Littoral 0+ fish assemblages in three reservoirs of the Nové Mlýny dam (Czech Republic)

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ABSTRACT: A synchronous study of 0+ juvenile fish in three lowland reservoirs (Mušov, Věstonice, Nové Mlýny) of the Nové Mlýny dam (Czech Republic) was conducted in July 1997. Fish were sampled by fry beach seine and backpack electro fishing gear at 32 sites in three types of inshore habitats: concrete stepped embankment, stony rip-rap and sandy-gravel beach. In total, we registered 0+ juvenile fish of 17 species and one hybrid. The most common species was bleak *Alburnus alburnus* (62.7%), followed by roach *Rutilus rutilus* (12.8%), ide *Leuciscus idus* (6.2%) and asp *Aspius aspius* (5.5%). More than 53% of 0+ fish samples were caught in beach sites, 43% in rip-rap sites and only 3.4% in concrete embankment. The littoral assemblages of 0+ fish differed between the three adjacent reservoirs and also between the shoreline types.

Keywords: YOY; lowland dam; inshore assemblages; shallow reservoir; cyprinid fishes; Dyje River

The ichthyofauna of reservoirs contains mainly riverine species that are able to adapt themselves to the lentic environment (Fernando and Holčík, 1991). Lakes with more complex habitat structure in terms of substrate, macrophytes and depth gradient may represent a more diverse habitat for fish (Benson and Magnuson, 1992). However, most of the typical reservoirs in Europe are deep valley lakes with steep banks with little or no aquatic or terrestrial vegetation and low diversity of habitats. The relationship between different degrees of steepness and other habitat characteristics of 26 reservoirs and the fish fauna was analysed by Duncan and Kubečka (1995). The 0+ juvenile fish assemblages were intensively investigated in deep valley reservoirs (e.g. Vostradovský, 1965; Černý and Pivnička, 1973; Kubečka and Švátora, 1993), however, the knowledge of 0+ fish in shallow man-made lakes is scarce (Zalewski *et al*., 1990; Jurajda *et al*., 1997).

Three shallow man-made reservoirs of the Nové Mlýny dam in the Southeast of the Czech Republic became the subject of ichthyological interest after their construction (Lusk, 1981; Libosvárský, 1991). Many studies of adult fish were conducted on fecundity, growth, diet, migration and fishery management, the results of which were summarised by Prokeš and Baruš (1994) and Lusk *et al*. (1994).

Autecological studies of 0+ juvenile fish were concerned with growth (Prokeš, 1985, 1990, 1993; Prokeš and Řebíčková, 1989; Prokeš and Horáková, 1988) or diet (Kokeš and Sukop, 1984; Kokeš, 1993). A pilot study of 0+ fish assemblages of the lowest reservoir at Nové Mlýny was described by Jurajda *et al*. (1997), but information about littoral 0+ fish assemblages in the other two reservoirs is still missing.

This study is a synchronous pilot survey of littoral 0+ juvenile fish along all available types of inshore nursery habitats in all three reservoirs of the Nové Mlýny dam.

Supported by the Grant Agency of the Academy of Sciences of the Czech Republic (Grant No. 6093106) and the Grant Agency of the Czech Republic (Grant No. A6087503).

MATERIAL AND METHODS

Study area

The Nové Mlýny lowland dam (161–171 m above sea level) was built on the Dyje River (Danube basin) in southern Moravia, Czech Republic in the years 1975–1989. The dam consists of three reservoirs: Mušov (area 528 ha, max. depth 4.3 m, operated since 1979), Věstonice (1 031 ha, 5.2 m, 1982) and Nové Mlýny (1 668 ha, 7.7 m, 1989) (Figure 1). By their morphology, the reservoirs resemble large carp ponds (small depth, highly eutrophic) with climatic conditions anticipating high productivity. The Mušov Reservoir has an inlet of the Dyje River, the Věstonice reservoir has two inlets (Jihlava and Svratka Rivers), and the Nové Mlýny Reservoir has no tributary. Almost all the shoreline of these reservoirs is man-made (stony rip-rap, concrete stepped embankment) with the exception of some sand-gravel beaches. For a detailed description of the study area see Pellantová and Franek (1994).

