Fish and macrozoobenthos in the Vlára stream drainage area (Bílé Karpaty Mountains)

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ABSTRACT: Fish fauna and macrozoobenthos were surveyed at 51 and 32 sampling sites, respectively, in mountain and submountain streams of the Vlára stream drainage area in the Bílé Karpaty Mountains. The aim of the study was to bring wide knowledge of their aquatic communities with their indicative value of the ecological quality of particular sites. Fish were sampled by electrofishing and macrozoobenthos was collected by kick-sampling using a bottom net (mesh size 500 µm) at the majority of the respective sites. In total, 15 fish species were registered in all profiles. At four headwater sites no fish were recorded at all. Brown trout (*Salmo trutta* m. *fario*) and stone loach (*Barbatula barbatula*) were the most frequent species at the sites under study (73% and 67%, respectively). A similar frequency (41%) was documented for chub (*Leuciscus cephalus*), gudgeon (*Gobio gobio*) and minnow (*Phoxinus phoxinus*). The species richness increased downstream in the mainstream of the Vlára stream with the maximum of 10 species found at the lowest study site. Qualitative data on fish assemblages did not fully correspond with the environmental stress. On the other hand, macrozoobenthos indicated a minor decrease in water quality downstream of small villages and farms. Larvae of dipterans (Chironomidae and Simuliidae in particular) and mayflies (Ephemeroptera) dominated among the temporary water macroinvertebrates while numerous populations of *Gammarus fossarum* (Amphipoda) and in some cases also of *Asellus aquaticus* (Isopoda) were recorded as permanent inhabitants of clean and polluted stretches, respectively.

Keywords: fish community; macroinvertebrates; bioindicators; Bílé Karpaty Mountains; Czech Republic

According to the EU Water Framework Directive, Member States are obliged to protect, improve and restore all surface waters with the aim of achieving a good ecological status by 2015 (Pont et al., 2006). Fish and macrozoobenthos are two of the four biological indicators that have been used for the ecological status assessment (Simon, 1999). Many ichthyological and/or hydrobiological surveys were done in rivers and river stretches in the Czech Republic (Lojkásek et al., 2004; Namin and Spurný, 2004), but not many of them cover larger drainage areas (Hohausová et al., 1996; Lojkásek et al., 2000; Švátora et al., 2002; Lusk et al., 2004); nevertheless, many others remain without such limnological survey.

Our knowledge of fish in the waters of Bílé Karpaty Mountains is limited and studies were usually conducted a long time ago (e.g. Libosvárský and Wohlgemuth, 1973). The Vlára stream is one of the most studied waters of the Bílé Karpaty Mountains and a few studies were published about its fish communities. Libosvárský et al. (1967) studied fish in the Vlára stream tributaries in relation to pollution more than 30 years ago. Lelek and Peňáz (1963)

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described the nase (*Chondrostoma nasus*) spawning process in the Brumovka brook, but none of these studies had the aim to monitor the fish occurrence in the whole drainage area of Vlára stream. From the Slovak part of the Vlára stream, there are some reports on the occurrence of fish mainly in the lowest part of the river, above the confluence with the Váh River (e.g. Kux and Weisz, 1964; Blahák, 1981).

A list of fish in the Bílé Karpaty Mountains was summarised by Lusk (1992). In 1999 a pilot survey of the Vlára stream main channel was conducted (Jurajda et al., 2000). Data from the lower part of the Vlára stream were published by Lusk et al. (2002). These papers show that the fish assemblage of the Vlára stream is rich with high abundance of protected species (Jurajda et al., 2000; Lusk et al., 2002).

Macroinvertebrates were surveyed only sporadically in the Vlára drainage area. The majority of available data is summarised in a monograph on the Bílé Karpaty Landscape Protected Area (Kuča et al., 1992). Adámek and Obrdlík (1981) summarized the results of complex evaluation of the Vlára stream and Sviborka brook, which also includes macrozoobenthos and fish assemblages.

The aim of this study was to describe fish communities and macrozoobenthos in the whole drainage area of the Vlára stream and to use this assessment of aquatic organisms as a potential indicator for evaluation of the ecological status.

MATERIAL AND METHODS

Study area

The study area is situated in the eastern part of the Czech Republic in the Bílé Karpaty Mountains. The Vlára stream, together with its tributaries, drains the Czech-Slovak border part of the Bílé Karpaty Mountains into the Váh River (Danube River basin).

The Vlára stream has a spring at the altitude of 650 m above sea level, south-east of Pozděchov village and its confluence with right side of the Váh River is near Nemšová village at the altitude of 219 m above see level. The total drainage area is 371.6 km^2, the total length 47.6 km and mean discharge at the confluence amounts to 3.6 m^3/s (Vlček et al., 1984). Main tributaries are the Říka stream (drainage area 38.9 km^2, length 13.8 km and mean discharge at the confluence 0.40 m^3/s) and the Brumovka stream (drainage area 86.5 km^2, length 18.7 km) (Figure 1).

A major part of the drainage area of the Vlára stream is included in the Bílé Karpaty Protected Landscape Area (PLA) of the Czech Republic (323 km^2). The stream length in the Czech territory is 30.7 km and average annual discharge is 3.20 m^3/s.

