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The role of ecotones as feeding grounds for fish fry in a Bohemian water supply reservoir

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Key words: littoral fry, perch, roach, diet overlap

Abstract

The food composition of young-of-the-year (YOY) roach, common bream and perch, the dominant fish species in Římov reservoir, was investigated during 1989 and 1990. The littoral fry assemblages were dominated by roach and perch, while bream larvae migrated into deeper water early in their development. The YOY roach fed opportunistically. Up to 15 mm length they remained close to the shoreline, preferring periphyton, *Chydoridae* and larval *Chironomidae*. Perch larvae between 10–15 mm long gradually became demersal but their diet continued to consist of the planktonic *Cyclops spp.* and *Diaptomus spp.* Resource partitioning was a characteristic feature of the littoral fry assemblages. The only significant overlap in diet occurred with *Polyphemus pediculus*, which was positively selected by both roach and perch fry.

Introduction

The ichthyofauna of reservoirs contains mainly riverine species that are able to adapt themselves to the lentic environment. True lacustrine species are very rare in reservoirs of the temperate zone (Fernando, Holčík, 1991). The land/water ecotones (Wetzel, 1990) serve as spawning areas for the dominant cyprinids in European reservoirs – roach (*Rutilus rutilus*) and common bream (*Abramis brama*) (Mark *et al.*, 1989). The land/water ecotones play further an important role as feeding grounds for fish fry in reservoirs. Cyprinids larvae form schools in the shallow littoral after hatching and begin to move offshore only after several weeks (Rheinberger *et al.*, 1986). Many authors investigated the food composition of YOY cyprinids (e.g. Townsend *et al.*, 1986; Weatherley, 1987; Mark *et al.*, 1987; Schiemer *et al.*, 1989). Perch larvae become limnetic after hatching and remain pelagic for about one month until full development of fins. The juveniles then move inshore to the ecotonal zone (Craig, 1987). The food of YOY perch was described for example by Spanovskaya & Grigorash (1977), Thorpe (1977), Guma'a (1978), and reviewed by Craig (1987).

The aspects of mutual relationships between planktivorous fish and zooplankton were reviewed by Lazzaro (1987).

The aim of this paper was to evaluate the role of the land/water ecotone in the Římov Reservoir as a feeding ground for the three dominant fish species – roach, common bream and perch.

Description of the reservoir

The Římov Reservoir (Fig. 1) on the Malše River in Southern Bohemia, was impounded in 1978.

Fig. 1. Map of Římov Reservoir showing the location of the littoral sampling stations A and B and the 10 m depth contour.

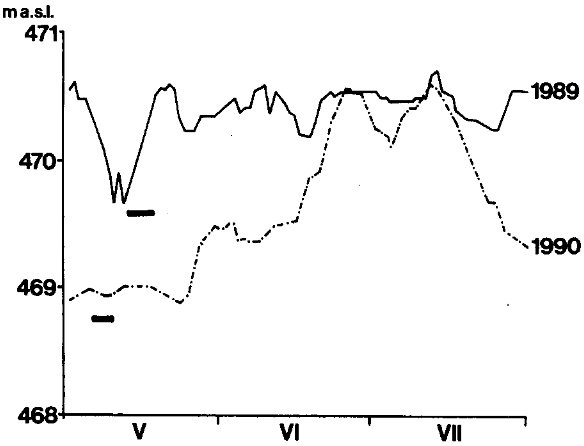

Fig. 2. Water level fluctuations in Římov Reservoir during 1989 and 1990. The horizontal bars indicate the mass spawning period of the cyprinids.

Its surface area is 210 ha, total volume 34 x 10^6 m^3, altitude 470 m above sea level, theoretical retention time 90 days, maximum depth 43 m, and average depth 16 m. Fluctuations of the water level during 1989–90 investigation are shown in Fig. 2. The slope of the banks is quite steep. A typical ecotonal zone is developed only at a few sites. Submerged vegetation is almost absent. A detailed description of the locality was given by Stach and Kubečka (1990). Development of the ichthyofauna was described by Kubečka (1989). The population of perch (*Perca fluviatilis*), the most abundant species during the first few years after impoundment, is still declining. The estimated total biomass was about 150 kg per ha in the investigated years.

