Folia Zool. – 55(4): 386–398 (2006)

Fish migrations in a large lowland river (Odra R., Poland) – based on fish pass observations

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Received 23 May 2005; Accepted 26 October 2006

A b s t r a c t . Observations of a chamber fish-pass at the lowest situated dam and power station on the Odra River were conducted between March 2002 and February 2003. Twenty two fish species were recorded during 21 catches at the pass, with dominant species *Alburnus alburnus* (90.8% of individuals), *Rutilus rutilus* (4.9%) and *Gobio gobio* (1%). The most intense upstream migrations were observed in spring and early summer during the spawning period of most species occurring there. The migration intensity of most analysed species was positively correlated with water temperature. No potamodromous fishes were observed in the pass at water temperatures below 8 ºC. The only diadromous species recorded were *Anguilla anguilla*, *Vimba vimba* and *Salmo trutta trutta*, all represented by very few individuals.

Key words: potamodromous and diadromous fishes, river obstacles, migratory activity, fish community restoration

Introduction

Fish may migrate for purposes of reproduction, feeding and refuge (L u c a s & B a r a s 2001). Understanding their migrations pattern is important for recognition of biological interactions in the functioning of aquatic ecosystems (S c h i e m e r 1985, J u n g w i r t h et al. 1998, N o r t h c o t e 1998, W i ś n i e w o l s k i 2002). Hydroconstructions such as dams and weirs lead to river fragmentation and consequent disturbance and interruption of its biological continuity (V a n n o t e et al. 1980, J u n g w i r t h 1998). In many dammed rivers, upstream migrations of fishes and other aquatic organisms are impossible or much limited (J u n g w i r t h et al. 1998 and references cited therein). Fish passes and other devices aimed at overcoming these difficulties are built in order to facilitate fish migration. At the same time, they allow for observing such migrations in large rivers.

In the middle and upper Odra basin the loss of river connectivity, long-term pollution and overexploitation have resulted in a total disappearance of six anadromous species of lamprey and fish i.e. see lamprey *Petromyzon marinus,* Atlantic sturgeon *Acipenser oxyrinchus,* Atlantic salmon *Salmo salar,* smelt *Osmerus eperlanus,* allise shad *Alosa alosa* and ziege *Pelecus cultratus*. Several other species, most of all some rheophilic cyprinids (vimba *Vimba vimba,* barbel *Barbus barbus,* nase *Chondrostoma nasus,* spirlin *Alburnoides bipunctatus*) are at present on the brink of extinction (W i t k o w s k i et al. 2000). The lowest-situated weir on the Odra R. – 'Wały Śląskie', with its accompanying fish pass of a limited efficiency for the fish (W i t k o w s k i et al. 2004a), probably contributes significantly to the impoverishment of the ichthyofauna of the basin. Studies on fish migrations through the pass may provide very important data from the viewpoint of ichthyofauna protection, and especially for the programme of restoring migratory fish populations which has been recently launched in

Poland (S y c h 1996, B a r t e l 2001, 2002). Within this programme attempts have been made at restoration and enhancement of populations of *Salmo salar*, *Salmo trutta trutta* and *Vimba vimba* in the upper and mid sections of the Odra R. (W i t k o w s k i et al. 2004b).

The present study aims to describe the diversity of fish entering the pass and their migratory activity in regard to the season, temperature and discharge – several factors which are considered to be among the most important for determining fish movements (L e l e k & L i b o s v á r s k ý 1960, N o r t h c o t e 1998, L u c a s & B a r a s 2001). The rich pertinent literature shows specific characteristics of migration of diadromous and potamodromous fishes in particular rivers (e.g. B a l l e r i v a & B e l a u d 1998, J u r a j d a et al. 1998, L a i n e et al. 1998, J e n s e n et al. 1998, P r i g n o n et al. 1998, T r a v a d e et al. 1998, S v e n d s e n et al. 2004) and suggests a need to accumulate comparative data. We focused on the analysis of such dependences during spawning of the potamodromous species which dominate in this section of the river (W i t k o w s k i et al. 2000). An additional question was the size of migrating fish. A larger body size generally enhances migration abilities (e.g. increase of metabolic efficiency and swimming capacity) (D o d s o n 1997) and may result in the largest individuals in the population being the first to undertake spawning migrations (L u c a s & B a r a s 2001); another aim of this paper was to provide empirical data for a broader description of the problem.

