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Fish Assemblages in the Berounka River and its Tributaries (Úhlava and Mže) in 1975–2004 – Environmental Parameters, Fishery Statistics, and Electroshocker Data

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Abstract: The stepwise growth of the concentration of nitrates, ammonia, and chlorides up to the end of 1980's with its recent decrease and gradual decrease of BOD since 1975 was observed in the Berounka River and its tributaries since 1962. The yields of all fish species with exception of carp decreased in the Berounka R. fishing wards during 1975–1999 (2003) but increased in wards from Plzeň to Praha (carp 10–160, forage fish 0.5–22, carnivorous fish 0.5–10 kg/ha). In 1998–2004 altogether of 23851 fish of 26 species were caught in the Berounka River near Radnice and 2336 fish of 21 species in the Úhlava River near Předenice by electrofishing. The relative abundance of the fish caught by electroshocker in the Berounka ranged between 758 and 4812/ha, the biomass between 64 and 430 kg/ha, in the Úhlava between 186 and 2648 fish/ha, and between 31 and 175 kg/ha. The cluster analysis was applied to compare fish assemblages in the whole longitudinal profile of the Berounka and Úhlava rivers, more thoroughly in the Berounka R. near Radnice, and in the Úhlava R. near Předenice. Clusters were used also for evaluation of changes in fish assemblages caught in the Mže, Úhlava, and Berounka rivers by sport fishermen.

In the Berounka near Radnice we estimated, using fin clipped and tagged fish, in average of 1165 barbel, 1159 chub and 709 roach and dace (total of 3033 fish/ha). Judging from the length composition of barbel and chub it appears that the strong year classes of both species were born in flood years 1997 and 2002. In the Úhlava near Předenice we estimated 200–400 barbel, 330–690 chub, 250–520 dace, and 120–240 roach/ha, altogether 900–1860 fish/ha. In the fishing ward B7 (45 ha) 45 000 fish≥15 cm was estimated; together with fish preferred by fishermen 50–60 thousands of fish. In a typical under weir site of the Berounka River (Třímany, ward B7) five species ≥ 10 cm produce 323 kg/ha/year, fish > 15 cm 193 kg. In the whole ward the production of fish caught by fishermen attains in average the value of 24 kg/ha. Taken into account the fishing efficiency on a level of 20–33%, the production of all these fish should be round 70–120 kg per ha and year.

The negative influence of NH_4^+ and Cl^- on fish yields evaluated by RDA and CCA showed that both factors covered as much as 29.9% of the yield variability, the positive or negative effect of carp catches on yields of other fish was not shown.

Key words: water quality, fishery management, fish abundance and production, clusters, multivariate analysis

INTRODUCTION

Rivers of higher than 6th order (Vannote et al. 1980), or with the watershed of more than 5000 km^2 (Meador, 2005) are considered as large. They are in the focus of interest of ichthyologists, ecologists, sport fishermen, managers, public as well as politicians. Recently, rivers are investigated from a landscape perspective and sometimes are viewed as “riverscape” (Allan, 2004). The interest in rivers is also associated with the dramatic deterioration of their water quality in the second half of the 20th century. The subsequent improvement in the last 10 to 20 years (Eklőw et al. 1998), however, concerned neither the physical environment nor the diversity of habitats, which actually decreased and therefore further decrease of the number of species is expected in the future (Aarts et al. 2004).

For more than 100 years it is generally accepted that ichthyocoenoses gradually change within the river longitudinal profile. At the end of the 19th century, Fritsch (1872, in Holčík et al. 1989) divided streams into so called fish zones depending on the occurrence of important fish species – the brown trout, barbel, wels, stone loach, and tench. The fish zones were already understood coenologically and stepwise completed (Holčík et al. l.c.). Up to the present time, the concept of fish zones is being used by ichthyologists and in the fishery practice.

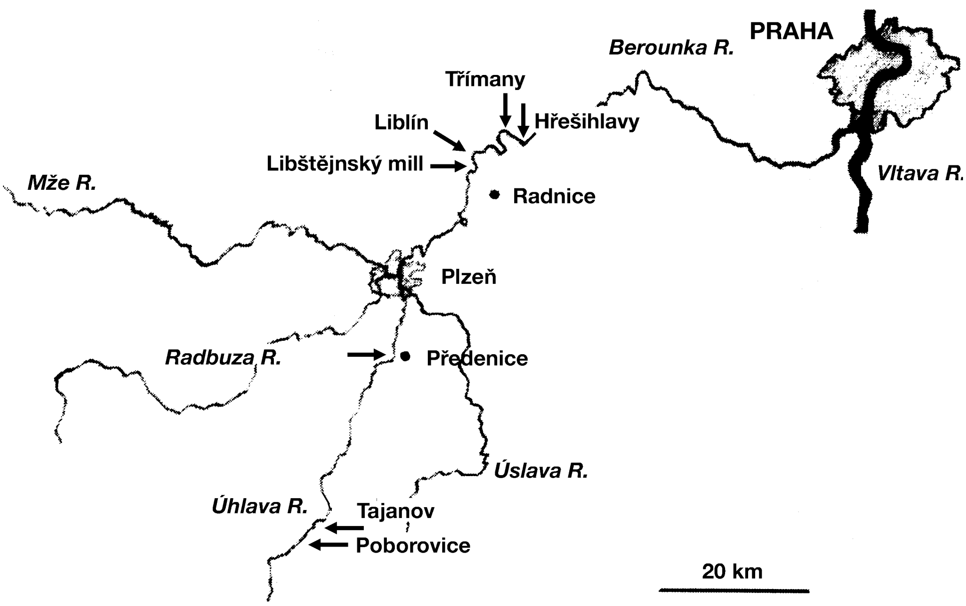
Recently, the function of river ecosystems has been accented; the well-known river continuum concept (RCC), Vannote et al. (1980) furthermore serves for understanding the dynamics of physical-geomorphic, environmental and biological functioning of rivers. Several other concepts were published since then (Thorp et Delong, 1994).

Karr (1981) used fish assemblages for indication of the biotic integrity of rivers; his IBI was stepwise adjusted for different types of streams in North America, Europe as well (Oberdorff et Hughes 1992). The study of ichthyocoenoses in running waters (Jowett et Richardson 1996, Richardson et Jowett 2003) is steadily associated with the nature of the streams and their whole basins as well as with human activities (fishery management, management in watershed). Beside fish the dynamics of important environmental factors affecting ichthyocoenoses has been simultaneously evaluated (Jackson et al. 2001), and suitable indicators of changes are tested (Gergel et al. 2002). Outcomes for the practice are the rehabilitation of streams with the aim to document its positive effects on the species diversity, abundance and biomass (Pretty et al. 2003).

The Czech Hydrometeorological Institute regularly monitors among others also the Berounka River, together with its tributaries, the fishery statistics being kept by Czech Fishing Union. To take advantage of all these data the quantitative electrofishing was organized in 1998 to 2004 on the Berounka River near the town Radnice (northeast of Plzeň) and in the lower part of the Úhlava River (near the village Předenice) in cooperation with the Regional Fishing Union in Plzeň and Local Fishing Club in Radnice. The purpose was to study the dynamics of the species diversity, abundance, biomass, and production of the whole ichthyocenoses. Fishery statistics and environmental data were evaluated with the aim to assess the influence of fishery management and water quality on fish assemblages over a long-term period.

MATERIAL AND METHODS

In 1998 to 2004, four sites – Libštejnský mill, Liblín, Třímany, and Hřešihlavy on the Berounka River near town Radnice were repeatedly fished in May to June (exceptionally also in the first decade of July) and in August. All the fished sites were under the weirs; their length and width ranged between 150 and 250 m and 50 to 60 m, respectively. Other fishing activities were organized in the Úhlava River near the village Předenice at three sites, one of them being under and two between weirs, see Map 1.



Map 1. Study area; arrows indicate the sites studied

The stream sections were fished by wading in two passes with comparable effort with two (Berounka) or one (Úhlava) electroshocker. Fishery statistics are available for fishing wards Berounka 7 and 8 for the period of 1975–2003 and for all wards in the Mže, Úhlava and rest of the Berounka for 1975–1999 (2001). List of fished sites together with further data is in Tab.1

Fishing wards B7 and B8 overlap with four sites fished by electricity and were, therefore, studied in more details. B8 starts under the weir Libštejnský mill (33 km downstream of Plzeň) and it ends above the weir in Třímany; B7 starts under the weir in Třímany and ends above the weir in Zvíkovec (57 km downstream of Plzeň). Both fishing wards are typical habitats of the middle Berounka in deep valley with a narrow riparian area. Both together have 105 ha, their length is 19 km and both are stocked by the Local Fishing Club in Radnice.

Tab. 1. List of sites fished by electroshocker in 1997–2004; Berounka River 139 km (together with Mže River 250 km), Úhlava 108.5 km. River km is always measured from the mouth

Berounka River	**Abbr.**	**River km** /Distance from the source (Mže)	**Area in m²,** average in brackets	**Years**	**Coefficient for conversion** on ha
Libštejnský mlýn	**LM**	105.6/144	7. 6. 02 7300; 13. 5. 03 8740; 7. 7. 03 8600; 15. 9. 03 8000 **(8200)**	2002–2003	1.22
Liblín	**L**	101.4/149	27. 6. 00 4600; 15. 9. 00 4200 16. 9. 03 4400, **(4400)**	2000–2003	2.27
Třímany	**T**	92.9/157	22. 6. 98 8500; 7. 9. 99 7500 14. 5. 03 7900; 18. 9. 03 7100 **(7800)**	1998–2004	1.28
Hřešihlavy	**H**	87.9/162	22. 5. 03 7460; 9. 7. 03 7820 **(7600)**	1993	1.32
Úhlava River					
Předenice, Bridge	**PB**	25.5/83	(2500)	1997–2001	4.0
Předenice, Under weir	**PW**	26.5/82	(3300)	1997–2001	3.0
Předenice, Shoot	**PS**	28.5/80	(3300)	2001	3.0
Tajanov	**T**	64.5/44	(2500)	2001	4.0
Poborovice	**Pb**	69.5/39	(2500)	2001	4.0

Number of weirs and their parameters, watersheds area and gradient conditions were read off from the hydrological map 1:50 000, data on the flow rates and water quality were based on information of the Czech Hydrometeorological Institute; flow rates at profiles Liblín, Berounka R.; Štěnovice, Úhlava R.; and Lhota, Radbuza R. are on Fig. 1., water quality at profiles Nýrsko – Úhlava R.; Lučina and Radčice – Mže R., and Bukovec, Liblín, and Srbsko – Berounka R is mentioned in Chapter I. Physico-chemical parameters of water of the Czech streams are since 1962 at the address http://hydro-chmi.cz/ojv/. We evaluate the dynamics of the basic parameters of water N NO_3^-, N NH_4^+, BOD_5 and Cl^- for the period of 1962–2003.

Only fish > 50 mm of standard length (SL) were measured and weighed, fish > 100 mm marked, and fish > 150 mm tagged. For tagging fish we used the anchor full plastic tags (Floy Anchor Tag, type FD-94), in most cases fin clipping was applied as a control. Survival rate was estimated from the ratio between the number of recaptured tagged (marked) fish per 100 captured and 100 tagged (marked) fish in two or more successive seasons. The length growth of the fish was taken into consideration under the assumption that 2 cm of average annual increment was achieved during the spring – autumn, whereas 1 cm during the period of autumn – spring.

The growth of fish in length (SL) and weight was evaluated using the last length (weight) increment in a given age group (AG) in the years "t" and "t-l"; the length-weight relationships and fish production were calculated by known procedures (Ricker, 1975).

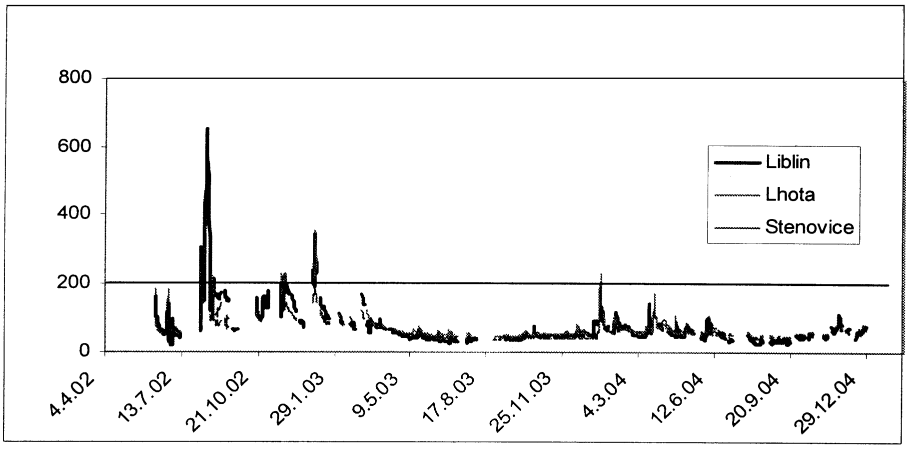


Fig. 1. Mean daily water levels in cm, Berounka R. (Liblín), Radbuza R. (Lhota) and Úhlava R. (Štěnovice) in 2002–2004. The water level of above 200 cm allows upstream movement for largre rheophile species (barbel)

For estimation of the abundance we have used the Jolly-Seber method, which is more realistic for open populations. Peterson method was used in cases when fish were marked and caught during two (three) days. The computation procedures, both for the Jolly-Seber and Peterson estimates and 95% confidence limits followed the program by Krebs, 1999.

The Petersen estimate assumes that the population assessed is separated in a space and the fish migration is excluded. This cannot be guarantee in the river; never--theless a considerable limitation of the fish movement due to weirs in the Berounka was demonstrated thanks to the tagged (marked) fish and fish equipped by transmitters.

For the study of the similarity of ichthyocoenoses, the cluster analysis, the Ward method, and the Euclidian distances were employed (Libosvárský 1989, McGarigal et al. 2000, Aaland 1993). As basic data, we used the presence or absence of species and/or their relative abundance. Based on this information, clusters of fish assemblages, sites, and seasons were defined. The index of specie saturation (ISS) comparing the number of fish in the given stream with the standard and its upper predictive limit for Czech streams was calculated using formula $ISS = 1 - \{[(\sum (x_{i(UPL)} - x_{i\ (obsv.)})/x_{i\ (UPL)}]:i\}$, Pivnička (1996)

Fish assemblages were further analyzed by a detrended correspondence analysis (DCA). The aim was to evaluate the strongest gradient of assemblages' composition, which is not constrained to any pre-defined environmental variables. Finally, the direct gradient canonical correspondence analysis (RDA) was applied for the evaluation of the assemblage structure in relation to the changes of selected environmental factors. The pure effect of each significant environmental factor was detected in partial CCA's (ter Braak & Šmilauer 2002). In these analyses, the individual contribution of each factor was tested, while the variability caused by the other significant factors was (together with the individual streams' variability) partialled out as covariables. Multivariate statistical analyses were performed by CANOCO ver. 4.5. Throughout the text we used common names of fish species, their Latin equivalents are in Tab.1/III.

The Berounka River basin

The Berounka River, having together with the Mže River the length of 250 km, average flow rate in its mouth of 36 m^3, and basin area of 8861 km^2, is the sixth largest stream in the Czech Republic. It originates in Plzeň by the confluence of the Mže River and Radbuza River just joining the Úhlava River, and still in the cadastre of the city of Plzeň it accepts the Úslava River. It discharges into Vltava River in Prague, Tab. 2. Flow rate and water levels in 2002 to 2004 are summarized in Tab. 3. Average daily changes of water levels in cm and derived flow rates in m^3 are attainable on the web site http://hydro.chmi.cz/inetps/main.php. Longitudinal profiles of the streams of interest were

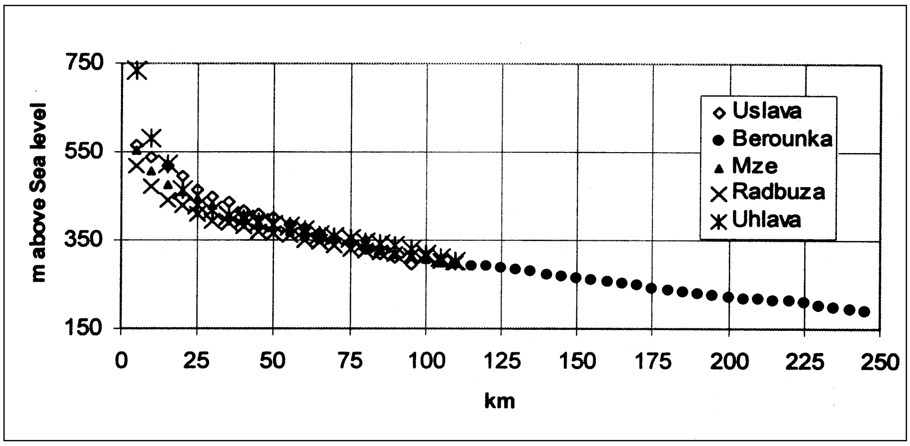


Fig. 2. Longitudinal profiles of the Berounka R. and its tributaries

Tab. 2. Basic information about the Berounka River and its main tributaries

River	**Spring** m above sea level	**Mouth** m above sea level	**Length** of stream km	**Watershed** km^2	**Mean flow** m^3/sec	**No of reservoirs, big ponds*** (ha)
Berounka	298**	188	139	8861	36	0
Mže	680	298	111	1830	8.6	2 (80 a 470)
Radbuza	720	298	112	2179	11.1	1 (152)
Úhlava	1110	303	109	919	5.7	1 (148)
Úslava	695	296	94	797	3.6	2* (110)

Tab. 3. Q_1–Q_{100}: [m^3s^{-1}] / water level in cm

River/locality	Q_1	Q_5	Q_{10}	Q_{50}	Q_{100}
Berounka R./Liblín	242 / 225	511 / 339	649 / 386	1020 / 493	1190 / 536
Mže R./Stříbro	61 / 172	129 / 231	165 / 254	259 / 303	305 / 323
Radbuza R./Lhota	41 / 236	96 / 388	126 / 455	211 / 612	254 / 681
Úhlava R./Štěnovice	43 / 183	98 / 270	127 / 307	206 / 387	246 / 421
Úslava R./ Koterov	55 / 181	111 / 246	139 / 272	212 / 327	247 / 350

Tab. 4. Weirs on Berounka R. and on its main tributaries

River	No of weirs	Height in m/ ranges	Distance between weirs km/ ranges	Length of weirs/ ranges
Berounka R.	28	1.23 / 0.3–2.5	5.20 / 1–12.5	123.6 / 72–260
Mže R.	34	1.6 / 0.4–3.2	2.40 / 0.5–10	30.6 / 4–61.5
Radbuza R.	42	1.65 / 0.5–2.9	2.48 / 1–5.5	19.5 / 5–54.2
Úhlava R.	46	1.75 / 0.3–3	2.27 / 0.5–7	21.7 / 8–33.7
Úslava R.	40	1.32 / 0.3–2.2	2.23 / 0.6–6.5	26.6 / 6–50.5

Tab. 5. Basic information about the riparian area of the Berounka River and of its main tributaries

River	Stream flows through (in brackets relative values in %)			
	Settlements	Agriculture landscape	Natural landscape (forest, meadow, grassland)	Total (km)
Mže	11 (10.0)	39.5 (35.6)	56.5 (50.9)	111
Radbuza	25 (22.3)	77 (68.8)	9.0 (8.0)	112
Úhlava	15 (13.8)	81 (74.3)	12.5 (11.5)	109
Úslava.	20 (21.1)	62.5 (65.8)	12.0 (12.6)	95
Berounka	23 (16.5)	53.5 (38.5)	63.5 (45.7)	139
Total	94 (16.6)	313.5 (55.4)	153.5 (27.1)	566

measured from the hydrological map each 5 km Fig. 2. Number of weirs on particular stream, their average height and distances between the weirs are summarized in Tab. 4. With respect to the weirs height, the water level of above 2 m allows movement for larger rheophile species (barbel) in both directions, at levels exceeding 3 m, when the river floodplain is flooded, most weirs can be overcome by the other species and sizes of the fish.