0+ fish sampling

The representative sampling of 0+ juvenile fish in large reservoirs is very complicated, because of both the size of habitat and 0+ juvenile fish behaviour. The larvae of many lacustrine fish may move into the pelagic zone of large lakes for weeks or months before returning to the littoral zone where they reside as juveniles (Matěna, 1995a; Post, *et al*. 1995; Mooij, 1996). Due to the fact that the sampling of both pelagic and littoral 0+ fish assemblages would be more complex, this study was oriented only to-

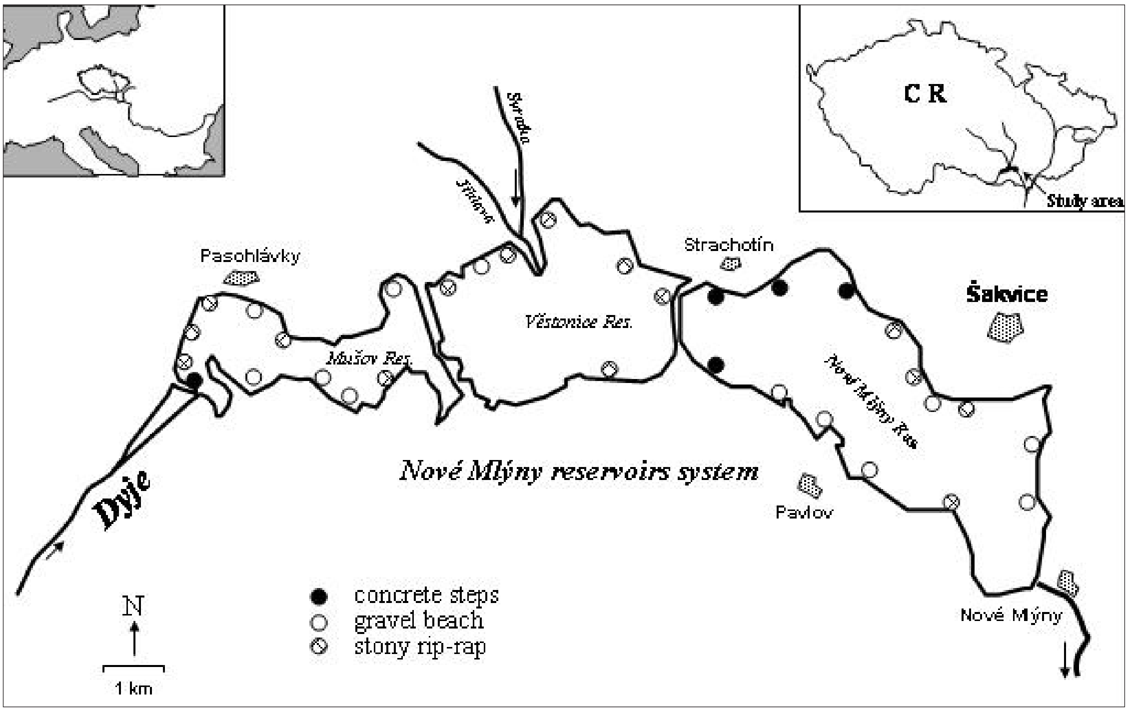

Figure 1. Map of the Nové Mlýny dam, identifying the study sites sampled in July 1997, and their characteristics

Table 1. Estimated distribution of three type of shorelines (%) and the numbers of study sites (*n*) in particular reservoirs in the Nové Mlýny reservoirs system in 1997

Reservoirs	Rip-rap		Gravel beach		Concrete steps		Total
	%	*n*	%	*n*	%	*n*	*n*
Mušov	45	5	53	5	2	1	11
Věstonice	56	6	44	1	0	0	7
Nové Mlýny	57	1	15	6	28	4	14

wards the sampling of littoral 0+ assemblages. We supposed that the sampling time was late enough to catch resided juveniles in the littoral zone. Then, the sampling took place within a short time period with comparable environmental conditions.

Juvenile fish were collected during daylight hours at 32 representative sampling sites along the reservoir's shoreline from 10–17th July 1997. We sampled 11 sites in Mušov, 7 sites in Věstonice and 14 sites in the Nové Mlýny Reservoirs. The number of sites sampled along the particular shoreline type was, where possible, according to its proportion in the reservoir (Table 1). Juvenile fish were sampled using a fry beach seine (length 5 m, depth 1 m, mesh size 1.0 mm). In each site, we sampled 3 consecutive seine hauls at a distance of about 10 m apart, not to be affected by each other. In rip-rap sites, we also used backpack electro-fishing in areas enclosed by a beach seine.

After capture, all juvenile fish were fixed in 4% formaldehyde. The fixed fish were identified and measured (standard length to the nearest 0.01 mm) in the laboratory. Collected data are expressed as catch per unit of effort (CPUE) for 1 m of beach seine.

