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The food of dominant fish species in the Rożnów dam reservoir (Southern Poland) and their food resources*

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Abstract — Quantitative and qualitative analyses of the food of the dominant fish species *Abramis brama* L., *Rutilus rutilus* L., *Lucioperca lucioperca* L., *Perca fluviatilis* L., and *Aspius aspius L.* caught in the reservoir were carried out from 1982—1984. Seasonal variation in the filling of the alimentary canal was observed in non-predatory fish and in predators. Additionally, the coefficient of food selectivity was calculated for non-predatory fish. The greatest food competition was found to be between the perch and pikeperch.

Key words: dam reservoirs, food of fish, food selectivity, food competition

1. Introduction

Since its construction in 1942, investigations on the development and succession of biocenoses in the dam reservoir at Rożnów on the River Dunajec have been carried out almost without interruption (Starzykowa 1972)

In recent years (1981—1984) a complex hydrochemical investigation was carried out by the Institute of Freshwater Biology of the Polish Academy of Sciences in Kraków. The aim of the study was to examine the current state of biocenosis in the reservoir, strongly polluted by muni-

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cipal sewage from Nowy Sącz (B o m b ó w n a 1975). The investigation covered the qualitative and quantitative composition of phytoplankton, zooplankton, and macrofauna (D u m n i c k a et al. 1986) and of ichthyofauna (J e l o n e k, A m i r o w i c z unpubl. data).

The last and so far the only investigation of the food of fish in the reservoir was that by P a s c h a l s k i (1959), which concerned the food of the roach (*Rutilus rutilus* L.) and nose-carp (*Chondrostoma nasus* L.) only.

The aim of the present work was to examine the food of fish species currently dominating in the reservoir, to study the food selectivity of the bream and roach as depending upon age, on the basis of knowledge of the food resources elaborated by the authors mentioned above, and to determine the degree of food competition between fish spcies in the reservoir.

2. Material and method

During a 3-year period (1982—1984) about 2300 alimentary canals taken from fish caught in spring, summer, and autumn in the Rożnów reservoir were analysed. The description of the reservoir and hydrological data are given by D u m n i c k a et al. (1986). Fish catches for investigation of their food were carried out with non-selective gill nets with 24—70 mm mesh apreture.

According to the structure of ichthyofauna of the Rożnów dam reservoir given by J e l o n e k and A m i r o w i c z (unpubl. data) the following fish species were selected: the bream (*Abramis brama* L.), the roach (*Rutilus rutilus* L.), the pikeperch (*Lucioperca lucioperca* L.), the perch (*Perca fluviatilis* L.), the asp (*Aspius aspius* L.).

The alimentary canals (in predators only stomachs) were taken from fish previously measured and weighed, including scales, from the lateral line. Age was determined by retrospective calculations of the growth rate. The ends of the alimentary canals were tied and preserved in 4% solution of formalin. The content of each digestion tract was analysed separately.

In the quantitative-qualitative analysis of food content the gravimetric method of wet weight (P a r k e r 1963) and the volumetric method (H e l l a w e l, A b e l 1971, J u d e 1973, H y s l o p 1980) were used. Material from the alimentary canals was determined using a stereomicroscope with magnification 10—100×.

The degree of filling of alimentary canals was calculated from the formula:

$$S = \frac{g \cdot 100}{G} \text{(S c h u l z 1975)}$$

where: g — weight of food of the fish (g),
G — body weight of the fish (kg).
S was calculated on the basis of arithmetical means.

The quantitative relation between the percentage share of different organisms appearing in the alimentary content and their number in the reservoir was determined using the Ivlev (1955) formula for food selectivity:

$$E = \frac{r_1 - p_1}{r_1 + p_1}$$

where: r_1 — percentage of organism appearing in the food of fish,
p_1 — percentage of organisms appearing in the aquatic environment.

In evaluating food competition in the fish the Rekonen (1938) coefficient of food identity I_D — "Dominantenidentität" was applied. This expresses the degree of coincidence of food types of two fish species (Gerstmeier 1985). Calculation of the index I_D was based on 14 food categories: 1 — *Chlorophyta*, 2 — vascular macrophytes, 3 — *Oligochaeta*, 4 — *Cladocera*, 5 — *Copepoda*, 6 — *Chironomidae larvae*, 7 — *Ephemeroptera*, 8 — *Odonata*, 9 — *Heteroptera*, 10 — *Coleoptera*, 11 — *Mollusca*, 12 — detritus with mud and sand, 13—14 — fish which were taken as one group (13) or separately according to species: ablet, *Leucaspius delineatus* Heck., other *Cyprinidae*, stone perch, perch, pikeperch (14).

