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THE PASSAGE OF FISH THROUGH THE FISHWAY AT ROŻNÓW DAM IN THE 1997-2003 PERIOD

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Abstract. The species composition and biomass of the fish passing through the chamber fishway located in the Rożnów Reservoir dam in the fall, spring, and summer was determined. Fish samples were collected by electrofishing in the resting chamber. The numbers of other species were estimated in the remaining chambers. In the 1997-2003 period the presence of seventeen species was recorded. The decided dominant was bleak, which comprised 79.2% of all fish at 28362 specimens. Cyprinids comprised 98.8% of all the fish examined. Significant variations were observed in the abundance of fish in particular years and seasons. Fish from older year classes passed through the fishway. Only common bream, barbel, and possibly bleak were undertaking spawning migrations. Only three sea trout specimens were observed in the study period. In order to gain a complete picture of the fish passing through the fishway, monitoring should be conducted on a permanent basis.

Key words: FISHWAY, ICHTHYOFAUNA, MIGRATIONS

INTRODUCTION

During the inter-war period in Europe and North America, scientists began investigating the biological foundations for the design of fishways to be placed in the dams of valley reservoirs (Calderwood 1926, 1930, Menzies 1934, Pryce-Tannatt 1937). O'Melantain (1952) and others continued investigating this topic following World War II. In Poland the leading work on this subject in the inter-war period was by Spiczakow (1935), who thoroughly described the principles and aim of building fishways into valley dams. Following the war, Sakowicz and Żarnecki (1954) published their wide-ranging and richly illustrated monograph on this topic.

Inappropriately situated dams or poorly directed currents disturb the ecological continuity of rivers and lead to the liquidation of migratory fish populations. The dam on the Vistula River in Włocławek caused the near extinction of the Vistula sea trout population by cutting off access to its spawning grounds in the river's

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Carpathian tributaries (Wiśniewolski 1997). In 1935-1941, the longest fishway in Poland (463.5 m) was built in the valley dam on the eightieth kilometer of the Dunajec River. It is comprised of 77 chambers, and the total drop is 30.6 m. Each chamber in the dam measures 5×2 m and each one outside it 6×3 m. Water is directed from the lake through a pipeline with a 30 cm diameter, which opens into the first and ninth chambers of the fishway (Olejarski 2003). The storage power station is fitted with four Kaplan turbines (installed power of 12.5 MW) that is situated on the right-bank of the dam. An inventory of fishways conducted from 1962 to 1965 indicated that of the approximately 200 existing structures of this type, few functioned appropriately (Szczerbowski 1993). The Rożnów Dam fishway is considered to function the best, thus a several-year long study was undertaken to determine the species composition and biomass of the fish that pass through this fishway in spring, summer, and fall.

MATERIALS AND METHODS

The study of the passage of fish through the Rożnów Dam fishway was conducted in the 1997-2003 period on the days listed below:

1997 – September 17, 18, 19;

1998 – September 22, 23, 24;

1999 – October 20, 21, 22;

2000 – November 15, 16, 17;

2001 – May 10, 11; July 6, 7; October 17, 18;

2002 – May 13, 14; July 29, 30; October 9, 10;

2003 – May 16, 17; July 25, 26; October 9, 10.

Fish samples were collected in the resting chamber with electrofishing. An IVP-12 battery pack was used after the intake gate had been closed and the water level lowered. The number of fish located in the remaining chambers was counted and their biomass was estimated. The fish caught were measured (*longitudo corporis*) to the nearest 1 mm and weighed to the nearest 1 g. They were segregated by species and scales were collected from the dominants to determine age.

RESULTS

In the 1997–2003 period, 28326 fish specimens belonging to 17 species were studied. The dominants were bleak, *Alburnus alburnus* (L.), European perch, *Perca fluviatilis* L.,

TABLE 1

Species composition and number of specimens of the ichthyofauna caught in the Rożnów fishway
in the 1977-2003 period