Material and methods

The two years investigated, 1989 and 1990, differed with respect to the water level during the spawning period of cyprinids (Fig. 2). There was no flooded terrestrial vegetation in 1990. While in 1989 some areas had flooded vegetation. The water level of the reservoir was dropped by about 0.5 m after the mass spawning of cyprinids in 1989 and several preceding years. The aim was to destroy the eggs. Two sampling stations were chosen along the banks (Fig. 1). Station A represented a typical ecotonal zone with sandy bottom, moderate slope (<8%) and vegetation tolerant of flooding (mainly *Phalaroides arundinacea*). Station B had a steep slope (approx. 30%) and gravel bottom and thus served for comparison in 1990. Sampling was carried out from May to August. Hand nets (0.7 mm mesh size) were used during several days immediately after hatching. Later on, a seine net (10 x 1.8 m, mesh size 1 mm) was used. Samples were usually taken from 9 a.m. to 1 p.m.

In 1989 a 24-hour trial was carried out at sampling station A, with samples taken every 3 hours. The whole catch was immediately preserved in 10% formaldehyde. In the laboratory, the standard length of fry was measured and the gut contents of at least 10 specimens were analysed. Permanent mounts in polyvinylalcohol of the whole gut contents were prepared and counts were made of organisms present. The diet was designated using the numerical method (Hyslop, 1980).

Quantitative zooplankton samples were taken simultaneously with fish sampling by means of a 3 l Patalas sampler. The volume sampled on each occasion was 30–50 l. A net of 40 μm mesh size was used for retaining the zooplankton.

Ivlev's electivity index

$$E = \frac{r_i - p_i}{r_i + p_i}$$

was used for evaluation of selectivity of different fish species for particular food items, where r_i is the share of a given food item in the ration, and p_i is the share of the same food item in the environment.

The diet overlap between two species was calculated according to Zaret and Rand (1971)

$$C_{XY} = \frac{2 \sum_{i=1}^{S} X_i Y_i}{\sum_{i=1}^{S} X_i^2 + \sum_{i=1}^{S} Y_i^2},$$

where X_i, Y_i are the relative proportions (in %) of a given food item in the diets of the compared fish species and S is the number of distinguished food items.

The individual daily ration was estimated in the field on July 3–4, 1989, according to Elliott and Persson (1978). The instantaneous evacuation rate (R) (Persson, 1979, 1982) was used, adapted to the actual temperature during the experiment (19 °C).

Results

Composition of littoral fry assemblages

The ecotonal zone served as a spawning ground for roach and common bream. Both species spawned mainly in the flooded terrestrial vegetation in shallow water up to 0.5 m deep but bream eggs have been found even at a depth of 8 m. Mass spawning of roach coincided with the beginning of spawning of common bream (Fig. 2). In the absence of flooded vegetation in May 1990, due to low water levels, both species spawned successfully on rocks and gravelly bottom near the shoreline.

Table 1. Species composition of cyprinid larvae in the littoral zone on 18th May 1990 (%). Average percentages of 8 sampling stations.

Species	x	±	s.d.
Rutilus rutilus	88.2	±	5.9
Abramis brama	11.8	±	5.9

Immediately after hatching, the species composition of the littoral fry was homogeneous over the whole reservoir, from the dam to the tributary area (Table 1) with roach the more abundant. No perch larvae were found in the ecotonal zone at this time but they were present in the pelagial. Later, the perch larvae gradually became demersal on reaching a length of about 10 mm and a typical summer littoral fry assemblage developed which was dominated by perch and roach (Fig. 3). The percentage frequency of common bream larvae was generally low, with two peaks in 1989 corresponding with the hatching of new cohorts from successive spawnings. From June to August, at least three overlapping cohorts of bream could be distinguished.

By late summer, the abundance of fry gradually decreased in the ecotonal zone and, at the same time, the species composition of the 1989 littoral fry assemblage became dominated by rudd (*Scardinius erythrophthalmus*). No such corresponding change was seen in 1990 (Fig. 3).

The frequency of occurrence of particular fry species varied considerably between the subsequent samples during the 24-hour trial run on July 3rd–4th 1989. During daytime, perch (72.4%) predominated over roach (16.2%) but at night the reverse was seen, with 23.9% perch and 66.4% roach (Fig. 4).