Study Area

The Odra is the second largest river in Poland. Its length is 854.3 km, of which 741.9 km is within the Polish borders; the catchment area is 118.86 km^2 (106.06 km^2 in Poland). As a result of the regulation in the 18th and 19th c., the river is a highly fragmented watercourse, used for shipping. Construction of 48 (26 in Poland, 22 in the Czech Republic) dams and locks has considerably limited or rendered impossible fish migrations to the mid and upper parts of the basin. Several hydro-electric power stations, not all of them provided with fish-passes, present especially difficult obstacles. The lowest situated is the power station at the weir 'Wały Śląskie' (N 51°15'40", E 16°45'58"), ca. 30 km below Wrocław. It was built in 1959, 488 km from the mouth of the river. The mean annual flow (1951–1995) in this section of the Odra is 168 m^{3}s^{-1}. The power station has four 2.7 MW Kaplan turbines and the difference between the upper and lower water level is 7.3 m. The power station is provided with a fish-pass of 27 chambers (first three of 4.2 x 2.5 m, the remainder of 4.0 x 2.3 m), with openings of 45 x 45 cm. Four partitions in the top part of the pass provide water supply and serve as an exit for the fish to the river upstream. The flow in the pass is maintained at about 0.9 m^{3}s^{-1}. Additionally, a one-chamber lock, 219.7 m long and 12.1 m wide, is located near the dam and used for barge locking. These two routes may enable fish to move upstream of the dam (Fig. 1).

Methods

The study was carried out between March 21st 2002 and February 22nd 2003 (for exact dates of observations see Figs 2 and 3). Most of the total of 21 observation sessions were conducted in the period from spring until autumn. During sampling the presence of fish in the chambers 9–27 of the pass was checked twice (10 a.m. and ca. 5 p.m). The lower part of the pass (chambers 1–8) was excluded from observations because of technical difficulties implied in