RESULTS

Species richness and community structure

A total of 2 141 0+ fishes of 17 species and 1 hybrid were caught across all 32 sites. In the upper Mušov Reservoir, we found 13 species and 1 hybrid, in the middle Věstonice Reservoir 12 species and in the Nové Mlýny Reservoir 9 species. Only 7 species were registered in all three reservoirs (roach, ide, asp, bleak, bream *Abramis brama*, perch *Perca*

Table 2. The list of littoral 0+ juvenile fish and qulitative composition (dominance in %) in the three reservoirs of the Nové Mlýny reservoirs system surveyed in July 1997 (reproductive guilds according Balon, 1975)

Code	Scientific name	Common name	Reproduction guild	Mušov	Věstonice	Nové Mlýny
RR	*Rutilus rutilus*	roach	F-L	10.63	54.46	9.79
LL	*Leuciscus leuciscus*	dace	F-L		0.89	
LC	*Leuciscus cephalus*	chub	L	0.29	1.79	
LI	*Leuciscus idus*	ide	F-L	1.82	0.89	30.89
SE	*Scardinius erythrophthalmus*	rudd	F		0.89	0.91
AU	*Aspius aspius*	asp	L	0.29	8.04	31.50
PR	*Pseudorasbora parva*	Japanese minnow	F-L		1.79	
AA	*Alburnus alburnus*	bleak	F-L	76.56	17.86	5.81
BJ	*Abramis bjoerkna*	silver bream	F	2.88		
AB	*Abramis brama*	common bream	F-L	2.64	8.93	3.36
RS	*Rhodeus sericeus*	bitterling	O	0.06		
CA	*Carassius auratus gibelio*	goldfish	F	0.06		
SG	*Silurus glanis*	wels	F	0.06		
PF	*Stizostedion lucioperca*	zander	F			7.03
SL	*Perca fluviatilis*	perch	F-L	0.71	2.68	8.26
GC	*Gymnocephalus cernuus*	ruffe	F-L	0.71	0.89	2.45
PM	*Proterorhinus marmoratus*	tubenose goby	S	2.00	0.89	
RR/AB	hybrid			0.06		
Non-identified				1.23		
Sample size (*n*)				1 702	112	327
Number of species				13	12	9

Table 3. The qualitative (dominance in %) and quantitative (CPUE) composition of littoral 0+ juvenile assemblages along the three types of shorelines in the three reservoirs of the Nové Mlýny reservoirs system surveyed in July 1997

Fish species	Gravel beach						Stone rip-rap						Concrete spets			
	Mušov (5)		Věstonice (1)		Nové Mlýny (6)		Mušov (5)		Věstonice (6)		Nové Mlýny (4)		Mušov (1)		Nové Mlýny (4)	
	d (%)	CPUE	d (%)	CPUE	d (%)	CPUE	d (%)	CPUE	d (%)	CPUE	d (%)	CPUE	d (%)	CPUE	d (%)	CPUE
RR	16.4	2.14	44.4	0.28	8.4	0.20	3.6	0.38	55.3	0.66	11.9	0.12			12.3	0.14
LL									1.0	0.01						
LC	0.1	0.01					0.5	0.06	1.9	0.02						
LI	3.3	0.43			34.5	0.81			1.0	0.01	47.5	0.49			4.6	0.05
SE					1.5	0.03			1.0	0.01						
AU	0.4	0.06	44.4	0.28	39.4	0.93	0.1	0.01	4.8	0.06	35.6	0.36			3.1	0.03
PR			11.1	0.07					1.0	0.01						
AA	70.8	9.24			1.5	0.03	84.6	8.86	19.4	0.23					24.6	0.28
BJ							6.5	0.68								
AB	3.8	0.50			3.9	0.09	1.2	0.13	9.7	0.12	1.7	0.02			3.1	0.03
RS							0.1	0.01								
CA	0.1	0.01														
SG	0.1	0.01														
PF	0.3	0.04			5.9	0.14			2.9	0.03	3.4	0.03	100.0	0.63	20.0	0.23
SL					2.0	0.05									29.2	0.33
GC	1.3	0.17			3.0	0.07			1.0	0.01					3.1	0.03
PM	3.2	0.42					0.5	0.06	1.0	0.01						
RR/AB	0.1	0.01														
Non-identified							2.8	0.29								
Total	100	13.04	100	0.63	100	2.35	100	10.47	100	1.19	100	1.02	100	0.63	100	1.13
Number of species	12		3		9		8		12		5		1		8	

fluviatilis and ruffe *Gymnocehpalus cernuus*). Bleak was the most common species in the 0+ juvenile fish near shore assemblages in all reservoirs (dominance 62.7%), followed by roach (12.8%), ide (6.2%) and asp (5.5%). More than 53% of 0+ fish samples were caught in beach sites, 43% in rip-rap sites and only 3.4% in concrete embankment.