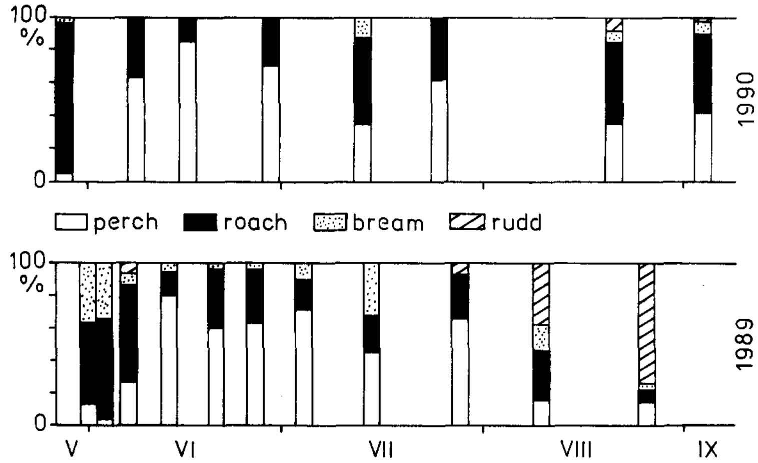

Fig. 3. The species composition of the littoral fry assemblages at station A in Římov Reservoir during 1989, when the vegetation was flooded, and in 1990, when the vegetation was not flooded.

Composition of the fry diets

Phytophilous and periphytic organisms were more evident in YOY roach diet in 1989 (Fig. 5a) than in 1990 (Fig. 6a, b). The ecotonal zone was well developed with flooded vegetation in 1989 and the phytophilous and periphytic fauna developing there was used effectively by roach larvae (Fig. 5) from an average length of 10 mm onwards. Chironomid larvae (*Cricotopus sp.*,

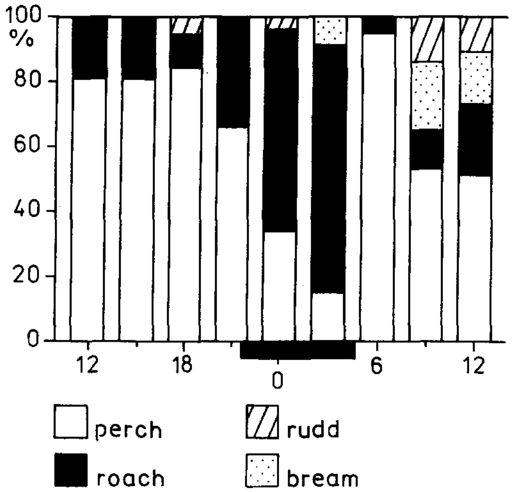

Fig. 4. Diurnal changes in the species composition of the littoral fry assemblage at station A in Římov Reservoir during July 3rd–4th 1989.

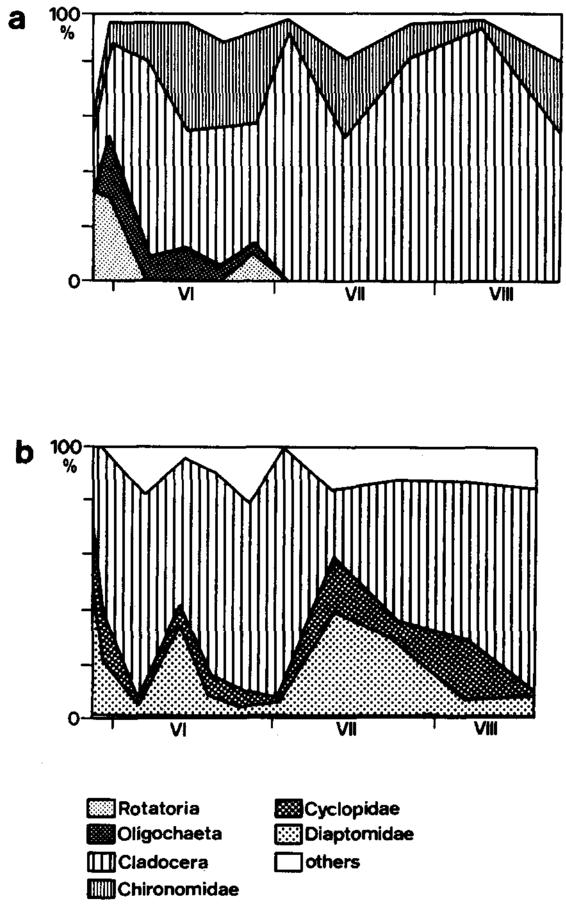

Fig. 5. The composition of the diet of YOY roach and perch at station A in Římov Reservoir during 1989: (a) roach; (b) perch.