3. Results

3.1. Quantitative analysis of the food of fish

During 3 seasons of the investigation (spring, summer, and autumn) non-predatory species, the bream and roach, showed fairly uniform values of coefficients of filling of the alimentary canal (S).

For the bream the values of S varied from the lowest in summer (0.78) to the highest in autumn (0.99) (Table I). A different situation was found in the roach where the S index was about 2 times larger than in the bream. The highest values of S were noted in summer and the lowest in autumn.

Predatory fish showed a greater seasonal variation in the filling of the stomach. It should be stressed that in the populations of roach, perch, and asp the greatest values of the S coefficient were observed in the summer (Table I).

Moreover, both for predators and non-predatory fish a general rule was found according to which the coefficient of filling of the alimentary

Table I. Number of samples (N), mean coefficient of filling of alimentary canal ($\bar{S}$), and standard deviation (SD) for 5 fish species during three seasons in 1982-1984

Species	Spring			Summer			Autumn		
	N	$\bar{S}$	SD	N	$\bar{S}$	SD	N	$\bar{S}$	SD
Bream	140	0.81	0.52	160	0.78	0.58	160	0.99	0.94
Roach	150	1.87	0.71	170	2.30	1.45	160	1.81	0.97
Pikeperch	145	3.50	0.79	170	3.27	1.36	140	2.05	1.48
Perch	155	2.92	1.01	175	4.81	2.16	135	2.52	0.73
Asp	95	0.76	0.31	140	1.22	0.48	120	0.86	0.35

Table II. Linear regression (S = a+b·age) for reduced filling of alimentary canal (S) along with age in 5 fish species

Species	b	P
Bream	-0.22	0.001
Roach	-0.32	0.001
Pikeperch	-0.23	0.02
Perch	-0.27	0.05
Asp	-0.12	0.02

canal decreased with increasing body weight and progressing ontogenesis. The calculated regression of this dependence was significant, especially for the roach and bream, though, the relation was not absolutely exact (Table II).

In predatory fish analysis of the filling of the stomach showed that the ratio of empty and full stomachs changed throughout the 3 seasons in 1983, the largest number of empty stomachs being found in the perch, pikeperch, and asp in the spring (Table III).

Table III. Ratio of empty to filled stomachs of 3 predatory fish species during 3 seasons in 1983

Species	Spring	Summer	Autumn
Perch	2.4	0.4	0.6
Pikeperch	1.7	0.2	0.2
Asp	1.2	0.1	0.3

3.2. Qualitative analysis of the food of fish

Qualitative analysis of the food of the bream showed that during the first 3 years of live it consumed phytoplankton (*Chlorophyceae: Ulothrix* sp., *Cyanophyta: Anabaena* sp.) and zooplankton (*Copepoda*, *Cladocera*, and *Rotifera*). In the fourth year its feeding habit changed. In that period the share of macrobenthos, i.e., *Chironomidae* (*Procladius* sp. and *Chironomus* sp.) and *Oligochaeta* (*Tubificidae*), increased. *Coleoptera* and *Trichoptera* larvae and fragments of unidentified *Mollusca* were sporadically