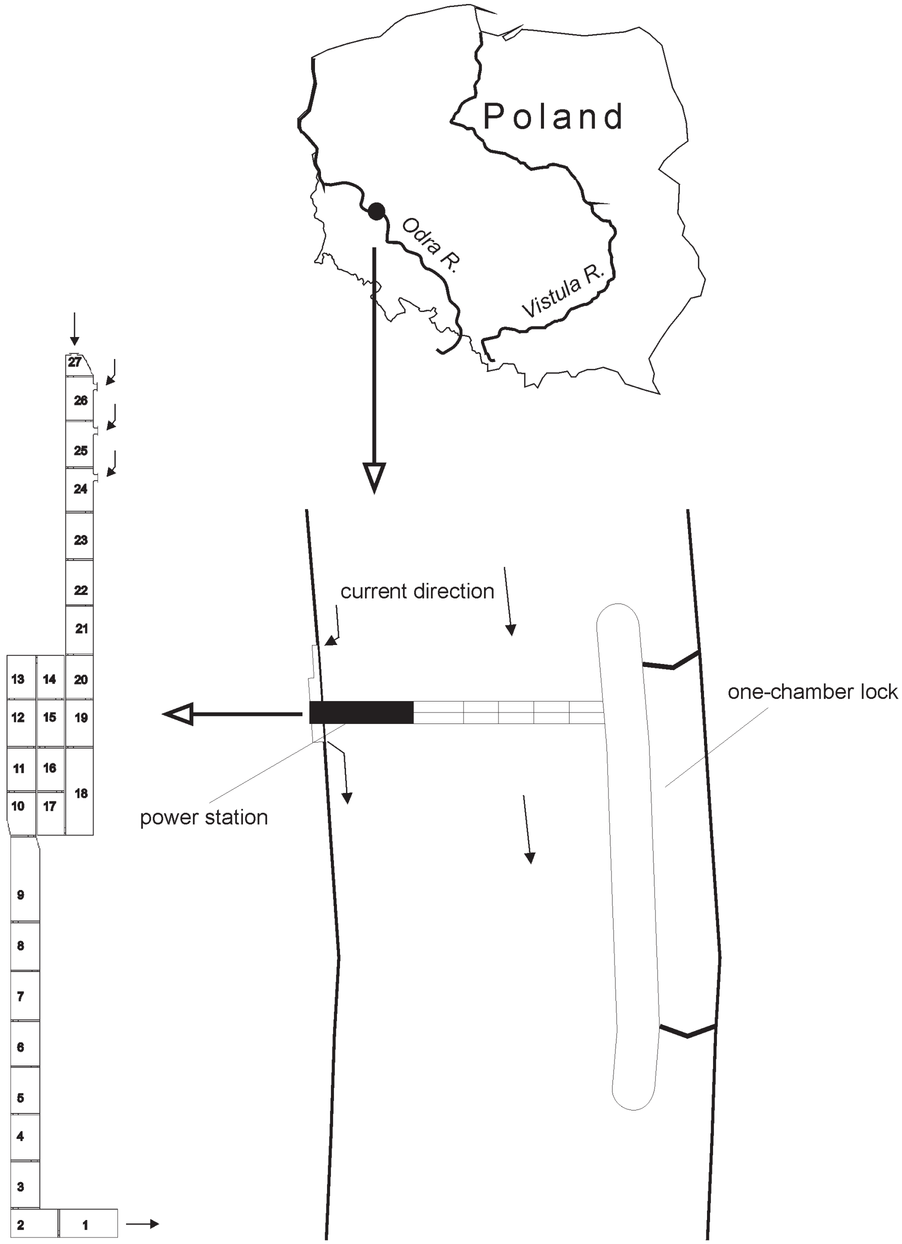

Fig. 1. Location of the dam "Wały Śląskie" and the scheme of the fish-pass. Small arrows indicate the water flow direction.

fish catches in chambers located below the power station building (7 and 8). During the catch the lower part of the fish-pass was blocked between chambers 8 and 9 with a grill (1 cm mesh) and the water supply was stopped through complete closure of the upper culverts. This caused all the water to drain away and all the fish were caught with a net. The fish were identified and measured (TL) to the nearest 0.1 cm. When the catch was large, random samples of 37–94 individuals were measured. After the first fishout a grill was placed in chamber 24 and the culverts were opened. At the same time the grill was removed from chamber 9 to enable the fish to enter and move up to the higher chambers. A successive control catch of chambers 9–27 was conducted five hours later. A repeated catch of the same species (represented by individuals of similar sizes) within a day was then interpreted as an upstream migration.

The migration intensity of each fish species was analysed over the whole period, considering the water level and water temperature. The data on the two physical parameters were obtained from the permanent measuring point of the Institute of Meteorology and Water Management in Wrocław. The dependence between these physical factors and the migration intensity was analysed for 10 most abundantly represented species: bleak *Alburnus alburnus,* roach *Rutilus rutilus,* gudgeon *Gobio gabio,* whitefin gudgeon *Gobio albipinnatus,* silver braem *Abramis bjoerkna,* bream *A. brama,* European chub *Leuciscus cephalus,* ide *Leuciscus idus,* common dace *Leuciscus leuciscus* and European perch *Perca fluviatilis*, using standard model of multiple regression. The number of individuals of a given species caught on the same day (in two catches) was the dependent variable, independent variables being the temperature and water level. Variables of a distribution different from normal (based on Shapiro-Wilk test, $p<0.01$) were logarithmically transformed $\mathrm{Log}_{10}(x+1)$ prior to using them in the regression model. Two independent analyses for each species were performed: for the whole study period and for the period of the peak migration activity of potamodromous fish species in Poland (10th April to 6th July) (B r y l i ń s k a 2000).

The same species served to analyse seasonal changes in the body size of migrating fishes. The mean total length (TL) of fish caught in consecutive months was compared. One-way ANOVA was used, followed by post-hoc HSD-Tukey test at the significance level of $\alpha=0.05$. The critical abundance of the analysed samples was $n\geq8$.

Results

Fish species caught in the pass

A total of 30,127 fish representing 22 species were caught in the fish-pass in the study period (Table 1). The dominants were cyprinids (99.6% all fish), especially bleak (90.8%). Besides, only roach (4.9%) and gudgeon (1%) constituted a significant proportion. The remaining species formed fractions of a percent of the total, though 7 of them (European chub, ide, common dace, bream, silver bream, European perch, whitefin gudgeon) were caught very regularly, a few to several dozen individuals per each sampling session. For samples of $n>6$ individuals of a given species per 1 sampling session the species composition was the same in the morning and afternoon catches. Diadromous fishes were surprisingly scarce; only European eel, vimba and see trout were recorded.

The actual number of species in that section of the Odra is somewhat higher than that noted in the pass, since also common carp *Cyprinus carpio*, silver carp *Hypophthalmichthys molitrix*, wels *Silurus glanis*, burbot *Lota lota*, three-spined stickleback *Gasterosteus aculeatus* and zander *Sander lucioperca* occur there (A. W i t k o w s k i – unpublished data).

Annual dynamics of migration

The data indicate that the period of potamodromous fish migrations in the mid section of the Odra started in April, at the temperature of 8ºC and continued until the end of October

Table 1. Fishes caught in the fish pass during the whole study period (21st March 2002 untill 22nd February 2003). Fish occurrence recorded only in 2002.

