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Sławomir WIELGOSZ, Magdalena TADAJEWSKA

FACTORS DETERMINING DIET COMPOSITION AND FOOD AVAILABILITY FOR BREAM, *ABRAMIS BRAMA* (L.), AND WHITE BREAM, *BLICCA BJOERKNA* (L.), IN WŁOCŁAWEK DAM RESERVOIR

UWARUNKOWANIA STRUKTURY DIET I DOSTĘPNOŚCI POKARMU LESZCZA *ABRAMIS BRAMA* (L.) I KRĄPIA *BLICCA BJOERKNA* (L.) W ZBIORNIKU WŁOCŁAWSKIM

Chair of Zoology, Academy of Agriculture and Technology, Olsztyn, Poland

Food composition of bream and white bream was studied in 1982–1984. Frequency of the rood components in the fish intestines pointed to the importance of *Chironomidae Copepoda, Mollusca* and *Macrophyta*. Particular cohorts of the two fish species were characterized by considerable differences of the diet composition, both in the phenologic season and in particular years. White bream females fed more intensively than bream females and males of the same size. Statistically significant differences were found as to the consumption of chironomids by bream and white bream, size and length of the larvae consumed and intensity of feeding. Consumption of chironomids by the two euryphages increased with water temperature, reaching an optimum at 21°C. Prey density determined the food spectrum of bream and white bream. Both species grazed in the same areas but differed as to the intensity of sediment penetration and size of the chironomids consumed.

INTRODUCTION

The two euryphages, bream (*Abramis brama* L.) and white bream (*Blicca bjoerkna* L.) penetrate similar habitats and are characterized by similar diets. (Klimczyk-Janikowska 1974, Brabrand 1984, Lammens 1982) notwithstanding their high plasticity with respect to the edaphic conditions. Zonation of the habitats and thei different distribution in lakes determine prey availability and activate biotope penetration by the fishes of different food requirements. Bartell (1982), Eggers (1977) and Żiteneva (1983) stated that total consumption and diet composition depended on prey density. The food spectre of the euryphages is inversly proportional to prey availability, the latter being expressed as prey abundance and size (Lammens 1984). This mechanism explains partly the phenomenon of lake pelagial penetration by bream, while white bream sticks to the littoral zone. Diet composition of the two species results from inter-species relations and stability of the environmental conditions. Rheolimnetic conditions in the lowland dam reservoirs induce considerable differences in the availability of the food resources, both for the planktivorous and benthivorous species.

Bream and white bream represent main components of the ichthyofauna in eutrophic lakes and dam reservoirs. Hence, their feeding behaviour has been a subject of many studies (Prejs 1973, Klimczyk-Janikowska 1974, Bakanov and Strižnikova 1979, Lammens 1984, Brabrand 1984). Our studies constituted a part of complex research project on the trophic nets of the fishes in Włocławek Dam Reservoir[1]. Their objective was to describe composition of bream and white bream diet, and to clarify the relationships between the intensity of reeding, fish sex and size, and density and size of the prey organisms, as well as to determine the conditions of possible competition between the two species.

MATERIAL AND METHODS

Włocławek Dam Reservoir was constructed in 1970 after damming of the Vistula River. Its length is 57 km, width 0.5–2.5 km. Working capacity of the reservoir is 55 million m^3. At average flow rate of 1000 m^3 $\cdot$s^{-1} the retention time is 4.5 days (Giziński et al. in print).

Table 1

The analysed food tracts of bream and white bream cohorts, totally for 1982–1984

Species	I	II	III	IV	V
Bream	95	341	136	236	283
White bream	70	207	130	81	0
Total	165	548	266	317	283

[1] The studies were financed by the Institute of Ecology of the Polish Academy of Sciences.

The materials consisted of breams and white breams caught in 1982–1984. The fishes were caught with gill nets (mesh size 35, 40, 50 and 60 mm) and a seine of 30 mm mesh size, wing length 150 m. In 1982 and 1984 catches were performed since April till October, at 2-week (1982) or monthly (1984) intervals. In 1983 seasonal catches were performed (April, July, October). All fishes were weighed (10 g SE) and measured (Lt and Lc, 0.5 cm SE), and their sex was determined. Breams were divided into 5 size groups on the basis of body length (Lc): 10.0–15.0 cm (I_b), 15.1–20.0 cm (II_b), 20.1–25.0 cm (III_b), 25.1–30.0 cm (IV_b) and over 30.1 cm (V_b). White breams caught were divided into 4 groups: (I-IV_{wb}) with an analogic interval of 5 cm. Totally, 1579 food tracts were analysed, 1091 of bream and 488 of white bream (Tab. I).

The fish food tracts were preserved in 4% formalin. The isolated content of the food tracts was analysed for each fish, using a stereoscopic microscope (magnification 16–25 x). Bigger specimens of *Gastropoda, Hirudinea, Macrophyta* were thus identified. *Chironomidae* were identified to the lowest possible systematic unit. Each time the intestine content was analysed for the presence of *Oligochaeta* bristles. Weight of the food components was reconstructed from individual length (L): *Cladocera* $W = 52\ L^{3.0,2}$ (Pechen 1965), *Copepoda* $W = 55\ L^{2.73}$ (Klekowski and Šuškina 1966). Reconstruction of other taxons was based on weight standards of Morduchaj-Boltovskoj (1954). In case of the chironomids, length of the specimens was reconstructed from head size (when it was impossible to measure the individuals in quastion, Czeczuga et al. 1968), and then weight was recalculated from the equation $W = KL^3$ (Morduchaj-Boltovskoj 1954). For most chironomids $K = 3.5$. $K = 7$ only for *Procladius sp., Cryptochironomus sp., Cladopelma viridula* and *Parachironomus gr. varus*. Biomass of uncalculable components (plants, organic particles) was not estimated due to their low share in the fish diet.