In 1999, a pilot ichthyological survey was conducted at 11 selected sites of the Vlára stream main

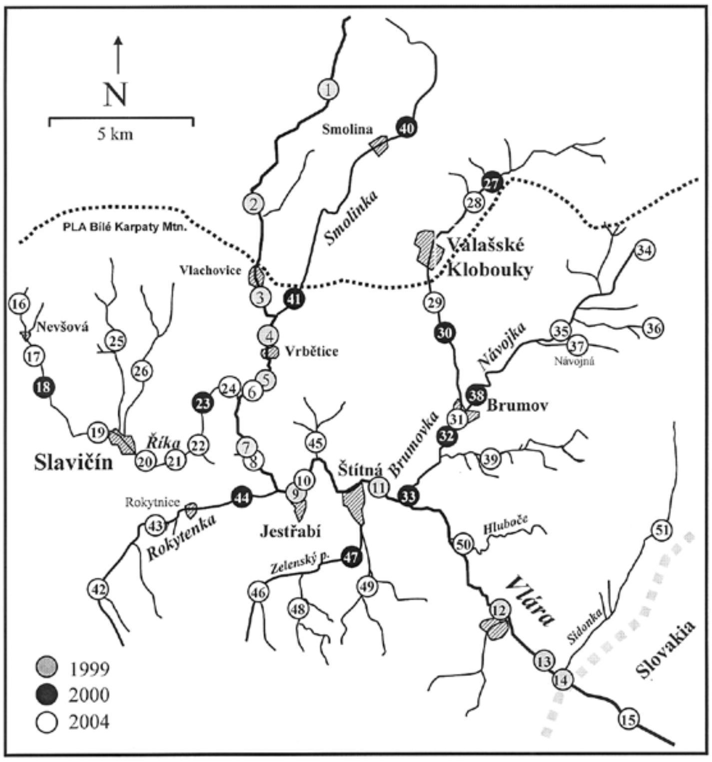

Figure 1. Map of the Vlára drainage area with the study sites indicated. The dotted line represents the borders of the Bílé Karpaty PLA

Table 1. A list of study sites in the Vlára drainage area with the habitat character indicated (sites with macrobenthos analyses underlined)

No.	Date	Watercourse	Site	Width	Depth	Dominant substrate
1	16.11.1999	Vlára	Drnovice	1.5	0.3	stones
2	16.11.1999	Vlára	Podpolí	3.5	0.5	stones, gravel, clay
3	16.11.1999	Vlára	Vlachovice below weir	5.2	0.8	stones, gravel
4	16.11.1999	Vlára	Vrbětice	6.3	0.5	gravel
5	16.11.1999	Vlára	U Polomíka below weir	4.6	0.8	gravel
6	16.8.2004	Vlára	upstream Říka confluence	4.5	0.8	gravel, stones, sediment
7	16.11.1999	Vlára	Bohuslavice	6.1	0.8	gravel, clay
8	14.7.2004	Vlára	Bohuslavice-Jestřebí	5.0	1.0	gravel, stones, clay
9	16.11.1999	Vlára	Jestřabí	6.9	1.0	gravel, stones, clay
10	14.7.2004	Vlára	Jestřebí-Popov	7.0	1.0	gravel, stones, clay
11	16.11.1999	Vlára	Trávníky	6.2	1.0	stones, gravel
12	16.11.1999	Vlára	Sv. Štěpán	12.2	0.6	gravel, pebbles, stones
13	16.11.1999	Vlára	customs inspection office	14.2	0.5	gravel, pebbles, stones
14	16.11.1999	Vlára	border	10.0	0.8	gravel, pebbles, stones
15	30.7.2004	Vlára	Srní	8.0	0.5	gravel, pebbles, stones
16	13.7.2004	Říka	upstream Nevšová	1.0	0.3	stones
17	13.7.2004	Říka	downstream Nevšová	1.3	0.3	stones
18	7.8.2000	Říka	Nevšová-Slavičín	2.2	0.3	stones, sediment
19	16.8.2004	Říka	Slavičín	3.0	0.4	stones, sediment
20	13.7.2004	Říka	Hrádek	3.0	0.4	stones, gravel, sediment
21	13.7.2004	Říka	upstream WTP	3.0	0.4	stones, gravel, sediment
22	16.8.2004	Říka	Divnice	3.0	0.5	stones, gravel, sediment
23	7.8.2000	Říka	near training college	3.5	0.8	gravel, stones, sediment
24	16.8.2004	Říka	upstream confluence	4.0	1.0	stones, organic sediment
25	13.7.2004	Lukšinka	summer camp	1.8	0.5	gravel, stones
26	13.7.2004	Lipovský p.	upstream Slavičín	1.0	0.4	gravel, stones
27	7.8.2000	Kloboučka	upstream Poteč	3.2	0.5	stones, sediment
28	16.8.2004	Kloboučka	in Poteč village	3.0	0.5	stones, sediment
29	16.8.2004	Kloboučka	downstream WTP	4.5	0.5	stones, sediment
30	7.8.2000	Kloboučka	downstream Valašské Klobouky	4.0	0.5	stones, sediment
31	14.7.2004	Kloboučka	downstream Návojka confluence	6.0	0.5	gravel, stones
32	7.8.2000	Brumovka	downstream Brumov	6.0	0.5	gravel, stones
33	7.8.2000	Brumovka	upstream confluence	7.0	0.5	gravel, stones
34	14.7.2004	Návojka	headwater stretch	0.5	0.2	stones
35	14.7.2004	Návojka	Nedašov-Návojna	4.3	0.4	stones
36	14.7.2004	Nedašovský p.	Na Salaši	1.5	0.3	stones
37	14.7.2004	Návojná	upstream Návojná	1.1	0.3	stones
38	7.8.2000	Návojka	upstream Brumov	4.5	0.4	stones
39	14.7.2004	Bylnička	upstream agriculture farm	1.0	0.3	stones
40	7.8.2000	Smolinka	upstream Smolina	3.0	1.0	gravel, stones
41	7.8.2000	Smolinka	upstream confluence	3.5	0.8	gravel, stones
42	13.7.2004	Rokytenka	in Šanov village	3.0	0.7	gravel, stones
43	13.7.2004	Rokytenka	upstream Rokytnice	3.5	0.8	gravel, stones