In human-dominated landscapes the proportion of agricultural, urban, and natural lands directly influence the riparian area and clearly correlate with the number of the suitable habitats for fish. For Berounka and its tributaries these data are summarized in Tab. 5. The largest proportion of natural habitats is found in the longitudinal profile of the Mže followed by the Berounka; the Úhlava, Radbuza and Úslava most frequently flow through the agricultural land, and the Radbuza and Úslava through settlements.

RESULTS

I. Water quality

The stepwise growth of the concentration of nitrates up to the end of 1980's with its subsequent decrease is quite distinct. A parabola most properly smooths all values. The lowest values in the first two-headwater profiles of the Úhlava and Mže correspond to low agricultural activities, low density of the human population and farm animals living here. The parabolic shape of all curves is associated with high doses of basic nutrients used in agriculture, stepwise up to 250 kg ha^{-1} $year^{-1}$ of NPK as pure nutrients up to the end of the 1980's and with their rapid decrease to less than half at the beginning of the 1990's, *Fig. 1/I;* (*figures and tables in italic are at the end of the paper*).

The ammonia concentration exerts similar dynamics as nitrates. Ammonia is present in water ecosystems due to agricultural activities and decomposition of biological waste; it is toxic to fish (Randall et Tsui, 2002). The ammonia makes up to the bulk of nitrogenous waste and it is in equilibrium with the high toxic NH_3. Toxicity of NH_3 increases with water temperature and pH, so that in the summer period, values of order of magnitude of tenths mg/l NH_3, which are already found, are lethal for the fish. In general, it is possible to observe low values at the beginning of the 1960's, an increase in the half of the 1970's and a considerable decrease starting from the 1990's, *Fig. 2/I*. Only the BOD value stepwise decreases at all the profiles of interest, *Fig. 3/I*. The most considerable improvement of the water quality can be observed at the locality Bukovec, 5 km under the water treatment plant in Plzeň and at a locality Liblín, situated 20 km downstream. In the first locality the BOD decrease from 12 to 3 mg/l, in the second from about 9 to 3 mg. Long-term low and stabile concentrations of chlorides of about 5 mg/l are in both headwater areas (Úhlava and Mže), the dynamics of their concentration in the other profiles approach the dynamics of NO_3^- with a typical parabolic shape, maximum at the end of the 1980's, and subsequent decrease in the 1990's, *Fig. 4/I*. The sources of chlorides in waters are certain industrial wastewaters, in the winter period also spreading of salt on roads. Chlorides are present in the urine and thus, they can indicate the pollution from feces.

II. Fishery management

The Berounka River and its four main tributaries (the Mže, Radbuza, Úhlava, and Úslava R.) are divided into 35 fishing wards with the so-called carp management. Their total length is of 442 km and area of 1089 ha. Two reservoirs, the Litice Rs. on the Radbuza R. (152 ha, 4 km long) and the Hracholusky Rs. on the Mže R. (470 ha, 20.4 km), form two further independent wards, which were not evaluated, Tab. 1/II. In upstream parts of all the tributaries the fishery management is oriented, in additional 7 fishing wards on so called trout management with brown trout as the main stocked species. Number of fish caught and its average weight is in Tab. 2/II.

The number of carps caught in wards of the Mže, Úhlava and Berounka and the total number of the fish per ha are in *Fig. 1/II*. A parabola fits well individual points with its

Tab. 1/II. Fishing wards in the Berounka River and its main tributaries (Mže, Úhlava, Radbuza, and Úslava R.), * without reservois, Y yields

Name of river	No of wards	km	ha	1	2	3	4
				Y carp kg/ha/year	Y all other species kg/ha/year	Total	1 in % 3
Mže	6	74	129*	78.37	32.62	111	71
Úhlava	6	71	95	112.60	36.75	76	76
Berounka	10	138	711	47.01	44.21	91	52
total	22	283	935				
Radbuza	8	91	95*				
Úslava	5	68	59				

Tab. 2/II. Number of fish caught (per ha) and average weigh of one fish in kg

River/Fish per ha	Carp	Tench	Bream	Chub	Perch	Barbel	Zahrte	B. trout	Other. fish
Berounka R.	22.46	2.22	10.88	11.48	3.75	2.10	9.57	0.26	20.17
Berounka 7	15	1.8	2.2	4.14	5.2	1.1	1.6	0.2	10.2
Mže R.	47.89	1.67	18.42	4.14	8.33	0.33	0.21	5.39	9.45
Úhlava R.	79.67	6.57	10.69	5.57	9.52	0.51	0.18	2.47	15.57
Average weight when caught									
Berounka R.	1.99	0.55	0.63	0.50	0.30	1.48	0.36	0.33	0.21
Mže R.	1.67	0.51	0.40	0.62	0.26	1.59	0.28	0.37	0.22
Úhlava R.	1.64	0.46	0.72	0.59	0.26	1.46	0.72	0.65	0.24
Catchable length achieved after (x) years	2–3	2	8	10	6	12	7	5	6

River/Fish per ha	Grayling	Pike	P. perch	Wels	Eel	Asp	R. trout
Berounka R.	0.07	4.08	1.13	0.20	2.36	0.30	0.33
Berounka 7	7.7	1	0.07	2.9	0.1		
Mže R.	8.46	3.17	1.00	0.07	4.84	0.21	0.62
Úhlava R.	5.17	6.41	0.43	0.08	11.47	0.18	0.44
Average weight when caught							
Berounka R.	0.19	2.10	1.75	8.30	0.74	1.34	0.26
Mže R.	0.39	2.21	1.96	3.07	0.75	0.99	0.37
Úhlava R.	0.40	1.80	1.50	8.91	0.58	1.22	0.52
Catchable length achieved after (x) years	4	5	6	9	8	7	4

vertex oriented downward to fishing wards M1-B4. Most carps have been caught in wards M2 (89), U6 (137) and B2–B1 (44–74 carps), substantially lower numbers of carps in the less attended middle part of the Berounka. The average weight of the carp stocked ranged between 0.2 and 1 kg, mostly between 0.6 and 0.7 kg, in the 1970's the stocked carps weighted sometimes only 0.1 kg.

Figures 2–7/II show (a) yield of a given species in selected wards in 1975–1999 (2003) and (b) the trend of the total yield of the species summed for 25 years in fishing wards from Plzeň (B10 to Praha (B1). Differences in yield of carp in particular wards and years (high values at the beginning of the 1980's and 1990's and 2000's (10-years cycles) are clearly associated with the stocking dynamics, *Fig. 2a/II*. The increase of yield of the carp in wards from Plzeň to Praha was caused by stocking and by fish coming from upstream wards during and after high water levels. For the period of 25 years from 206 (B8) to 3397 kg (B1) of the carp was caught in particular wards (in average, 22 to 74 kg/ha). The increased yields in wards from Plzeň to Praha were characterized by an exponential curve, *Fig. 2b/II*.

In chub, barbel, bream, zahrte, and perch, a decrease of the yields in most wards was recorded during 1975–1999 (2003) and their increase in wards from Plzeň to Praha like in carp, *Figs 3–7/II*. The highest increase was observed in bream (from 2 to 22 kg/ha) and in zahrte (0.5–16 kg), the lowest in barbel (0.2–8 kg) and perch (0.5–2.5 kg/ha). The reasons are in the higher fishing pressure in the vicinity of Prague and in cumulating of fish in lower parts of the river after floods. In certain species (bream, zahrte), the higher yields in downstream wards could be expected with respect to their habitat requirements. Yields of the important forage fish species and carp are in *Fig. 8/II*.

Average yields (1975–1999) of carnivorous species, (pike, pikeperch, eel, and wells, *Figs 9–12/IIab*) decreased except for the wels, which has been recently intensively stocked. Nevertheless, yields in the longitudinal profile from Plzeň to Praha (B10-B1) increased similarly as in carp and forage species. Only the pike avoids this trend, whose yield fluctuated between 8 to 9 kg/ha/year. The yield of all carnivorous species ranges from 11.8 to 18.7 kg/ha, the largest portion being formed by the pike. The maximum yield was achieved at the beginning of the 1980's and 1990's, and 2000's, i.e. always after ten years, *Fig. 13/II*.

The differences between the biomass of the carp caught and stocked (kg/ha, average value for B7 and B8) are shown in *Fig. 14/II*. In 1985 to 2003, altogether 967 kg carps were stocked into both wards and 804 kg were caught in the same period i.e. 17% of the stocked biomass was lost. The biomass stocked exceeded markedly the biomass caught in 1987/8, 1996/7 and 1999/00, in 2001 to 2003 the yields were higher particularly thanks to massive stocking in 1999. The correlation between the stocked and caught biomass in kg/ha (B7) is highly significant, $r = 0.727$, $p < 0.01$. The stocking rate up to 100 kg ha^{-1} gives of about one half yields, of 200 kg/ha of one quarter, so the 100 kg can be considered as still appropriate here, *Fig. 15/II***.** Pike is stocked up to its total length of 10 cm, the C/S ratio achieves in average 0.21 (0.06 to 0.33), the relationship between the two variables being significant, $r = 0.367$, $p < 0.05$ (*Fig. 16/II*). In average, 25%, at most 33% of the stocked pike is caught.

Comparing the yields of carp, forage, and carnivorous fish, one can see that yield of carp significantly increased, the proportion of FF insignificantly decreased, whereas the decrease of the CF was at a significance limit *Fig. 17/II*. Among the forage fish the chub prevails (6.8 kg/ha in average), catch of the other species ranges between 0.5 to 4 kg, (*Fig. 18/II*). The highest catch of the FF was achieved at the beginning of the 1980' at the half of the 1990's, and in 2001 when the yield of the carp was lower. Pike was a dominant species among carnivorous fish (*Fig. 19/II*), its highest yield in 1980, 1995 and 2001 correspond to the highest yields of the FF. The catch trends in B8 are similar to those in B7 for particular species; however, in average they achieve only half of values in the B7.

In the Mže and Úhlava the largest numbers of carp has been stocked and caught in M2, U6 and U2, the relationship between stocked and caught fish has a typical parabolic shape, very high stocking rates results in decreased catches. The carp prevails in M7, M5, (in average 100 kg/ha) and M2 (140 kg/ha) and in U6 and U3 (207, 220 kg/ha), the forage fish (bream and chub) and carnivorous fish (pike and eel) are equally abundant in all mentioned wards. Yields of the pike are well balanced in all the wards of the Mže, Berounka as well as of the Úhlava, indicating that this species is well adapted to different habitats.

In clusters, species with similar abundance and frequency, caught in different wards or years are grouped. Among clusters of species caught by anglers in the ward B7 an outstanding cluster is formed by the category "all fish without the carp" (total – C), the second cluster comprises the pike and chub and all the remaining species fall into the third cluster, Fig. 20/II. The cluster analysis of particular fishing seasons (1975 to 2003, all species) shows a distinct cluster of years 2000 to 2003, further three clusters were differentiated at a linkage distance level of 150 and 75 units (Fig. 21/II). The yields in the first cluster ranged between 83 and 120 kg/ha, in the second between 30 and 37 in the third between 60 and 73 and in the fourth between 47 and 64 kg. When yield of the carp and total catch was excluded (Fig. 22/II.) the value of the linkage distance was reduced to about one third, however, four clusters were again clearly differentiated. In the first cluster, the catches ranged between 19 and 23, in the second between 40 and 49, in the third between 24 and 31, and in the fourth between 30 and 36 kg/ha. Fishing seasons of the first cluster from Fig. 21 were dissipated in all the clusters except for 2002, which now pertains to the cluster with the largest catches (40 to 49 kg/ha).

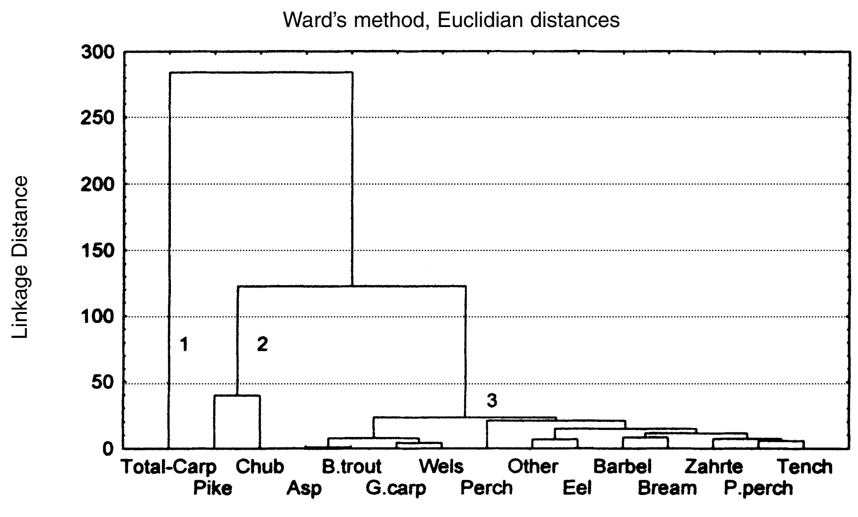


Fig. 20/II. Clusters of species in Berounka R., B7, kg/ha, 1975–2003

Ward's method, Euclidian distances

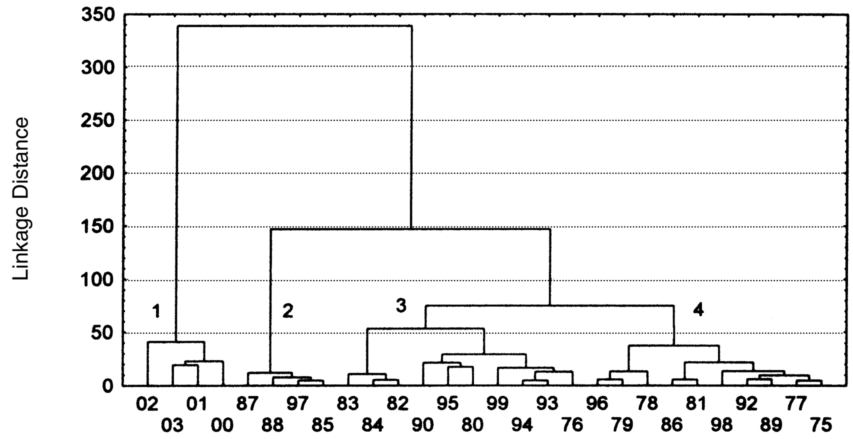


Fig. 21/II. Clusters of years in B7, kg/ha, 75–03

Ward's method, Euclidian distances

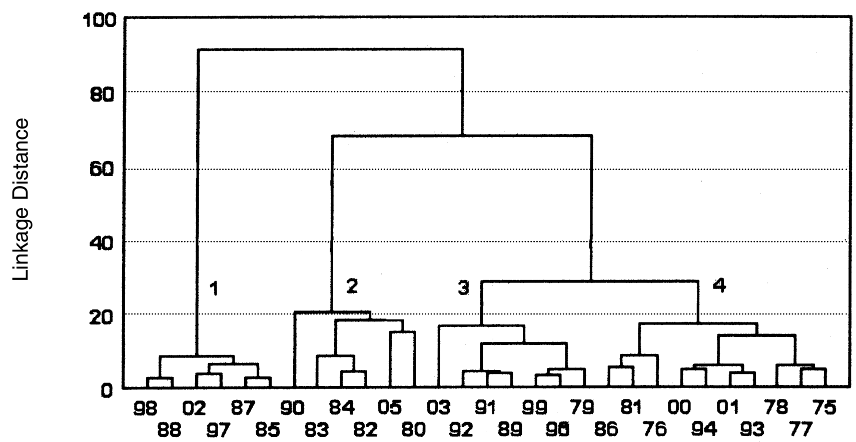


Fig. 22/II. Clusters of years, carp and total catch eliminated, B7, kg/ha, 75–03

Cluster analysis of wards in the longitudinal profile of the Mže and Berounka and Úhlava and Berounka separated again the clusters with large, intermediate, and low yields from each other. Clusters of species include fish with comparable biomass, when the carp and the total yield were excluded the linkage distance decreased. Only two clusters with higher and lower average catches (57 and 25 kg/ha), respectively were differentiated from wards of the Mže and Úhlava R.

III. Fish Assemblages

Total of 23 851 specimens of 26 species were caught in the Berounka River near Radnice (four sites) and 2336 specimens of 21 species in the Úhlava River near Předenice (three sites). In about the same period of 1998 to 2003, in B8 and B7 (100 ha), sport fisherman caught 27 394 specimens, 18 species plus 2–4 additional species in the category "other fish" (roach, dace, white bream, and bleak), in U2 (10 ha), 2336 specimens, 18 species plus 2–4 species in the category "other fish", Tab. 1/III. Altogether 29 fish species were caught in the Berounka and 25 in the Úhlava Rivers.

The relationship between the number of species (S) and distance of sites from the source (D) using additional data from the Chodská Úhlava and Berounka rivers from 1976 to 2000 (UB curve, 37 sites), together with the standard curve for Czech streams (1138 localities) and its 95% upper predictive limit is on *Fig. 1/III*. The Index of Species Saturation (ISS) calculated for number of species lying on the UB curve and on the 95% UPL of the standard curve for 1138 Czech localities achieved a value of 0.78, for standard curve and its UPL only 0.64. The species – distance curve (SD) for the Úhlava and Berounka is above the Czech standard showing a higher diversity of fish in both rivers. Species-distance curve for Úhlava and Berounka rivers was in the next step extrapolated from 250 to 1000 km and compared for SD curve of the Labe River, *Fig. 2/III*. Well seen is the low species diversity in the German part of the Labe associated with narrowing and dredging of the main channel of the river, which is used for transportation purposes.

The relative abundance of the fish caught per ha in the Berounka River near Radnice ranged between 758 and 4812 fish. Five important species (roach, barbel, chub, dace, gudgeon) achieved in average 89%, ten species (+ perch, brown trout, pike, eel, bleak) 98% of the relative abundance of all species. The biomass ranged between 64 and 430 kg/ha, five and ten species formed 89 and 95%, of the total biomass respectively. In the Úhlava the relative abundance ranged between 186 and 2648 fish/ha, out of this five important species formed 83%, ten species 96% of the total relative abundance, the biomass ranged between 31 and 175 kg/ha, biomass of five and ten species corresponds to 83 and 90% of the total relative biomass respectively, *Tab. 2/III*.

The Sperman correlation coefficient calculated for 25 pairs of species caught in the Berounka R. sites near Radnice was significant ($p \leq 0.05$) for the following pairs of species (roach-dace; roach-perch; barbel-chub; chub-bleak; dace-gudgeon; dace-perch; gudgeon-perch); out of ten pairs of most important species caught in the Úhlava for chub-roach; dace-grayling; dace-burbot. The abundance and biomass of ten important species (roach, barbel, chub, dace, gudgeon, perch, brown trout, pike, eel, bleak) fluctuates between 1000–5000 and 50–250 kg/ha *Fig. 3/III*. An increase of the abundance in autumn 2003, one year after the flood in 2002 was caused mainly by the high abundance of fish of the 1st AG (barbel, chub and dace). In 2003, 306 barbel up to 10 cm were caught in average in all sites, whereas in 1998 to 2002 only up to 30 specimens/year. Only for one locality (Třímany), corresponding values for barbel are 637 and 39, respectively. The semilogarithmic relationship between the biomass and abundance for barbell and chub (fish ≥ 15 cm) is highly significant, $r = 0.7169$, $n = 24$, *Fig. 4/III*. Certain synchrony in the biomass at the locality Třímany for the five most important species in different years can be observed in *Fig. 5/III*.