The results were interpreted taking advantage of the index of relative importance (IRI). The index is a sum of the share of a given component in numbers (n) and weight (w) multiplied by the frequency (f) : IRI = f/n+w//Pinkas et al. 1971). Relative index of the feeding intensity was calculated as the relation between food weight and fish weight in $^{\circ}/_{ooo}$. Food convergence of particular bream and white bream cohorts was estimated from the Šorygin's index (1939). Unifactorial analysis of variance was used to determine the relations between the diet of males, females and juveniles. Student's T-test was used to determine the significance of the differences in the correlated pairs of bream and white bream males and females. Linear correlation and regression was used to describe the dependencies between particular features of the fish diet, individual parameters, and water temperature.

RESULTS

Individuals of the same sex of the two fish species differed as to their body length (Lc), the differences being significant ($T = 8.073$, $p < 0.001^{x}$). Differences of body

* $p < 0.001$ for all dependencies described.

Table 2

Frequency (%) of the food components in the diet of bream and white bream cohorts in 1982 and 1983

White bream				Diet components	Bream				
IV	III	II	I		I	II	III	IV	V
31.1	9.8	30.1	36.7	sand, mud, detritus plant seeds	24.5	35.6	26.1	38.1	34.4
	14.3	18.0	27.8	*Macrophyta* n. det.	9.7	19.3	33.2	9.0	9.6
		4.0	11.1	*Algae n. det.*	13.9	3.3	9.0	3.5	5.6
				Nematoda n.det.			2.0	0.6	
		1.2		*Oligochaeta* n.det.		3.7	12.0	2.7	8.3
	1.3	1.0		*Erpodbella* sp.		0.8		0.3	
31.9	31.3			*Bithynia tentaculata* L. *Bithynia sp., Valvata Viviparus sp. Pulmonata* n.det. *Pisidium sp.*					
7.7		0.6		*Sphaeriidae* n.det.					1.9
	2.5			*Dreissena polymorpha* Pall.					
51.6	43.7	34.4	17.2	*Mollusca* n.det.	5.2	8.5	11.1	14.4	17.0
2.2				*Hydracarina* n.det					
		3.6	13.9	*Cladocera* n.det	12.5	6.8		0.3	
				Ostracoda n.det.	4.2				
		14.7	27.8	*Copepoda* n.det et *nauplius*	33.3	13.5	12.0	1.7	
		2.2		*Diptera* n.det (imago)					
98.4	77.2	56.7	44.4	*Chironomidae**	58.9	29.7	77.7	92.4	83.5
0.4	4.0	5.0	8.3	*Insecta* n.det		1.5		1.8	
23	22	25	12	Number of components	10	22	18	24	18

* components in table 2a

Table 2a

Frequency (%) of the food components in the diet of bream and white bream cohorts in 1982 and 1983

White bream				Diet components	Bream				
IV	III	II	I		I	II	III	IV	V
				a) rapacious *Chironomidae*					
4.8	1.9	2.8	5.6	*Procladius sp.*	10.2	3.4	10.0	9.8	8.9
	6.5	1.8		*Crycptochironomus* gr.		1.6	14.8	5.9	1.6
		0.5		*defectus* gr. *conjugens*		0.1		0.7	
				Cladopelma viridula				0.6	
4.8	8.4	5.1	5.6		10.2	5.1	24.8	17.0	10.5
				b) plants *Chironomidae*					
				Cricotopus bicinctus Mg		0.4	0.1		
3.7				*Isocladius silvestris* (Fabr)			0.1		
4.0		1.0		*Parachironomus varus*		0.4			
		0.9		*Endochironomus tendens* Fabr					
5.6	1.6	1.4	8.3	*Glygtotendipes gripekoveni*			0.1	1.7	3.1
	6.8	2.0		*Dicrotendipes nervosus* (Staeg)		0.8	0.1	2.4	2.8
				– tritomus K.				0.3	
		1.5		*Polypedilum nubeculosum*		0.4	0.1	3.3	1.4
		1.6		– sp.p.					
				Cladotanytarus mancus		0.4	0.9		
				Paratanytarsus lauterborni					
14.7	8.4	8.4	8.3			2.4	1.4	7.7	7.3
				c) bottoms *Chironomidae*					
5.6	2.0	0.6		*Chironomus semireductus*					
5.6				gr. *anthracinus*					
2.4	0.6	4.2		– sp (*plumosus?*)				7.1	
				Psetrocladus psilopterus		1.6		1.5	0.8
44.3	39.2	27.8	11.1	*Chironomus sp. larvae*	32.0	13.5	40.3	52.1	50.2
15.4	14.6	7.8	11.1	*Chironomus sp. (pupae)*	16.7	6.7	10.3	3.7	11.9
5.6	4.0	2.8	8.3	*Chironomidae* n. det *larvae*		0.4	0.9	3.3	2.8
65.3	57.8	38.4	30.5		48.7	20.6	51.5	59.1	64.9

Table 3

Average indices of importance of the main food components in the cohort II of bream and white bream in 1982 and 1984