Table 1. to be continued

No.	Date	Watercourse	Site	Width	Depth	Dominant substrate
44	7.8.2000	Rokytenka	downstream Rokytnice	2.0	0.5	sand, stones
45	14.7.2004	Havránkův p.	upstream confluence	1.7	0.5	gravel, stones, sediment
46	13.7.2004	Kochavec	in Kochavec village	1.1	0.4	stones
47	7.8.2000	Zelenský p.	upstream Štítná	4.5	0.4	stones
48	13.7.2004	Zelenský p.	Forestry house	1.5	0.5	stones
49	13.7.2004	Vápenický p.	upstream Žírce	2.0	0.5	stones
50	14.7.2004	Hluboče	upstream confluence	0.5	0.3	stones
51	14.7.2004	Sidonka	upstream Sidonie	3.0	0.7	stones

channel in the territory of the Czech Republic (Jurajda et al., 2000). In 2000 and 2004 research at 40 profiles of 18 streams within the Vlára stream drainage area continued. Results of these studies were also used in this study for objective and thorough analyses of the area (Figure 1). In total, data on fish and macrozoobenthos communities from 51 and 32 sites, respectively, of 18 streams and brooks were analysed (Table 1).

Macroinvertebrates

In 2000, macrozoobenthos samples were collected from a stony substrate using Surber's net (1 000 cm^2, 500 μm mesh size) enabling quantitative processing including abundance and biomass assessments per square meter. In 2004, the semi-quantitative sampling procedure ("kick-sampling") using a bottom net (500 μm mesh size) was applied at one-minute time periods. Collected macroinvertebrates were preserved in 4% formaldehyde solution and determined and counted in the laboratory.

Saprobiological index (SI) of macrozoobenthos was determined according to the Czech National Standard CSN 75 7716 (Water Quality – Biological Analysis – Determination of Saprobic Index, 1998) based on Sládeček (1973). The Shannon's index H´ (Begon et al., 1997), based on ln values, was used to evaluate macrozoobenthos diversity.

Only the sites where both ichthyological and macrozoobenthos surveys were conducted (32 in total) entered the multidimensional analysis of macrozoobenthos assemblages. A distance matrix of the sites was calculated, using the number of particular macroinvertebrate groups (*Oligochaeta, Hirudinea,*

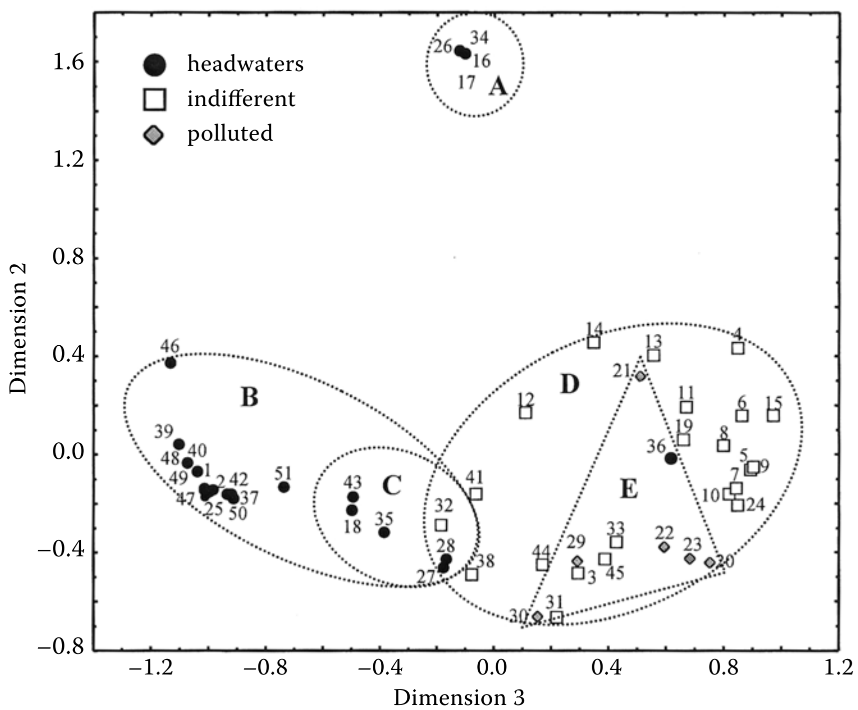

Figure 2. Two-dimensional MDS graph based on the distance matrix of fish assemblages of the Vlára drainage area in the Czech Republic during surveys in 1999, 2000 and 2004

Isopoda, Amphipoda, Ephemeroptera, Plecoptera and Trichoptera) as variables and percent disagreement as a distance measure. Multidimensional scaling (MDS) method (Kruskal and Wish, 1978) was used to project the distance matrix into a two-dimensional space. To categorize depicted data, sites were assorted into poor and good quality hotspots. The occurrence and/or absence of poor (*Hirudinea* and *Asellus*) and good (Plecoptera) water quality indicator groups were used as decisive criteria together with the SI threshold value 2.2. Two sites investigated in 1978 (Adámek and Obrdlík, 1981) were also fitted into the graphic representation (Figure 2) to demonstrate the former issues of water quality in the region.