Species	IX.1997		IX, X 1998		IX, X 1999		XI.2000		V.2001		VII.2001		X.2001		V.2002		VII.2002		X.2002		V.2003		VII.2003		X.2003		Total		
	n	%	n	%	n	%	n	%	n	%	N	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	
<i>Salmo trutta</i>	1	0.6	1	0.1	-	-	-	-	-	-	-	-	1	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0.01
<i>trutta m. trutta</i>																													
<i>Oncochinchus mykiss</i>	4	2.6	3	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	0.02
<i>Rutilus rutilus</i>	31	19.9	11	0.9	50	5.6	-	-	-	-	150	3.8	218	2.3	2	1.0	149	4.3	21	1.3	6	2.1	158	6.5	102	5.0	898	3.17	
<i>Leuciscus cephalus</i>	1	0.6	9	0.8	11	1.2	25	1.2	1	0.1	1	0.0	1	0.0	2	1.0	-	-	-	-	-	-	-	-	-	-	51	0.18	
<i>Barbus barbus</i>	1	0.6	13	1.1	1	0.1	25	1.2	7	1.0	77	2.0	6	0.1	13	6.4	106	3.1	150	9.12	6	2.1	140	5.7	145	7.1	680	2.44	
<i>Barbus peloponnesius</i>	1	0.6	4	0.3	9	1.0	18	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32	0.11	
<i>Abramis brama</i>	50	32.1	32	2.7	5	0.6	15	0.7	17	2.5	148	3.8	34	0.4	8	3.9	197	5.7	-	-	-	-	292	12.0	55	2.7	853	3.01	
<i>Silurus glanis</i>	1	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.00	
<i>Anguilla anguilla</i>	4	2.6	50	4.3	6	0.7	21	1.0	1	0.1	-	-	19	0.1	1	0.5	1	0.0	10	0.6	-	-	41	1.7	2	0.1	156	0.55	
<i>Sander lucioperca</i>	1	0.6	1	0.1	2	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.0	-	-	5	0.02	
<i>Perca fluviatilis</i>	5	3.2	905	77.2	345	38.9	16	0.8	263	38.3	415	10.6	2	0.0	71	35.0	349	10.1	72	4.4	56	19.7	365	15.0	296	14.5	3160	11.16	
<i>Alburnus alburnus</i>	50	32.1	139	11.9	449	50.7	1900	93.6	395	57.6	3125	79.8	9149	97.0	106	52.2	2641	76.7	1388	84.6	216	76.1	1438	59.0	1440	70.6	22636	79.21	
<i>Salmo trutta trutta m. fario</i>	2	1.3	4	0.3	4	0.5	5	0.2	1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.0	17	0.06	
<i>Aspius aspius</i>	4	2.6	-	-	4	0.5	4	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	0.04	
<i>Chondrostoma toxostoma</i>	-	-	-	-	-	-	-	-	1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.00	
<i>Esox lucius</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.0	-	-	-	-	-	-	-	1	0.00	
<i>Abramis bjerckia</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0.1	-	-	3	0.01	
Total	156	100	1172	100	886	100	2029	100	686	100	3916	100	9430	100	203	100	3444	100	1641	100	284	100	2438	100	2041	100	28326	100	

roach, *Rutilus rutilus* (L.), common bream, *Abramis brama* (L.), and barbel, *Barbus barbus* (L.), which comprised respectively, 79.21, 11.16, 3.17, 3.01, and 2.14% of the total. The remaining species comprised from 0.01 to 0.55% of the total number of studied fish (Table 1).

During the fall, the dominant species in the 1997-2003 period were, in 1997, common bream and bleak at 32.1%, in 1998 perch – 77.2%, and bleak in 1999-2003, which comprised 50.6, 93.6, 97.0, 84.6, and 70.6% in subsequent years (Table 1).

During the springs of 2002 and 2003, bleak dominated at 57.6 and 52.2% and comprised 76.1% of all fish. The domination of this species was also noted in the summer in the 2001-2003 period, when the share of this species in the fishway was 79.8, 76.7, and 59.0%, respectively (Table 2).

TABLE 2

Dominant species – percentage of total fish caught in the fishway in different years and seasons

Year	<i>Alburnus alburnus</i>			<i>Perca fluviatilis</i>			<i>Rutilus rutilus</i>			<i>Abramis brama</i>			<i>Barbus barbus</i>		
	spring	summer	fall	spring	summer	fall	spring	summer	fall	spring	summer	fall	spring	summer	fall
1997	-	-	32.1	-	-	3.2	-	-	19.9	-	-	32.1	-	-	0.6
1998	-	-	11.8	-	-	77.2	-	-	0.8	-	-	2.7	-	-	1.1
1999	-	-	50.6	-	-	38.9	-	-	5.6	-	-	0.5	-	-	0.1
2000	-	-	93.6	-	-	0.8	-	-	0.0	-	-	0.7	-	-	1.2
2001	57.6	79.8	97.0	38.3	10.6	0.01	0.0	3.8	2.3	2.5	3.8	0.4	1.0	2.0	0.1
2002	52.2	76.7	84.6	35.0	10.1	4.4	1.0	4.3	1.3	3.9	5.7	0.0	6.4	3.1	9.1
2003	76.1	59.0	70.6	19.7	15.0	14.5	2.1	6.5	5.0	0.0	12.0	2.7	2.1	5.7	7.1