0+ juvenile fish assemblage structure was considerably different between reservoirs (Table 2). Bleak and roach formed a major part of 0+ fish samples in the Mušov and Věstonice Reservoirs (87% and 72%, respectively) but in different proportions (Table 2). Bleak dominated in Mušov (76.6%) however roach dominated in Věstonice (54.5%). More diverse 0+ fish assemblages were registered in the Nové Mlýny Reservoir (Table 2). Due to different assemblage structure in each reservoir, also different assemblages in particular shoreline types between reservoirs were found (Table 3).

Relative fish density

Relative density (pooled CPUE in all sites) of 0+ juvenile near shore fish assemblages was almost 10 times higher in Mušov (CPUE = 10.7) than in Věstonice (CPUE = 1.1), and Nové Mlýny (CPUE = 1.6). Considerably higher CPUE were found in sand-gravel beach sites and stone rip-rap shoreline types in the Mušov Reservoir (CPUE = 13.04 and 10.47, respectively) than in other sites (CPUE < 2) (Table 3).

DISCUSSION

The adult fish community in the Nové Mlýny Dam is composed of at least 25 species, with dominant silver bream, *Abramis bjoerkna* (L.), roach and bream (Prokeš and Baruš, 1994; Lusk *et al*., 1994). Our single sampling of 0+ juvenile fish revealed 17 species, which is a relatively high number from the approximately 20 potential species reproducing there (Prokeš and Baruš, 1994). From the adult dominant fish, (Prokeš and Baruš, 1994; Lusk *et al*., 1994), only roach was well represented in our 0+ juvenile samples. A dissimilar proportion of bleak in juvenile and adult samples might be influenced by the sampling method used. Gill nets used in the adult fish surveys (Prokeš and Baruš, 1994; Lusk *et al*., 1994) probably underestimated bleak in catches. On the other hand, the low proportion of bream and silver bream in our 0+ samples could be due to the off-shore occurrence of these species or their movement. Similarly, as in the study carried out in 1995 (Jurajda *et al*., 1997), asp, ide and roach were the dominant species in the lowest Nové Mlýny Reservoir in this study, however in different proportions.

Pavlov *et al*. (1987) documented the downstream displacement of fish from the middle reservoir into the Dyje River (at the time the lowermost reservoir had not been built), with silver bream, bream, roach and rudd (*Scardinius erythrophthalmus*) being the most numerous species. It appears that fish migrate upstream to spawn in tributaries of the middle reservoir and drift downstream as older juveniles. It also seems that other species migrate upstream to middle reservoirs through open gates (equal water level) and to tributaries for spawning (Šebela, 2000). According to the number of fish species and their abundance, the presence of tributaries could play a similarly crucial role for fish reproduction in these lowland reservoirs as it does in deep valley reservoirs (Hladík and Kubečka, 2003). Perhaps, the succession stage of lake and habitat and fish community stability in particular reservoirs could influence the natural reproduction of fish (Baruš, pers. com.).

The sampling efficiency of 0+ fish is rather variable with different sampling methods in large water bodies such as the Nové Mlýny dam. Compared with a single survey in a large river where relatively high water velocity forces most of the 0+ juvenile fish inshore, shoreline sampling for density in large standing water bodies may give rise to underestimates.

Beach seine nets are most efficient on flat structured substrates (Dauble and Gray, 1980; Frankiewicz *et al*., 1986). Thus, the use of beach seines in reservoirs is limited to suitable substrates (Kubečka and Pivnička, 1991; Švátora, 1992). However, beach seining is commonly adopted even along structured shorelines (Benson and Magnuson, 1992; Bryan and Scarnecchia, 1992), and rarely with correction for the variable capture efficiency (Pierce *et al*., 1990).

The smallest catches in the present study were found along the concrete steps; however this habitat may be efficient enough for sampling fish by seining. The low abundance of 0+ fish was probably affected by the fish avoidance of this homogeneous shoreline without any shelters. Capture efficiency was lowest along stony rip-rap in comparison with the other habitats sampled. The combination of beach seining with electrofishing on stony rip-rap may give better results (Bagge and Hakkari, 1985).