Tab. 1/III. Number of fish caught by sport fishermen (SF) in 1998–03 and by electroshocker (E) 1998–04, Berounka near Radnice, wards B7 and B8 and Úhlava near Předenice, ward U2, (SF) 1998–01 and (E) 1997–01, S number of species

Latin name	Common name	B7 (E)	B7 (E)	B7 (SF)	U2 (E)	U2 (SF)
	Species	Fish ≥ 5 cm	Fish ≥ 15 cm		Fish ≥5 cm	
Ctenopharyngodon idella	G. carp	1	1	139		3
Aspius aspius	Asp	149	20	73	2	7
Stizostedion lucioperca	Pikep.	12	3	221		29
Blicca bjoerkna	White b.	69	31		4	
Abramis brama	Bream	14	6	1413	1	242
Gogio gobio	Gudgeon	4607			262	
Gymnocephalus cernua	Ruffe	24			13	
Cyprinus carpio	Carp	16	14	10 939	14	5490
Carassius carassius	C. carp	11	1	48	1	2
Carassius auratus	Giebel	24	20			
Tinca tinca	Tench	16	8	275	21	72
Thymallus thymallus	Grayling			8	52	77
Lota lota	Burbot	1	1		27	8
Barbatula barbatula	S. loach	137			23	
Perca fluviatilis	Perch	339	114	1828	66	125
Alburnus alburnus	Bleak	1142	4		13	
Barbus barbus	Barbel	4624	2136*	530	113	46
Oncorhynchus mikyss	R. trout			3		2
Vimba vimba	Zahrte	99	54	1387	4	3
Scardinius erythrophthalmus	Rudd	1				
Rutilus rutilus	Roach	3264	623		724	
Salmo trutta fario	B. trout	121	78	24	9	24
Leuciscus leuciscus	Dace	2590	230		620	
Pseudorasbora parva	Stone moroco	1				
Silurus glanis	Wels	17	13	67		2
Esox lucius	Pike	60	60	3011	9	287
Leuciscus cephalus	Chub	6461	2967**	3205	331	235
Hypophthalmichthys molitrix	S. carp			21		
Anguilla anguilla	Eel	53	51	1273	27	210
	Other fish*			2929		278
	Total	23 851	6434	27 394	2336	7142
	S	26	21	18	21	18
	Total S	29			25	

Other fish – Roach, White bream, Dace, Gudgeon, Bleak; * 560 Barbel ≥ 35 cm ** 730 Chub ≥ 25 cm

In the Úhlava River near Předenice, two sites were repeatedly fished, the third one only on September 11, 2001, Tab. *3/III*. The first locality, Bridge is rich by rapids and locally deep segment (about 1 m), second locality under a weir by quiet and shallow water and subsequently deeper quiet segments, and third locality (Shoot) by shallow rapids (about 0.5 m) with several deeper sites. The abundance and biomass on particular dates were well comparable each to other except for the site Bridge on June 6. 01, up to 2500 fish/ha and 170 kg/ha (*Fig. 6/III*). The biomass of barbel, chub, dace, and roach corresponded to the habitat differentiation of particular sites (*Fig. 7/III*).

The cluster analysis was applied to compare fish assemblages caught in the longitudinal profile of the Úhlava and Berounka rivers and the abundance and biomass of fish assemblages in different sites and years in the Berounka River near Radnice. As basic data the presence or absence of 29 species on the 32 localities starting with the upper Úhlava (Poborovice) and ending with the lower Berounka (Radotín) were used (Fig. 8/III). Two, three, and four independent clusters were differentiated above the linkage distance of 21, 9, and 6. In the first cluster, there are species present at 1–7 localities, in the second at 22–31 localities, in the third at 12–25 localities, and in the fourth cluster at 10–17 localities.

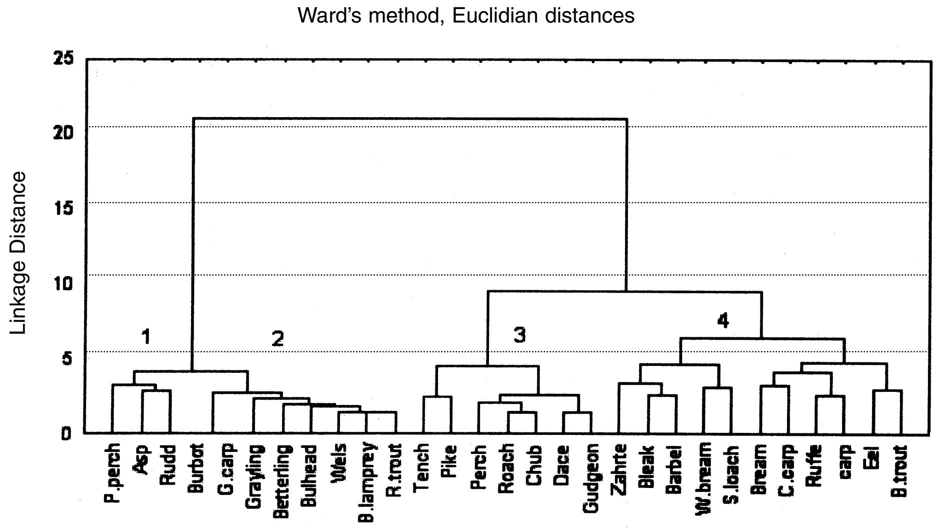


Fig. 8/III. Clusters of species for 32 sites; km 36–246 from the source of the upper Úhlava up to the Berounka R. mouth into Vltava R., presence-absence of species, data from electroshocker

In clusters of sites, we expected in a given cluster sites lying at similar distance from the source, as a reaction to the continuous changes of the environment and fish assemblages downstream. Of two arrangements, the first with 29 species, second after eliminating species affected by fish management (carp, tench, pike, eel, pikeperch, asp, rainbow trout, and golden carp), i.e. with 20 species, the second corresponds more properly to our expectation. Stocked species considerably affect the proportion of species at particular localities and thanks to it in a given cluster there are localities from up and downstream sections of the river depending mainly on the stocking intensity. This

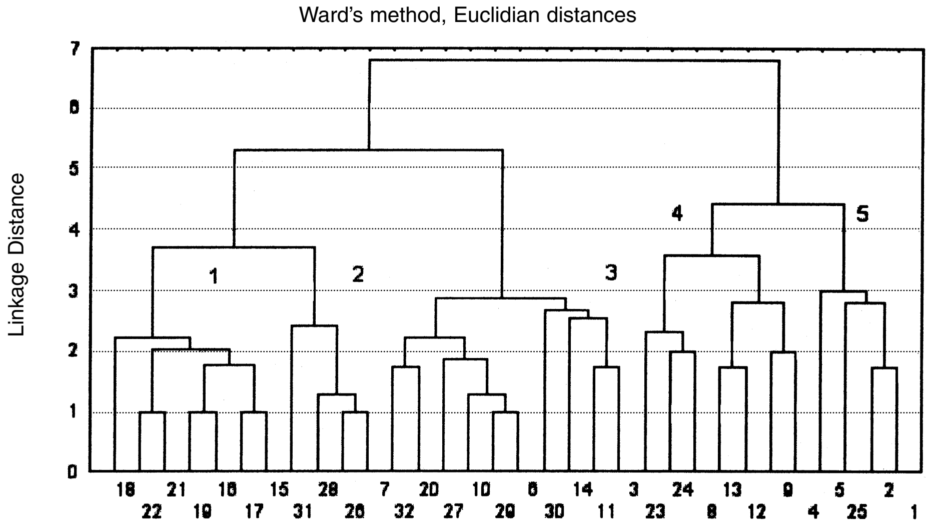


Fig. 9/III. Clusters of sites (fish assemblages), sites as in Fig. 8/III., 20 species, presence–absence, electroshocker data

particularly holds for clusters comprising species with the highest frequency (cluster 1). Thus, for 29 species, localities 4, 8, 9, 24, 25, 32 are grouped together, for 20 species localities 15, 16, 17, 18, 19, 21, 22, (Fig. 9/III).

Using relative abundance of species in the Berounka near Radnice the first cluster contains the barbel, chub, gudgeon, dace and roach, the second only bleak, and rest of species are in the third cluster, using biomass in first cluster there are the chub with barbel, in second gudgeon with dace and roach, in third asp, pike, zahrte, pikeperch, carp, eel, brown trout bleak, perch, last cluster contains the rest of species with the lowest biomass. Total of four clusters of sites (criterion abundance) were distinguished, the 1st cluster includes only one site (Třímany, September 9, 2003) with 17 species and 4812 fish/ha, the 2nd cluster sites with 11–17 species and 177 to 4407 fish per ha, the 3rd cluster sites with 12–20 species and 950 to 1294 fish/ha, and the 4rd cluster sites with 10–19 species and 308 to 1295 fish/ha. Three clusters (criterion biomass) include in 1st cluster 12–17 species and 191 to 280 kg per ha, in 2nd 10–19 species and 23 to 99 kg per ha and in 3rd cluster 10–17 species and 96 to 177 kg per ha (Figs 10–11/III).

Clusters of species from sites of the Úhlava – Předenice, Tajanov, Poborovice (criterion abundance) contain in the 1st cluster roach, dace, gudgeon, chub, in the 2nd cluster grayling, perch, barbel and 3rd cluster all other species. Only two clusters were distinguished using the biomass; in the 1st cluster roach, carp, dace, chub, barbel were together and all the other species were in the 2nd cluster. Within clusters of sites, the site Bridge, June 20, 2000 was distinctly separated with the absolutely highest abundance of the fish (2684) from the 2nd cluster with intermediate abundance (507 to 800) and from the 3rd cluster of with the lowest abundance (168 to 376). Three clusters of species with the criterion abundance/ha include in the first cluster dominant species (roach, dace,

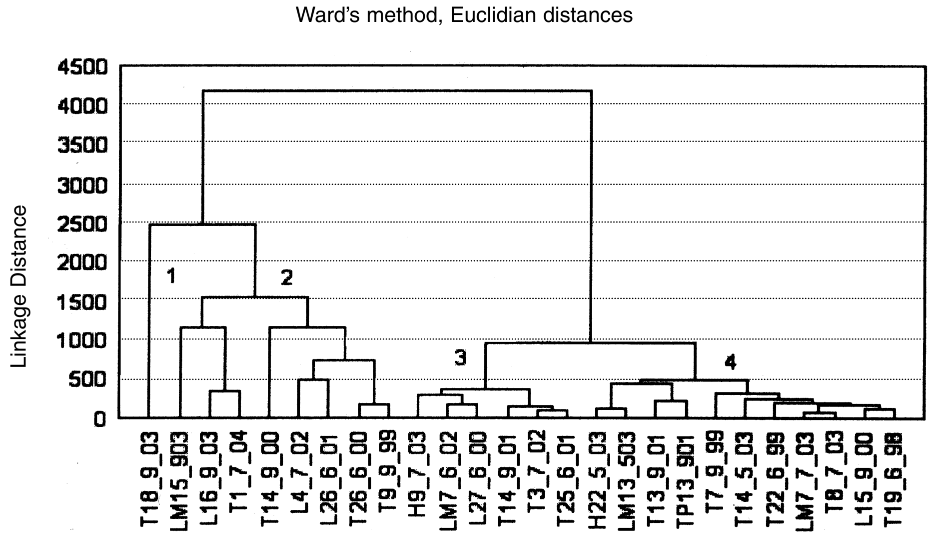


Fig. 10/III. Clusters of sites on Berounka River near Radnice, Libštejnský mill (LM), Liblín (L), Třímany (T), Hřešihlavy (H), electroshocker data, abundance/ha, 1998–2004

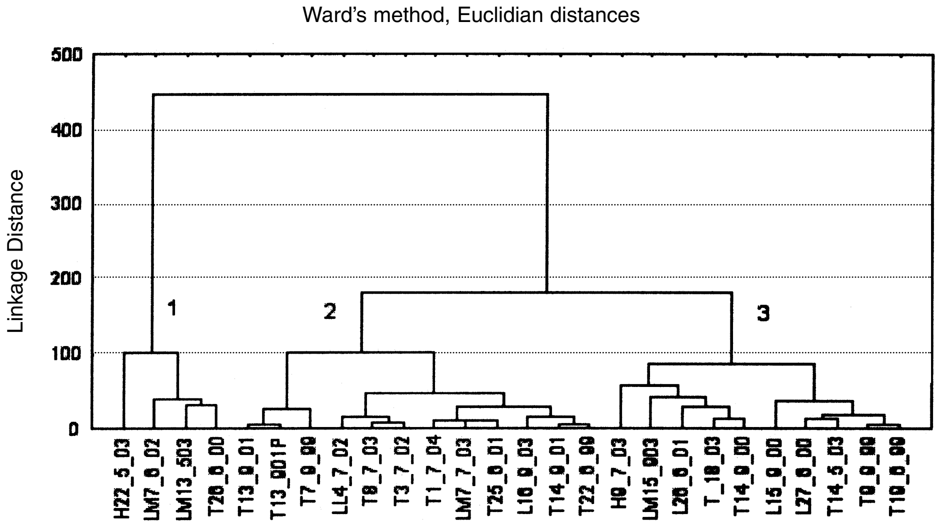


Fig. 11/III. The same as in Fig. 10/III., biomass/ha 1998–2004

gudgeon, and chub), in the 2nd grayling, barbel, and perch, and in the 3rd cluster all the other species. There is a nearly triple difference in the linkage distance between the Úhlava and Berounka; the first cluster is very similar on both site sets, in the Berounka it includes the barbel, in the Úhlava, barbel is present in other cluster with the stocked grayling and native perch.

Finally, we have compared clusters of fish species in sections of the Mže and Berounka River managed by sport fishermen for all fish species and for non-managed (native) species. The similarity in arrangement of clusters in both cases indicates that the sport fishermen are fishing the native species in the proportions, which are very near to their relative abundance in the given river section. Knowing the limits of fishery statistics we can use them for description and analyzing of fish assemblages in a long time span.

IV. Length composition of main species

Length composition was studied for the locality Třímany. In 1999 two catches were carried out in September 7. and 9 with the main aim to bring the evidence that the length composition of the barbel and chub would be similar, particularly in the young age groups (Figs *1–2/IV*). Really we did not observed any considerable changes in the length composition of fish caught in a period of days. The dominant length groups of the barbel (17–18 cm) was represented by the 3rd AG , in the chub (13 cm) by the 2nd AG and in the roach and dace (12–13cm) by the 2nd AG.

Provided that there are not any observable changes in the length composition e.g. due to the migration of the fish, and the dominant length group prevalently contains fish of the same age group, it is possible to assume that the shift in peaks of frequency correspond to the average length increment of the given AG. For the barbel the length increment of the 3rd AG from June 99 to September 99 was 2–3 cm, for the 2nd AG of chub 2–3 cm, and for roach and dace in 2nd AG 1 cm and 1–2 cm AG respectively (*Figs 3–4/IV*). The length increment of 1–2 cm in the 2nd AG was also ascertained in the gudgeon.

In barbel the dominant length group (8 cm in 1998) increased its length after one year to 14 cm, furthermore in 2000 to 18–20 cm, in 2001 to 22–23 cm, and still was observable in 2002 as 24 cm long. Only in 2003 a further dominant length group occurred (fish about 9 cm, 1+ AG) hatched in 2002. Of this group, only a small portion of the most rapidly growing individuals was caught on July 8, 2003. A really strength of this age group was observed in September 2003 when we caught about 700 individuals. The time period between the formations of both dominant age groups was 5 years (1997 and 2002), both years with high floods, (*Figs 5–6/IV*). In chub, the succession of dominant length groups is similar to that in the barbel (*Figs 7–8/IV*), the high abundance of the new age group hatched in 2002 was manifested only in autumn catch and again in 2003, (150 individuals). Also in this species, it is possible to observe a five-year period between strong year classes. More rapid rotation of length groups, not associated with floods, was observed in the roach (*Fig. 9/IV*) and in the gudgeon (*Fig. 10/IV*).

In the barbel, Fig. 11/IV a considerably low number of the fish in length groups of 27 to 33 cm at all localities i.e. fish of 6th to 7th AG was observed. With respect to the average length caught by fishermen (1.6 kg, i.e. fish over 40 cm), the absence of these age groups cannot be explained by fishing. A more probable explanation is associated with occurrence of mentioned strong year classes after five or more years. In the period of 1998 to 2004, there was only one year (2003), when the number of caught fish (10–15 cm) was about ten times higher then in the other years and next comparable year was 1998. The chub exerts to some degree a similar shape of the right part of the catch curve (Fig. 12/IV). Length groups of 10 to 20 cm are scarcer, and as the fishermen do not catch them, two strong age groups could hatch in the same years as the barbel i.e. in 1997 and 2002.

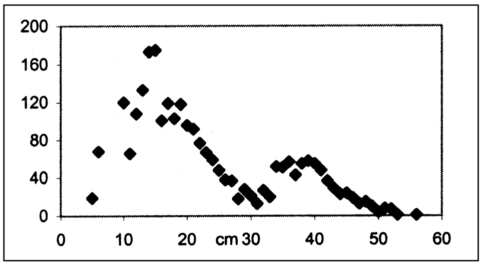


Fig. 11/IV. Total number of barbels in length groups (alltogether 4381 fish, 1998–2004) Berounka R. near Radnice

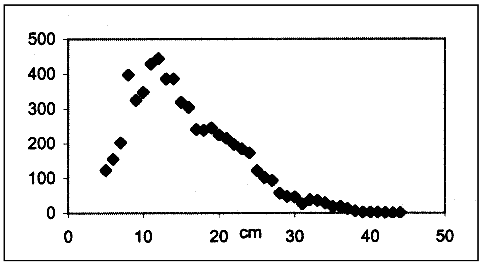


Fig. 12/IV. The same as in Fig. 11/IV. for chub, 6199 fish

The decreased number of recaptured barbel and chub (per 100 caught and 100 marked fish), starting from the 3rd AG was used for estimates of the survival and mortality. The length growth of fish was taken into consideration using only fish longer by 2 cm after the period of June–September and by 1 cm in June of the following year. The resulting values are realistic also with respect to maximum lengths (and age) of the fish caught (Tab. 1/IV). The total survival rate for barbel was assessed as 0.852 • 0.800 = 0.682 and for chub as 0.824 • 0.821 = 0.677.

Tab. 1/IV. Survival estimation for barbel and chub, Berounka River near Radnice

Spring–Autumn	**Barbel/Chub**	**Autumn–Spring**	**Barbel/Chub**
22. 6. 99– 7. 9. 99	0.856/0.846	14. 9. 00–25. 6. 01	0.718/0.883
22. 6. 99– 9. 9. 99	0.939/0.910	14. 9. 01– 3. 7. 02	0.801/0.975
26. 6. 00–14. 9. 00	0.778/0.860	14. 9. 00–25. 6. 01	0.967/0.913
25. 6. 01–14. 9. 01	0.935/0.846	14. 9. 01– 3. 7. 02	/0.703
25. 6. 01–14. 9. 01	0.750/0.656	14. 9. 00–25. 6. 01	0.703/0.519
		14. 9. 01– 3. 7. 02	0.812/0.934
Total barbel	0.852 ± 0.09		0.800 ± 0.11
Total chub	0.824 ± 0.087		0.821 ± 0.16

Year survival S = 0.682 (barbel) and 0.677 (chub)

V. Abundance estimates

The values of abundance of the barbel, chub, roach, gudgeon, and dace in the Berounka River near Radnice, and barbel, chub, roach, and dace on sites of the Úhlava River near

Předenice) are in *Tab. 1–2/V*). At the locality Hřešihlavy, only data from two visits, from May 22, 2003 and July 9, 2003 were available and the Petersen estimate has to be used. The Petersen estimate was also applied for fish of 10–15 cm of SL at the locality Třímany (between September 7, and 9, 1999 and between September 7–9, 1999 and June 26, 2000), *Tab. 3/V*.