The numbers of fish caught in particular seasons during the 1997-2003 period are as follows: in the 1997-2003 period – 17355 in fall; in the 2001-2003 period – 1173 in spring, 9798 in summer, and 13112 in fall (Table 3).

TABLE 3

Total number of fish (specimens) caught in the Rożnów fishway in spring, summer, and fall in the 2001-2003 period

Year	Spring	Summer	Fall
2001	686	3,916	9,430
2002	203	3,444	1,641
2003	284	2,438	2,041
Total	1,173	9,798	13,112

The share of bleak in the ichthyofauna in the fishway in fall ranged from 11.8 to 97.0%, in spring from 51.6 to 76.1%, and in summer from 59.0 to 76.7% (Table 2). The share of perch in samples collected in the fall ranged from 0.8 to 77.2%, in spring from 19.7 to 38.3%, and in summer from 10.1 to 15.0% (Table 2). The percentage of roach in the samples ranged in fall from 0.0 to 19.9%, in spring from 0.0 to 2.1%, and in summer

from 3.8 to 6.5% (Table 2). The share of common bream in the samples in fall ranged from 0.0 to 32.1%, in spring from 0.0 to 3.9%, and in summer from 3.8 to 12.0% (Table 2). The share of barbel in the samples from fall ranged from 0.1 to 9.1%, in spring from 1.0 to 6.4%, and in summer from 2.0 to 5.7% (Table 2).

The age of bleak in the studied sample ranged from 2 to 8 years. The year classes that occurred most frequently were 5⁺ and 6⁺ at 30.0% and 4⁺ at 13.0%. The 2, 3, and 7⁺ year classes represented 6.0% of the fish and 8⁺ only 3.0%. In the perch sample (4⁺-12⁺) studied, 36.0% of the fish were from the 5⁺ year class, 28.0% – 6⁺, and 16.0% – 7⁺. The remaining year classes comprised from 2.0 to 8.0% of all the fish. In the roach sample (3⁺ – 9⁺) studied, 36.0% was comprised of fish from the 7⁺ year class, and 16.7% were from the 6⁺ and 8⁺ year classes. Year classes 4⁺ and 5⁺ comprised 11.1% of the fish, and 3⁺ and 9⁺ 5.6 and 2.8%, respectively. In the common bream sample (3⁺ - 8⁺) studied, 26.0% of the fish belonged to the 6⁺ year class, 22.0% to 7⁺, 18.0% to 4⁺ and 5⁺, and 10.0 and 6.0%, respectively, to the 3⁺ and 8⁺ year classes. In the case of barbel, 47.3% of the fish belonged to the 8⁺ year class, 21.1% – 7⁺, and 18.8% – 6⁺, while 3.5% of the fish belonged to the 5⁺, 9⁺, and 11⁺ year classes and 2.3% of the fish to the 12⁺ year class (Table 4).

TABLE 4

Age distribution of the five dominant species in the ichthyofauna of the Rożnów fishway

<i>Alburnus alburnus</i> (2 ⁺ -8 ⁺) 100 fish		<i>Perca fluviatilis</i> (4 ⁺ -12 ⁺) 100 fish		<i>Rutilus rutilus</i> (3 ⁺ -9 ⁺) 74 fish		<i>Abramis brama</i> (3 ⁺ -8 ⁺) 100 fish		<i>Barbus barbus</i> (5 ⁺ -12 ⁺) 85 fish	
Age	%	Age	%	Age	%	Age	%	Age	%
5 ⁺	36	5 ⁺	36	7 ⁺	36	6 ⁺	26	8 ⁺	47.3
6 ⁺	30	6 ⁺	28	6 ⁺	16.7	7 ⁺	22	7 ⁺	21.1
4 ⁺	13	7 ⁺	16	8 ⁺	16.7	4 ⁺	18	6 ⁺	18.8
3 ⁺	6	8 ⁺	8	4 ⁺	11.1	5 ⁺	18	5 ⁺	3.5
2 ⁺	6	10 ⁺	6	5 ⁺	11.1	3 ⁺	10	9 ⁺	3.5
7 ⁺	6	4 ⁺	2	3 ⁺	5.6	8 ⁺	6	11 ⁺	3.5
8 ⁺	3	9 ⁺	2	9 ⁺	2.8	-	-	12 ⁺	2.3
-	-	12 ⁺	2	-	-	-	-	-	-