Diet components	1982						1984					
	Spring		Summer		Autumn		Spring		Summer		Autumn	
	Bream	White bream	Bream	White bream	Bream	White bream	Bream	White bream	Bream	White bream	Bream	White bream
sand	+		+		+		+	+	+	+		
Macrophyta n.det.	+						+	+	+	+	+	
Algae n.det.		+					+		+	+		
Mollusca n.det.		196.4	431.6	724.1	79.4		112.1	74.3				
Oligochaeta n.det.	+						+		+			
Cladocera n.det.							391.0	877.8			4072.4	90.2
Copepoda n.det.	184.0						1879.6	4896.5	84.6		74.6	728.0
Procladius sp.						4.1			481.7		31.6	50.9
Chironomus sp. larvae	3816.0	1964.3	3679.7	5463.5	2141.8	4476.7	478.2	295.0	1326.9	151.0	179.4	3079.9
– sp. (pupae)			2980.4	310.1		23.8			320.8	1427.1	1770.2	826.7
Chironomidae n.det. (larvae)				1381.5		245.1						101.0
extensity (%) of the *Caryophyllaeus laticeps* infection							56.9	16.7	17.0	22.2	20.0	
participation (%) to fill guts	15.6	18.2	16.7	38.8	4.2	40.0	32.8	56.1	42.2	55.4	17.8	26.0

+ non-calculable components present

weight between the two populations were also significant ($T = 7.109$), the average individual weight being 544.6 g for bream and 285.1 g for white bream.

Comparing Lc of bream, significant differences were found between length of males and juveniles ($T = 5.871$) and length of females and juveniles ($T = 6.518$). Similar disproportions were observed with respect to male and juvenile weight ($T = 6.244$), and female and juvenile weight ($T = 6.518$). No significant differences were noted between the sexes.

As regards white bream, significant differences were found with respect to Lc and weight of females and males ($T = 4.888$ and 4.695 respectively).

DIET COMPOSITION

39 components were identified in white bream diet, and 32 in bream diet. Higher degree of mollusc digestion in bream stomachs limited the food spectrum. Food components were present with different frequencies. Food composition was determined by the fish size and changes in the environmental factors, affecting the food resources. Generally, the most important components of the diet of the two species were: *Chironomidae, Copepoda, Mollusca* and *Macrophyta* (Tab. 2). From among the chironomids, benthic forms were found, such as *Chironomus sp.* as well as predatory i.e. *Cryptochironomus spp.* and *Procladius sp.*, and polytophilic ones – *Cricotopus bicinctus, Isocladius sylvestris, Cladotanytarsus mancus* and *Paratanytarsus lauterborni* (Tab. 2a). Predatory and phytophilic larvae, of average length 2–6 mm were more frequent in bream stomachs than in white bream. Most frequent were the larvae from the genus *Chironomus*. Bream belonging to cohort I consumed these larvae more frequently. In other cohorts of the two fish species this frequency was more or less similar. *Copepoda* were more frequent in juvenile fishes, although they were found also in the diet of cohorts III_b and IV_b. No copepods were found in the intestines of the cohorts III_{wb} and IV_{wb}. Different patterns were observed as regards consumption of *Mollusca*. They were always more frrquent in white bream diet than in bream. Most pronounced differences in the frequencies of this diet component were observed between white bream cohorts III_{wb} and IV_{wb}, and between the same bream cohorts. Sand between the same bream cohorts. Sand grains were frequent in both fish species.

Diet composition of particular fish cohorts differed considerably in the phenologic seasons 1982/1983 and 1984. This was proved by the indices of component importance in the diet of bream and white bream, which illustrate various aspects of the component share in the diet. Comparison of these indices for the cohorts II_b and II_{wb} in 1982 and 1984 (Tab. 3) revealed significantly different share of the larvae of *Chironomus sp.*, *Copepoda* and *Cladocera* in the fish diet. In 1982 *Chironomus sp.* predominated in the diet of both fish species, representing 87.4% of the numbers and 76.3% of the food weight in bream, the respective values for white bream being 84.1 and 68.4%. Share of *Chironomidae* pupae increased only in summer (21.7% of the numbers and 57.3% of the weight of all organisms consumed), and mostly in case of bream. In 1984 these patterns

Table 4

Average indices of importance of the main food components in the cohort I of bream and white bream in 1984

Diet components	Spring		Summer		Autumn	
	Bream	White bream	Bream	White bream	Bream	White bream
sand			+	+	+	
Macrophyta n.det.			+	+	+	
Algae n.det.			+			
Mollusca n.det.			1141.2	2261.9		
Cladocera n.det.		1724.0			6720.0	168.2
Ostracoda n.det.					747.5	
Copepoda n.det.	16383.0	12373.0		241.3		1520.1
Procladius sp.			203.5		1295.0	92.6
Chironomus sp. (larvae)	1617.0		404.4		1365.0	1267.3
– sp. (*pupae*)			6060.3			8259.2
Glyptotendipes gripekoveni		1639.5				
Chironomidae n.det. larvae)		425.0				
Extensity (%) of the *Caryophyllaeus laticeps* infection			7.4	11.1		16.7
participation (%) to fill guts	12.5	33.3	28.3	31.4	12.4	25.0

+ – non – calculable components present

Table 5

Average indices of importance of the main food components in the bream cohort V in 1982 and 1984. In autumn 1984 fishes of this size were not caught

Diet components	1982			1984	
	Spring	Summer	Autumn	Spring	Summer
Sand	+	+	+	+	
detritus		+	+		
Macrophyta n.det.	+	+		+	
Mollusca n.det.		1895,3		740,2	
Oligochaeta n.det.	+	+		+	
Procladius sp.		17,6	329.3		376.0
Chironomus sp. (laryae)	341,3	3426.1	15011.3	8190.9	13120.8
–*sp. (pupae)*		13.8		2335.5	2219.8
Dicrotendipes nervosus (Staeg.)					280.0
Glyptotendipes gr. *gripekoveni* K.				207.4	
Chironomidae n.det. *(larvae)*		211.4	1095.7	820.1	355.7
extensity (%) of the *Caryophyllaeus laticeps* infection	42.9	42.9		12.5	
participation (%) to fill guts	37.5	20.5	49.0	87.5	72.2