Fish assemblages

Fish were sampled using a continual survey (one run) by electrofishing (backpack type LENA, 220 to 240 V, 1.5–2 A, 80–90 Hz) within the whole channel profile of study sites. Two anodes were used in the river stretches wider than 5 m. Study sites were limited upstream by natural (shallow riffles, boulder ramp) or artificial (weir, water splash) transversal barriers. The fish were immediately determined on the bank, measured (standard length to the nearest 1 mm) and released back into water. The fish assemblages were presented in the abundance of specimens per hectare.

All the sites where the ichthyological survey was conducted (51 sites in total) entered the multidimensional analysis of fish assemblages. A distance matrix of the sites was calculated from densities of individual species, using the reversed value of quantitative Sörensen index of similarity (1-So) as a distance measure. MDS method was used to project the distance matrix into a two-dimensional space. To categorise the depicted data, the sites were assorted into headwater sites, sites with apparent pollution sources (polluted sites) and indifferent sites.

RESULTS

Macroinvertebrate community

Altogether, 157 taxa of benthic macroinvertebrates were recorded in running waters of the Vlára basin (in the Czech territory). Larvae of dipterans (Chironomidae and Simuliidae in particular) and mayflies (Ephemeroptera) dominated among the temporary water macroinvertebrates while numerous populations of *Gammarus fossarum* (Amphipoda) and in some cases also of *Asellus aquaticus* (Isopoda) were recorded as permanent inhabitants of clean and polluted stretches, respectively.

Oligochaets (Oligochaeta) and leeches (Hirudinea) occurred at 59 and 43% of the examined sites, both of them being represented by common genera and/or species. Isopods (Isopoda) and amphipods (Amphipoda) were recorded at 32 and 70% sites, respectively. Water insects, represented by at least one species of the EPT group (mayfly nymphs, Ephemeroptera, stonefly nymphs, Plecoptera, and caddisfly larvae, Trichoptera) were registered at all studied sites. Mayfly and stonefly nymphs were recorded at 89 and 23% of the monitored sites, respectively. Caddisfly larvae occurred at 75% of the sites.

Macroinvertebrates as bioindicators

The Shannon's biodiversity index ranged from 0.08 to 2.47 in the Říka brook, upstream the water treatment plant, and in the Rokytenka brook, respectively. The majority of biodiversity indices lied below 2.0 (84%) where a considerable proportion of the sites had a very low diversity of macrozoobenthos (< 1.0–41%). Saprobic index ranged from 0.99 (oligosaprobity) to 3.35 (alpha-mesosaprobity). Water quality corresponding to oligosaprobity, beta-mesosaprobity and alpha-mesosaprobity was recorded at 53, 40 and 7% of the monitored sites, respectively.

The sites with the lowest macrozoobenthos diversity and the highest saprobic indices ("hotspots") were found in the Říka stream, upstream and downstream the water treatment plant (sites 21 and 22, SI 3.26 and 2.90 and H´ 0.08 and 0.77, respectively), and in Hrádek (site 20, SI 3.35 and H´ 0.22). On the other hand, the highest macrozoobenthos diversity (H´ 1.16–2.37) occurred in the stretches with SI 1.28–2.39 (oligo- and beta-mesosaprobity), such as stretches in the Rokytenka (sites 42–44) and Kloboučka (sites 27–31) brooks.

MDS ordination of sites according to macrozoobenthos assemblages confirmed the existence of three distinct groups of sites (poor and good quality hotspots and indifferent sites) formed by

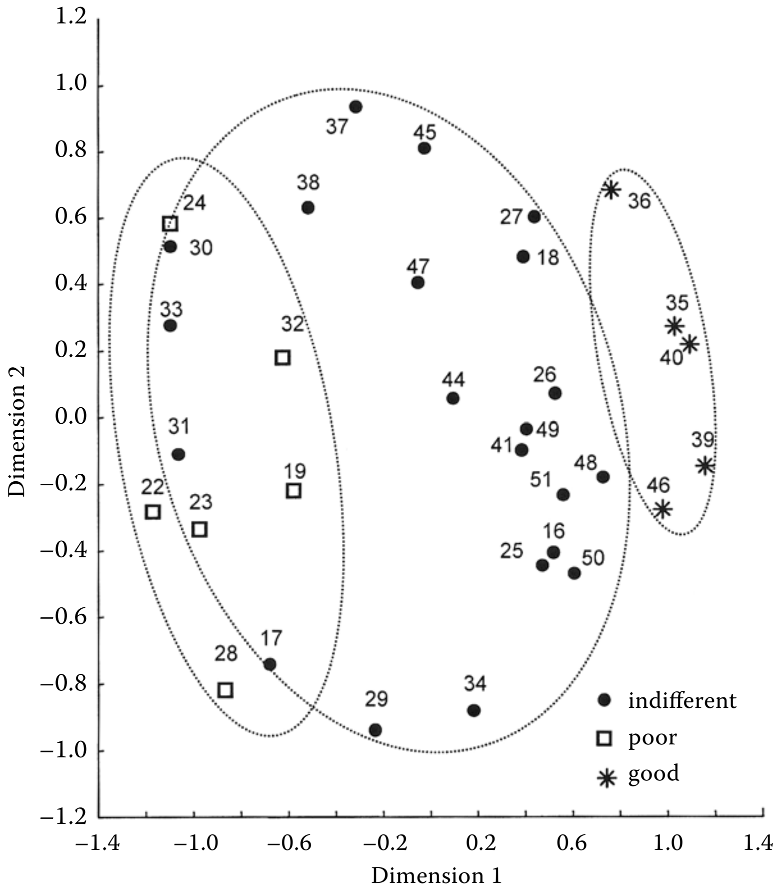

Figure 3. Two-dimensional MDS graph based on the distance matrix of macrozoobenthos assemblages of the Vlára drainage area in the Czech Republic during surveys in 2000 and 2004