Species	Period of occurrence	No of samples	No of fish caught in morning/ afternoon sessions	Mean TL [cm] (n)	SD	Range [cm]
Anguilla anguilla	6 Jul, 9 Aug	2	13/0	47.07 (13)	6.58	35.0-55.0
Barbus barbus	31 May, 12 – 25 Oct	3	8/2	26.8 (10)	9.53	6.2-36.4
Carassius gibelio	16 May, 11 Jun	2	3/0	22.07 (3)	3.37	18.2-24.4
Ctenopharyngodon idella	16 May	1	2/0	43.4 (2)	1.98	42.0-44.8
Gobio gobio	28 Apr – 28 Jul. 19 Aug – 18 Sep.	10	173/116	12.97 (186)	1.36	7.8-18.0
Gobio albipinnatus	16 May, 11 Jun – 18 Sep	8	43/10	9.42 (48)	1.07	7.0-12.4
Tinca tinca	28 Jul	1	1/0	-	-	21
Abramis brama	16 May – 11 Jun, 28 Jul, 19 Aug, 25 Oct.	6	25/43	38.31 (67)	6.70	15.0-51.0
Abramis bjoerkna	28 Apr – 11 Jun, 19 Aug	6	63/102	21.62 (132)	3.59	11.0-33.0
Abramis ballerus	31 May – 11 Jun	2	1/3	36.77 (4)	2.32	34.5-40.0
Rutilus rutilus	10 Apr – 25 Oct.	15	608/868	17.82 (730)	2.76	10.2-35.0
Chondrostoma nasus	28 Apr – 7 May	2	6/1	20.77 (7)	5.01	12.2-27.8
Aspius aspius	28 Apr – 18 Jul	7	22/11	28.68 (33)	10.56	5.0-57.6
Leuciscus leuciscus	10 Apr – 31 May, 12 – 25 Oct	8	47/110	15.97 (144)	1.51	13.2-23.2
Leuciscus idus	20 Apr – 18 Sep	12	114/46	14.71 (160)	11.24	6.00-37.20
Leuciscus cephalus	20 Apr – 19 Aug		198/25	28.25 (223)	5.40	10.6-50.0
Alburnus alburnus	20 Apr – 25 Oct	15	23,504/3,848	13.31 (478)	1.58	10.0-20.0
Ameiurus nebulosus	18 Jul, 19 Aug	2	3/1	23.27 (4)	2.01	21.2-25.5
Esox lucius	19 Aug	1	1/0	-	-	20.0
Salmo trutta trutta	21 Mar	1	1/0	-	-	21.0
Perca fluviatilis	7 – 16 May, 11 Jun – 18 Sep	9	67/37	16.35 (98)	2.26	10.5-23.8
Gymnocephalus cernuus	19 Aug	1	1/0	-	-	8.0

(T=9.6ºC) (Figs 2 and 3). The first species to start migration (since half of April, when the water temperature reached 8ºC) were roach and common dace. In the same months the peak of European chub migration was noted (temperatures 10–12ºC). Another wave of migrants included bleak, gudgeon, silver bream, bream, and European perch, which were the most numerous in the pass in the period mid-May – end of June; water temperature 12–20ºC. The last to start its migration was whitefin gudgeon (beginning of July; temperature 20–24ºC). In summer, another peak of bleak abundance was noted in the fish pass, and migration of some juveniles of ide was observed. The autumn was characterised by a rather small activity of fish. At that time the water temperature decreased steadily to ca. 10ºC and only roach, bream and common dace used the fishway, *R. rutilus* being the most numerous. No fish movements at the pass were observed in winter (temperatures below 8ºC) (Figs 2 and 3).

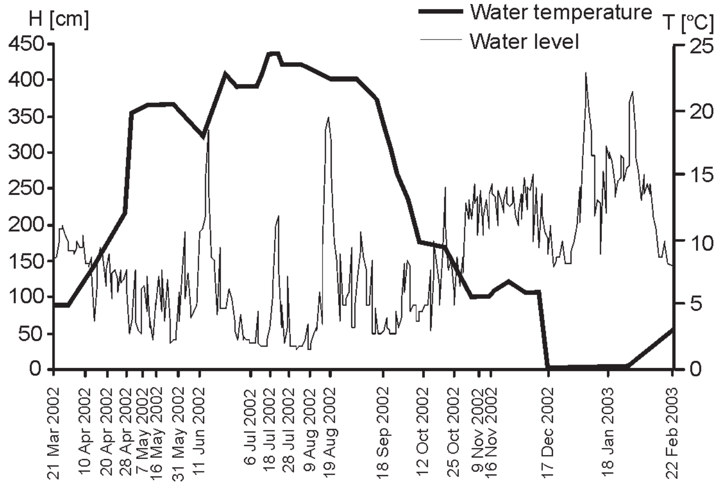

Fig. 2. Water temperature and water level values obtained from the permanent measuring point near Wały Śląskie in the study period.