were quite different. Fish cohorts II_b. and II_{wb} fed mostly on *Copepoda* and *Cladocera* Indices of importance of these two components amounted respectively to 684.3 and 2314.1 in bream diet, and to 2826.4 and 496.7 in white bream diet. The copepods constituted main component of white bream diet, while cladocerans were consumed by bream. In summer 1984, similarly as in 1982, *Chironomidae* larvae predominated together with *Macrophyta* and algae remnants. The fishes showed quite an elasticity in consuming the prey, this being confirmed by the food composition of juvenile fishes I_b and I_{wb} in 1984 (Tab. 4). In spring, the fishes consumed mostly *Copepoda* (68.7% of the food weight in bream and 56.9% in white bream) with an addition of *Chironomus sp.* in bream and of *Cladocera* and *Glycotendipes gripekoveni* in white bream. In summer, bream food consisted in 42.9% of *Chironomus sp. pupae,* and in 26.3% of *Mollusca.* On the other hand, white bream consumed molluscs (86.9% of the food weight) and sporadically copepods. In autumn, *Cladocera* were most important in bream diet, and *Chironomus sp.* pupae in white bream diet. This comparison illustrates the food spectrum of the two species. Both could feed on the same food components as well as were able to complete their diet with the components of different ecological formations.

Food content in the intestines of the cohorts IV_b, V_b and IV_{wb} was somewhat different. These fishes fed mostly on benthic organisms. *Chironomus sp.* larvae were most frequent and represented basic food items in all seasons. Additionally, their pupae were consumed in late spring and summer. Share of molluscs also increased in summer. Bream was highly infested with *Caryophyllaeus laticeps* (42.9% of the fishes from the cohort V_b) both in spring and summer 1982 (Tab. 5). It seems that this might have been caused by intensive grazing on *Oligochaeta.* Infestation of the *Oligochaeta* by procecroids of *Caryophyllaeus laticeps* was noticed in a sample consisting of four perch stomachs collected in May 1984. It was calculated that 78% of the consumed *Oligochaeta* were

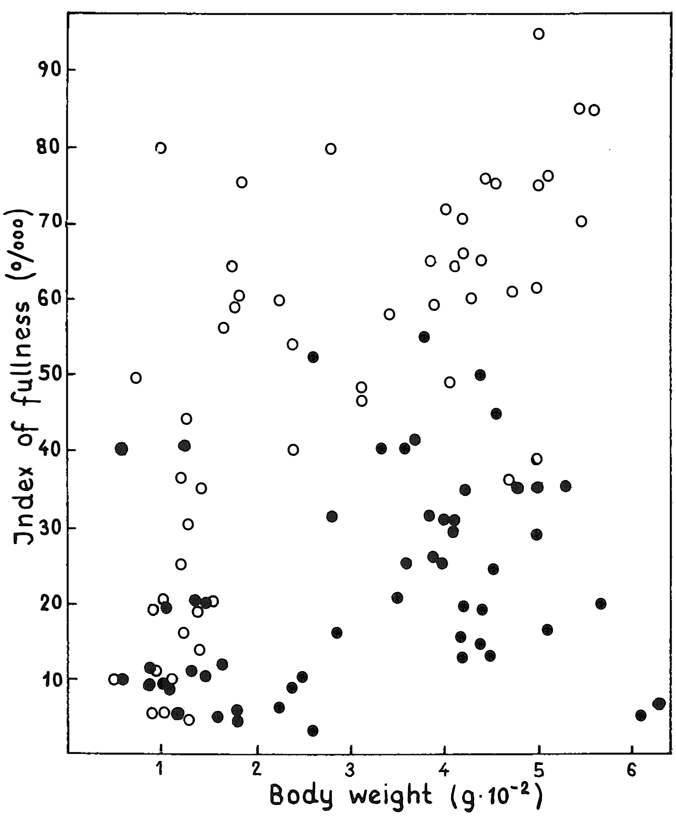

Fig. 1. Relationship between the index of intestins filling with food and bream (dark points) and white bream (light points) weight.

Table 6

Intensity of feeding ($^{o}/_{ooo}$) of bream males and females and of white bream in the phenologic season. Average values for the years 1982–1984

Specification	April		May		June		July		August		September		October	
	Bream	White bream	Bream	White bream	Bream	White bream	Bream	White bream	Bream	White bream	Bream	White bream	Bream	White bream
males	39.2	27.3	8.7	17.7	14.6	23.8	10.9	12.4	12.9	22.4	19.9	18.0	6.0	12.3
females	38.1	37.9	21.2	35.7	24.3	32.0	12.9	23.8	24.4	31.8	47.4	26.5	19.8	32.4
water temperature – °C	11.8		13.7		19.3		20.1		22.2		11.5		10.2	

Table 7

Intensity of feeding ($^{o}/_{ooo}$) of the females and males from the bream cohort IV, and of the females from the white bream cohort IV in the phenologic season. Average values for the years 1982–1984

Sex	April		May		June		July		August		September		October	
	Bream	White bream	Bream	White bream	Bream	White bream	Bream	White bream	Bream	White bream	Bream	White bream	Bream	White bream
males	51.2		10.8		18.2		19.1		8.8		–		–	
females	34.8	58.5	13.1	36.2	28.4	50.6	16.1	27.4	22.6	60.0	58.3	–	14.3	33.8

infected. Although this high infestation of *Oligochaeta* (especially *Limnodrilus hoffmeisteri* and *L. spp.*) might have been accidental and local, it appeared that bream and white bream infestation with the parasite increased with increasing consumption of *Oligochaeta* (Tab. 3 and 5).