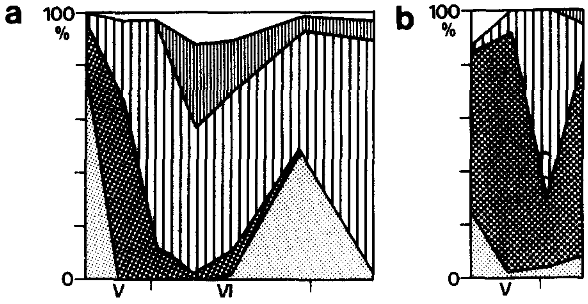

Fig. 6. The composition of the diet of YOY roach at stations A and B in Římov Reservoir during 1990: (a) station A; (b) station B. For key to diet organisms, see Fig. 5.

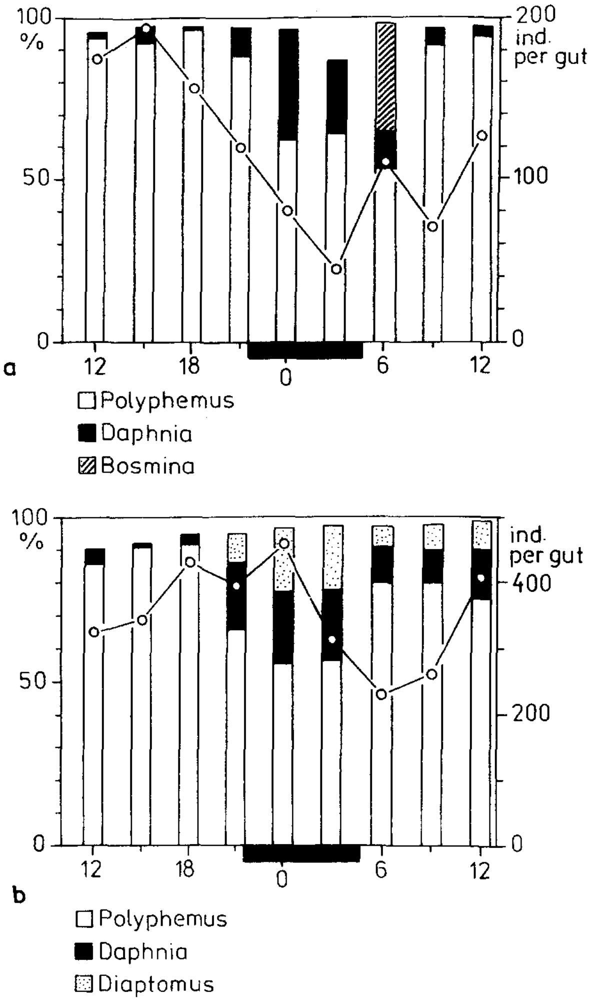

Fig. 7. Diurnal changes in the gut contents of YOY roach and perch at station A in Římov Reservoir during July 3rd–4th 1989. The histograms give percentage frequencies of the diet organisms given in the key. The plotted line gives the mean number of prey organisms per fish gut: (a) roach; (b) perch.

Corynoneura sp.) and *Oligochaeta* (*Stylaria sp.*) were the most frequently encountered food items of this group. Detailed analysis of Cladocera consumed by roach fry showed the prevalence of littoral Chydoridae till July. *Polyphemus pediculus* was preferred whenever this species occurred even in low numbers in the reservoir. *Daphnia galeata* appeared in significant numbers in the diet only after the fry reached an average length of 15 mm. The proportion of detritus and bluegreen algae in the diet increased during the summer.

The ecotonal zone was almost absent in 1990, due to the low water level (Fig. 2). The lack of flooded vegetation resulted in a higher frequency of pelagic organisms, mainly cyclopoid nauplii, in the diet of roach larvae at the beginning of exogenous nutrition (Fig. 6a). At sampling station B, without a developed ecotonal zone, the roach larvae were found only during the first six weeks after hatching. Their diet consisted mainly of cyclopoid nauplii and cladocerans (Fig. 6b).

The food composition of perch fry in the ecotonal zone consisted mainly of *Cladocera* and *Copepoda* (Fig. 5b). Compared with the roach diet, the lack of periphytic forms (*Chironomidae*, *Stylaria*, *Chydoridae*) is apparent.