Dependence between water temperature and level and the fish migrations

In the whole period of studies the physical parameters: water temperature and level, were negatively correlated ($r=-0.49$, $p<0.02$). The two variables showed normal distribution (Shapiro-Wilk, $p>0.05$). Multiple regression showed a dependence between these factors and migration intensity of most dominant fish species (Table 2.). Statistically significant standardized correlation coefficients (Beta) were found only for the dependence between the number of caught fish and the temperature; only roach and common dace showed no such dependence. The dependent variable (number of individuals of particular species in consecutive catches) did not show normal distribution (Shapiro-Wilk, $p<0.05$) and the data were logarithmically transformed prior to using them for the regression model.

At the migration peak of the studied species (10th April 2002 – 06th July 2002) the significant correlation of the number of caught fish and the studied physical parameters included only gudgeon, silver bream and bream (Table 3). Like in the previous analysis, the significance of the correlation was dependent on the temperature rather than on the water level.

Seasonal differences in the size of fish caught in the fish pass

In the case of four species – whitefin gudgeon, silver bream, common dace and European perch – no significant differences in TL were found between consecutive months of the study (Table 4). In the case of bleak and raoch the first individuals to appear (April) were significantly larger than those caught in May (Tukey HSD, $p<0.05$). The bleak showed the decreasing tendency in the body size till September. From June till September the roach reached a size similar to that in April, but the largest individuals were caught in October. The decreasing tendency in the body size was noted also in the case of bream and gudgeon, but the significant decrease took place somewhat later, in June and July, respectively (Tukey HSD, $p<0.05$) (Table 4). The large decrease in the mean size of ide in July resulted from the high