As regards the diet composition it was found that:

– bream and white bream showed considerable placticity as regards the food spectrum;

– diet of older fishes was predominated by *Chironomus sp.* larvae, and they were quite abundant also in juvenile fishes;

– consumption of the zooplankton, molluscs and chironomids by particular bream and white bream cohorts differed in the phenologic cycles and particular years. The disproportions were due to periodic increase of the consumption of supplementary components accompanying Chironumus sp. (such as molluscs in summer, *Chironomus* pupae and *Oligochaeta*), or else to more permanent changes of the diet induced by prey availability;

– cohorts I_b and I_{wb} fed more on plankton, while older fishes on benthic organisms with an addition of planktonic ones.

Intra-and inter-species changes of the food weight.

Significant differences were observed as regards food weight in bream males and juveniles ($T = 3.335$, $p = 0.001$), and in bream females and juveniles ($T = 4.513$, $p = 0.001$). In white bream the differences were found between females and males ($T = 2.704$, $p = 0.008$). There were not statistically significant differences as to the weight of food consumed by bream and white bream, but filling of their intestines did differ. Fig. 1 presents the relationship between intestine filling with food and fish weight. It can be concluded that white breams fed more intensively than breams of the same individual weight. The index of intestine filling with food is a relative measure of the intensity of feeding. Nevertheless, it appeared that white breams 200–600 g in weight usually had the intestines more packed with food (35–95$^{\circ}/_{ooo}$) than breams (10–50$^{\circ}/_{ooo}$). There were also differences as to the feeding intensity between the sexes (Tab. 6). In April, bream males fed more intensively than females, both of bream and white bream, consumed more food than the males. Due to the fact that these trends represented also the effect of gonad weight and sex ratio in the white bream stock (Tab. 7), feeding activity of the IV_b cohort was compared of that of the females in the IV_{wb} cohort. Ratio between bream males and females and white bream females in these cohorts was as 1 : 1.6 : 1.4. Data presented in Tab. 7 suggest that each time the intensity of feeding by white bream was much higher than of bream females and males.

Weight of food consumed by the fishes depended on the size size of the larvae. White bream consumed more larvae of the chironomids than bream ($T = 3.003$, $p = 0.003$). Size of the larvae consumed by bream was more differentiated (Fig. 3, $T = 3.491$, $p = 0.001$). Moreover, bream consumed smaller larvae more frequently ($T = 2.289$, $p = 0.024$).

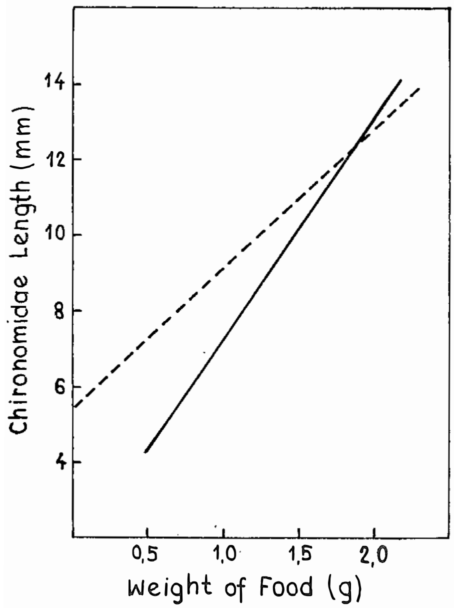

Fig. 2. Relationship between weight of the food consumed by bream (C_b) and average size of the Chironomids (L): $C_b = 0.168\ L - 0.193$, $r = 0.288$, $p = 0.05$ (straight line), and between weight of the food consumed by white bream (C_{wb}) and average size of the Chironomids (L): $C_{wb} = 0.332\ L - 2.299$, $r = 0.449$, $p = 0.01$ (dashed line)

comparable cohorts of the two fish species, juveniles in the cohort II_b consumed twice more *Chironomidae* larvae of average size than the cohort II_{wb} (Tab. 8). Intestines of older fishes contained more or less the same number of average-sized and big larvae.

Amount of the chironomid larvae consumed by the fishes differed, but usually increased with water temperature (Fig. 4). In case of white bream this trend was quite noticeable and confirmed by a significant dependence between food weight and water temperature (Fig. 5). Consumption by bream was more varied (Fig. 4). It depended significantly on the effect of water temperature upon decreasing length of the consumed *Chironomidae* larvae (Fig. 6). The trends related to fish grazing on the chironomids suggest that the fishes fed most intensively within the temperature range of from 17–18 to 20–21°C.

Similarity of the food composition in the cohorts I, II and III is presented in Fig. 7. In spring and autumn indices of the similarity were quite high, about 40–50%. Most pronounced differences as to the food composition were observed in August.

DISCUSSION

It was found that *Chironomidae* larvae (especially *Chironomus sp.*), *Mollusca* and zooplankton were the most important measurable components of the diet of both bream and white bream. Food composition was similar as described by other authors (Bakanov and Strižnikova 1979, Klimczyk-Janikowska 1974, Zadorožnaja 1978, Prejs 1973, Žiteneva and Strižnikova 1981, Kokeš and Gajdušek 1978).