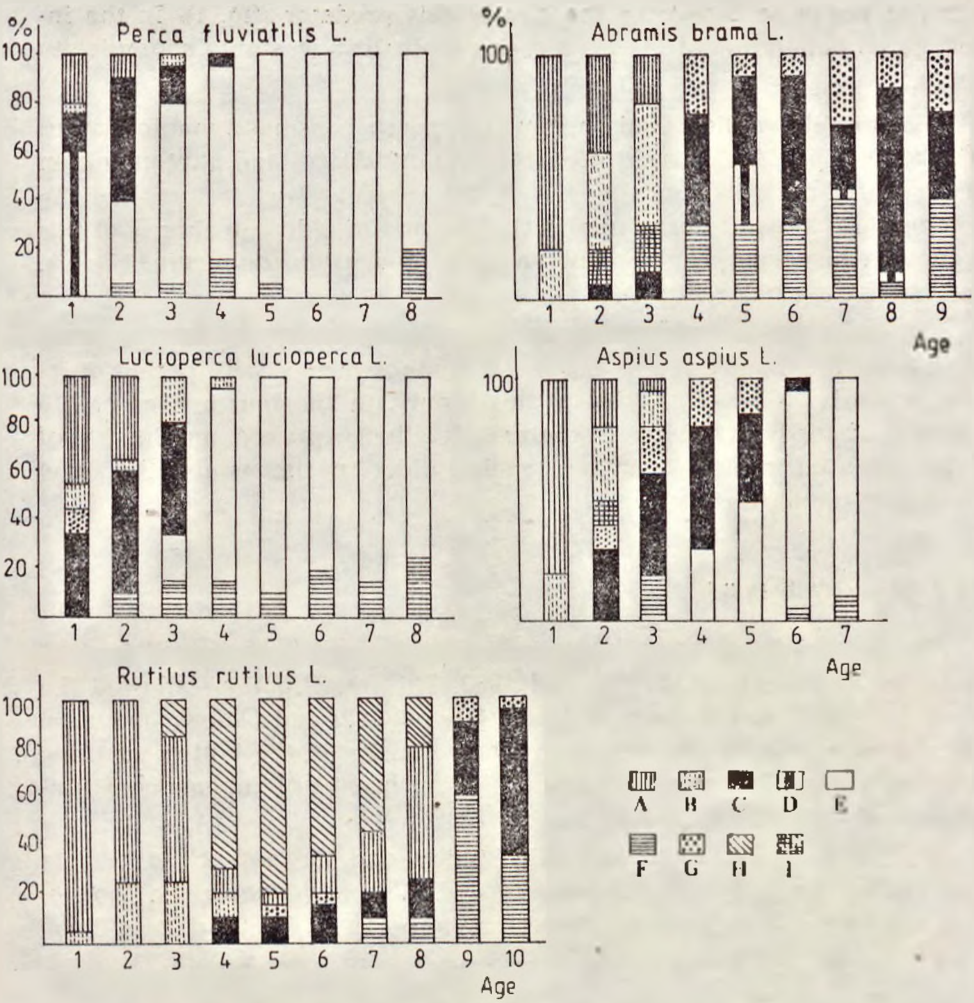

Fig. 1. Percentage composition of food of 5 fish species in different age classes. A — *Chlorophyta*; B — *Cladocera*; C — *Chironomidae*; D — other aquatic invertebrates (*Ephemeroptera*, *Odonata*, *Heteroptera*, *Coleoptera*, *Mollusca*); E — fish; F — detritus; G — *Oligochaeta*; H — aquatic vascular macrophytes; I — *Copepoda*

observed. In older specimens the share of detritus increased in spring and summer (fig. 1).

In the first 3 years of life of the roach phytoplankton, chiefly green algae, prevailed in its food, while in age classes from 4—7 aquatic vascular macrophytes constituted over 50% of it. Later, in 9—10 year old roaches, *Chironomidae* and detritus prevailed in the alimentary content.

In the first period of life of the pikeperch from 1—3 years, it chiefly consumed phytoplankton and macrobenthos. From the third year the stone perch, perch, *Leucaspius delineatus* Heck, ablet, and other *Cy*-

prinidae began to appear in the diet of this predator (fig. 1). In the investigated population of the pikeperch cannibalism was only sporadically noted.

Like the above-discussed species, the perch consumed macrobenthos (*Procladius* sp., *Tubifex* sp., *Coleoptera* and *Mollusca*) and phytoplankton in the early period of its life. But in the second year, earlier than the pikeperch, it began to prey upon fish. The diet of older specimens of this predator consisted only of pikeperch, ablet, *Leucaspius delineatus* H e c k. and other *Cyprinidae* (fig. 1).

The asp, a predatory representative of the family *Cyprinidae*, gathered phytoplankton, zooplankton, and macrobenthos in the early period of its life, similarly as other species of this family. In the fourth year of life its way of feeding became predatory. It chiefly preyed on the fry of *Cyprinidae* but in the alimentary canal of older specimens also the stone perch was found (fig. 1).

3.3. Food selectivity in fish

The bottom fauna of the Rożnów reservoir was investigated in 1963 and 1964 and recently in 1982 and 1983. The investigations showed the dominance of two groups of animals, *Oligochaeta* and *Chironomidae*, in the macrobenthos of the reservoir. Their density in the bottom at three different stations is given in Table IV. Other groups of animals constituted only a small percentage.