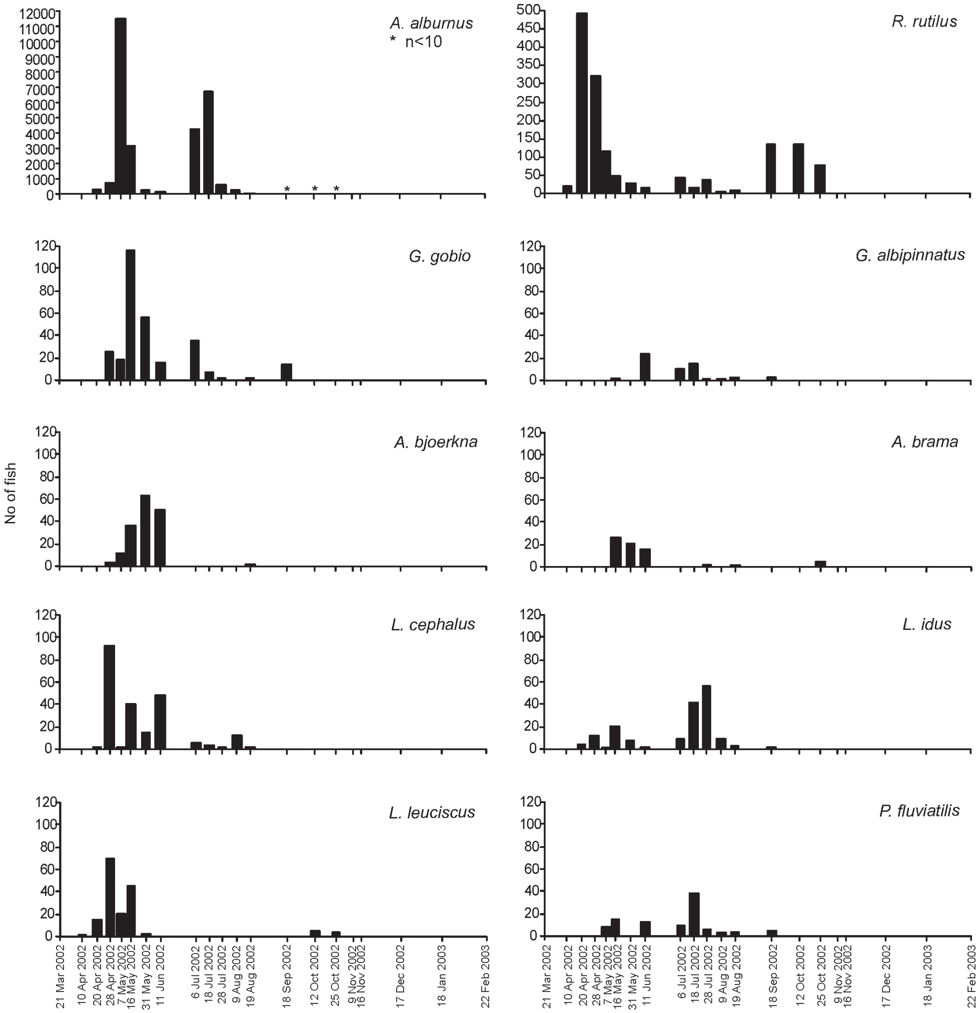

Fig. 3. Migration intensity of particular fish species (both control catches jointly) in the study period.

abundance of juvenile individuals (6–8 cm TL), which could easily get to the fish pass from upstream, passing through the grid which was placed in chamber 24 between the morning and afternoon catches. Thus the changes in the body size of this species cannot be interpreted in the context of upstream migration. European chub showed significant changes in its body size only from May to June (Tukey HSD, $p<0.05$) (Table 4).

Discussion

The bulk of the ichthyofauna in the mid section of Odra River is formed by potamodromous, mainly cyprinid fishes (W i t k o w s k i et al. 2000). Most species occurring there spawn in spring and early summer (B r y l i ń s k a 2000). Their spawning migrations are probably the reason for the highest migration activity in the fish pass in that period. This is also indicated by earlier peaks of migrating activity of the species which require lower spawning temperatures, such

Table 2. Multiple regression analysis of the effect of water level H (in cm) and temperature T (in °C) on the intensity of potamodromous fish migration in the fish pass during the whole study period (21th March 2002 – 22th Feb 2003). Number of fish log-transformed.

		R^2	F	p	Beta	SE Beta	B	SE B	p
A. alburnus									
	intercept						0.41	0.67	0.546
	H	0.71	21.90	0.000	-0.22	0.15	-0.04	0.00	0.147
	T				0.71	0.15	0.13	0.03	0.000
R. rutilus									
	intercept						1.33	0.63	0.050
	H	0.31	4.03	0.036	-0.36	0.22	0.00	0.00	0.131
	T				0.29	0.22	0.03	0.02	0.218
G. gobio									
	intercept						-0.05	0.47	0.912
	H	0.38	5.55	0.013	-0.06	0.21	0.00	0.00	0.785
	T				0.59	0.21	0.05	0.02	0.013
G. albipinnatus									
	intercept						-0.38	0.27	0.182
	H	0.41	6.37	0.008	0.18	0.21	0.00	0.00	0.401
	T				0.71	0.21	0.04	0.01	0.003
A. bjoerkna									
	intercept						-0.59	0.45	0.211
	H	0.25	2.96	0.077	0.30	0.23	0.00	0.00	0.218
	T				0.57	0.23	0.04	0.02	0.026
A. brama									
	intercept						-0.42	0.35	0.251
	H	0.23	2.63	0.099	0.28	0.24	0.00	0.00	0.246
	T				0.55	0.24	0.03	0.01	0.034
L. cephalus									
	intercept						-0.27	0.45	0.544
	H	0.31	4.14	0.033	0.11	0.22	0.00	0.00	0.622
	T				0.61	0.22	0.05	0.02	0.014
L. idus									
	intercept						0.01	0.30	0.962
	H	0.61	14.01	0.000	-0.16	0.17	0.00	0.00	0.362
	T				0.69	0.17	0.05	0.01	0.001
L. leuciscus									
	intercept						0.73	0.48	0.148
	H	0.07	0.69	0.513	-0.29	0.26	0.00	0.00	0.288
	T				-0.04	0.26	0.00	0.02	0.871
P. fluviatilis									
	intercept						-0.17	0.26	0.517
	H	0.41	6.37	0.008	0.17	0.21	0.00	0.00	0.401
	T				0.71	0.21	-0.05	0.01	0.003

as roach, common dace or European chub, and later migrations of more thermophilous species (bleak, gudgeon, silver bream, bream, whitefin gudgeon) (B r y l i ń s k a 2000). Another peak of bleak activity at the beginning of summer resulted probably from the second spawning.

Table 3. Multiple regression analysis of the effect of water level H (in cm) and temperature T (in °C) on the intensity of potamodromous fish migration in the fish pass at the peak of the migration in Poland (10th Apr. 2002 – 6th Jul. 2002). Number of fish log-transformed. Only significant correlations (0.05) are listed.