The range of fish movement in particular season and/or years was evaluated using tagged (marked) fish and fish with special transmitters. In the Berounka near Radnice altogether 5133 barbel and chub were caught, 4489 tagged, and among them were 872 recaptured fish. Up to 2002 only four fish with tags from the other locality then tagged were recorded (two barbel and two chub), three fish with the tag moved upstream from Třímany to Liblín, one in the opposite direction. In 2003–04 after flood in 2002, total of 12 fish were recorded (6 barbel and 6 chub) – five fish migrated from Třímany to Libštejnsky mill, one fish from Liblín to Libštejnský mill, three from Liblín to Třímany, one from Liblín to Hřešihlavy, and two from Třímany to Hřešihlavy. Of 872 recaptured fish, only 18 were from the other locality then tagged (2.06%). The movement of fish among localities after the flood in 2002 increase, however, their proportion was quite negligible.

In 2003 and 2004 special external transmitters attached on fish monitored the movement of the barbel between the weirs in Třímany and Hřešihlavy. The reach between the weirs is 3.8 km long, about 1000 m downstream there is a rapid part and, after that deeper water with slowing down the stream to the weir in Hřešihlavy. The fish with transmitters were registered every two weeks by double wading of the whole distance.

In half of the November 2003, 12 barbel (240–420 mm and 250 to 850 g) were equipped with external transmitters (maximum 2% of the body weight). At the end of November, the fish with transmitters remained on the place of its release under the weir in Třímany. Only one specimen was located of about 200 m downstream. Also in further months (December, January, February), the fish resided in rapid segments under the weir in one of three branches. At the beginning of March, the movement activity of the fish enhanced and three individuals were found at distances of 130 to 200 m from the site of their release. At the end of March, only 6 individuals resided under the weir, whereas further 6 individuals were at a distance of about 120 to 250 m downstream.

In May 2004, new transmitters were attached to further 13 barbel (250–500 mm, 280–2300 g). Spawning of these fish was recorded at the end of May in the rapid segment, about 90 m downstream. After spawning, in June, the fish with the transmitters ever resided under the weir in the vicinity of the place of its release, in July, ten fish were located in the rapid reach about 1000 m downstream. In further months fish returned back under the weir in Třímany, however, till the end of November, when the life of the transmitters terminated, several individuals remained about 1000 m downstream. Of the total of 25 barbel with transmitters all fish were located either directly under their home weir or at most 1 km downstream.

In the four sites of the Berounka River near Radnice we estimated in average of 1165 barbel, 1159 chub and 709 roach and dace (total of 3033 fish/ha ≥ 15 cm), *Tab. 1/V*. Figs 1–2/V. The ratio of fish caught with electroshocker and of their assessed abundance represents 12.6% for barbel, 19% for chub, and 11% for roach and dace, four species represent in average 15.3% of their assessed abundance, *Tab. 2/V.*

In one locality Třímany, where the higher number of independent estimations was made, the estimated fish ≥15 cm represent 90 (83–97%) of all fish species of the same length caught, fish longer than 5 cm 26%. Therefore the absolute abundance of all fish ≥ 15 cm can be estimated here as 3370 fish/ha. In length groups of 10 to 15 cm, (September 7. and 9. 1999) altogether 13 194 fish was assessed. In this case the number of fish caught by electroshocker formed 6–13% of the Petersen estimate; in chub 9%, in dace 13%, in roach 6%, and 9% in the gudgeon. In average, the catch of four species made 9.3% of the estimated abundance, *Tab 3/V.*

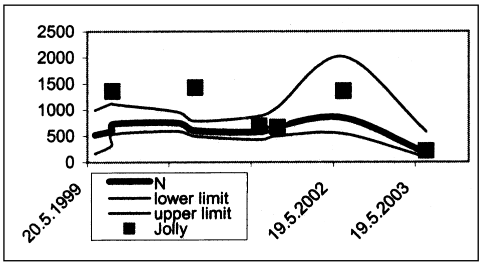


Fig. 1/V. Estimated barbel abundance by Petersen method, as compared with Jolly-Seber method and its limits, fish≥ 15 cm, locality Třímany

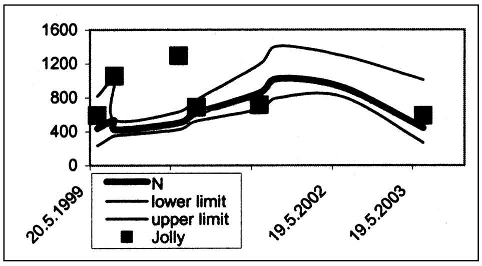


Fig. 2/V. The same as in Fig. 1/V for chub

Tab. 2/V. Relation between the number of caught and estimated fish/ha

Locality	**Třímany**			**Liblín**		
	estimated (E)	caught (C)	C/E	estimated (E)	caught (C)	C/E
Season	Barbel					
S 99						
A 99	1356	259	0.19			
S 00						
A 00	1423	96	0.06			
S 01	691	88	0.13	1621	150	0.09
A 01	667	81	0.12			
S 02	1354	72	0.05	LM		
S 03	215	61	0.28	1218	126	0.1
A 03				Hrešihlavy 989	104	0.1
Total ave.	**1165**		**14%**			**10%**

Locality	**Třímany**			**Liblín**			**Třímany**		
	estimated (E)	caught (C)	C/E	estimated (E)	caught (C)	C/N	estimated (E)	caught (C)	C/N
Season	Chub						Roach+Dace		
S 99	591	92	0.16						
A 99	1052	248	0.24				707	123	0.17
S 00	1292	210	0.16						
A 00	686	182	0.27				892	49	0.05
S 01	712	145	0.2	2751	288	0.1			
A 01							529	56	0.11
S 02				LM					
S 03	585	146	0.25	4510	162	0.04			
A 03	2106	224	0.11	Hrešihlavy 655	244	0.37			
Total ave.	**1159**		**20%**			**17%**	**709**		**11%**

In the locality Předenice, Bridge 200–400 barbel, 330–690 chub, 250–520 dace, and 120–240 roach/ha was estimated by Jolly-Seber method, altogether 900–1860 fish/ha and in the locality Under Weir 615 fish/ha. *Tab. 4/V*. The percentage of fish caught with electroshocker represent for barbel, chub, roach, and dace 23 and 29% of assessed abundance at the first locality and 21% at the second locality. All estimated fish ≥ 15 formed 95% of all fish species of the same length, so we can calculate here with about 950–1960 fish and 650 fish/ha in the Localities Bridge and Under Weir, respectively.

Leontovyč et al (1980) published valuable data on the structure and abundance of ichthyocenoses in the Berounka River between cities Plzeň and Praha. He reported from ten different sites under weirs in average 1629 fish/ha, our data from the locality Třímany (13 independent catches) gave in average 1678 fish/ha. The fish assemblages above weirs are, however, distinctively different, particularly by a low numbers of the barbel, chub and dace and higher number of other species (bleak) Fig. 3/V. From five such sites, including Leontovyč et al (l.c.) and our data from the Berounka R. near Křivoklát (mouth of the brook Rakovnický and under the weir in Třímany), gave in average 669 fish fish/ha. The proportion of fish longer than 15 cm was 20%, i.e. 134 fish/ha, and the total abundance of these fish we assessed on 700 fish/ha. Forasmuch as the number of fish caught by electroshocker per unit effort by him and our data from 1998–04 (fish longer than 5 cm) are well comparable as to the number of fish caught per ha, as well as in the species composition, we used them for further calculations.

The knowledge of the values of fish abundance in most important habitats of the Berounka River enabled an estimate of the total number of fish longer than 15 cm in B7 (8 km, 45 ha). In this ward there are two areas under weir, one ha each with 3 to 4 thousand fish, i.e. of 6–7 thousands, two rapid stretch, one ha each, with about 2 to 3 thousand fish per ha, i.e. of 4 to 6 thousands and 41 ha of stretch above weirs, with about 700 fish/ha, i.e. of 30 thousands of fish, altogether 45 thousands of fish. Together with fish preferred by fishermen (carp, tench, bream, pike, pikeperch, and eel) and under assumption the fishermen

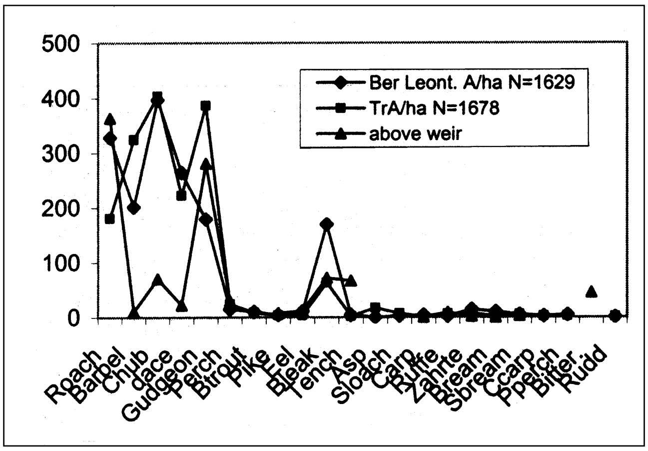


Fig. 3/V. Relative abundance of fish caught by Leontovyč et Vostradovská, 1980 in the whole Berounka River under weirs, in Třímany under weir (own data), and by Leotovyč et Vostradovská l. c.) in localites above weirs

caught one third to one fifth of these fish, about 50–60 thousands of fish longer than 15 cm could be present in the whole ward. Out of this, the barbel and chub form 2300 • 2 (two areas under weir) + 1500 • 2 (two rapid segments) + 80 • 41 (segments above weirs in ha) = 3280, i.e. about 10–11 thousands of fish out of them 4280 barbel and 6600 chub.

The ratio of fish longer than 25 cm (body length), i.e. the size that is regularly caught by sport fishermen, is 22% in the chub, 17% in the barbel (in average 20%). Thus, there could be 2500 large fish, of them 1500 chub and 1000 barbel. Out of them the fishermen caught 600 chubs (40%) and 51 barbles (5%). Additionaly we suppose here about 1360 carps (one half of the catch) and about 1260 of carnivorous fish (one third of the catch).

VI. Fish production and its use by fishermen

The length and weight growth of the barbel, chub, and dace was estimated using fish caught in the Berounka and Úhlava River during our field operation, the growth of further species (roach, gudgeon, bleak, pike, bream, pikeperch, asp) was evaluated from published data, Tab. 1/VI. The length-weight relationship was calculated for chub, barbel and dace (Fig. 1/VI), the average length-weight equation ($y = ax^b$ taking the coefficient “b” = 3) for barbel, chub, roach, and dace as $\log W = 3(\log L - 4.776)$. This equation was used for conversion of the published length data in weight. The changes in the weight growth characterized by the sum of weight increments in longitudinal profile of some streams in Czech Republic for barbel and chub are in Fig. 2/VI. The expected semilogarithmic (parabolic) character was confirmed for the chub, for barbel rather linear relation was obtained but the growth data from large rivers are not at hand.

Tab. 1/VI. Length and growth weight of important fish, Berounka R. near Radnice 1998–2000. AG age group, SL standard length, N abundance, ∆ W weight increment

Chub				**Barbel**			
AG	SL mm	Wt g	∆W g	AG	Lt mm	Wt g	∆W g
1	47	2	1. 7	1	52	2	2
2	94	14	13	2	113	23	20
3	130	37	27	3	153	57	34
4	152	59	30	4	185	99	44
5	187	110	43	5	250	241	95
6	213	162	58	6	288	364	123
7	242	238	69	7	333	557	118
8	275	349	80	8	335	567	106
9	282	376	61	9	361	706	144
10	309	495	114	10	413	1048	162
11	320	550	230	11	413	1048	221
12				12	430	1180	247
∑ ∆W 4–10		455		∑ ∆W 4–10			792
Dace				Gudgeon			
1	38	1	1	1	55	2.8	2.8
2	85	9	8	2	88	10.4	7.6
3	115	24	15	3	105	17.2	6. 8
4	142	45	21	4	118	23	5.8
5	154	58	13	5	126	29	6
6	170	79	21	6	132	33	4

Growth of roach, bleak, bream, and pike was evaluated using data by Vostradovský (1966), Liška (1980), and Hanel et Oliva (1991)

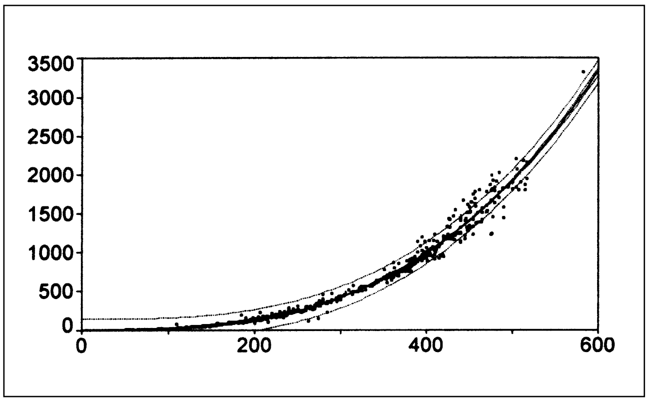


Fig. 1/VI. Length-weight relationship for barbel, (length in mm, weight in g on y axis), Berounka River, Třímany; n = 761, R^2 = 0.9828, y = ax ^{b}, a = 1. 3090e^{-05}, b = 3. 0252;
dace n = 389, R^2 = 0.9529, y = ax^b, a = 4. 9855e^{-05}, b = 2. 77656; and chub n = 902, R^2 = 0.9699, y = ax^b, a = 1. 1269 e^{-05}, b = 3. 0924; 95% confidence and prediction limits are given

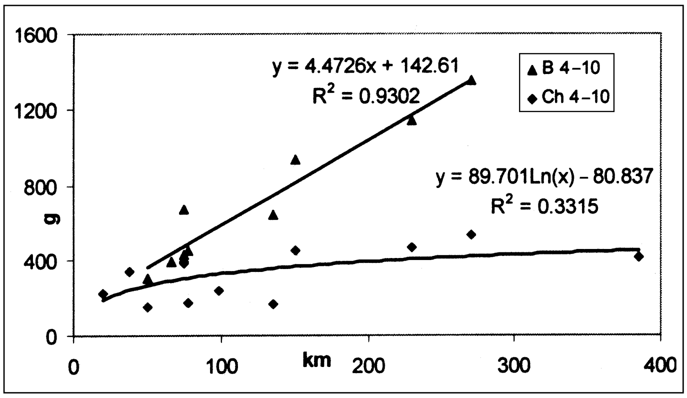


Fig. 2/VI. Relationship between the growth rate of barbel (B) and chub (Ch) measured as the sum of weight increments of the 4th–10th AG and the distance of site from the source. The growth data are also from papers by Peňáz 1968, 1977; Oliva et al 1979; Libosvárský et Prokeš 1978; and Hanel 1982

In average 48, 80 and 22 carp/ha were caught in the Mže, Úhlava, and Berounka River, respectively in 1975–1999 (2003), their weight range between 1.7 kg and 2 kg. Data on the carp growth rate are not available, however, judging from the growth rate of the other fish species (barbel, chub), the carp achieves the mean legal weight two years in the Berounka and three years after stocking in the Mže and Úhlava. The carp increment in the Berounka ranges between 1 and 1.5 kg i.e. 0.5 to 0.75 kg/year (in average 0.6 kg). With the 22 carps caught in average, their production is assessed on 13.2 kg/ha/year. In B7 only 15 carps is caught per ha i.e. 40% of the stocked fish with the production of 9 kg (the total production of all stocked carps should be 22.5 kg). In the Úhlava and Mže, the annual increment was estimated on 0.4 kg. For 79 and 48 carps caught, the net annual production of this fish could be 31.6 and 19.2 kg per ha, respectively.

Weight increments for other species caught by anglers are calculated only for the Berounka R. Average weight of the stocked tench ranges between 0.1 and 0.2 kg and that of caught is roud 0.55 kg. The annual weight increment can be estimated as 0.15 kg, giving a year production of 0.3 kg/ha with two specimens caught. Weight increment for the pike is 0.8 kg, 0.5 kg for the pikeperch, 0.4 kg for the eel, wells is not caught in B7. Taking into account 9 predatory fish caught per year their production is about 7 kg. The average weight increments of the bream, barbel, chub, and zahrte could be of 0.15 kg annually. For 35 specimens it represents a production of 5.3 kg. Finally 24 caught fish (roach, dace, bleak silver bream), could produce of 2.4 kg. The average production of all fish caught by fishermen in the whole Berounka River is about 28 kg/ha (for fishing ward B7 24 kg). The fishermen caught in average one third to one fifth of all fish, their production should be round 80–140 kg, (for B7 70–120). Carnivorous fish consume yearly 60–80 kg of fish mostly up to 15 cm of the body length.

The production of barbel, chub, dace, and roach in the locality Třímany per 1000 fish each is in Tab. 2/VI. We consider here a uniform decrease of the number of fish in successive age groups i.e. a constant survival rates as estimated in Chapter IV. The really

Tab. 2/VI. Production of four important fish> 15 cm (LC), Berounka R. locality Třímany. SL standard length, N abundance, ∆W weight increment, P production

Barbel						**Chub**		
AG	SL	N	∆ W	P(g)	Lt	N	∆ W	P(g)
3	153	232	37. 3	8659				
4	185	181	54. 4	9839	152	287	30	8610
5	250	141	72. 6	10254	187	210	43	9009
6	288	110	92. 1	10145	213	153	58	8871
7	333	86	112. 9	9693	242	112	69	7704
8	335	67	134. 8	9031	275	82	80	6520
9	361	52	158. 0	8255	282	59	61	3629
10	413	41	182. 4	7434	309	43	114	4951
11	413	32	208. 0	6613	320	32	140	4439
12	430	25	234. 9	5824	315	23	160	3703
13		19	263. 0	5086	345			
14		15	292. 3	4409	355			
Total per 1000 fish		1001	95. 2 kg			1000		57. 4 kg
Total per ha 1165			111 kg			1157		66. 0 kg
from 10th AG onw.			29 kg	from 6th AG				39. 8 kg
		Dace				**Roach**		
AG	Lt	N	∆ w	P(g)	Lt	N	∆ w	P(g)
5	154	460	13	5980	163	379	22	8338
6	170	276	21	5796	166	246	25	6159
7	180	166	31	5134	178	160	30	4804
8	190	99	45	4471	182	104	18	1873
9	198				195	68	28	1894
10					204	44	25	1099
Total		1001		21. 4 kg		1001		24. 2 kg
Total per ha		350		7. 5 kg		359		8. 7 kg

estimated 1165 barbel and 1157 chub produce 111 and 66 kg/ha, respectively. Further two specimens produce 21 and 24 kg of new biomass, estimated 350 and 359 fish 7.5 and 8.7 and kg/ha, respectively. In total of 193 kg of new biomass is produced by 3031 specimens of four mentioned species. This production, however, is valid for area of 2–5 ha taking into account the fish movement. Length groups of 10 to 15 cm – 13194 fish (barbel, chub, dace, roach and gudgeon) produce of 130 kg/ha annually, we suppose that only one half of this production was made under the weir. Altogether five species (fish 10 cm and longer), gudgeon produce here 323 kg/ha/year, in reality 100–160 kg/ha/year. The production of all fish species caught with exception of carp in the locality Třímany could be round 200 kg/ha.

VII. Fish assemblages as influenced by selected environmental factors

First two ordination axes of the indirect gradient analysis (DCA) for 23 species and four sites repeatedly fished on for sites in the Berounka River near Radnice explain as much as 40.5% of the variability in species composition. The first axes itself explains 25.2% and it is extended trough the highest variability of the species composition, Fig. 1/VII. The species composition of fish assemblages in different sites and years are very similar. The variability of the species composition was then studied by direct redundancy analysis (RDA). Here the individual sites explain 23.8% of the variability in species, ($p < 0.084$) and the same was found for different years. Significantly different were only species composition for sites fished in spring and autumn ($p < 0.0042$), Fig. 2/VII. This season variability is responsible for 16.4% of the variability in species composition. The species score shows how strongly are individual species associated with the given season, species on left with spring, on right with autumn, Fig. 3/VII. This arrangement is strongly dependent on the year class strength of species which spawn and live as YOY under weirs.