the presence/absence of indicator groups and SI threshold value (Figure 3). The position of sites in MDS ordination corresponds to the fish community evaluation only partially – the group of headwater stretches, indicated by the fish, is in good accordance with good-quality streams, indicated by macrozoobenthos. The only exception was the Nedašovský potok brook (site 36), which, despite the rich density of pollution susceptive benthic macroinvertebrates, hosts a very poor fish community consisting of only single specimens of stone loach and gudgeon. It seems that these specimens originated from an accidental stocking by local people, as they do not form any population there. The nearest occurrence of gudgeon was registered at the Brumovka confluence with the Vlára stream, distant about 10 km downstream (site 33).

Fish species richness

In total 3 677 fishes of 15 species from seven families were recorded during the survey (Table 2). There was no evidence of fish at 4 fished locations. All 4 locations were a spring stream stretch with minimum water flow. The highest species richness was registered in the main channel of the Vlára stream and also in its lower part (10 species)

Table 2. A list of fish species recorded in the drainage area of Vlára stream in the Czech Republic during surveys in 1999, 2000 and 2004

Common name	Scientific name	Code
Brown trout	*Salmo trutta* m. *fario*	St
Brook trout	*Salvelinus fontinalis*	Sf
Grayling	*Thymallus thymallus*	Th
Roach	*Rutilus rutilus*	Rr
Dace	*Leuciscus leuciscus*	Ll
Chub	*Leuciscus cephalus*	Lc
Minnow	*Phoxinus phoxinus*	Pp
Nase	*Chondrostoma nasus*	Cn
Gudgeon	*Gobio gobio*	Gg
Barbel	*Barbus barbus*	Bb
Spirlin	*Alburnoides bipunctatus*	Ap
Stone loach	*Barbatula barbatula*	Bb
Golden loach	*Sabanejewia balcanica*	Sa
Perch	*Perca fluviatilis*	Pf
Sculpin	*Cottus gobio*	Cg

Table 3. Species composition and abundance (n/ha) of the fish assemblages registered at 51 study sites of the Vlára drainage area (for the fish code see Table 2, s = number of species)

No.	Watercourse	Site	St	Sf	Th	Rr	Ll	Lc	Pp	Cn	Gg	Bb	Ap	Nb	Sa	Pf	Cg	Total	s
1	Vlára	Drnovice	2 667															2 667	1
2	Vlára	Podpolí	1 452															1 452	1
3	Vlára	Vlachovice below weir	230		192						307			998			653	2 380	5
4	Vlára	Vrbětice	23		163			187	210		8 427			257				9 267	6
5	Vlára	U Polomíka below weir			37				184		184			147				552	4
6	Vlára	upstream Říka confluence				606		2 559	135	269	5 118		471	673				9 831	7
7	Vlára	Bohuslavice	43					733	388		4 573		1 208	992				7 937	6
8	Vlára	Bohuslavice-Jestřebí			32	288		1 154	32		1 635		1 122	1 250				5 513	7
9	Vlára	Jestřabí				23		937	187		913		328	539				2 927	6
10	Vlára	Jestřebí-Popov	17			17		602	69		568		688	878				2 839	7
11	Vlára	Trávníky	42					127	21		212	127	42	85				656	7
12	Vlára	Sv. Štěpán	214	28				177			130	19	93	19				680	7
13	Vlára	customs inspection	73					128	73	14	119	69	265	18			50	809	9
14	Vlára	border	146	21				292	104		21		354					938	6
15	Vlára	Srní	24					1 297	236	47	425	1 392	495	377	47		283	4 623	10
16	Říka	upstream Nevšová																0	0
17	Říka	downstream Nevšová																0	0
18	Říka	Nevšová-Slavičín	3 058											1 157				4 215	2
19	Říka	Slavičín	57			1 034		9 138			4 655		115	1 667				16 666	6
20	Říka	Hrádek						133			33			567				733	3
21	Říka	upstream WTP						49						49				98	2
22	Říka	Divnice												139				139	1
23	Říka	near training college				92		783	1 567		415			1 843				4 700	5
24	Říka	upstream confluence						625	188		406			563				1 782	4
25	Lukšinka	summer camp	1 250															1 250	1
26	Lipovský p.	upstream Slavičín																0	0
27	Kloboučka	upstream Poteč	903											2 645				3 548	2
28	Kloboučka	in Poteč village	862											2 126				2 988	2