		R^2	F	p	Beta	SE Beta	B	SE B	p
G. gobio									
	intercept						-0.58	0.80	0.505
	H	0.71	6.02	0.046	-0.07	0.25	0.00	0.00	0.786
	T				0.82	0.25	0.11	0.03	0.024
A. bjoerkna									
	intercept						-1.97	0.84	0.066
	H	0.70	5.96	0.047	0.56	0.25	0.01	0.00	0.080
	T				0.82	0.25	0.12	0.04	0.024
A. brama									
	intercept						-1.93	0.71	0.042
	H	0.71	6.12	0.045	0.65	0.25	0.01	0.00	0.049
	T				0.77	0.25	0.09	0.03	0.029

Though our observations indicate some particular features of the species diversity and timing of fishes in the mid Odra, in many respects they agree with the results of similar studies on the rivers of Central and Western Europe (Juszczyk 1950, Rosengarten 1954, Żarnecki & Kołder 1955, Lelek & Libosvárský 1960, Vøllestad & L'Abee-Lund 1987, Prignon et al. 1998, Travade et al. 1998). The cited authors observed the highest activity of potamodromous species in fish passes during their spawning periods. The temperature values below which no migrations are observed are also similar. According to Lelek & Libosvárský (1960) at water temperatures below 7ºC no fish were observed in fish passes in the Dyje River (Czech Republic). In the Garonne and Dordogne rivers in the south of France the minimum temperature at which cyprinids (14 species) used fish passes was 9–10ºC (Travade et al. 1998). In the Meuse River, Belgium, (5 cyprinid species) it was 8ºC, however significant migrations took place only when water temperature reached 10ºC (Prignon et al. 1998).

Numerous studies show that the temperature, besides the day length and water flow intensity, is the main environmental factor determining fish migrations (Scott 1979, Lam 1983, Lelek & Libosvárský 1960, Northcote 1998, Travade et al. 1998, Lucas & Baras 2001). Lelek & Libosvárský (1960) found furthermore that an increase in temperature and a decreasing discharge strongly stimulated the onset of spawning migrations of most cyprinids in the Dyje River (Czech Republic). Our observations confirm the positive correlation of the migration intensity with the water temperature for 9 potamodromous species during the whole study period. The water level, though negatively correlated with the temperature, showed no marked influence on the number of migrating fish. Because of the great variation of this environmental factor in different years, the results of one-year observations presented here are not sufficient to conclude about the absence of its influence on the fish migratory behaviour (Balleriva & Belaud 1998). The temperature of ca. 8–12ºC, enabling the spring spawning migrations for majority of species, is a threshold above which the fish can migrate in masses. The beginning of migration is thus of an "explosive" character, and the dependence between the further increase in temperature and the number of

Table 4. Results of one-way ANOVA testing the differences in fish length (TL) in different months.

		Apr	May	Jun	Jul	Aug	Sep	Oct
A. alburnus								
	M [cm]	14.5	13.17	13.71	11.98	12.4		
	SD	0.96	1.49	1.84	0.85	1.37		
	n	131	1.56	46	108	27		
		F = 64.00 df = 6 p = 0.000						
multiple comparisons		Apr, Jun, May, Aug, Jul						
R. rutilus								
	M [cm]	17.62	16.15	19.25	18.12	17.96	17.12	20.08
	SD	1.85	1.32	4.26	2.5	1.42	2.07	3.48
	n	260	122	17	54	8	132	137
		F = 31.78 df = 6 p = 0.000						
multiple comparisons		Oct, Jun, Aug, Jul, Apr, Sep, May						
G. gobio								
	M [cm]	13.63	13.09	13.81	12.37	11.84		
	SD	0.52	1.04	1.31	1.9	0.6		
	n	25	88	16	43	14		
		F = 9.07 df = 4 p = 0.000						
multiple comparisons		Jun, Apr, May, Jul, Aug						
G. albipinnatus								
	M [cm]			9.11	9.71			
	SD			0.71	1.25			
	n			23	25			
		F = 4.05 df = 1 p = 0.051						
A. bjoerkna								
	M [cm]		22.11	21.05				
	SD		3.76	2.87				
	n		81	50				
		F = 2.89 df = 1 p = 0.091						
A. brama								
	M [cm]		39.41	32.99				
	SD		4.14	9.37				
	n		45	15				
		F = 12.93 df = 1 p = 0.001						
L. cephalus								
	M [cm]	28.67	26.54	30.36	26.11	26.46		
	SD	4.74	5.37	5.78	7.7	4.47		
	n	95	57	48	9	14		
		F = 4.34 df = 4 p = 0.002						
multiple comparisons		Jun, Apr, Aug, Jul, May						
L. idus								
	M [cm]	29.79	31.87		7.71			
	SD	3.79	1.96		3.53			
	n	15	28		112			
		F = 768.55 df = 2 p = 0.000						
multiple comparisons		May, Apr, Jul						
L. leuciscus								
	M [cm]	15.87	15.67					
	SD	1.17	1.37					
	n	71	66					
		F = 0.80 df = 1 p = 0.372						
P. fluviatilis								
	M [cm]		16.59	15.48	16.36			
	SD		2.19	1.7	2.46			
	n		23	12	53			
		F = 0.95 df = 2 p = 0.391						