DISCUSSION

The 1997-2000 study of the fish that passed through the fishway at Rożnów concentrated on monitoring in the fall to check for the presence of migratory trout, *Salmo trutta* L. spawners, which were part of the migratory fish restitution program (Sych 1996). Not until 2001 did studies of the fishway ichthyofauna include the spring and summer periods (Table 1). Juszczyk (1949) and Żarnecki and Kołder (1955) conducted their studies during the same periods. The comparison of the results of these studies with those of the present one indicates that there has been a change in the dominating species and the quality com-

position of the ichthyofauna. In the study by Juszczyk (1949), of the 12,813 fish caught bleak also dominated (77.4%), but nase, *Chondrostoma nasus* (L.) was in second place (17.2%), followed by barbel (2.5%) and sea trout, *Salmo trutta trutta* L. (1.1%). Of the 11395 fish caught in the Żarnecki and Kołder (1955) study, nase (55.42%) dominated over bleak (22.35%), barbel (11.78%), and asp, *Aspius aspius* (L.) (4.62%). These authors confirmed the presence of ten species, of which ruffe, *Gymnocephalus cernuus* (L.) and vimba bream, *Vimba vimba* (L.), do not currently occur. However, in the current study rainbow trout, *Oncorhynchus mykiss* (Wal.) and brown trout, *Salmo trutta* m. *fario* L., common bream, European catfish, *Silurus glanis* L., pikeperch, *Sander lucioperca* (L.), pike, *Esox lucius* L., and silver bream, *Abramis bjoerkna* (L.) were all noted. The data presented confirm the hypothesis that rheophilous fish are disappearing, especially nase (decline from 55.0 to 0.0% (1 specimen)). It also confirms the negative impact the dam at Włocławek has on the spawning run of sea trout (decline from 1.08 to 0.01%). Some species were represented by single specimens, including rainbow trout, European catfish, pikeperch, pike, and silver bream (Table 1). The fishway suits cyprinids especially well as 98.8% of all fish caught and observed came from this fish family, which is not counted among typically migratory fish.

Particular species of fish dominate in the fishway in different periods of the year in varied numbers (Table 5).

TABLE 5

Number of individuals of dominant species in the Rożnów fishway in three seasons of the year in the 2001-2003 period

Year	<i>Alburnus alburnus</i>			<i>Perca fluviatilis</i>			<i>Rutilus rutilus</i>			<i>Abramis brama</i>			<i>Barbus barbus</i>		
	spring	summer	fall	spring	summer	fall	spring	summer	fall	spring	summer	fall	spring	summer	fall
2001	395	3,125	9,149	263	415	2	-	150	218	17	148	34	7	77	6
2002	106	2,641	1,388	71	349	72	2	149	21	8	197	-	13	106	150
2003	216	1,438	1,440	56	365	296	6	158	102	-	292	55	6	140	145

Bleak dominated in all the samples except in fall 1998. During comparable periods (2001-2003) its share in the spring ranged from 57.6 to 76.1%, in summer from 59 to 79.8%, and in fall from 70.6 to 97.0% (Table 2). These data are similar to the results of Juszczyk (1949) but are much higher than those of Żarnecki and Kołder (1955), who estimated the bleak share in 41 observations to be 22.35%.

The share of the other dominant, perch, ranged in spring from 19.7 to 38.3%, in summer from 10.1 to 15%, and in fall from 0.01 to 14.5% (Table 2). In the study by Juszczyk (1949) no perch was recorded, and in that of Żarnecki and Kołder (1955) in 1951 and 1952 it comprised 0.87 and 0.18%, respectively, and was at the end of the list

of species with regard to abundance of occurrence. The next dominant was roach, which comprised 3.2% of all recorded fish in the present study. Its share in the spring period ranged from 0.0 to 2.1%, in summer from 3.8 to 6.5%, and in fall from 0.0 to 19.9% (Table 2). In the study by Juszczuk (1949) this species comprised 0.27% of all the fish caught, while in that by Żarnecki and Kołder (1955) only single specimens of it occurred and it was grouped together with other species. Common bream is the fourth most abundant species in the ichthyofauna noted in the fishway in the current study comprising 3.0% of all fish. It was not noted by either Juszczuk (1949) or Żarnecki and Kołder (1955). The share of barbel, which in the current study is at 2.44%, is close to the results of Juszczuk (2.54%), and lower than those of Żarnecki and Kołder (1955), who described it at 11.8 and 7.2% in 1951 and 1952, respectively.

