (Kakareko 2000). It is caused by technical difficulties in fishing by means of the most effective dragged tools (Sych et al. 1986) and poor spawning conditions (less developed litoral zone, invariable shoreline, water level fluctuations) in this reservoir.

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POKARM, WZOST I KONDYCJA LESZCZA, *ABRAMIS BRAMA* (L.) W ZBIORNIKU WŁOCŁAWSKIM

STRESZCZENIE

W latach 1997–1999 w Zbiorniku Włocławskim badano skład pokarmu oraz tempo wzrostu i kondycję leszcza, *Abramis brama* (L.) – dominującego gatunku ryby. Pokarm narybku badano latem na tarliskach położonych w górnej części zbiornika, a pokarm ryb starszych (w wieku od 1+ do 10+) – w sezonie wegetacyjnym zarówno w górnej, jak i środkowej oraz dolnej jego części. Podstawą diety narybku były przydenne wioślarki Chydoridae oraz larwy Chironomidae. W górnej, rzecznej części zbiornika, starsze ryby w zależności od wielkości zjadały głównie Oligochaeta (leszcze 10,1–30,0 cm *SL*), bądź larwy Chironomidae (leszcze > 30,1 *SL*). W środkowej i dolnej części akwenu, o mniej lotycznym charakterze, w pokarmie ryb różnych wielkości (> 10,1 cm *SL*) dominowały larwy Chironomidae. Uzupełniającym składnikiem pokarmu, w całym zbiorniku, były głównie drobne małże Sphaeriidae. Wyjątkowa obfitość fauny dennej w Zbiorniku Włocławskim sprawia, że leszcze już w pierwszym roku życia zaczynają intensywnie odżywiać się zoobentosem i osiągają bardzo duże przyrosty masy i długości ciała oraz mają dobrą kondycję. Z danych z literatury wynika, że na początku lat 1980, gdy zoobentosu w zbiorniku było zdecydowanie mniej, leszcze przyrastały wolniej.

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