A PREDICTION MODEL OF RUNNING WATERS ECOSYSTEM IN THE CZECH REPUBLIC BASED ON MAYFLY TAXOCENES OF UNDISTURBED RHITHRAL STREAMS

Světlana Zahrádková[1], Tomáš Soldán[2], and Jiří Kokeš[3]

[1] Department of Zoology and Ecology, Faculty of Science
Masaryk University, Kotlárská 2, 611 37 Brno, Czech Republic
[2] Institute of Entomology, Academy of Sciences of the Czech Republic
Branišovská 31, 370 05 Ceské Budejovice, Czech Republic
[3] Water Research Institute T.G.M. Prague, Dept. Brno
Drevarská 12, 657 57 Brno, Czech Republic

ABSTRACT

Samples of mayfly larvae and main environmental variables from 80 undisturbed localities evenly distributed in the Czech Republic were taken and measured during 1994-1997. Data were examined by TWINSPAN and by canonical correspondence analysis (CCA) to define mayfly taxocenes characteristic of different areas and to prepare a mayfly database for a prediction model of effects of environmental changes (HOBENT). To test the general applicability of the model, mayfly species composition at 13 localities was compared to a hypothetical, desired taxocenes. Although restricted only to a part of aquatic macroinvertebrate communities (mayflies), this procedure permitted evaluation of environmental degradation of other 13 localities. Despite some restrictions, the planned total number of 400 background localities seems to be sufficient for successful application of this prediction model.

INTRODUCTION

Aquatic macroinvertebrates studies have been widely used to estimate water quality based on saprobial (e. g. Zelinka and Marvan, 1961) and diversity or species richness indices. In many places, organic pollution is being gradually decreased and recovery of aquatic biotopes (restoration) represents one of the most important research problems. Consequently, determination of desired environmental characteristics of watercourses and respective target communities is urgently needed. As much as possible, the natural (or original) conditions are most desirable. To meet this need, the system PERLA, a new approach to evaluate the environmental quality of running waters based on macroinvertebrate communities analyses, is being gradually developed in the Czech Republic. The

Trends in Research in Ephemeroptera and Plecoptera
Edited by E. Dominguez, Kluwer Academic/Plenum Publishers, 2001

most important tool of this system is the recently developed program HOBENT (Kokeš, 1997) constructed in a similar way to the British RIVPACS (for details see e.g. Armitage et al. 1983, Wright 1995, Wright et al. 1989, 1993). This system is based on a comparison of the actual macroinvertebrate diversity at particular place with a respective target or desired community. Target community (or taxocoene) is defined as an unaffected community of the (reference) localities with no or minimal human-mediated environmental pressure. The comparison of targets with actual community composition enables evaluation of the extent of disturbance and prediction of the probability of successful recovery. Careful selection of localities, though to be reasonably pristine, analysis of their biodiversity and abiotic variables, definition of interrelations and computer processing of data represent the first step in a development of a reference database. The objectives of this paper are: (i) to develop a mayfly database for the prediction model; (ii) to define characteristic mayfly taxocenes of a modeled area (rhithral of the Czech Republic); and, (iii) to test the prediction model.

Table 1. List of reference localities with basic characteristics and associated TWINSPAN groups

No. of locality	Name of watercourse	Sampling site	River basin	Distance from source	Altitude [m]	Orographic unit	Biogeographic subprovince of CR	Coordinates*	TWINSPAN group
1	ŘÍČKA	Říčky	L	7.7	625	IV	Hercynicum	57-64	A
2	ORLIČKA	Orlička	L	0.5	473	IV	Hercynicum	59-66	G
3	BROOK	Horní Lipka	L	8.9	605	IV	Hercynicum	58-66	G
4	JIZERA	Splzov	L	93.7	279	IV	Hercynicum	53-57	J
5	MUKAŘOVSKÝ BROOK	Splzov	L	2.0	327	IV	Hercynicum	53-57	G
6	VLTAVA	Pěkná	L	58.7	725	I	Hercynicum	71-49	J
7	KRASETÍNSKÝ BROOK	Krasetín	L	1.8	585	I	Hercynicum	71-51	G
8	ČERNÁ	Benešov	L	16.5	654	I	Hercynicum	73-54	G
9	LUŽNICE	Stará Hlína	L	98.5	430	II	Hercynicum	70-54	H
10	NOVÁ ŘEKA	Mláka	L	2.2	432	II	Hercynicum	69-55	H
11	ŽIDOVA STROUHA	Nuzice	L	2.8	375	II	Hercynicum	67-52	H
12	FILIPOHUŤSKÝ BROOK	Filipova Huť	L	2.8	1020	I	Hercynicum	69-47	A
13	ZHŮŘSKÝ BROOK	Turnerova chata	L	0.5	945	I	Hercynicum	69-47	A
14	PRÁŠILSKÝ BROOK	Prášily	L	4.8	905	I	Hercynicum	68-46	A
15	OTAVA	Sušice	L	94.3	490	I	Hercynicum	67-47	A
16	OSTRUŽNÁ	Sušice	L	3.3	475	I	Hercynicum	67-46	J
17	BLANICE	Blažejovice	L	78.6	748	I	Hercynicum	70-49	J
18	ZLATÝ BROOK	Záhoří	L	24.2	659	I	Hercynicum	70-50	G
19	ZÁVIŠÍNSKÝ BROOK	Bezdědovice	L	3.6	435	II	Hercynicum	65-49	I
20	STRŽSKÝ BROOK	Cikháj	L	10.0	650	II	Hercynicum	63-61	I
21	SÁZAVA	Ledeč	L	93.4	351	II	Hercynicum	62-57	L
22	TRNÁVKA	Hrádek	L	30.5	475	II	Hercynicum	65-56	I
23	BLANICE	Světlá	L	30.5	365	II	Hercynicum	63-55	I
24	ZAHOŘANSKÝ BROOK	Davle - Libřice	L	2.5	225	V	Hercynicum	61-52	I
25	SENNÝ BROOK	Drmoul	L	4.5	554	I	Hercynicum	60-41	G
26	MŽE	Milíkov	L	53.0	380	V	Hercynicum	62-43	J
27	KLABAVA	Kamenné	L	40.0	601	V	Hercynicum	62-47	G
28	STŘELA	Ondřejov	L	24.6	348	III	Hercynicum	60-45	L
29	KRALOVICKÝ BROOK	Dolní Hradiště	L	13.5	320	V	Hercynicum	60-47	I
30	VELKÁ LIBAVA	Arnoltov	L	11.0	568	III	Hercynicum	58-41	G
31	TEPLÁ	Teplička	L	18.0	453	III	Hercynicum	58-43	J
32	LOMNICE	Kyselka	L	160.0	360	III	Hercynicum	57-44	G
33	OHŘE	Kadaň	L	125.0	285	III	Hercynicum	56-43	L
34	BROOK	Prackovice	L	0.9	225	VI	Hercynicum	54-50	C
35	TELNICKÝ BROOK	Adolfov	L	6.5	645	III	Hercynicum	52-49	C
36	PLOUČNICE	Mimoň	L	76.0	283	VI	Hercynicum	53-54	H
37	LESNÍ BROOK	Šluknov	L	1.8	349	IV	Hercynicum	50-52	G
38	TROJANOVICKÝ BROOK	Trojanovice	O	1.5	720	IX	Hercynicum	64-75	C
39	ČERNÁ OPAVA	Mnichov	O	9.9	610	IV	Hercynicum	58-70	C
40	STŘEDNÍ OPAVA	Vidly	O	2.9	770	IV	Hercynicum	58-69	C