Fishing statistics from the B7 and data about the quality of water published by Czech Hydrometeorological Institute were used for evaluation of the influence of environmental factors (NH_4^+, Cl^-, SO_4^{2-} and BOD) on yields of important fish species (carp, pike, chub, barbel, bream, perch, "other fish", and zahrte). The direct gradient analysis RDA and CCA were used in this case. After sequential selection of the environmental factors, two were eliminated as insignificant (BOD and $SO4_2^-$), remaining two factors were used in the model ($P < 0.0001$), Fig. 4/VII. First ordination axes represent the most important gradient

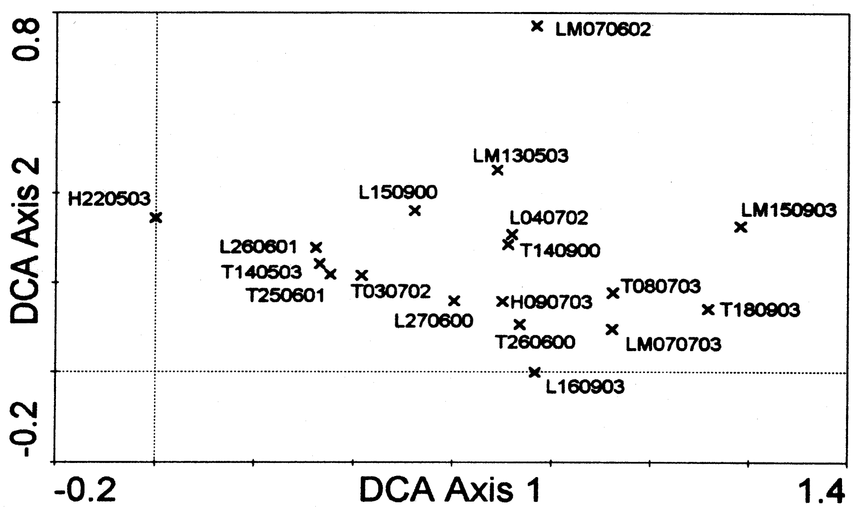
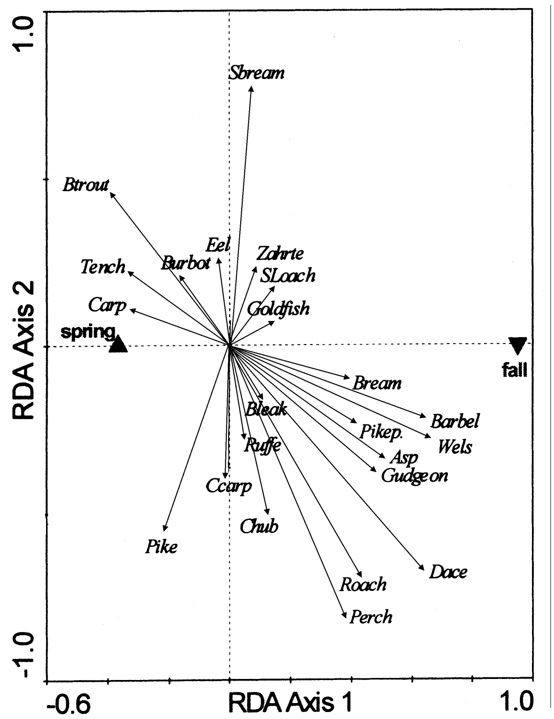


Fig. 1/VII. DCA analysis, Berounka River near Radnice (23 species 18 sites), LM Libštejnský mill, L Liblín, T Třimany, H Hřešihlavy

Fig. 2/VII. RDA analysis (the same data as in Fig. 1



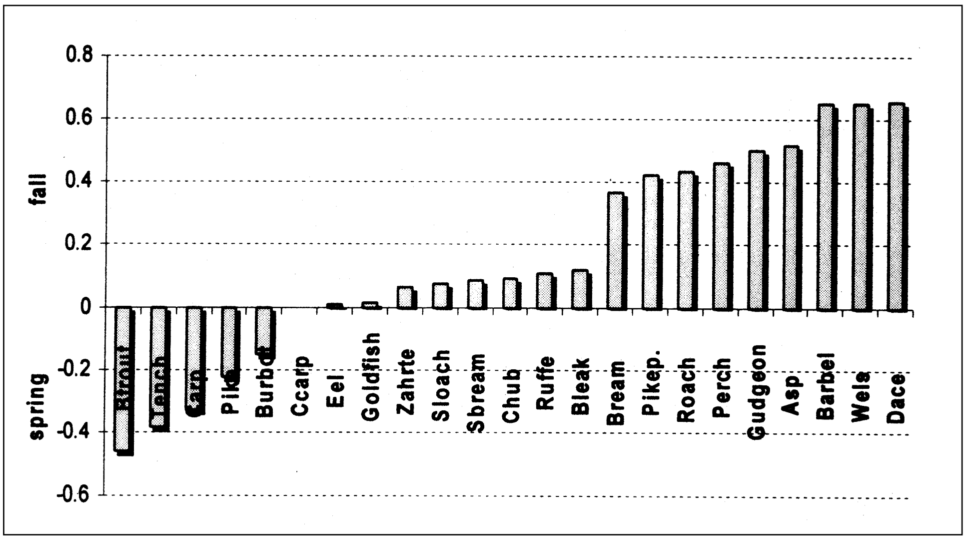


Fig. 3/VII. Association of fish species with season (spring and fall)

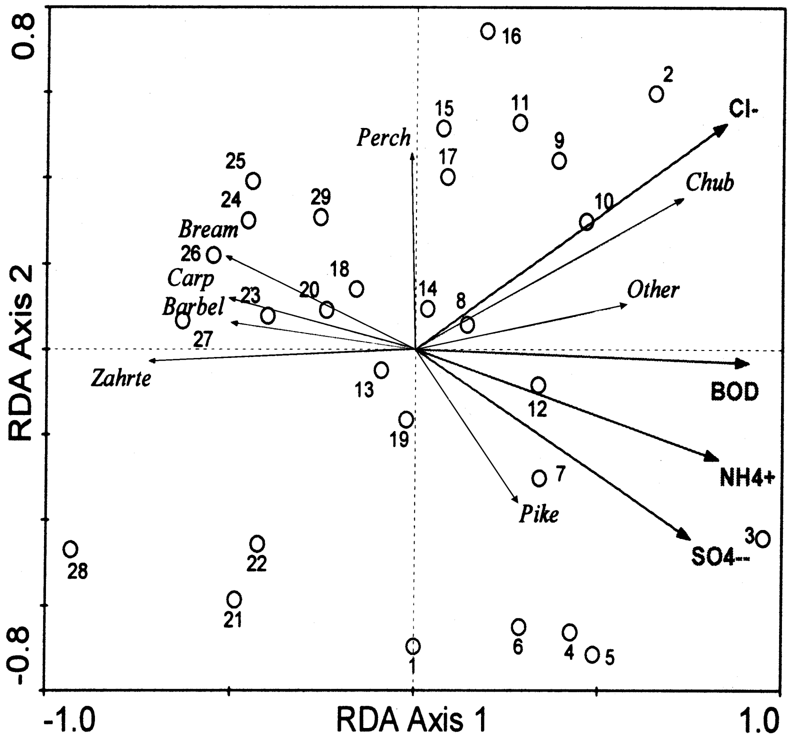


Fig. 4/VII. RDA analysis, influence of environmental factors on angler's catches of important fish species. Numbered circles represent fishing seasons from 1975 to 2003, B7

correlated with the concentration of NH_4^+ and Cl^-. Both factors covered as much as 29.9% of the variability in fish yields. The pure influence of NH_4^+ and Cl^- detected by partial analysis attained the values of 8.5% ($p < 0.0097$) and 10.3% ($p < 0.0009$) respectively, overlap (11.1%) indicate their important mutual influence. As the carp catches could strongly influence the yields of other fish species, in our last model we used carp as next environmental factor and assessed its influence on fish yields. The model was significant as a whole ($p = 0.0052$), the effect of the carp itself was, however, not significant. From all environmental factors used a significant result was documented only for Cl^- 19% ($p = 0.0013$).

DISCUSSION

Total of 28 weirs on the Berounka River, distanced from each other in average by 5.2 (1–12.5) km, considerably alter the frequency and extend of particular habitats. Lotic habitats under weirs continue in average up to 0.5–1 km downstream, additional one or two lotic habitats are often found between weirs (about 0.5–1 km long). Lentic habitats are as a rule above weirs; their length is influenced by the weir height and by the character of the river profile between weirs. The average length of these habitats is about 1–2 km. In the whole river (140 km), there are about 40 km of lotic, 30 km of lentic habitats, the rest of habitats being transitive ones. Dead and semi-dead arms, and disconnected biotopes, which influence positively above all juvenile fish assemblages Nikolas et Pont (1997), are scarce along this river.

For maintaining the fish diversity in the Berounka, secondary lotic arms separated by small islands, and formed mainly after floods under weirs, are of importance. They can be in function for tens or more years. Short streams often interconnect these arms. With a flow rate of 10 (100) l /sec. these habitats offer good conditions for YOY of a number of fish species (barbel, gudgeon, dace, chub, roach). Special independent habitats are flumes of mills and power stations that frequently form a further type of lotic habitats.

The deterioration of water quality in the second half of the last century was often coupled with a reduction of the diversity of fish assemblages (Gatz et Harring 1993) and decrease of the abundance of key species (nase, barbel) (Lusk, 1995, 1996; Mann, 1996). However, in most studies from that time, only measured values of physical-chemical parameters (NH_4^+, NO_3^-, BOD, heavy metals) were presented without numeric evidence of their influence on fish (Philippart et al. 1987; Turnpenny et al. 1987). The improvement of the water quality recorded at the end of the last century was correlated with an increase of abundance of some species by Eklöv et al. (1998), more recently the multidimensional statistical methods were employed for quantitative evaluation of effects of environmental factors on fish assemblages (Penzak et al. 2004). However, in spite of better quality of water, the loss of habitats ever occurs and the hydrological connectivity between the main river and its floodplains is not being improved (Aarts et al. (2004). Persisted loss of habitats in the main channel and in floodplains strongly correlate with the landform and land use (Allan 2004).

In the Berounka River and its tributaries (the Úhlava and the Mže Rivers), the stepwise growth of the concentration of nitrates, ammonia, chlorides up to the end of 1980 s with its subsequent decrease is quite distinct. All values are most properly smoothed by a parabola, only for BOD the stepwise decreases at all the profiles was observed. The fishery statistics and data about the water quality gave the opportunity to asses the influence of water quality parameters (NH_4^+ and Cl^-) on fish yields. RDA showed that both environmental factors covered as much as 29.9% of the yield variability. The pure influence of NH_4^+ and Cl^- detected by partial analysis attained the values of 8.5%, $p < 0.0097$, and 10.3%, $p < 0.0009$, respectively. In the pike and chub it was impossible to demonstrate the expected negative correlation between yields and NH_4^+ (pike) and Cl^- (chub). In next model we take carp as environmental factor and assess the influence of its yield on yields of other species. This model was significant as a whole ($p = 0.0052$), the effect of the carp was, however, not confirmed.

Yield of the carp in smaller streams with flow up to 10 m^3/sec (Mže, Úhlava) attains about 75% of the total catch, in the larger stream with flow up to 40–50 m^3 about 50% in the Berounka, or 40–70% in the Dyje River, Baruš et al. (2000). The total yield of carnivorous species ranges from 11.8 to 18.7 kg/ha in the Berounka and from 10 to 15 kg in the Mže and Úhlava, the largest portion being formed by the pike.

The ratio between the numbers of carps stocked and caught (S/C) in the fishing wards of the Berounka ranges between 0.127 and 0.48, average weights of the stocked carps between 0.59 and 0.75 kg, sometimes only 0.1–0.2 kg. The relationship between stocked and caught fish is expected to be linear at low numbers (biomass), at higher and very high numbers its shape changes, reaching its maximum and decreasing at very high stocking rates, again. This was confirmed for wards B7 and B8 where the data about stocking and catching fish are most complete. The high number of stocked fish in 1999 (357 carps/ha weighting 0.2 kg in average) negatively influenced the S/C ratio, however, paradoxically contributed to the increase of the number of fish caught in 2000–2003, see in *Fig. 14–15/II*. Similar results were already published for Czech reservoirs Pivnička (1985) and rivers Smutný et Pivnička (2001). The growth tempo and survival rate of stocked fish play important role.

Stocking of carp, pike, brown trout, and non-native species indisputably influence native fish assemblages in all types of inland waters (Pivnička et al. 1996, Hickley et Chare, 2004). On the other hand fishery statistics may be employed for studying of effects of environmental changes on fish in a long time span (Cowx et Broughton, 1986).

At the end of the 19th century, in the main stream of the Labe River and in its backwaters in Bohemia, 22 fish species were recorded (Frič et Vávra, 1903). After almost 100 years, the International Commission for Protection of the Elbe (1996) presented in its report 30 species. Such an increase of the number of species is known also from other European rivers; the high abundance of widely adapted species (roach, perch, chub) and/or of invasive species (golden carp) is often mentioned. Among the fish with high frequency and abundance, the perch and roach are considered as indicators of the degradation of streams (Wolter et Vilcinskas, 1997). Of further streams from the Middle Europe the Pilica River (a tributary of Warta River) in Poland has total of 31 species (Backiel et Penczak 1989), 29 species are reported by Wolter et Vilcinskas (l.c.) for regulated rivers and canals in the NE Germany (Labe watershed). Gradual increase of the fish species further downstream but its successive decrease in large rivers in stretches used for naval transport is known.

Leontovyč et al. (1980) registered in the whole longitudinal profile of the Berounka in 1976–1979 (20 sites, 9457 fish) 26 species; the most frequent ones were chub, roach, gudgeon, bleak, barbel and dace. In our catches performed in 1998–2004 23 851 fish and 26 fish species were ascertained in four sites repeatedly fished. Together with fish caught by anglers (grayling, rainbow trout, silver carp) 29 fish species were ascertained here. The species structure in both time periods was almost the same. In our catches, bitterlig, bulhead, and nase did not occur; stone morocco and golden carp (invasive species of the end of the 20th century) and burbot were caught additionally. Both data sets were employed to provide an estimate of the Index of Species Saturation (ISS) for the sites in the longitudinal profile from the Úhlava headwaters to the mouth of the Berounka (UB curve), comparing the UB curve with standard curve and its 95% upper predictive limit for Czech streams (Pivnička, 1996, Pivnička et Humpl, 2005). The Index of Species Saturation (ISS) calculated for the number of species lying on the UB curve and on the

95% UPL of the standard curve for 1138 Czech streams achieved a value of 0.79, for standard curve and its UPL 0.64; the diversity of fish assemblages in the Úhlava and Berounka rivers is distinctive higher than average diversity in Czech streams.

The number of clusters of fish species caught by anglers in wards of the Mže and Berounka Rivers for all species and for only non-managed (native) species is very similar the only exception being the values of linkage distances separates different clusters. The same was observed when comparing clusters of species using the fishery statistics and eloctroshocker data. So the sport fishermen catch the native species in the proportions, which are not far from their relative abundance in the given river section. Knowing the limits of fishery statistics we can use them for description of fish assemblages in rivers (Pivnička et al. 2004).

Zalewski (1985) compared the accuracy of values of fish abundance obtained by the different catch-effort methods with the total catch and came to the conclusion (stone loach and minnow) that the abundance ascertained by Zippin method was in average of 60% of the total catch (five fishing runs and rotenone treatment). Comparing the abundance of barbel in the 6.47 ha stretch in the Jihlava River in autumn 2001 (Peňáz et al. 2003) assessed by Petersen estimate 370 fish/ha, and simultaneously organized quantitative electro-fishing survey gave 316 barbel/ha and represented 88.4% of the estimate. Meador (2005) presented data for non-wadeable streams and found out that the first electrofishing pass yielded about 65.5% of total fish species, the second one 89.2% depending on the number and kind of species, the values of abundance, however, are not presented.

For barbel, chub, roach and dace (fish >15 cm) the number of fish caught in two successive runs represented 17–20% for chub, 10–14% for barbel, and 11% for dace and roach of the total number assessed by the Joly Seber method. The relation of all fish >15 cm to all fish >10 cm ranges between 10 and 40 %. For several streams from the Labe River watershed, the number of the fish >15 cm caught in the first run related to the total abundance assessed by Petersen method decreases exponentially (y (%) = 84.9 ∗ e^ –0.0081 ∗ x (km) downstream. About 80% were caught at 10th km, 65% at 50th km, 40% at 100th km and 25% at 150th km. In streams of the Labe and Odra River watersheds in Bohemia, data on the abundance and biomass of fish are available for almost 500 sites. Most sites are located in headwaters up to 50 km from the source; further downstream the data are scarcer. The high variability of abundance and biomass in streams up to 50 km is associated with intensive stocking of brown trout, often also with relatively small areas fished. In average, in streams up to 50 km, it is possible to catch during the first run about 1 to 4 thousand fish with biomass roud 100 kg/ha. In larger streams the average abundance remains nearly constant; however, it is necessary to expect a decrease in the fishing efficiency as it was shown above. In streams from 100 to 200 km from the source during the first run we can catch up to 15 000 fish with biomass from several kg up to 600 kg/ha (Figs 1. and 2.). For illustration we compare the biomass in the longitudinal profile of three streams (the Blanice R. up to 88 km, South Bohemia; L. Nisa R. up to 256 km, North Bohemia and Germany; and Teplá R. up to 64 km, West Bohemia). Lužická Nisa is influenced by industrial and municipal effluents shows a decreased trend of biomass, minimally affected Blanice a logarithmic trend, and in the Teplá River the managed ponds in the middle part of the watershed cause an increase of the biomass, Fig. 3.