The diurnal changes of gut contents (Fig. 7) and daily food ration of roach (mean length 20.5 mm) and perch fry (mean length 25.3 mm)

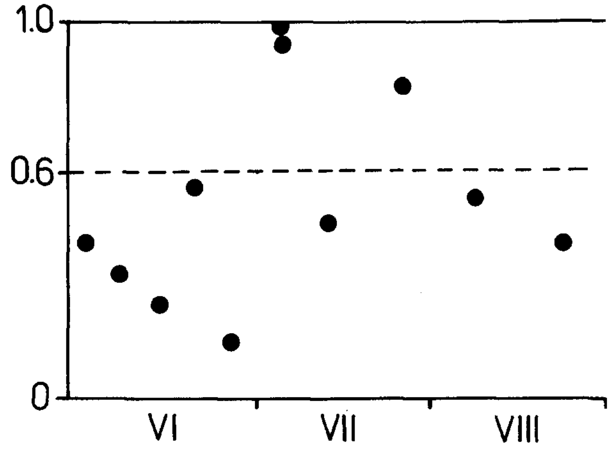

Fig. 8. Diet overlap index (C_{xy}) of YOY roach and perch in the Římov Reservoir, 1989. The value of 0.6 indicates significant overlap.

were estimated in the field in early July 1989. *Polyphemus pediculus* formed more than 90% of the diet in both species during daytime in spite of its low frequency in the nearshore zooplankton (16.6%) (Ivlev's electivity index: + 0.69 for both species). Individual daily food ration was 615 *Polyphemus* in roach and 1680 in perch.

A significant diet overlap of both species, compared by Morishita's index (Zaret & Rand, 1971), occurred only when *Polyphemus pediculus* was eaten (Fig. 8). Despite forming mixed schools sometimes, a clear resource partitioning was present in the littoral fry assemblages. Perch favoured pelagic copepods, while roach avoided them, but used periphytic organisms such as chironomid larvae. Diet overlap of roach and common bream was estimated only in June and early July, 1989, due to irregular occurrence of bream in the ecotonal zone. The values of $C_{xy} = 0.6–0.8$ indicate significant diet overlap of these species at that time.