Studies by Ermolin (1979), Morošničenko (1978) and Žiteneva (1982) revealed considerable importance of *Oligochaeta* in the diet of benthic-feeding fishes. We have also observed remnants of *Oligochaeta* in the fish intestines as well as extensive infection of bream and white bream with the plerocercoid *Caryophyllaeus laticeps*. Abundant presence of tape worm in the intestines might have decreased fish condition, but also may suggest their intensive feeding on *Oligochaeta*. Milbrink (1975) used *Caryophyllaeus laticeps* to interpolate the size of *Oligochaeta* consumed by bream in Lake Mälaren. In Włocławek Dam Reservoir average infestation of the bream population did not exceed 31.5%, and of white bream 14.1%. The most extensive infestation was observed in spring – 85,7%–33.3% for bream, and 6.8%–19.6% for white bream. Bigger fishes were usually more infested than smaller ones. This confirms earlier data by Anderson (1974) and Milbrink (1975). Usually, the infestation decreased in course of the phenologic season. Infestation of bream amounted to 17.8% in summer and 8.1% in autumn, the respective numbers being 9.2% and 4.3% for white bream. This was due to maximal

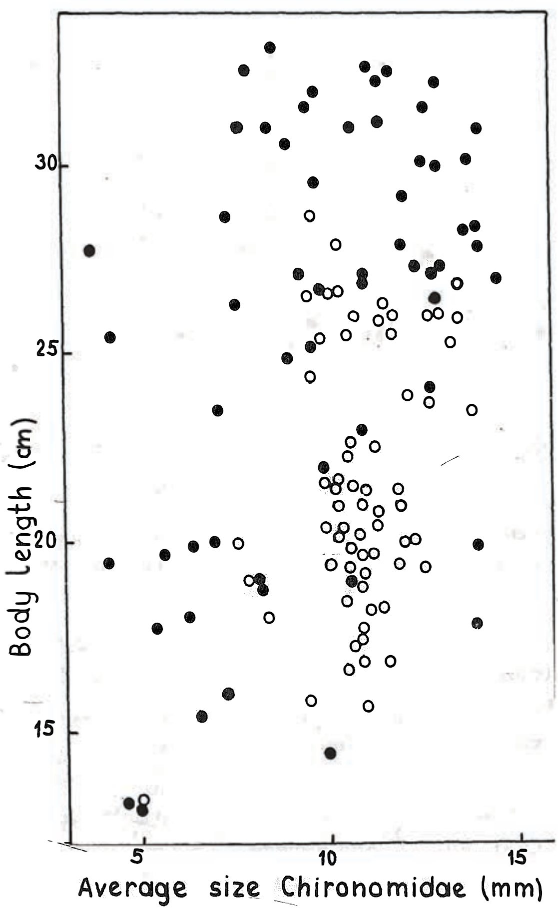

Fig. 3. Relationship between average size of the chironomids and bream (dark points) and white bream (light points) body length.

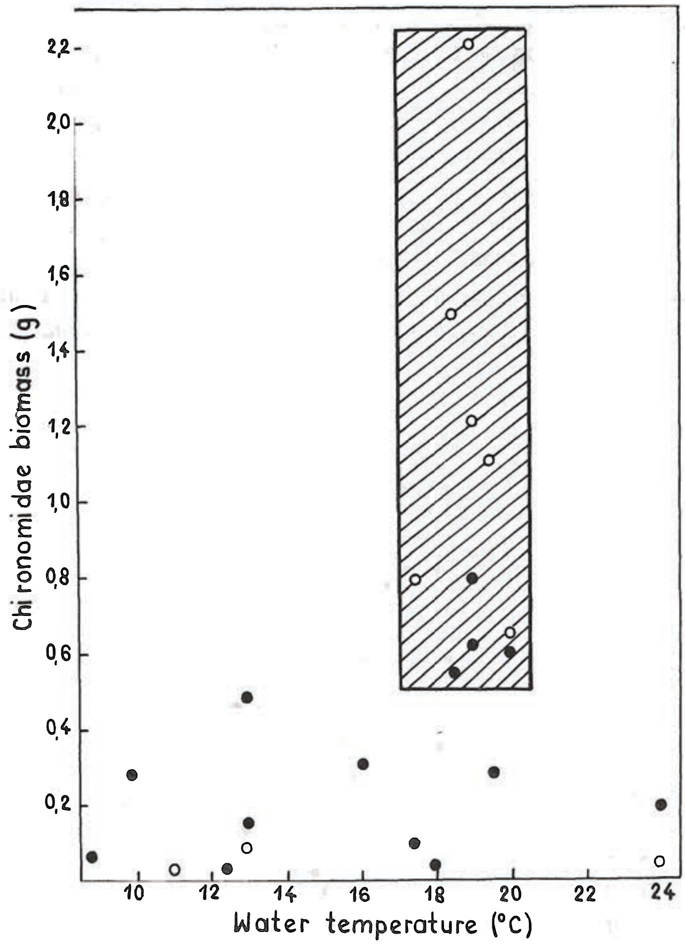

Fig. 4. Relationship between reconstructed weight of *Chironomidae* in bream (dark points) and white bream (light points) diet and water temperature. Denoted field represents the highest consumption of *Chironomidae* larvae

consumption of the worms in spring. Žiteneva (1983) showed that *Oligochaeta* were present in bream intestines when their biomass in the zoobenthos exceeded 2 g.m^{-2}. Analyses of the benthic fauna (Giziński et al., in print) in Włocławek Reservoir showed that the ratio between *Oligochaeta* and *Chironomidae* numbers amounted to 10 in 1982–1984. Drastic disproportions were observed in May 1984: numbers of *Chironomidae* amounted to 39 indiv. m^{-2} and their biomass to 0.06 mg.m^{-2} while numbers of *Oligochaeta* reached 6500 indiv.m^{-2} and biomass 22.6 g.m^{-2} (Ciunelis 1985). Abundance of the two groups was more or less similar in summer (3:1) and autumn (2:1), but in spring *Oligochaeta* must have constituted an important component of older bream and white bream. In case of drastic decrease of the preferred food, the fishes were forced to change their diet composition. Hence, the diet was modified by the environmental factors

Table 8

Share (%) of average (less than 10 mm) and big (more than 10.1 mm) *Chironomidae* larvae in the diet of particular bream white bream cohorts

Cohort	Medium		Big	
	Bream	White bream	Bream	White bream
II	81.9	42.4	18.1	57.6
III	41.3	42.1	58.7	57.9
IV	34.6	49.7	65.4	50.3
V	39.3	–	60.7	–

which affected abundance and composition of the available food resources. Similar relations between the environment and fish feeding were observed for the cohorts I_b and I_{wb}. Density of the zooplankton was twice higher in 1984 than9in 1982, amounting to 1560 indiv.dm^{-3} (Giziński et al. in print). Consequently, the juvenile fishes fed more intensively on *Copepoda* and *Cladocera*.