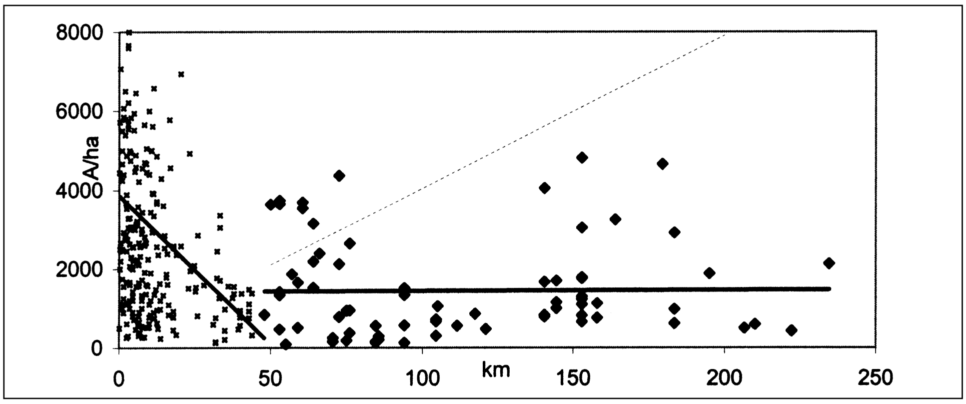


Fig. 1. Abundance of fish in streams in the Labe watershed, up to 50 km from the source, 245 sites and in sites between 51–250 km, 73 site. Dashed line shows expected abundances for 100% fishing efficiency

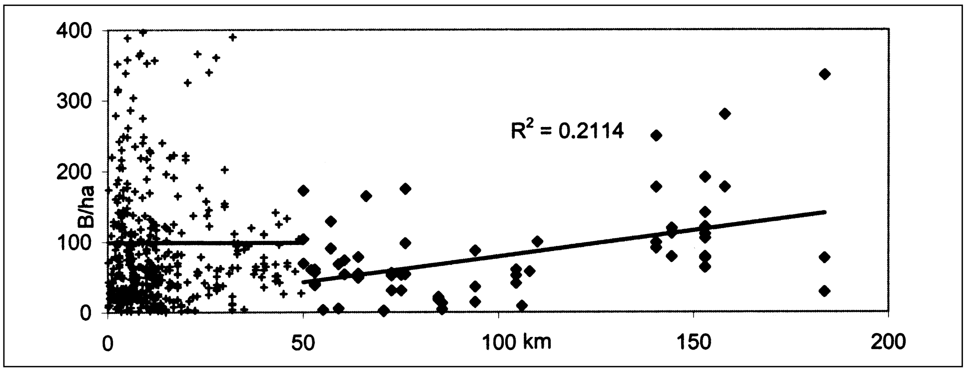


Fig. 2. Biomass of fish as in Fig. 1. 1–50 km 420 sites, 51–190 km 68 sites. The expected biomass for 100% fishing efficiency was not calculated

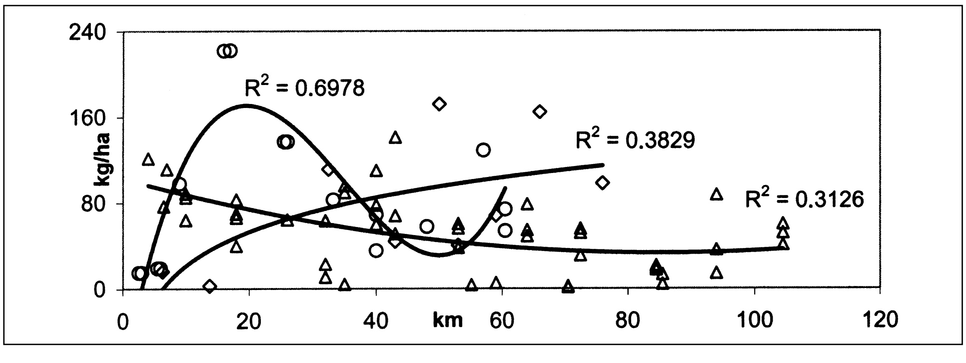


Fig. 3. Biomass of fish (kg/ha) as caught by electrofishing in L. Nisa River – triangles, Blanice River – diamonds, and Teplá River – circles

More realistic data on the fish abundance are at hand for some species and fish ≥ 15 cm. Abundance of barbel in the Berounka River near Radnice (155 km from the source, 30 m^3) was in average 1165 fish per ha (ranges 667–135), in the Úhlava R. (80 km, 5.8 m^3) 200–400 fish, and in the Divoká Orlice R. (Kostelec nad Orlicí, 85 km, 8.3 m^3) 280 fish. In the Jihlava R. (135 km, 9 m^3) Peňáz et al. (2003) estimated in average 425 barbel (233–563) and Hunt et Jones (1974) in the River Severn (200 km) 240–2020 barbel longer than 18 cm per ha.

Estimation of the production of the barbel, chub, roach and dace (fish > 15 cm) is based on the absolute weight increments and estimated abundance of fish. Values of production are lower than when estimated by the Ricker's method (Ricker, 1975) as they represent only the net production (available production). The sum for four species (193 kg/ha/year) is valid for the sites under weirs, in reality this production should be spread on 2–5 ha taking into account the fish migration. The production of fish between 10 and 15 cm of the same species and gudgeon was assessed on 130 kg/ha but its spreading onto two hectares is more realistic. Altogether 323 (max. 400) kg could be produced yearly by five species, fish ≥ 10 cm or 100–160 (200) kg taking into account the area where the production was made. The predators caught by anglers consume annually per one kg of their production about five kg of biomass of forage fish, i.e. 60–80 kg of fish per ha. For the average length of caught predators (50 to 60 cm), the size of prey can range between 10 and 15 cm (Popova, 1967).

Randal et al. (1995) summarized the fish production from 22 rivers round the world as 273 kg per ha in average; the production of YOY was not included. Our estimation for fish > 10 cm is on a level of 400–500 kg for habitats under weirs and only part of this production in lentic habitats. Predators considerably utilize the production of fish flesh; their more intense stocking (pike, pikeperch, asp) could help in estimates of the production potential of managed streams.

CONCLUSIONS

In 1998 to 2004, four sites on the Berounka River near town Radnice, fishing wards B7 and B8 (sites Libštejnský mill, Liblín, Třímany, and Hřešihlavy), and two sites on the Úhlava River, fishing ward U2 (Předenice) were repeatedly fished in two runs with two (Berounka) or one (Úhlava) electroshocker.

Fishery statistics for B7 and B8 (1975–2003) and for all remaining fishing wards with carp as main species in the Mže, Úhlava, and Berounka River from 1975–1999 (2001) were used as additional source of data. Water quality data and flow rates were taken from the database of the Czech Hydrometeorological Institute.

Only fish longer than 50 mm (SL) were measured and weighed, fish > 100 mm marked, and fish > 150 mm tagged. For tagging fish the anchor full plastic tags were used, all tagged fish were additionally marked by fin clipping for a control. The growth of fish in length and weight was calculated by known procedures, for estimation of the abundance we used the Jolly-Seber and Peterson method.

The similarity among ichthyocenoses, sites, and years was evaluated by cluster analysis, the changes in fish assemblages in years and sites, and the relationship among environmental variables and ichthyocenoses by the indirect DCA and by the direct gradient canonical correspondence analysis (RDA, CCA).

The stepwise increase of the concentration of nitrates, ammonia, and chlorides (1962–2003) up to the end of 1980's with its subsequent decrease was generally found; only for the BOD the decrease in all sites and years was observed.

In all wards carp catch significantly increased during 1975–2001 (3) thanks to intensive stocking and its preference by anglers, the yields of carnivorous and forage fish decreased. Of carnivorous fish the stocked pike was dominant; its high yields in 1980, 1995 and 2001 corresponded with the high yields of the forage fish. Well-balanced yields of pike in all the wards indicate good adaptation of pike to different habitats. Among the forage fish the chub dominated (6.8 kg/ha in average), catch of the other forage species ranged from 0.2 up to 2 kg/ha. The stocking rate of carp up to 100 kg ha^{-1} gives of about one half yields, of 200 kg/ha of one quarter, so the 100 kg can be considered as still appropriate.

The cluster analysis of fishing seasons in B7 showed an outstanding cluster for years 2000 to 2003, further three clusters were differentiated at a linkage distance of 150 and 75 units. The catches in the 1st cluster ranged between 83 and 120 kg/ha, in the 2nd between 30 and 37, in the 3rd between 60 and 73, and in the 4th between 47 and 64 kg. The number of fish, the linkage distances, and the number of species in clusters in the Mže and Berounka River, above all for non-managed species are very similar for both fishery statistics and electroshocker data. The sport fishermen catch the native species in the proportions approaching their relative abundance in the given river section. Knowing the limits of fishery statistics we can use them for studying the dynamics of the fish assemblages.

In the Berounka and Úhlava R. a total of 23 851 fish (26 species) and 2336 fish (21 species) respectively were caught with electricity. In about the same period (1998–2003), sport fisherman caught in B8 and B7 27 394 fish of 18 species plus 2–4 additional species from the category "other fish". In the Úhlava R. anglers caught 18 species and 2–4 species from the category "other fish". Altogether in fishery statistics and in electroshocker catches there were registered 29 species in the Berounka and 25 in the Úhlava River.

The increase of the species number in the longitudinal profile starting with the Úhlava headwaters and ending in the mouth of Berounka into Vltava River (UB curve) was compared with 95% UPL of the standard curve. The index of species saturation calculated for 37 sites achieved a value of 0.79. Species diversity in both rivers is above standard for Czech streams.

The relative fish abundance in the Berounka River ranged between 758 and 4812; five species achieved 90%, ten species 98% of the relative abundance of all fish caught. The biomass ranged between 64 and 430 kg/ha, 5 and 10 species formed 89 and 95% of the biomass caught by electricity. In the Úhlava River relative abundance ranged between 186 and 2648 fish/ha, out of this five species formed 83%, ten species 96. The biomass ranged between 31 and 175 kg/ha, of five and ten species corresponded to 83 and 90% of the caught biomass, respectively.

Two and five clusters of species were differentiated in the whole longitudinal profile of the Úhlava and Berounka River above the linkage distance of 20 and 5 with presence and absence of species as basic data. Using relative abundance of species in the Berounka R.

near Radnice three to four clusters were found, the 1st cluster contains the barbel, chub, gudgeon, dace and roach, in the 2nd bleak, and rest of species in the 3rd cluster, with biomass the 1st cluster contains the chub with barbel, the 2nd cluster the gudgeon with dace and roach, the 3rd the asp, pike, zahrte, pikeperch, carp, eel, brown trout bleak, perch, and the 4th cluster contains the rest of species with the low value of biomass.

Altogether three clusters of sites (criterion abundance) include in the 1st cluster sites with 11–17 species and 177 to 4812 fish/ha, in the 2nd cluster sites with 12–20 species and 950 to 1294 fish/ha, in the 3rd cluster sites with 10–19 species and 308 to 1295 fish. Three clusters (criterion biomass) include in the 1st cluster 12–17 species and 191 to 280 kg/ha, in the 2nd cluster 10–19 species and 23 to 99 kg/ha and in the 3rd cluster 10–17 species and 96 to 177 kg/ha.

The length structure of principal species was used for checking expected agreement between the length structure of species caught at one locality after one (two) days, for the evaluation of the length growth of dominant age groups in periods June – September and September – June, and for a comparison of the length structure, year class strength and its periodicity in barbell, chub, roach, dace, and gudgeon.

In the Berounka River near Radnice altogether of 5133 barbel and chub longer than 15 cm were caught, 4489 tagged, and 872 recaptured. Only four fish with tags from the other locality were caught up to 2002 and 12 after a flood in August 2002 in 2003–04. Of the 25 barbel with transmitters all fish were located either directly under their home weir or at most one km downstream for the whole life of transmitters (0.5 year).

In four localities (Berounka near Radnice) we estimated of 1165 barbel, 1159 chub and 709 roach and dace (total of 3033 fish/ha ≥15 cm), in two localities in the Úhlava R. near Předenice 950–1960 fish and 650 fish/ha. The ratios between the numbers of fish caught with electroshocker and of their absolute abundance for fish longer then 15 cm were 12.6% for barbel, 19% for chub, and 11% for roach and dace. Thus four fish species caught by electroshocker represent in average 15.3% of their absolute abundance (24% at localities in the Úhlava River).

In B7 (45 ha) there are two areas under weir, one ha each with 3 to 3.5 thousand fish, i.e. of 6 to 8 thousands, two rapid stretch, one ha each, with about 2 to 2.5 thousand fish per ha, i.e. of 4 to 6 thousands, and 41 ha of stretch above weirs, with about 700 fish/ha, i.e. of 30 000 fish, altogether about 45000 fish. The abundance of fish preferred by fishermen (carp, tench, pike, pikeperch, eel, bream) we estimate on 4–8 thousands. Altogether in the whole ward it could be 50–60 thousands of fish longer than 15 cm.

The value of production for four species (193 kg/ha/year, locality Třímany) is valid for the sites under weirs. The production of fish between 10 and 15 cm for the same species and gudgeon was assessed on 130 kg. Altogether 323 kg could be produced yearly by five species starting with 10 cm of body length. Sites under weirs are traps for fish and not all production is made here, the real production could be on the level of 100–160 (200) kg/ha/year. In the whole ward (B7) the production of fish caught by fishermen attains in average the value of 24 kg/ha. Reasoning the fishing efficiency is on a level of 20–33%, the production of all these fish should be round 70–120kg per ha and year.

The variability of the species composition studied by direct gradient analysis showed that individual sites explain 23.8% of the variability in assemblages, ($p < 0.084$). The differences in species composition were highly significant for sites fished in spring and autumn ($p < 0.0042$). Using the direct gradient canonical correspondence analysis (RDA) data on concentration of $NH4^+$and Cl^- and fishery statistics were evaluated. First ordination axe represents the most important gradient correlated with the NH_4^+ and Cl^- concentration. Both factors covered as much as 29.9% of the variability in fish yields ($p < 0.0001$). Considering the fact that the carp yields could strongly influence the yields of other fish species (anglers preference), we take carp as next environmental factor. The model was significant as a whole ($p = 0.0052$), the effect of the carp itself was, however, not significant.

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Tab. 2/III. Relative abundance (A/ha) of fish ≥ 5 cm caught by electroshocker in the Berounka River, locality Třímany, S number of species

A/ha/Date	19. 6. 98	22. 6. 99	7. 9. 99	9. 9. 99	26. 6. 00	14. 9. 00	25. 6. 01	14. 9. 01	3. 7. 02	14. 5. 03	8. 7. 03	18. 9. 03	1. 7. 04	Ave/ha
Roach	154	69	184	239	163	306	178	137	209	5	50	545	110	181
Barbel	128	114	146	198	315	207	118	83	90	136	155	1967	556	324
Chub	234	300	316	531	444	675	453	403	503	138	215	841	195	404
Dace	131	69	262	232	289	443	46	83	104	55	140	570	468	222
Gudgeon	175	205	296	517	493	1245	184	237	161	282	168	622	442	387
Perch	14	15	14	19	26	32	12	10	13	24	108	1	24	
B. trout	19	5	4	4	3	15	9	8	19	1	9	9		
Pike	1	3	4	4	5	5	1				6	1		3
Eel	1	3	5		1	4	3	3	4	6	3	6	3	3
Bleak	18	17	42	29	17	84	72	108	113	10	10	46	256	63
Tench	1					6	1	1		1			2	
Asp		1	1		3	5					31	77	1	17
S. loach	5		9	13	3	13	4	1	1	6		5	14	7
Carp			1								1			1
Ruffe			3								5	12		6
Zahrte			3	5		3		19	18		1	3		7
Wels			3			3		3			1	3	6	3
Bream			1			3		1				1		2
S.bream						13				1	1			5
C. carp						1					3	3	3	2
Giebel										1				1
Burbot														
Pikep.												3		3
G. carp														
Rudd											1			1
5 spec.	822	756	1204	1718	1704	2876	979	943	1066	616	727	4545	1770	1517
10 spec.	856	813	1275	1774	1756	3004	1082	1073	1203	652	772	4707	2039	1616
Total A/ha	861	815	1295	1792	1761	3044	1092	1098	1224	660	818	4812	2063	1641
Total B/ha	96.3	67.0	63.5	110.9	191.2	121.4	77.7	64.0	79.2	105.1	77.4	140.5	81.1	98
S	10	12	17	11	12	17	12	10	10	14	12	11	19	17

Tab. 2/III. continues, localities: Liblín (L), Libštejnský mill (LM), and Hřešihlavy (H)

A/ha	L 27. 6. 00	L 15. 9. 00	L 26. 6. 01	L 4. 7. 02	L 16. 9. 03	LM 7. 6. 02	LM 13. 5. 03	LM 7. 7. 03	LM 15. 9. 03	H 22. 5. 03	H 9. 7. 03
Roach	202	191	536	397	216	142	22	89	589	9	220
Barbel	209	207	227	86	513	233	277	190	825	220	205
Chub	397	200	760	788	166	459	235	168	411	199	272
Dace	109	141	202	138	413	21	16	128	1114	4	21
Gudgeon	111	154	536	89	257	6	54	168	625	131	79
Perch	18	7	61	18	34	5		21	132	3	22
B. trout	11		2		2	2	1			41	17
Pike	5		5	2		4	6	10	7		15
Eel	0	2	7			1	1		1	4	4
Bleak	70	66	145	141	20	20	127	29	290	66	230
Tench			5			1				5	
Asp					43	2	10	6	24	1	3
S. loach	14	9	61	7	16	1	12	13	2	16	9
Carp			16	2			2			5	
Ruffe							2	1	1	1	5
Zahrte	2	2	16	2	20	4	4		1	20	17
Wels	2	2	2				0		6		
Bream				2		4	1		5		
S. bream		18	2			18	10			32	
C. carp				2	1	0	1		4		
Giebel						24	0		4		
Burbot						1	0				
Pikep.						1	2		9		
G. carp							1				
Rudd											
5 sp.	1028	892	2261	1498	1564	860	604	744	3564	564	797
10 sp.	1133	967	2481	1659	1621	892	739	804	3994	677	1085
Total A/ha	1151	999	2583	1675	1700	950	784	826	4047	758	1123
Total B/ha	119.0	111.6	168.1	98.9	79.4	429.6	248.9	91.4	177.3	279.8	177.3
S	12	12	16	13	11	20	20	12	17	16	15

Tab. 3/III. Relative abundance (A/ha) of fish ≥5 cm caught by electroshocker in the Úhlava River. Repeatedly fished sites – Předenice Bridge (PB), Předenice Under Weir (PW) and sites fished once Předenice Shoot (PS), Tajanov (T), and Poborovice (Pb)

	PB 16. 10. 97	**PB 23. 6. 99**	**PB 20. 6. 00**	**PB 20. 6. 01**	**PB 11. 9. 01**	**PW 16. 10. 97**	**PW 23. 6. 99**	**PW 20. 6. 00**	**PW 20. 6. 01**	**PS 11. 9. 01**	**T 19. 6. 01**	**Pb 19. 6. 01**
B. lamprey												2
Barbel	9	21	31	19	17	1	7	3	4	1		
Chub	13	24	65	24	11	24	35	40	51	44		2
Dace	30	79	254	42	24	12	41	29	26	83	1	10
Roach	1	27	151	45	12	6	158	138	150	36	15	6
Bleak			4		2			3		4		
Gudgeon	17	25	119	19	8	6	4	30	20	14	9	2
Perch		1	6	1			7	17	34		28	13
Tench			1					3	17		1	
Pike		1	2	1			1	1	2	1	3	
B. trout		5	3	1							2	6
S. loach	1	2	9		2		1	1	6	1		
Eel	1	4	4	6	1		6	2	3		5	6
Burbot		1	1	1		4	11	9				
Grayling	20	10	4	8	1	2	2	4	1		10	68
Carp	2		7	1				1	3		4	2
Asp			1		1							
Bream								1				
S. bream							3			1		
Zahrte										4		
Ruffe						1		2	10		2	
C. carp									1			
Pikep.											1	
Total	**94**	**200**	**662**	**168**	**79**	**56**	**276**	**283**	**329**	**189**	**81**	**117**
S		12	16	12	10		12	15	15	10	12	10
Total N/ha	376	800	2648	672	316	186	919	942	1096	567	324	468
Total B/ha	54	64	175	83	46	31	81	53	74	47	42	50
Fish ≥ 15 cm		167	272	73			103	123	88	90		

Tab. 1/V. (a-i) Population estimates performed by Jolly-Seber method for selected seasons, sites, and species in the Berounka River near Radnice

a) Třímany, Barbel autumn 1999 – spring 2002, fish ≥ 15 cm

Sample	Proportion marked	Nt/**Nha**	Probability of S	Number joining	SE of Nt	Season
1			1.110			
2	0.089	1059/**1356**	0.914	158	282	Aut. 99
3	0.216	1112/**1423**	0.415	88	245	Aut. 00
4	0.329	540/**691**	0.886	46	166	Spr. 01
5	0.375	521/**667**	0.944	585	232	Aut. 01
6	0.193	1058/**1354**			620	Spr. 02
7	0.215					