Table 3. to be continued

No.	Watercourse	Site	St	Sf	Th	Rr	Ll	Lc	Pp	Cn	Gg	Bb	Ap	Nb	Sa	Pf	Cg	Total	s
29	Kloboučka	downstream WTP	151						129					647				927	3
30	Kloboučka	downstream Valašské Klobouky	219						63					3 406				3 688	3
31	Kloboučka	downstream Návojka confluence	230		115				259					3 994				4 598	4
32	Brumovka	downstream Brumov	1 806					417	8 333					4 028				14 584	4
33	Brumovka	upstream confluence	167			42	250	667	1 542		83	292	167	1 958				5 168	9
34	Návojka	headwater stretch																0	0
35	Návojka	Nedašov-Návojna	2 214											2 071				4 285	2
36	Nedašovský p.	Na Salaši									75			75				150	2
37	Návojná	upstream Návojná	1 250															1 250	1
38	Návojka	upstream Brumov	585											2 281				2 866	2
39	Bylnička	upstream agricultural farm	5 682															5 682	1
40	Smolinka	upstream Smolina	3 452															3 452	1
41	Smolinka	upstream confluence	952					130	779		216			563				2 640	5
42	Rokytenka	in Šanov village	2 286															2 286	1
43	Rokytenka	upstream Rokytnice	528											62				590	2
44	Rokytenka	downstream Rokytnice	333					333	3 889					2 333				6 888	4
45	Havránkův p.	upstream confluence	196					490	2 549		784			3 725		98		7 842	6
46	Kochavec	in Kochavec village	18 182															18 182	1
47	Zelenský p.	upstream Štítná	2 404															2 404	1
48	Zelený p.	Forestry house	4 364															4 364	1
49	Vápenický p.	upstream Žírce	2 596															2 596	1
50	Hluboče	upstream confluence	1 333															1 333	1
51	Sidonka	upstream Sidonií	3 133											200				3 333	2

(Table 3). In the two largest tributaries (Říka and Brumovka streams) the documented species richness was also high (7 and 10 species, respectively), but many species occurred only in the lower sections of these tributaries that freely communicate with the main Vlára stream. Smaller tributaries were occupied by maximally 6 species, but often only by 1 or 2 species (Table 3).

Fish assemblage composition

The most frequent species were brown trout (*Salmo trutta* m. *fario*) and stone loach (*Barbatula barbatula*), which were found at 37 (F = 72.5%) and 34 sites (F = 66.6%), respectively. Chub (*Leuciscus cephalus*), minnow (*Phoxinus phoxinus*) and gudgeon (*Gobio gobio*) were registered at 21 sites each (F = 41.2%). Brown trout occurred mainly in the headwaters of the drainage area, and in the majority of the small tributaries brown trout was the only fish species. This single species assemblage in headwaters could be natural because sculpin (*Cottus gobio*) in the Vlára drainage area was documented only in the main channel of the Vlára stream. The latest sculpin distribution is surprisingly separated into two distinguished sites, upstream of the Vlachovice village (site 3) and downstream of Svatý Štěpán (sites 13 and 15). The frequent occurrence of brown trout in headwaters is also supported by fisheries management, as these brooks are used for one- and two-year-old brown trout ranching.

In the lower stretches of brooks, stone loach occurred together with brown trout and they very often formed large populations (Table 3). Chub, gudgeon and spirlin (*Alburnoides bipunctatus*) were common in the middle and lower parts of the Vlára main channel. Minnow formed a strong population especially in the lower course of the Brumovka tributary.

In small brooks of the drainage area, fish assemblages were also formed only by brown trout and stone loach. Only in the Smolinka (site 41), Rokytenka (site 44) and Havránkův potok (site 45) brooks there were also recorded high numbers of minnow in addition to trout (Table 3).

Protected fish species

According to Act No. 114/92 Coll. and Regulation No. 395/92 on protected fish species, four protected fish species were found within the Vlára drainage area. From the category of critically endangered species, only golden loach (*Sabanejewia balcanica*) was recorded in this study only in the lower Slovak site (site 15). From the category of strongly endangered species, only spirlin, and from the category of endangered species minnow and sculpin were recorded. Although the minnow and spirlin are endangered species, their strong sustainable populations including young-of-the-year were documented.

Fish as a bioindicator

Species richness generally increases with the stream order, trophic level and discharge rates that do not fully correspond with the pollution level (Figure 2). Only in the case of Říka stream, very strong pollution from Slavičín caused a decrease in species richness from 6 to 1 and their density from 16 666 individuals/ha to 98 individuals/ha (Table 3). In the Kloboučka brook, the outlet of the water treatment plant in the town of Valašské Klobouky did not influence species richness, but the densi-ty decreased significantly (from 2 988 to 927 individuals/ha). Other small pollution sources were not reflected by the fish community changes at all.

MDS ordination of sites according to fish assemblages confirmed the existence of predicted groups only partially. The ordination did not differentiate polluted sites (Figure 2, group E) from indifferent sites (D). On the other hand, the ordination revealed that the fish assemblage structure of sites assessed as headwaters (A) differed from the other sites. Headwater sites, occupied by brown trout, were markedly separated, whereas sites with brown trout and stone loach (B) had a connecting link with the other sites. No fish were recorded at four sites assessed as headwaters (C). However, in regard to macrozoobenthos assemblages designating these sites as good water quality hotspots, the absence of fish would be caused by the small stream size rather than by unfavourable ecological conditions.

DISCUSSION

Macrozoobenthos

Several rare species of macroinvertebrates were recorded during the monitoring of the Bílé

Karpaty mountains streams. E.g. among the mayfly (Ephemeroptera) nymphs, the *Pseudocloeon inexpectatum* was previously reported to occur only in submountain streams of Slovakia (Zelinka, 1980). *Ecdyonurus helveticus* belongs to sporadically occurring water macroinvertebrates as well and *Electrogena samalorum* is considered as a possibly endangered species (Zahrádková and Soldán, 1998). Despite the importance of the Czech water bodies of the Bílé Karpaty Landscape Protected Area (and those of the Vlára stream drainage area in particular) their macroinvertebrates have not been the object of any detailed study yet. Summarising paragraphs of the monograph on the Bílé Karpaty Landscape Protected Area (Kuča et al., 1992) presented only one species (dragon fly larva *Calopteryx virgo*), which was recorded also in our surveys.