Water temperature accelerated rate of fish feeding and food digestion. An increase of water temperature to 21°C increased feeding by white bream, and activated feeding of white bream females more than of bream males and females. Water temperature affected also the metamorphosis and emergence of the fauna. As a result, size of *Chironomus sp.* larvae in the bream diet decreased. In lakes, spring emergence of the chironomids is shifted in time, but in dam reservoirs (which are shallower and of even depth) this process is rapid and usually short. This was confirmed by intensive feeding of the fishes on *Chironomidae* larvae during 13–18 days.

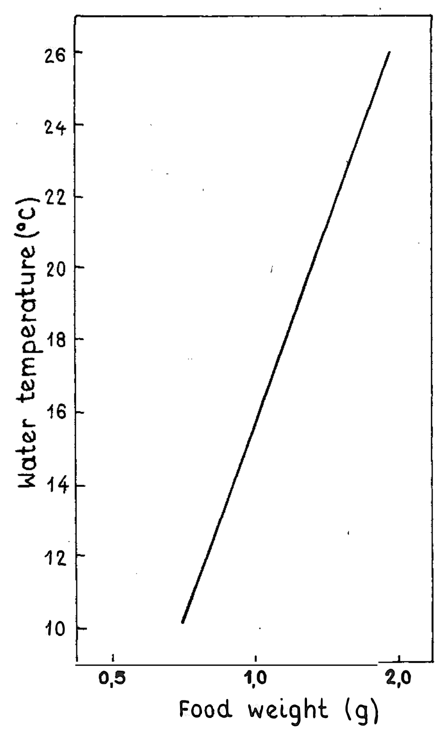

Fig. 5. Relationship between weight of the food consumed by white bream and water temperature (T): C_{wb} = 0.073 T + 0.017, r = 0.701, p = 0.01

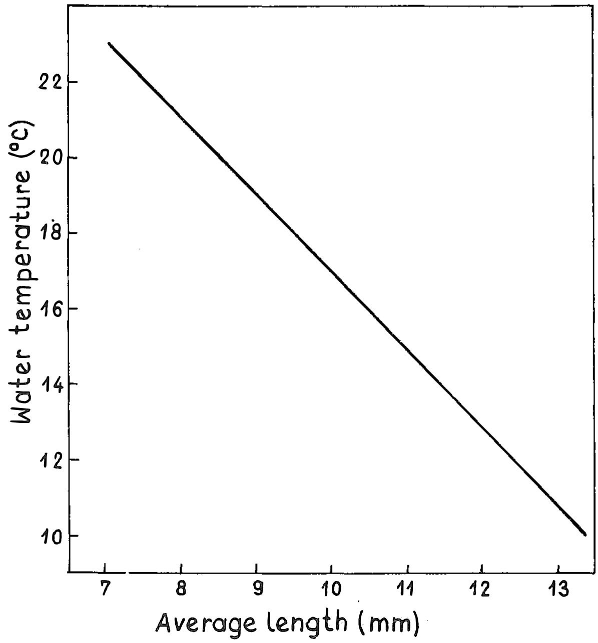

Fig. 6. Relationship between average length of *Chironomus* sp. larvae in bream diet (L) and water temperature (T): L = –0.484 T + 18.271, r = –0.679, p = 0.01

These examples conform the suggestions on considerable adaptability of the two fish species to the existing food resources. It appeared that food availability, measured mainly as the density of the organisms, determined selection of prey by the fishes. Lammens (1985) found that density of the organisms, determined selection of the prey by the fishes. Lammens (1985) found that density of the organisms determined the diet composition. Variations of this composition were inversly proportional to prey densities. Hence, total consumption was not connected with selectivity but rather with prey densities in the environment. In Lammens' study (1984), white bream usually consumed bigger organisms than bream. The author suggested that this was caused by the differences in the gill filtrating apparatus which allowed bream to select its prey more precisely. When bream and white bream feed by filtration, bream is more able to utilize smaller food fractions. This was confirmed by our studies. The II_b bream was decisively more effective in consuming average-sized chironomids than the II_{wb} white bream. Brabrand (1984) and Lammens (1985) observed that during feeding by bream and white bream populations, depth of penetrating the bottom sediments was a function of the fish length. Our studies revealed the reasons for greater variety in the size of *Chironomidae* larvae consumed by these fishes, but also showed that white bream diet contained more chironomids. This suggests that in case of the fishes of the same individual size, bream penetrates the bottom sediments more than white bream.

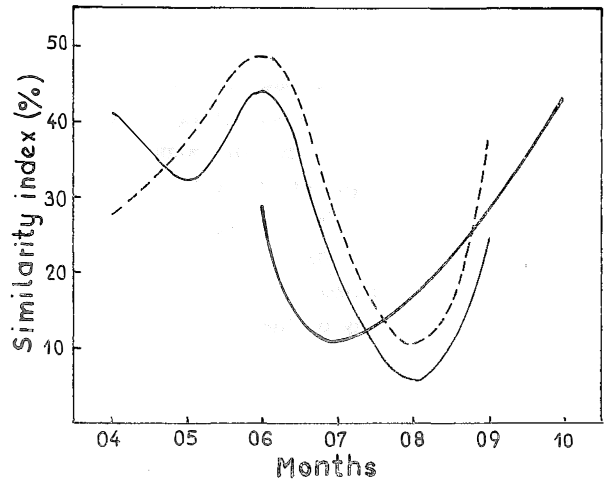

Fig. 7. Index of the food convergence for cohort I (straight thin line). II (dashed line) and III (straight thick line) of bream and white bream