No. Caught 88 201 267 69 63 56 106
No. Released 85 186 244 65 44 53 92

b) Třímany, Barbel 2003, after flood in August 2002

1			0.486			14. 5. 03
2	0.265	168/**215**			89	8. 7. 03
3	0.101					18. 9. 03

No. Caught 92 48 98
No. Released 92 48 94

c) Liblín, Barbel, 2000–02

1			0.820			15. 9. 00
2	0.164	714/ **1621**			447	26. 6. 01
3	0.361					4. 7. 02

No. Caught 153 66 35
No. Released 143 66 5

d) Libštejnský mill, Barbel 2003

1						13. 5. 03
2	0.144	998/ **1218**	0.424		723	7. 7. 03
3	0.111					15. 9. 03

No. Caught 234 103 80
No. Released 234 103 80

e) Třímany, Chub, 1999–2002

Sample	Proportion marked	Nt/**Nha**	Probability of S	Number joining	SE of Nt	Season
1			0.638			
2	0.159	462/**591**	1.477	192	68	Spr. 99
3	0.364	822/**1052**	1.129	85	126	Aut. 99
4	0.448	1009/**1292**	0.387	158	236	Spr. 00
5	0.360	536/**686**	0.699	186	111	Aut. 00
6	0.326	556/**712**			132	Spr. 01
7	0.303					Spr. 02

No. Caught	177	194	164	142	113	128	158
No. Released	115	159	160	110	106	112	145

f) Třímany, Chub 2003

1			0.899			14. 5. 03
2	0.165	457/**585**	1.526	948	140	8. 7. 03
3	0.159	1645/**2106**			901	18. 9. 03
4	0.250					1. 7. 04

No. Caught	84	114	175	55
No. Released	84	114	175	49

g) Liblín, Chub 2000–02

1			1.771			15. 9. 00
2	0.142	1212/**2751**			397	26. 6. 01
3	0.423					4. 7. 02
4						

No. Caught	101	126	110
No. Released	97	124	5

h) Libštejnský mill, Chub 2003

1			1.264		0.518	13. 5. 03
2	0.112	1987/**4510**		949		7. 7. 03
3	0.120					15. 9. 03

No. Caught	190	133	191
No. Released	176	133	171

i) Třímany, Roach and Dace 1999–2002

Sample	Proportion marked	Nt/**Nha**	Probability of S	Number joining	SE of Nt	Season
1			0.430			22 .6. 99
2	0.041	552/**707**	1.176	63	371	9. 9. 99
3	0.173	697/**892**	0.435	113	423	14. 9. 00
4	0.185	413/**529**			474	14. 9. 01
5	0.128					3. 7. 02

No. Caught	56	96	74	53	39
No. Released	53	83	67	44	10

Date		9. 9. 99	14. 9. 00	14. 9. 01
Roach/Dace	**(N/ha)**	**442/265**	**325/567**	**299/230**

Tab. 3/V. Petersen estimates for fish ≥ 15 cm (Hřešihlavy) and fish 10–15 cm (Třímany)

Hřešihlavy

22. 5. 03		9. 7. 03				
	M	C	R	R100/100	N(CL)	**N/ha**
Barbel	149	79	15		749 (517–1303)	**989**
Chub	138	185	51		496 (719–622)	**655**

Třímany**,** 7. 9. and 9. 9. 1999 S = 1,

	M	C	R	R100/100	N (CL)	**N/ha**
Barbel	11	30	0	0	(332*)	**425**
Chub	150	272	13	3.19	2944 (1842–5362)	**3768**
Dace	40	59	7	29.7	307 (183–724)	**393**
Roach	83	131	3	2.76	2271 (1217–6098)	**2907**
Gudgeon	87	404	7	2.09	4454 (1206–3511)	**5701**
Total						**13 194**

* abundance of barbel = 5854-N (chub+dace+roach)

Třímany (7. 9. + 9. 9. 1999) and 26. 6. 2000

7. 9. and 9. 9. 1999				26. 6. 2000				
	M	S	MS	C	R	R100/100	N (CL)	**N/ha**
Barbel	28	0.8	22	38	3	8.11	223 (98–492)	**285**
Chub	374	0.7	262	165	14	2.27	2910 (1822–4796)	**3725**
Dace	77	0.3	23	86	5	7.55	347 (171–702)	**444**
Roach	211	0.4	84	94	2	1.01	2690 (1050–5958)	**3443**
Total			391	383	24		6020 (4220–9454)	**7706**
26. 6. 00				14. 9. 00				
Chub	139	0.8	111	240	14	4.2	2248 (1408–3706)	**2877**
26. 6. 00				25. 6. 01				
	139	0.8	111	137	7	3.68	1551 (840–2898)	**1985**

Tab. 4/V. Population estimates performed by Jolly-Seber method, for selected seasons, sites, and species in the Úhlava River near Předenice,

a) locality Bridge, barbel, chub, dace and roach (22,37,28 and 13%), fish ≥ 15 cm

Sample	Proportion marked	Nt/**Nha**	Probability of S	Number joining	SE of Nt	Date
1			0.903			23. 6. 99
2	0.066	464/**1856**	0.521	–9	215	20. 6. 00
3	0.303	226/**904**			85	20. 6. 01
4	0.224					11. 9. 01

No. Caught	34	120	65	41
No. Released	34	108	61	10

2. barbel 408, chub 687, dace 520, roach 241 fish/ha, in total 1856 fish/ha
3. barbel 199, chub 334, dace 253, roach 118 fish/ha, in total 904 fish/ha

b) locality Under weir, barbel, chub and roach (8%, 46 and 46%)

1			0.503			23. 6. 99
2	0.159	205/**615**			189	20. 6. 00
3	0.068					20. 6. 01

No. Caught	79	43	73
No. Released	65	39	71

barbel 49 fish/ha, chub 283 fish/ha, roach 283 fish/ha, in total 615 fish/ha

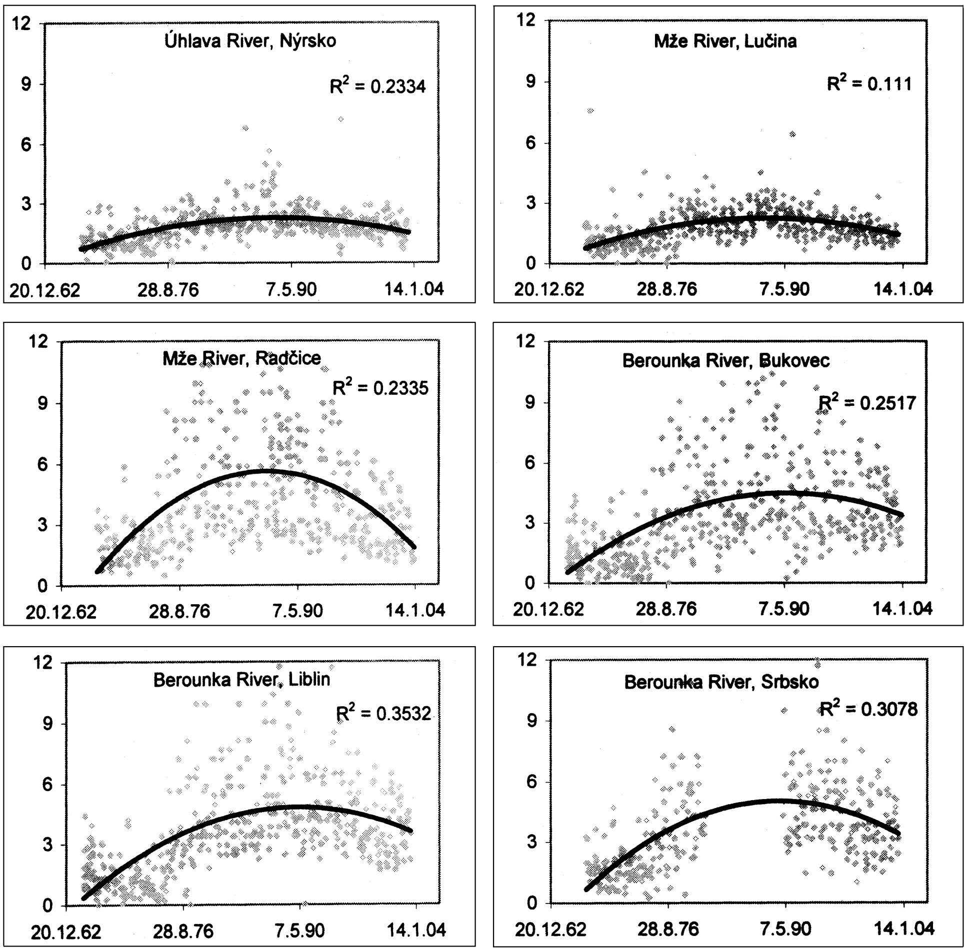


Fig. 1/I. Values of N NO_3^- (mg/l) in selected sites, Berounka, Úhlava, and Mže River, monthly measure ments

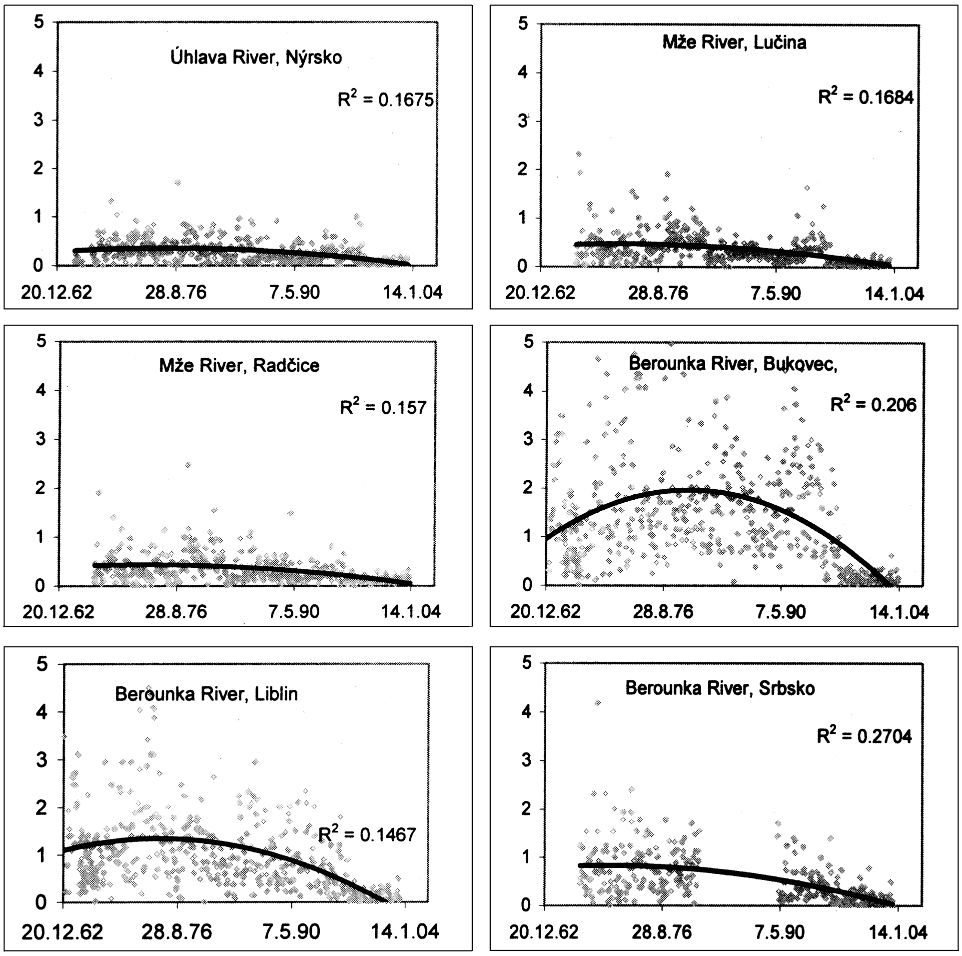


Fig. 2/I. Values of N NH_4^- (mg/l)

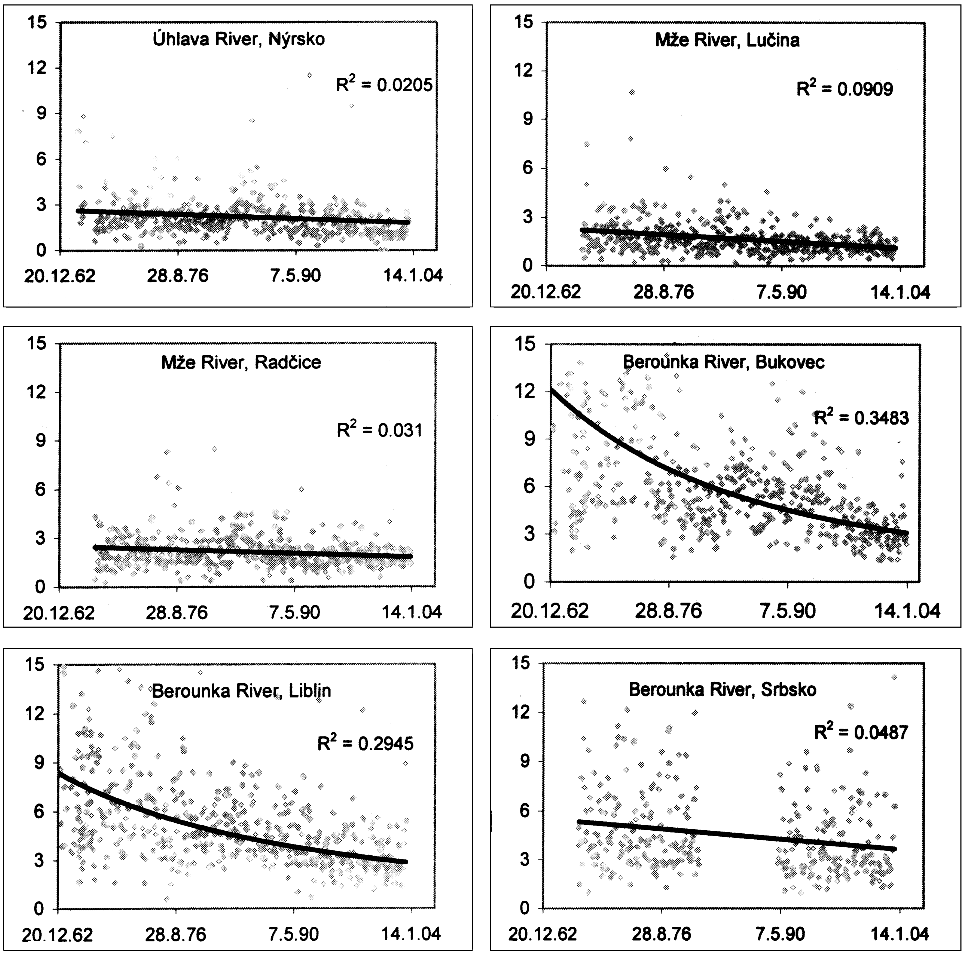


Fig. 3/I. Values of BOD (mg/l)

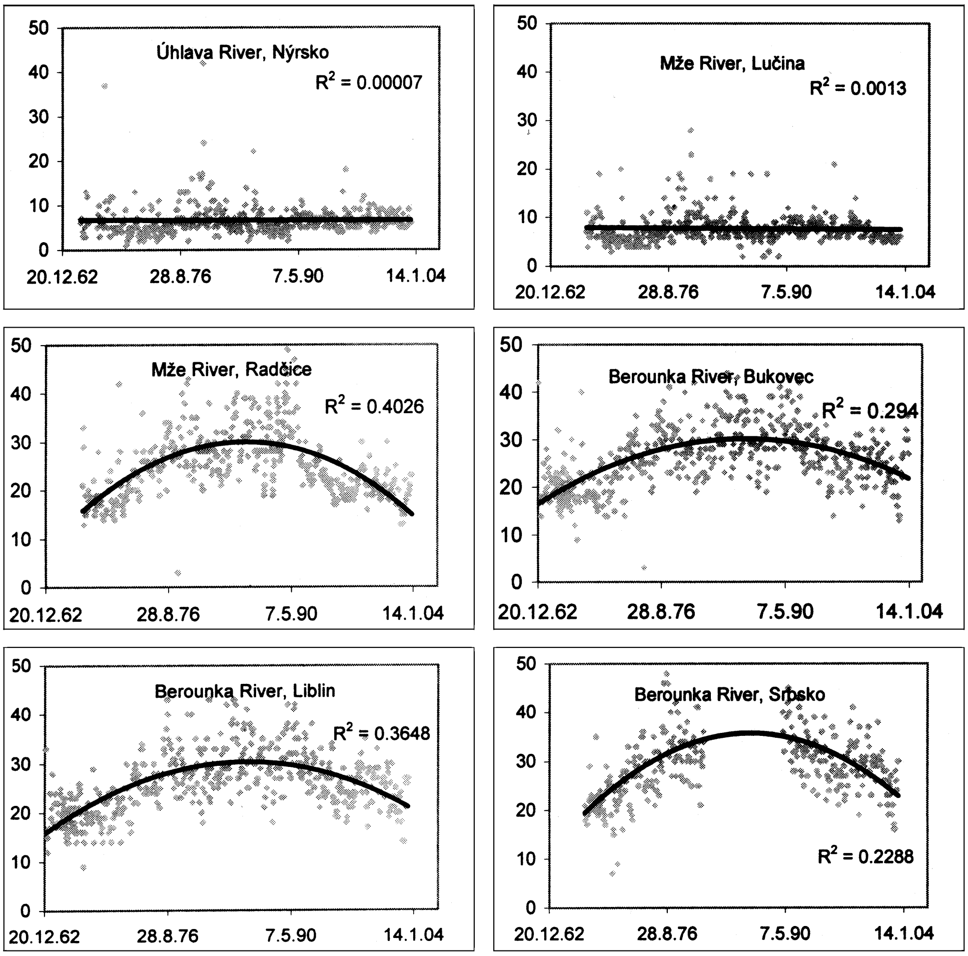


Fig. 4/I. Values of Cl^- (mg/l)

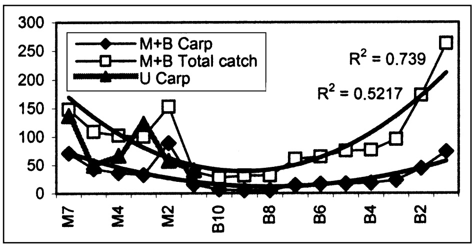


Fig. 1/II. Number of fish/ha caught in the Mže (M), Berounka (B) and Úhlava (U), average for 1975–1999

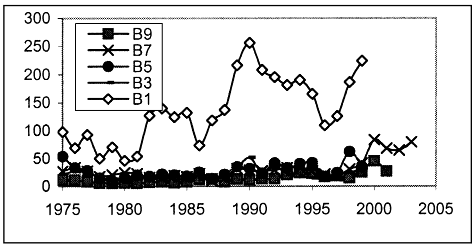


Fig. 2a/II. Yield of carp in kg/ha in wards of the Berounka R.

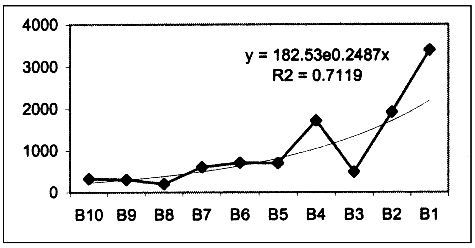


Fig. 2b/II. Total yield of carp in kg/ha in wards B10–B1 during 25 years

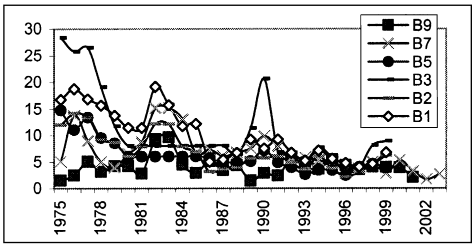


Fig. 3a/II. Yield of chub in kg/ha in wards of the Berounka R.