Based on the macrozoobenthos analyses, the water quality in the Bílé Karpaty brooks can be generally rated as good in approximately one half of the sites under study. A considerable proportion of the brooks under study had quite a good water quality but several of them showed signs of eutrophication originating from diffused agriculture sources and municipal pollution. These brooks were usually characterized by the medium saprobic index (beta-mesosaprobity) with low biodiversity. The Říka stream downstream the Nevšová village and the lower Brumovka stream are good examples of this kind of degradation. Adverse impacts of small brook and rivulet pollution from small settlements and diffused agriculture sources in highland regions of the Czech Republic were already reported in previous studies (Adámek and Jurajda, 2001), but some problems still persist, though not in the former extent.

Good and poor water quality was perfectly indicated by numerous occurrences of *Gammarus pulex* and *Asellus aquaticus*, respectively. All 31 sites with *Gammarus* showed the saprobic index between 0.99 (oligosaprobity) and 2.25 (beta-mesosaprobity), while in those with *Asellus* it ranged from 1.72 to 3.28 (beta-meso- and alpha-mesosaprobity, respectively). Similar rules also applied to the other indicator organisms such as clean water *Rhithrogena* (Ephemeroptera) and Plecoptera species inhabiting sites with SI 0.99–1.50 and 1.07–2.08, respectively, while polluted sites were preferred by *Tubifex* sp. (Oligochaeta), *Erpobdella octoculata* (Hirudinea) and *Chironomus riparius* (Chironomidae, Diptera) larvae which were recorded in sites with SI up to 3.35.

The most polluted stretches were characterised by the lowest biodiversity indexes of macrozoobenthos. As already reported by Adámek and Jurajda (2001), the relationship between water quality and macrozoobenthos diversity in highland streams (altitude > 400 m) is of a parabolic shape, which means that the lowest species numbers (diversity) of bottom dwelling macroinvertebrates sharply decline in the most polluted streams. According to previous findings (Adámek and Jurajda, 2001), the highest biodiversity of macrozoobenthos in highland streams occurred in SI 1.05, however, in the Bílé Karpaty streams the optimal SI values for the highest macrozoobenthos diversity lie rather in beta-mesosaprobity (SI 1.28–2.39). This disproportion might be due to the warmer climatic conditions of the Bílé Karpaty region and the increased water trophic status caused by agricultural land use and dispersed pollution from small human settlements.

Fish community

From the ichthyological point of view, the Vlára stream is a unique river in its size category with exceptionally high species richness and with the occurrence of nearly all protected fish species that can occur considering the river character. Comparing the findings of the present study with previous surveys it is clear that there was no decline in species diversity, but only some species (e.g. dace, bleak) were found more downstream (Libosvárský et al., 1967). However, these species did not belong to dominant species even 40 years ago and it is possible to assume that these species swam upstream into the Vlára stream from the Váh River. The fact that their abundance in the lower part of the river, at the confluence with the Brumovka brook, is higher than upstream the river, at the confluence with Říka stream, confirms this assumption (Libosvárský et al., 1967).

In the Slovak part of the Vlára stream, upstream the confluence with the Váh River, 12 fish species were recorded including vimba (*Vimba vimba*), Danube gudgeon (*Gobio uranoscopus*) and golden loach. All three species occurred only sporadically (Blahák, 1981). Golden loach was recorded for the first time in the Czech part of Vlára stream in 2001 by Lusk et al. (2002). This species seems to progressively increase its distribution upstream due to the absence of migration barriers and better water quality. Nevertheless, in 2003 we surveyed the identical site as Lusk et al. (2002) and the golden loach was not registered. It seems that the population density is still low and the upstream spreading has slowed down.

However, the relative abundance of dominant species in the Vlára drainage area did not change significantly (Lelek and Peňáz, 1963; Libosvárský et al., 1967) and the core of the fish community consists of chub, gudgeon, stone loach and somewhere also of minnow. Currently, the most abundant species from Bohuslavice village (site 7) downstream is spirlin.

In a small-scale seasonal study in 2005, researching only one site (Vlára main channel in Bohuslavice village, site 7), the occurrence of another nine species was documented (Konečná et al., 2006). Most of them (tench *Tinca tinca*, bream *Abramis brama*, Prussian carp *Carassius gibelio*, crucian carp *C. carassius*, carp *Cyprinus carpio*, sunbleak *Leucaspius delineatus*, topmouth gudgeon *Pseudorasbora parva*, bleak *Alburnus alburnus*) were registered only once and as a single specimen. These species originated from stagnant water bodies in the drainage area and did not form any stable populations in the stream. Only the pike *Esox lucius* occurred constantly but at a very low abundance (Konečná et al., 2006).

On the other hand, grayling (*Thymallus thymallus*) and exotic brook trout (*Salvelinus fontinalis*), whose occurrence was due to their stocking, were found during this study. In the higher part of the stream grayling and trout are being stocked, while in the lower part of the river the nase has been stocked in order to regenerate its previously abundant populations. Carp and pike are being stocked into a channelised river stretch below Štítná vilage, however, these two species were not recorded during our study due to the extreme depth of the stretch.

It is expected that the original species (vimba, dace, etc.) from the lower Slovak river stretch or from the Váh River will spread into the lowest Czech part of the Vlára stream, around the Czech–Slovak border, and therefore it is important not to restrict fish migrations by building barriers.