The relatively high fluctuation in the number of fish in the various years and seasons of the study does not confirm the theory put forward by Juszczuk (1949) that fish undertake migrations depending on water temperature. Over the span of years between studies, temperatures remained very similar in the same months; on average they were 12.0°C in spring (May), 22.6°C in summer (July), and 9.0°C in fall (October).

Both the average body weight and length of the dominating fish species that occurred in the fishway during particular seasons differed in different years (Fig. 1 and 2).

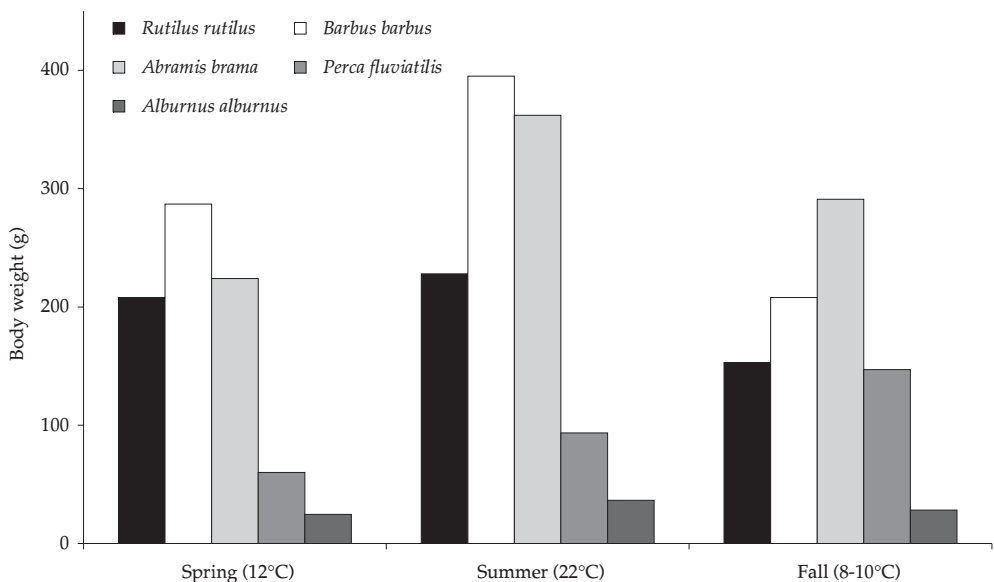


Fig. 1. Average body weight of dominant fish species (mean temperatures in parenthesis).

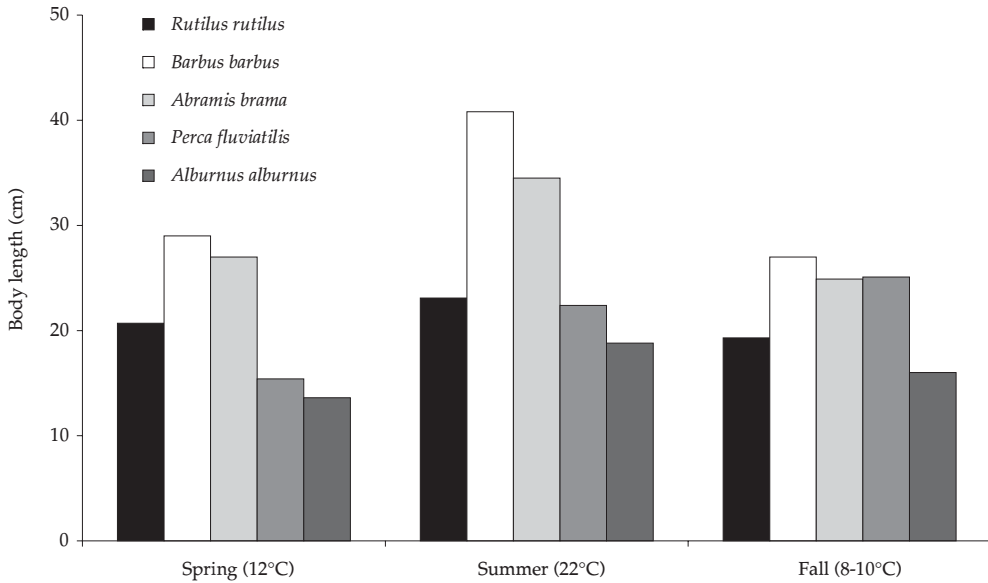


Fig. 2. Average body length of dominant fish species (mean temperatures in parenthesis).