In view of these facts, similarity of the diet of the two species in Włocławek Dam Reservoir should be regarded more as a co-feeding and less as competition. This is confirmed by the dependence between prey and fish size, prey densities, amount of food consumed and feeding activity of males and females of both species and of their particular cohorts. It may be concluded that the Šorygin's index (1939) refers here to the diet composition as determined by density of the preferred prey rather than the interspecies competition. Both species preferred chironomids, but consumed prey of different size. This was due to the fact that bream was more able to penetrate deeper layers of the sediments and thus to consume bigger larvae, but also to catch more smaller larvae than white bream. Bigger larvae originated mostly from soft sediments of the lenitic zone of the resorvoir. White bream fed more intensively over surface layers of the sediments and consumed average-sized larvae. It can be stated that bream is more plastic as regards size of the Chironomidae consumed and ability to use different levels of the food niche.

SUMMARY

Studies were carried out in 1982–1984 on the diet of bream and white bream. Analyses were performed of 1579 fish intestines (Tab. 1).

1. Over 30 food components were identified in the food tracts of the two species (Tab. 2). Their frequency depended on the fish size and trophic changes in the environment.

2. Bream and white bream appeared to be very plastic as regards their food spectrum.

Food of older fishes was predominated by *Chironomus sp.* larvae. Zooplankton, molluscs and chironomids were grazed upon with different intensity by particular bream and white bream cohorts as well as in different phenologic periods and years of studies (Tab. 3, 4, 5). The observed disproportions were due to periodically more intensive consumption of the components accompanying *Chironomus sp.* (for instance, *Mollusca* and *Chironomus sp.* pupae in summer, *Oligochaeta* in spring) or else to more permanent changes in the spatial distribution of the food resources, determining their availability.

3. Differences were noted as to the intensity of grazing. White bream females fed more intensively than other specimens of the two fish species (Tab. 6, 7, Fig. 1).

4. Food weight depended significantly on the size of the chironomid larvae consumed (Fig. 3) and tended to increase with their increasing size. White bream consumed more *Chirnomidae* than bream (T = 3.003, p = 0.003). *Chironomidae* larvae consumed by bream were of a wider size range (Fig. 3) than those consumed by white bream (T = 3.491, p = 0.001). Amount of the chironomids consumed by the two fish species differed but tended to increase with water temperature.

5. The relations between fish and prey size, prey density and food intake, as well as the intensity of grazing by males, females and particular cohorts suggest that bream and white bream co-feed rather than compete for food. Both species used the same food niche but differed as to the intensity of penetrating the sediments and utilizing the size fractions of *Chironomidae* larvae.

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Sławomir Wielgosz, Magdalena Tadajewska

UWARUNKOWANIA STRUKTURY DIET I DOSTĘPNOŚCI POKARMU LESZCZA *ABRAMIS BRAMA* (L.) I KRĄPIA *BLICCA BJOERKNA* (L.) W ZBIORNIKU WŁOCŁAWSKIM

STRESZCZENIE

W latach 1982–1984 badano strukturę diet leszcza i krąpia. Przeanalizowano 1579 jelit różnych kohort (Tab. 1).

1. Zidentyfikowano ponad 30 komponentów pokarmu w jelitach obu gatunków ryb (Tab. 2). Ich frekwencja warunkowana była wielkością ryb oraz dynamiką zmian warunków i zasobności środowiska.
2. Stwierdzono plastyczność leszcza i krąpia motywowaną szerokim spektrum pokarmowym. Dominowały larwy *Chironomus sp.* w diecie ryb starszych kohort. Obserwowano zmienne wyżerowanie zooplanktonu, mięczaków i chironomidów między poszczególnymi kohortami leszcza i krąpia, ich gatunkami, cyklami fenologicznymi i latami badań (Tab. 3, 4, 5). Dysproporcje te uzasadnione były okolicznościowym wzrostem spożycia okazów regularnie towarzyszących *Chironomus sp.* (np. *Mollusca*, poczwarki *Chironomus sp.*, wiosną *Oligochaeta*), bądź trwalszymi zmianami specjacji pokarmowej, warunkowanymi dostępnością ofiar.
3. Wystąpiły różnice aktywności żerowania. Samice krąpia żerowały aktywniej od innych okazów płci obu gatunków (Tab. 6, 7, Fig. 1).
4. Waga pokarmu ryb statystycznie istotnie zdominowana była rozmiarami chironomidów (Fig. 3) i wykazywała tendencję rosnącą z ich średnią długością. Krąp konsumował więcej larw *Chironomidae* niż leszcz (T = 3.003, P = 0.003). W diecie leszcza stwierdzono większą zmienność długości larw (Fig. 3) niż w pokarmie krąpia (T = 3.491, P = 0.001). Wyliczone wartości spożycia ochotkowatych przez oba gatunki ryb były różne, lecz rosły ze wzrostem temperatury wody.
5. Na podstawie zależności rozmiarów ofiar i ryb, zagęszczenia ofiar i wielkości spożycia oraz aktywności żerowania samców i samic poszczególnych kohort określono, że zasadą współżycia leszcza i krąpia jest współbiesiadnictwo. Oba gatunki wykorzystują wprawdzie te same nisze pokarmowe, lecz z różną intensywnością penetrują osady miękkie i w różnym stopniu wykorzystują frakcje wielkości preferowanych *Chironomidae*.

Author's address:

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Instytut Hydrobiologii
i Ochrony Wód
Akademia Rolniczo-Techniczna
10–957 Olsztyn-Kortowo
Polska (Poland)