In all reservoirs, inshore fry communities inhabit shallow littoral zones, while offshore fry communities exist simultaneously (e.g. Coles, 1981; Gliwitz and Jachner, 1992). The larvae of many lacustrine fishes spend weeks or months in the pelagic zone of reservoirs before returning to the littoral zone where they reside as juveniles (Matěna, 1995a; Post *et al*., 1995). The same species contribute to both communities but the relationship between the communities is not understood fully (Duncan and Kubečka, 1995). This phenomenon is known from deep valley reservoirs (e.g. Matěna, 1995b, Post *et al*., 1995), however the behaviour of most fishes in lowland shallow reservoirs is less known (Mooij, 1996). Juvenile fish may remain longer offshore in the shallow reservoirs, such as in the Nové Mlýny dam.

The inshore fry communities are better known because they are easier to study. The mean density of juvenile fish caught inshore lies within the same order of magnitude in different reservoirs. However, large differences were found in the littoral carrying capacity of different types of reservoirs by Duncan and Kubečka (1995). This was supported by this study, where a higher abundance of fish was found at beach sites (Table 1). It shows the importance of this habitat as a nursery habitat for 0+ juvenile fish in an impounded reservoir. Low availability of this habitat in the present study site may lead to a higher density of juvenile fish, which might increase density dependent mortality. Mortality rates of 0+ juvenile fish in Czech reservoirs are higher than in the more protective fry supportive marginal regions of natural lakes and rivers (Duncan and Kubečka, 1995). The rip-rap stabilised stretches of the reservoir shoreline do not seem to represent valuable nursery habitats for 0+ juvenile fish in the Nové Mlýny dam during the summer months. Potentially increasing shallow beach areas may increase the abundance of juvenile fish. The high differences of 0+ fish abundance between reservoirs could be affected by the different proportion of shoreline types in particular lakes. Similar mean density in deep valley reservoirs (Duncan and Kubečka, 1995) could be caused by similar shoreline habitats between lakes.

The results of the present study show that, in contrast with large rivers (e.g. Schiemer et al., 1991; Peňáz *et al*., 1991; Jurajda, 1995), a single survey of 0+ juvenile fish does not describe representatively the natural recruitment success in large shallow reservoirs. Even visual observations of fish spawning (P.J. pers. observation; Šebela, 2000) do not document the success of reproduction. Nevertheless, this study demonstrated the natural reproduction of 17 fish species (Table 2), but the final effect of recruitment was not evident (low abundance). It could be influenced by suboptimal nursery sites, high mortality of juvenile fish or their underestimation in offshore assemblages. Furthermore, the combination of different sampling strategies combined with several types of sampling methods may be more effective towards providing a reliable estimate of juvenile fish abundance and distribution in reservoirs (Bryan and Scarnecchia, 1992; Kubečka *et al*., 2003).

Acknowledgements

We would like to thank to M. Reichard, V. Prášek, E. Hohausová, R. Václavík and Z. Adámek for their field assistance. We thank the officials and managers of the Moravian Anglers' Associations and Fisheries Pohořelice who permitted the study in their waters. We are grateful to M. Harper for English revision of manuscript.

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Received: 04–04–02
Accepted after corrections: 04–08–14

ABSTRAKT

Litorální společenstvo 0+ juvenilních ryb ve třech nádržích vodního díla Nové Mlýny (Česká republika)

Synchronní průzkum 0+ juvenilních ryb (plůdek) ve třech nížinných nádržích vodního díla Nové Mlýny (Česká republika), byl proveden během července 1997. Ryby byly odchytávány plůdkovou zátahovou sítí a bateriovým agregátem na 32 stanovištích podél tří typů přítomné břehové linie: betonové schody, kamenný zához a štěrko-písčitá pláž. Celkově jsme zaregistrovali plůdek 17 druhů ryb a jednoho mezidruhového křížence. Nejvíce zastoupenými druhy byly ouklej obecná *Alburnus alburnus* (62,7 %), následovaná ploticí obecnou *Rutilus rutilus* (12,8 %), jelcem jesenem *Leuciscus idus* (6,2 %) a bolenem dravým *Aspius aspius* (5,5 %). Více než 53 % jedinců 0+ ryb bylo ve vzorcích odloveno na plážových lokalitách, 43 % podél kamenného záhozu a pouze 3,4 % na betonových schodech. Litorální společenstvo plůdku se lišilo mezi jednotlivými nádržemi stejně tak, jako mezi typy břehové linie.

Klíčová slova: YOY; nížinná přehrada; litorální společenstvo; mělká nádrž; kaprovité ryby; řeka Dyje

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