To improve the present state of fish communities, revitalising measures are not essential, but the elimination of negative impacts of potential technical interventions on the river should be considered. Heavy pollution from the Slavičín and Valašské Klobouky settlements also has a strong negative effect on the aquatic ecosystem, and potential accidents of all kinds still pose a serious threat to aquatic communities in such a small drainage area.

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REFERENCES

Adámek Z., Obrdlík P. (1981): Komplexní využití výsledků limnologických výzkumů k prognóze vývoje jakosti vody ve vodárenmských nádržích. Acta Univ. Agric. Brno, 29, 193–201.

Adámek Z., Jurajda P. (2001): Stream habitat or water quality – what influences stronger fish and macrozoobenthos biodiversity? Ecohydrol. Hydrobiol., 1, 305–311.

Begon M., Harper J.L., Townsend C.R. (1997): Ekologie: jedonci, populace a společenstva. Vydavatelství University Palackého, Olomouc.

Blahák P. (1981): Příspěvek k poznání ichtyofauny dolního toku Vláry. Acta Rer. Natur. Mus. Nat. Slov., Bratislava, 27, 123–139.

Hohausová E., Jurajda P., Prášek V. (1996): Fish assemblage of the River Vsetínská Bečva basin. Acta Univ. Carol. Biol., 40, 115–121.

Jurajda P., Reichard M., Ondračková M., Matějusová I., Prášek V. (2000): Fishes communities of the longitudinal profile of the Vlára stream in the Bílé Karpaty Mountains. Sb. Přír. klubu Uherské Hradiště, 5, 270–277.

Konečná G., Janáč M., Jurajda P. (2006): Sezónní variabilita vzorků rybího společenstva. In: Sbor. IX. České ichtyol. konf., 4.–5. 5. 2006, Vodňany, 43–45.

Kruskal J.B., Wish M. (1978): Multidimensional Scaling. Sage Publications, Beverly Hills, California.

Kuča P., Májsky J., Kopeček F., Jongepierová I. (1992): Chráněná krajinná oblast Bílé (Biele) Karpaty. Ekológia Bratislava, 380 pp.

Kux Z., Weisz T. (1964): Příspěvek k poznání ichtyofauny slovenských řek. Čas. Mor. Musea, 49, 191–246.

Lelek A., Peňáz M. (1963): Tření ostroretky stěhovavé *Chondrostoma nasus* (L.) v Brumovce. Zool. listy, 12, 121–134.

Libosvárský J., Lelek A., Peňáz M. (1967): Movement and mortality of fish in two polluted brooks. Acta Sci. Nat. Brno, 1, 1–27.

Libosvárský J., Wohlgemuth E. (1973): Estimates of abundance of fishes in the Olšava Creek, with respect to a long winter. Zool. listy, 22, 73–84.

Lojkásek B., Lusk S., Halačka K., Lusková V. (2000): Fish communities in the drainage area of the Osoblaha River and effect of the 1997 flood. Czech J. Anim. Sci., 45, 229–236.

Lojkásek B., Lusk S., Halačka K., Lusková V. (2004): Fish communities in the Poodří Protected Landscape Area (the Odra River basin). Czech J. Anim. Sci., 49, 121–130.

Lusk S. (1992): Ryby. In: Kuča P. et al. (eds.): Chránená krajinná oblasť Biele/Bílé Karpaty. Ekológia, Bratislava, 380 pp.

Lusk S., Májsky J., Lusková V., Halačka K. (2002): Výskyt sekavčíka horského – *Sabanejewia balcanica* (Karaman, 1922) v toku Vláry na území České republiky a Slovenska. Biodiverzita ichtyofauny ČR IV., Ústav biologie obratlovců AV ČR Brno a AOPK ČR Praha, 121–126.

Lusk S., Lusková V., Halačka K., Lojkásek B. (2004): Ryby říční sítě chráněné krajinné oblasti Beskydy. Biodiverzita ichtyofauny ČR V. Ústav biologie obratlovců AV ČR Brno a AOPK ČR Praha, 137–143.

Namin J.I., Spurný P. (2004): Fish community structure of the middle course of the Bečva River. Czech J. Anim. Sci., 49, 43–50.

Pont D., Hugueny B., Beier U., Goffaux D., Melcher A., Noble R., Rogers C., Roset N., Schmutz S. (2006): Assessing river biotic condition at a continental scale: a European approach using functional metrics and fish assemblages. J. Appl. Ecol., 43, 70–80.

Sládeček V. (1973): System of water quality from the biological point of view. Ergeb. Limnol., 7, 2–218.

Simon T.P. (1999): Assessing the sustainability and biological integrity of water resources using fish communities. CRS Press, Boca Raton, FL, 671 pp.

Švátora M., Moravec P., Pečina V. (2002): Ichtyofauna CHKO Železné hory. Biodiverzita ichtyofauny ČR IV., Ústav biologie obratlovců AV ČR Brno a AOPK ČR Praha, 155–160.

Vlček V., Kestřánek J., Kříž H., Novotný S., Píše J. (1984): Vodní toky a nádrže. Academia, Praha, 315 pp.

Zahrádková S., Soldán T. (1998): Determinační kurz makrozoobentosu. Ephemeroptera. MZLU, Brno, 30 pp.

Zelinka M. (1980): Řád jepic – Ephemeroptera. In: Rozkošný K. (ed.): Klíč vodních larev hmyzu. ČSAV, Praha, 39–67.

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