On the basis of recent faunistic studies and the author's own data concerning the share of *Oligochaeta* and *Chironomidae* in the food of fish, food selectivity was calculated for the potential benthophages. Food

Table IV. Density of two dominant groups of macrobenthos (Oligochaeta and Chironomidae) at three stations (Grzybowska 1965, Dumnicka et al. 1986). Percentages relate to mean numbers of the two groups

Period	Station	Mean number and range n m^{-2}	Percent	
			Oligochaeta	Chironomidae
1963–1964	1	3733 / 678–4796	18.1	81.9
	2	3245 / 576–5320	18.9	81.1
	3	3156 / 976–9040	79.3	20.7
1982–1983	1	5119 / 909–19037	53.6	46.4
	2	4258 / 3388–5852	83.7	16.3
	3	3395 / 2216–7289	76.5	23.5

selectivity of the bream was calculated in age classes from 4 to 9 years, since the representatives of this species are planktonphages in the early period of life. The Ivlev E coefficient showed that in all age classes this species prefers *Chironomidae* larvae, while the group of *Oligochaeta* sporadically appeared in the food (Table V).

Table V. Food selectivity (E) of the bream (Abramis brama L.) and roach (Rutilus rutilus L.) in age classes from 4-10 years in the period 1982-1984

Species	Major macrobenthos groups	Coefficient E						
		4	5	6	7	8	9	10
Bream	Oligochaeta	-0.67	-0.76	-0.72	-0.50	-0.62	-0.77	-
	Chironomidae	0.41	0.32	0.44	0.13	0.53	0.31	-
Roach	Oligochaeta	-0.83	-0.87	-0.84	-0.81	-0.86	-0.72	-0.85
	Chironomidae	-0.77	-0.41	-0.23	-0.74	-0.20	0.11	0.42

In the roach the E coefficient indicated that also in this species *Oligochaeta* were not readily consumed (negative values of E in all age classes) while older specimens showed a gradually increasing preference for midges. A distinct selectivity for this group of insects may be observed in 9—10 year old roach (Table V).

3.4. Food competition

On the basis of the I_D coefficient was calculated for the predominating fish species in the Rożnów reservoir, using the accepted 14 food categories.

High values of the I_D coefficient and also a great degree of coincidence of the food spectra were found for pike perch and perch, asp and bream, and roach and bream (Table VI). The indices suggest a distinct competition between the above species in gathering food differences in their way of adaptation to the utilization of food resources in the reservoir. Using the I_D coefficient, it is possible to compare other fish species.

Table VI. Coefficient I_D of 5 fish species in 1982-1984. The figures in brackets were obtained with fish as one food category. The other values were calculated on the basis of 14 food categories

	Perch	Pikeperch	Asp	Bream
Pikeperch	70 (74)			
Asp	30 (56)	54 (74)		
[illegible]	24	46	63	
Roach	20	45	45	59

4. Discussion

Compared with other predatory fish of the Rożnów reservoir, the shap and non-predators (bream and roach) showed fairly low indices of filling of the alimentary canal. Among other factors the differences resulted from the different food consumed and the manner of its digestion in the two groups of animals (Barrington 1957, Hunt 1960, Krayuhin 1963, Windell 1967).

The obtained results showed the highest S coefficients for the roach, perch, and asp in summer. In the roach this probably depended upon the mass development of phytoplankton and vascular macrophytes in the littoral and backwaters of the reservoir. As far as the perch and asp are concerned, large numbers of fry appeared in the reservoir during the summer after the spawning time of *Cyprinidae*.

Contrary to the three species mentioned above, in this period the lowest value of the S coefficient was found only for the bream. It seems that this may be associated with the mass emergence of imaginal insects of *Chironomidae*, which constituted its basic food in the investigated reservoir.

Small filling of the alimentary canal was found by Schulz (1975) in Lake Achensee during winter. Probably, in the Rożnów reservoir the poorest food consumption also occurred during the winter months, evidence of this also being an "apparent increase" in biomass of some species of invertebrates living in the bottom (Dumnicka et al. 1986).

During the investigation the highest percentage of empty stomachs of the perch, pikeperch, and asp was noted in spring, this clearly indicating poor feeding of these species at that time. However, the observation may be additionally distorted by the fact that fish caught in nets regurgitate the entire content of the stomach (Nüman 1940). Besides, although the author attempted to establish whether there occurred the phenomenon of cyclic changes in the percentage of empty stomachs, similarly as in Hartman's study (1975) no positive results were obtained.