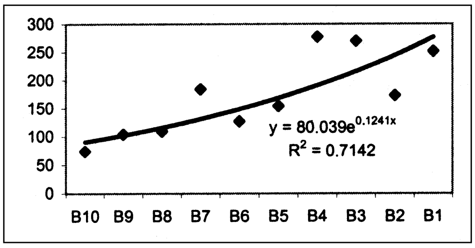


Fig. 3b/II. Total yield of chub in kg/ha in wards B10–B1 during 25 years

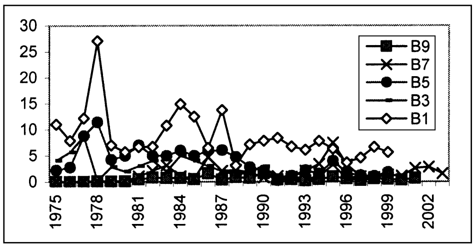


Fig. 4a/II. Yield of barbel in kg/ha in wards of the Berounka R.

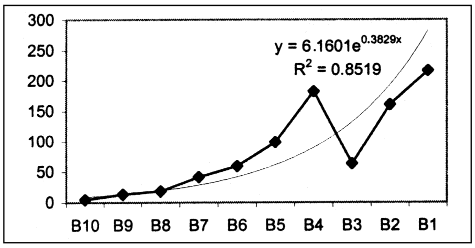
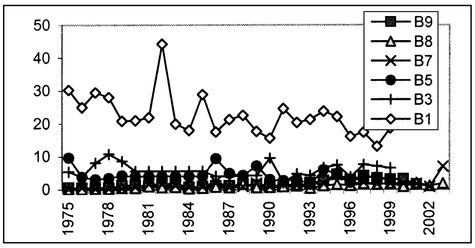


Fig. 4b/II. Total yield of barbel in kg/ha in wards B10–B1 during 25 years



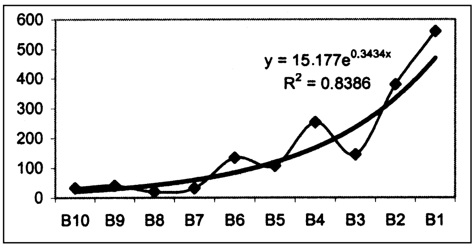
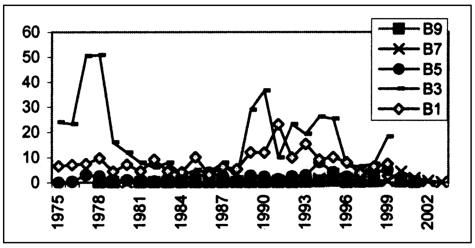


Fig. 5a/II. Yield of bream in kg/ha in wards of the Berounka R.

Fig. 5b/II. Total yield of bream in kg/ha in wards B10–B1 during 25 years



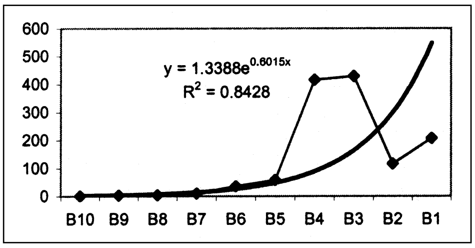
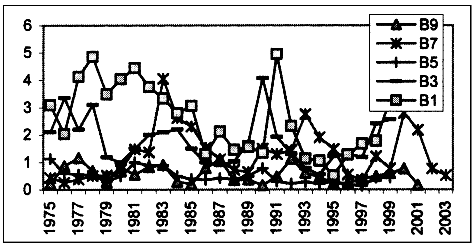


Fig. 6a/II. Yield of zahrte in kg/ha in wards of the Berounka R.

Fig. 6b/II. Total yield of zahrte in kg/ha in wards B10–B1 during 25 years



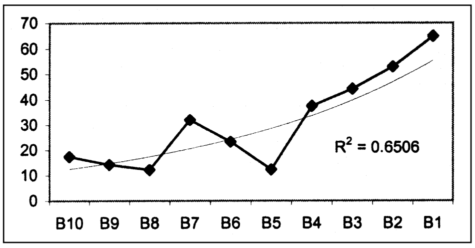


Fig. 7a/II. Yield of perch in kg/ha in wards of the Berounka R.

Fig. 7b/II. Total yield of perch in kg/ha in wards B10–B1 during 25 years

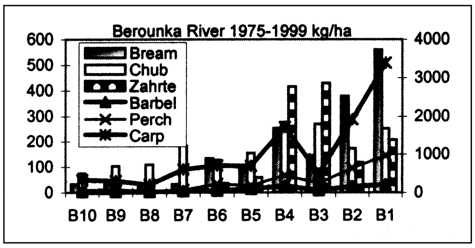


Fig. 8/II. Total yield of important species in kg/ha, all wards during 25 years, values for columns on the left axis

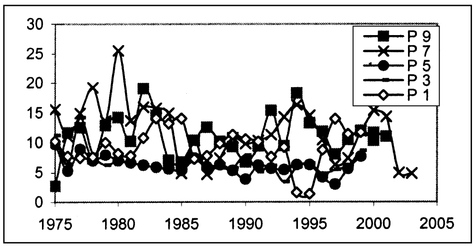


Fig. 9a/II. Yield of pike in kg/ha in wards of the Berounka R.

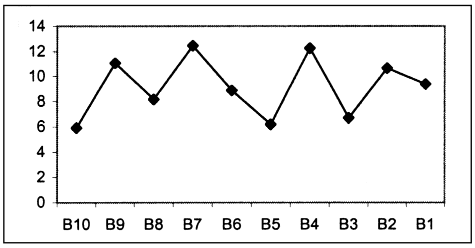


Fig. 9b/II. Average yield of pike in kg/ha in wards B10–B1 during 25 years

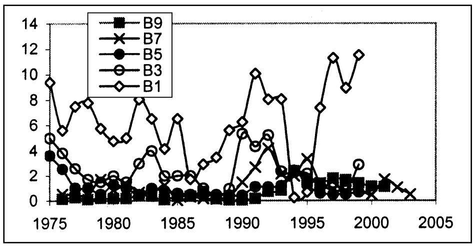


Fig. 10a/II. Yield of pikeperch in kg/ha in wards of the Berounka R.

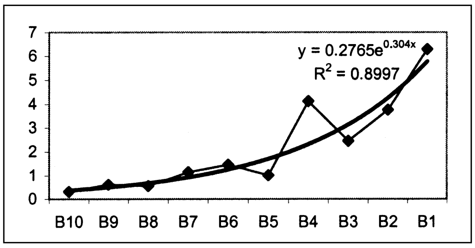


Fig. 10b/II. Average yield of pikeperch in kg/ha in wards B10–B1 during 25 years

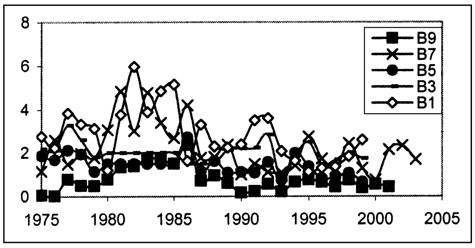


Fig. 11a/II. Yield of eel in kg/ha in wards of the Berounka R.

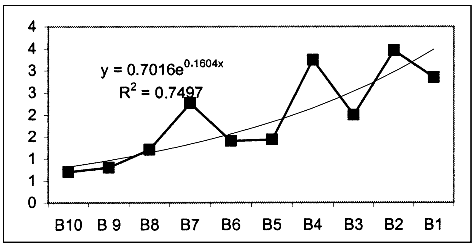


Fig. 11b/II. Average yield of eel in kg/ha in wards B10–B1 during 25 years

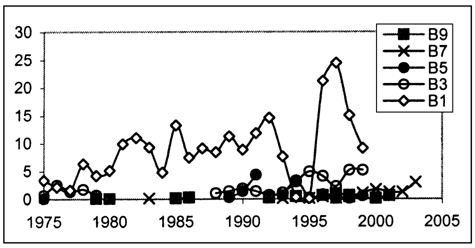


Fig. 12a/II. Yield of wels in kg/ha in wards of the Berounka R.

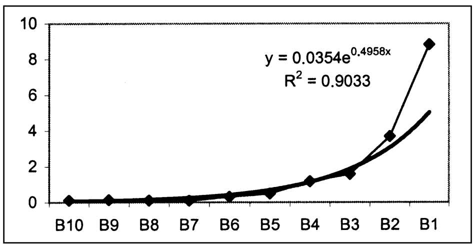


Fig. 12b/II. Average yield of wels in kg/ha in wards B10–B1 during 25 years

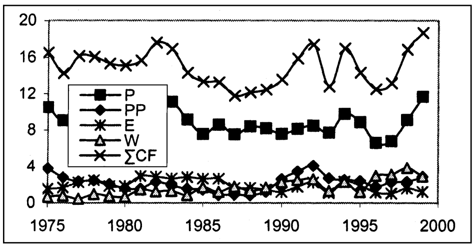


Fig. 13/II. Average yield of all carnivorous fish pike P, pikeperch PP, eel E, wels W and all carnivorous fish CF, wards B10–B1

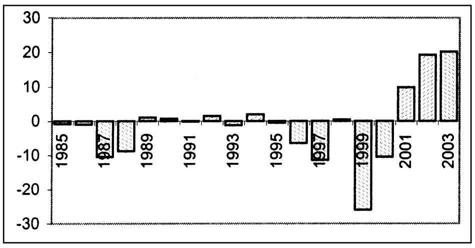


Fig. 14/II. Average difference between caught and stocked carps in B7 and B8, fish/ha

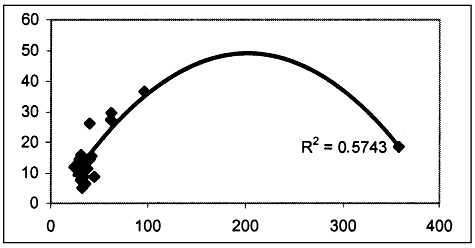


Fig. 15/II. Dynamics of stocked and caught carps in B7, kg/ha

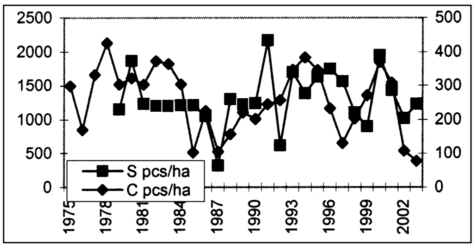


Fig. 16/II. Dynamics of stocked and caught (right axis) pike in B7

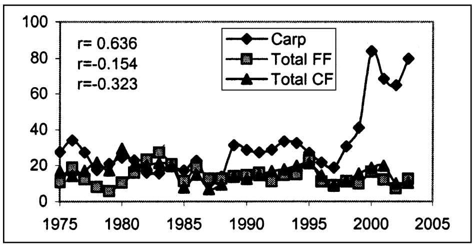


Fig. 17/II. Yield of carp, total forage, and total carnivorous fish in kg/ha, B7

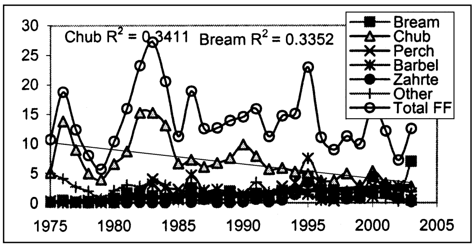


Fig. 18/II. Yield of forage fish in kg/ha, B7

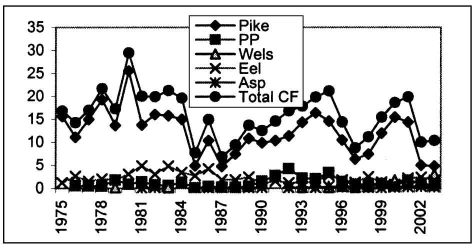


Fig. 19/II. Yield of carnivorous fish in kg/ha, B7

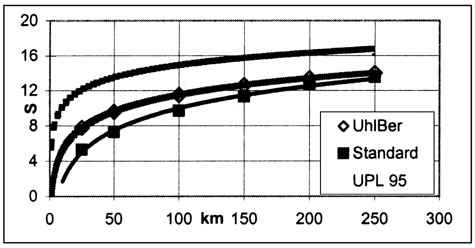


Fig. 1/III. Relationship between number of species (S) and distance from the source in km, Úhlava and Berounka R. Upper curve represents 95% predictive limit for standard

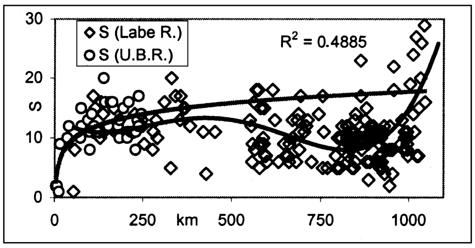


Fig. 2/III. Number of species in the Labe R. and Úhlava and Berounka R. the curve for UBR extrapolated behing 250 km

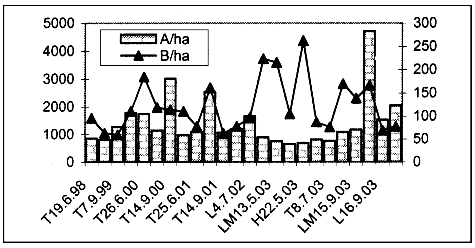


Fig. 3/III. Abundance and biomass of fish cauht by electroshocker, Berouka R. Třímany, Liblín, Libštejnský mlýn, and Hřešihlavy (10 species)

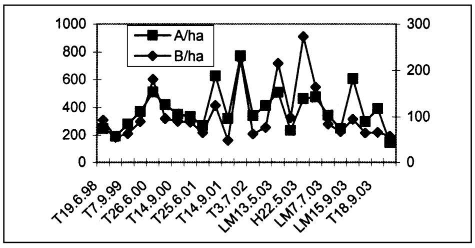


Fig. 4/III. The same as in Fig. 3/III, fish longer than 15 cm

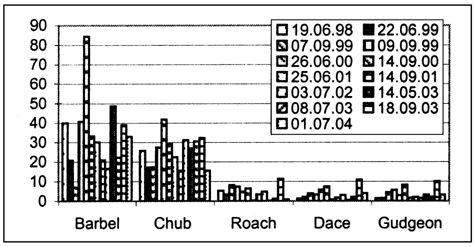


Fig. 5/III. Biomass of five species caught by electroshocker in the Berounka R. Třímany, kg/ha

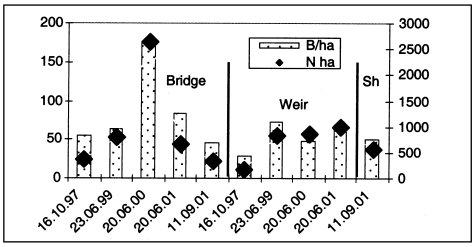


Fig. 6/III. Abundance and biomass of all fish cauht by electroshocker in the Úhlava R. Předenice

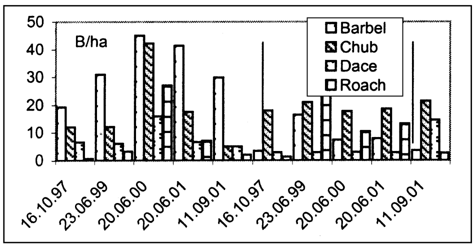


Fig. 7/III. The same as in Fig. 6/III, biomass per ha of 4 species

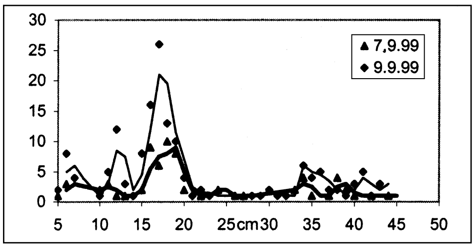


Fig. 1/IV. Length groups of barbel caught on September 7. and 9. 1999 in the Třímany, Berounka R.

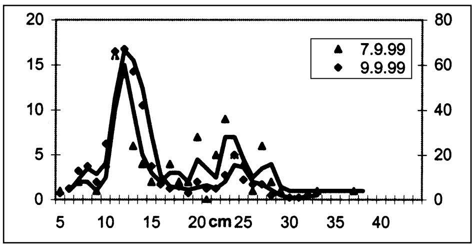


Fig. 2/IV. The same as in Fig. 1/IV, for chub

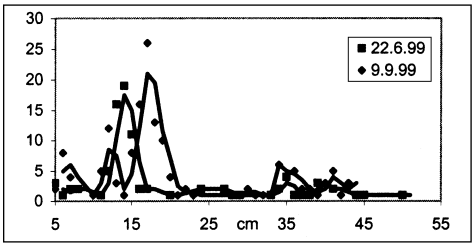


Fig. 3/IV. The length growth of barbel between July and September of 1999, Třímany

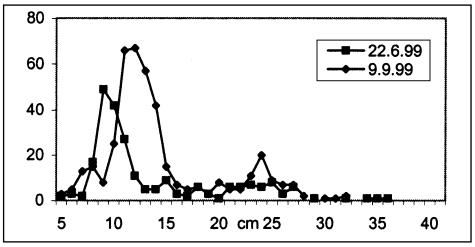


Fig. 4/IV. The same as in Fig. 3/IV, for chub

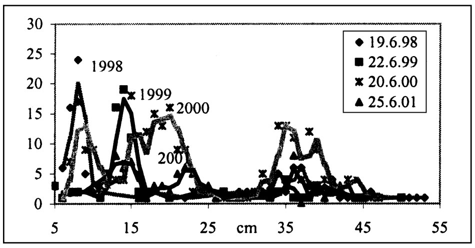


Fig. 5/IV. Changes in the relative abundance of length groups of barbel, Třímany 1998–2000

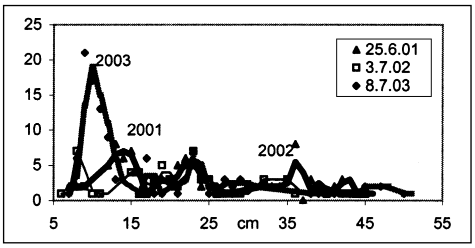


Fig. 6/IV. The same as in Fig. 5/IV for 2001–2003

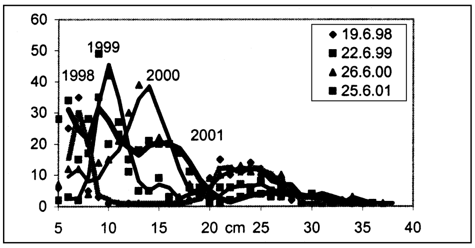


Fig. 7/IV. Changes in the relative abundance of length groups of chub, Třímany 1998–2000

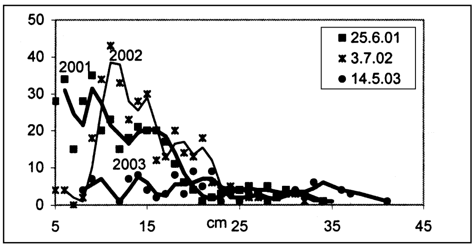


Fig. 8/IV. The same as in Fig. 7/IV for 2001–2003

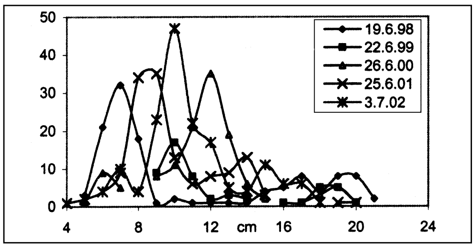


Fig. 9/IV. Changes in relative abundance of length groups of roach, Třímany 1998–2002

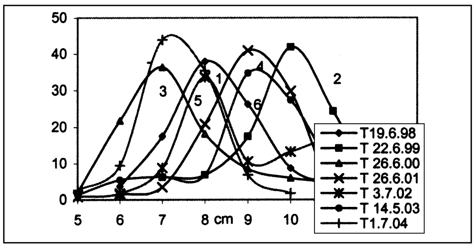


Fig. 10/IV. Changes in relative abundance of length groups of gudgeon, Třímany 1998–2002. Numbers 1–7 represent years