Bearing in mind the age readings (Table 4) and body length measurements (Fig. 2) it can be assumed, as in Brylinska (2000) that bleak maturing in the second (males) or third (females) years of life migrate through the fishway as spawners. This indicates that a distinct spawning migration occurred, as it should in the June-July period, while the fall bleak migration might signal a return to wintering grounds. Barbel, which are sexually mature in the second or third year of life (14-20 cm), migrated through the fishway only as spawners. The most were noted in the summer (323 individuals dominated by the largest specimens aged 6-8) and in the fall (301 individuals) (Fig. 1 and 2, Table 4). It can be assumed that this was a spawning migration. Roach mature in the second (males) and third (females) years of life at an average length of 8-14 cm (Brylińska 2000), thus all of the fish from the fishway that were examined were spawners (Table 4). The highest number of roach were observed in summer – 457 of the largest specimens (Fig. 1 and 2); they did not differ enough from those in

spring and fall to indicate equivocally that they were undertaking spawning migrations. In Polish waters, common bream generally achieve sexual maturity at an age of 6-7 years in the body length range of 17.5 to 37.5 cm and an average of 28.5 cm (Brylińska 2000). This species was most numerous in the fishway in summer (637 individuals) when the average length and weight of individuals was the highest (Fig. 1 and 2); this indicates that for the migrating spawners it was a spawning migration. Smaller specimens were observed in other periods of the year. Brylińska (2000) reported that perch attain sexual maturity in the second or third (males) and third or fourth (females) years of life at an average length of 9-16 cm. In the current study, perch occurred most frequently in the summer period (1129 specimens). All of the studied fish were spawners, the youngest of which had reached the 4⁺ age group. Since perch spawning occurs in Poland in late April and early May, it must be assumed that the summer migration of these fish through the fishway was not related to spawning and was possibly related to feeding.

The data discussed above indicates that older year classes of fish, the considerable majority of which were spawners, passed through the fishway. However, only bleak, barbel, and, especially, common bream were clearly undertaking spawning migrations. The results presented and discussed in this paper lead to the conclusion that single samplings of the ichthyofauna in fishways, not just in one season but in three, do not paint a full picture due to the significant differences in both species composition and numbers of fish in the same periods of different years. The only solution is to conduct continuous monitoring. The fish passing through the fishway in winter should also be studied. This should be done in light of the number of fish that were in the fishway in October. It is possible that the operation of the fishway in winter would provide full ecological access year-round to the entire length of the Dunajec River.

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STRESZCZENIE

PRZECHODZENIE RYB PRZEZ PRZEPLAWKĘ W ZAPORZE ZBIORNIKA ROŻNÓW W LATACH 1997-2003

W latach 1997-2003 przeprowadzono badania nad przechodzeniem ryb przez przepławkę w Zbiorniku Rożnowskim pobierając próby ichtiofauny za pomocą agregatu elektrycznego z komory spoczynkowej oraz określając wizualnie liczebność gatunków w pozostałych komorach. Ogółem wykazano obecność 17 gatunków, z których dominowała ukleja (*Alburnus alburnus* L.) przed okoniem (*Perca fluviatilis* L.), płocią (*Rutilus rutilus* L.), leszczem (*Abramis brama* L.) oraz brzaną (*Barbus barbus* L.) (tab. 1). Ukleja dominowała w ichtiofaunie przepławki we wszystkich badanych porach roku (tab. 2). W latach 2001-2003 najwięcej ryb odłowiono jesienią, a następnie latem i wiosną (tab. 3). Określono wiek gatunków dominujących oraz dominujące liczebnie roczniki (tab. 4) oraz ich średnie masy i długości (rys. 1 i 2). Wykazano, że przez przepławkę przemieszczają się starsze osobniki, lecz wyraźne wędrówki tarłowe mogą mieć miejsce w przypadku uklei, brzany, a szczególnie leszcza.