individuals migrating through the fish pass is no longer rectilinear. A temperature higher than the optimum for the spawning of a species does not stimulate spawning migrations (P r i g n o n et al. 1998). For this reason our regression analysis during the spawning period showed no relation between the temperature and the number of fish of most species (7), or the correlation was close to 95% confidence limits (3 species). The time and intensity of potamodromous fish migrations depend also on the combination of many other environmental factors, not studied here, which are sometimes regarded as more decisive than the water temperature and flow (L u c a s & F r e a r 1997, J u r a j d a et al. 1998).

A part of the fish caught by us got to the fish pass in search of appropriate feeding and refuge habitats rather than as a result of a spawning migration (L u c a s & B a t l e y 1996, L u c a s & B a r a s 2001). A good example is asp, with the highest numbers in the fish pass during the bleak migration peaks. At that time, its numerous attacks on the bleak gathering near the opening in the lower part of the pass were observed. Likewise, the presence of spring-spawning fishes in late summer and autumn does not indicate the reproductive purpose of such migrations.

The size of migrating fish may vary with season. It was noted for many species of different taxa (including cyprinids) that the largest and oldest fish were the first to migrate to spawning grounds (S a k o w i c z & S z c z e r b o w s k i 1964, L i b o s v á r s k ý 1967, T o l e d o et al. 1986, W i t k o w s k i 1988, W i t k o w s k i & K o w a l e w s k i 1988, T r a v a d e et al. 1998, K o t u s z et al. 2004). It is believed that smaller fish, especially in the case of cyprinids, undertake their migrations with decreasing water flow, since they are later to reach sexual maturity, it is easier for them to resist the water current (L u c a s & B a r a s 2001) and the energy expenditure is smaller (T o l e d o et al. 1986). Our studies indicate that in the first phase of spawning migration the mean size of bleak, roach and gudgeon – the most abundantly represented species – and also of bream, is slightly larger than in subsequent months. The trend does not always persist throughout the entire spring-summer season, and may show fluctuations (roach, gudgeon, chub), or may not be marked at all (whitefin gudgeon, silver bream, common dace and perch). The last groups should include also ide, since the biological background of its spring migration is different from that in the period of summer prevalence of juvenile individuals. The results are difficult to interpret unambiguously and at present do not support or contradict the tested hypothesis.

It is noteworthy that during the whole study period individuals of diadromous fishes (see trout, vimba and European eel) were very few. In that part of the Odra also river lamprey is found, but it was not observed in the fish pass. The fact that some rheophilic cyprinids (spirlin, nase, barbel) were observed rarely or not at all is disturbing and confirms the earlier signalled extinction threat to these species in the Odra basin (B ł a c h u t a 2000, W i t k o w s k i et al. 2000).

The whole hydroconstruction "Wały Śląskie" certainly contributes significantly to the decreasing abundance and/or extinction of fishes in the Odra basin, since it disturbs their life cycles, limits their access to a variety of habitats and the gene flow between conspecific populations. These three aspects of the effect of dams on river ecosystems are regarded as the most dangerous (J u n g w i r t h 1998, P e t e r 1998, L u c a s & B a r a s 2001, K n a e p k e n s et al. 2006). In this context the knowledge of the routes, timing and intensity of fish migrations in the mid section of the Odra river seems to be crucial for the success of restitution of fishes in this river basin and this study contributes to that objective.

A c k n o w l e d g e m e n t s

We are grateful to J. H o l č í k , Zoological Institute, Slovak Academy of Sciences, Bratislava (Slovak Rep.), W. W i ś n i e w o l s k i , Fishery Inland Institute, Olsztyn, Poland, M. P r z y b y l s k i , University of Lodz, Poland, for helpful comments on the earlier versions of this paper and to Beata M. P o k r y s z k o and Robert A.D. C a m e r o n for improving the English.

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