The role of the land/water ecotone can be dem-

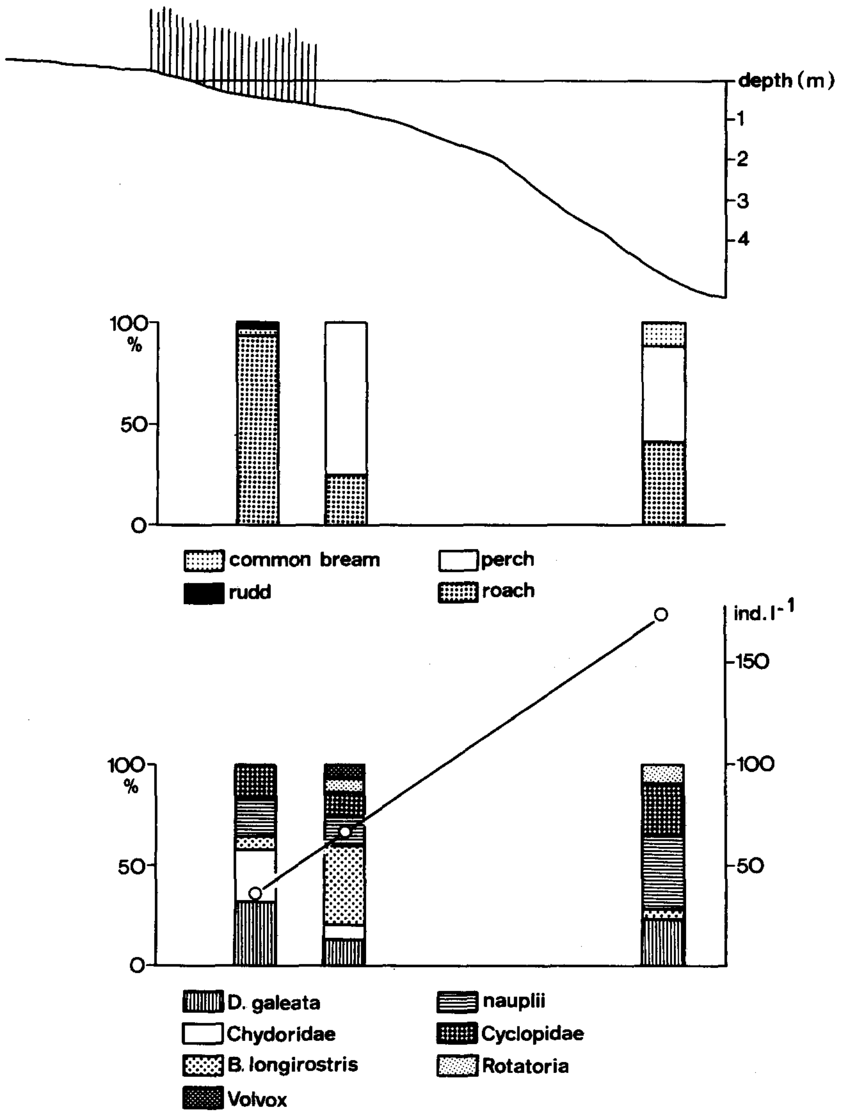

Fig. 9. Horizontal distribution of fish fry and zooplankton (abundance and composition) in the littoral zone, Římov Reservoir, 1.6.1990.

onstrated on the uneven horizontal distribution of zooplankton and the dominant fish species (Fig. 9). Distinct gradient in fry distribution was observed on most sampling dates. Perch fry were not found among flooded vegetation, corresponding with the lack of periphytic organisms in their diet. The decline of total zooplankton numbers in the shallow water nearshore was observed regularly on other sampling dates, too.

Discussion

Year-class strengths of cyprinids in reservoirs are highly variable (Kubečka & Böhm, 1991). The different water levels in 1989 and 1990 had no influence on the recruitment that was very high compared with several preceding years (Kubečka, unpubl. data). The drop of water level (Fig. 2), used as a biomanipulative too, was too low to reduce the recruitment of cyprinids in 1989 effectively.

Comparing the species composition of the ecotonal fry assemblages with that of older age classes, several differences are apparent. The numbers of common bream larvae in both years were very low compared with the share of this species found one year later during the fish population census in 1991. The roach: common bream ratio was 8:1 at the YOY age in 1990 and 2:1 in the 1+ age in 1991. It can be assumed that the first year mortality did not differ substantially between these two species. Fertilized eggs of common bream were found even at a depth of 8 m. It seems that spawning of this species is not confined to the very shallow parts of the ecotonal zone. Another possibility is the early migration of common bream larvae into deeper water. They were really caught in ichthyoplanktonic tows at depths of 6–8 m during the night (Matěna, unpubl. data).

The rudd fry showed a high affinity for the ecotonal zone in late summer. At that time rudd dominated the littoral fry assemblage in spite of forming only 0.2% of the fish stock in the reservoir.

The diurnal changes in the share of perch in the ecotonal zone (Fig. 4) might indicate the presence of diurnal inshore-offshore migrations, as described in yellow perch (*Perca flavescens*) by Post & Mc Queen (1988).

The diet of roach larvae in Římov Reservoir corresponds to the general scheme of succession in cyprinids: phytoplankton – rotifers – crustaceans – chironomid larvae. However, in 1989 Římov roach larvae shifted earlier toward larger phytophilous and/or periphytic organisms (*Oligochaeta*, *Chironomidae*) than those of studies by Hammer (1985) or Mark *et al.* (1987). This was probably caused by the low concentration of zooplankton (< 50 ind. l^{-1}) in the ecotonal zone of Římov Reservoir in June 1989. Similar results were obtained by Ponton & Stroffek (1987) in Lake Geneva. The diet of YOY perch in Římov Reservoir is in accordance with the results of Hartman (1983, 1986), who found a succession from nauplii to older copepods and to cladocerans in perch. Perch favoured pelagic *Copepoda*, while roach avoided them.

These findings differ from the results of Persson (1987), Persson & Greenberg (1990), and Diehl (1988). They found roach to be a more effective zooplankton feeder than perch. Perch, however, was more efficient than roach when feeding on macroinvertebrates. This caused juvenile perch to shift from feeding on zooplankton to macroinvertebrate prey. No such shift was observed in the Římov Reservoir, where the perch remained mainly planktivorous even in older age classes (Kubečka unpubl. data).

The land/water ecotones are of fundamental importance as feeding grounds for YOY roach in the Římov Reservoir. Perch, although abundant in this zone fed to a high degree on pelagic zooplankton. The ecotonal zone might serve as a shelter area in YOY perch to avoid predation during daytime. Common bream, the third abundant species in the reservoir, seemed to migrate offshore into deeper water early in its ontogeny.

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