During the successive periods of the investigation the S coefficient very distinctly decreased in the pikeperch. This may depend upon rise in the temperature of the water in the reservoir, and, in this connection, in the rate of digestion in the animals (Arnoldi, Fortunatova 1937, Karpevitch 1941, Molnar et al. 1967). However, not only temperature but also the degree of sexual maturity significantly affect the amount of food gathered by fish (Fortunatova 1961).

In the Rożnów reservoir a tendency to decreasing values of the coefficient S along with the growth and age of fish was found. A similar phenomenon was observed in the Goczałkowice reservoir in the pike, perch, and pikeperch (author's unpublished results). So far, only Schulz

(1975) has found a positive correlation between the coefficient $\bar{S}$ and the growth of *Salvelinus alpinus salvelinus* L. in Lake Achensee. The qualitative composition of the food changes with the age of fish. The bream consumed phyto- and zooplankton in the early period of its life after which it moved to the deepwater zone of the reservoir (vertical migration) where it feed on macrobenthos. This behaviour was also observed by Pliszka (1953) in Lake Harsz. In spring and autumn the bream consumed larger amounts of detritus, which had some nutritive value owing to the organic substances and bacteria contained in it (Pliszka et al. 1951). Of the two groups of macrobenthos animals, the bream decisively preferred *Chironomidae* and avoided *Oilgochaeta*. A similar type of food was found by Pliszka et al. (1951) in bream from the River Vistula, in which the share of midge larvae reached 80%.

The feeding behaviour of the roach in the Rożnów reservoir was investigated by Paschalski (1958). He found that this species chiefly consumed land plants. These plants are available in periods when the water of the reservoir is retained on wide meadows in the region of backwaters. The present study confirmed that the roach is a phytophilous species.

The perch and pikeperch are typical euryphagous animals in the early period of life. Later, fishes dominated in their food, similarly as in the perch from the Goczałkowice reservoir (Suskiewicz 1961, author's unpubl. data).

No great quantitative role is played by the asp in the Rożnów reservoir. Though in summer older specimens were found to consume a certain quantity of fry in the littoral zone. A similar coincidence of increased intensity of feeding with the summer period and the hatching of fry was observed by Fortunatova (1957).

In the common sense of the word competition means that two organisms or two populations use two types of similar and limited resources (Odum, Reicholf 1980). The obtained results, especially the coefficient I_D, indicate the strongest food competition between the pikeperch and perch in preying on fish, between the asp and bream with respect to macrofauna, and between the roach and bream with respect to phyto- and zooplankton and also partly to macrobenthos. However, the present study does not permit any conclusion to be drawn as to whether the food competition between these fish species may lead to a marked reduction in the population density of any of them. The coexistance of the species is constantly disturbed human agency through the introduction of new species to the reservoir and also sport and farming catches.

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5. Polish summary

Pokarm dominujących gatunków ryb zbiornika Rożnowskiego (Polska Południowa) z uwzględnieniem ich bazy pokarmowej

W pracy przeprowadzono ilościową i jakościową analizę treści pokarmowej leszczy, płoci, sandaczy, okoni (gatunków dominujących) i boleni złowionych w zbiorniku rożnowskim w latach 1982—1984.

Ryby spokojnego żeru (leszcz i płoć) wykazywały w czasie trzech sezonów badawczych (wiosna, lato, jesień) stosunkowo wyrównane średnie wartości wypełnienia przewodów pokarmowych S. Z kolei drapieżniki (sandacz, okoń i boleń) miały większe sezonowe zróżnicowanie indeksu S (tabela I).

W trakcie badań zauważono tendencję do zmniejszania się indeksu S wraz ze wzrostem i wiekiem ryb (tabela II). Najwyższy procent pustych żołądków u drapieżników znaleziono na wiosnę (tabela III).

Stwierdzono, że leszcze odżywiały się głównie makrobentosem, płocie — makrofitami naczyniowymi, starsze sandacze i okonie polowały przeważnie na jazgarze, okonie, słonecznice, ukleje i inne karpiowate, a w przewodach pokarmowych boleni znajdowano przeważnie narybek (ryc. 1).

Ponadto obliczono wybiórczość pokarmową E dla ryb spokojnego żeru w odniesieniu do makrobentosu (tabela IV). Leszcze preferowały tylko *Chironomidae*, pomijały natomiast skąposzczety. Płocie nie wykazywały wyraźnej wybiórczości pokarmowej w stosunku do makrofauny, z wyjątkiem osobników 9- i 10-letnich (tabela V).

Ustalono największą konkurencję pokarmową między okoniem i sandaczem (tabela VI).

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