* Coordinates according to European uniform grid system.

Table 1 (cont.)

No. of locality	Name of watercourse	Sampling site	River basin	Distance from source	Altitude [m]	Orographic unit	Biogeographic subprovince of CR	Coordinates*	TWINSPAN group
41	MORAVÍCE	Karlov	O	6.2	620	IV	Hercynicum	59-69	D
42	MORÁVKA	Strongy	O	2.0	707	IX	Carpathicum	67-77	C
43	MOHELNICE	Zlatník	O	3.8	625	IX	Carpathicum	64-77	C
44	LOMNÁ	Dolní Lomná	O	7.5	495	IX	Carpathicum	64-78	E
45	OLŠE	Třinec	O	20.8	309	IX	Carpathicum	63-78	K
46	TYRKA	Tyra	O	1.5	600	IX	Carpathicum	63-77	C
47	ROPIČANKA	Řeka	O	1.1	540	IX	Carpathicum	63-77	C
48	STŘÍBRNÝ BROOK	Nýznerov	O	6.8	750	IV	Hercynicum	57-68	C
49	ČERVENÝ BROOK	Červená Voda	O	2.5	400	IV	Polonicum	56-68	F
50	RAMZOVSKÝ BROOK	Ramzová	O	5.1	590	IV	Hercynicum	57-68	C
51	MORAVA	Dolní Morava	M	9.8	610	IV	Hercynicum	58-66	D
52	KRUPÁ	Seninka	M	2.0	700	IV	Hercynicum	57-67	C
53	BRANNÁ	Branná	M	3.0	750	IV	Hercynicum	58-68	C
54	BRANNÁ	Jindřichov	M	15.0	510	IV	Hercynicum	58-68	D
55	MERTA	Vernířovice	M	4.3	610	IV	Hercynicum	59-68	C
56	MORAVSKÁ SÁZAVA	Albrechtice	M	9.5	430	IV	Hercynicum	60-65	F
57	HYNČINSKÝ BROOK	Hynčina	M	3.0	420	IV	Hercynicum	61-67	C
58	MORAVSKÁ SÁZAVA	Lupěné	M	45.5	255	IV	Hercynicum	61-66	K
59	MÍROVKA	Mírov	M	10.0	350	IV	Hercynicum	62-67	F
60	SITKA	Šternberk	M	20.6	320	IV	Hercynicum	62-69	F
61	BYSTŘICE	Hlubočky	M	37.4	335	IV	Hercynicum	63-70	E
62	VSETÍNSKÁ BEČVA	Velké Karlovice	M	8.1	620	IX	Carpathicum	66-76	E
63	JEZERNÍ BROOK	Velké Karlovice	M	2.1	570	IX	Carpathicum	66-75	F
64	SENICE	Leskovec	M	27.2	370	IX	Carpathicum	67-74	K
65	ROŽNOVSKÁ BEČVA	above dam	M	1.5	510	IX	Carpathicum	65-76	D
66	JUHYNĚ	Troják	M	3.8	500	IX	Carpathicum	66-72	F
67	RÁZTOKA	Rusava	M	2.5	400	IX	Carpathicum	66-72	F
68	TRNÁVKA	Hrobice - Neubuz	M	9.0	290	IX	Carpathicum	67-72	F
69	OLŠAVA	Pitín	M	1.7	375	IX	Carpathicum	69-73	B
70	VELIČKA	Vápenky	M	3.9	470	IX	Carpathicum	71-71	C
71	BOLÍKOVSKY BROOK	Lipnice	M	6.7	550	II	Hercynicum	68-57	I
72	DYJE	Podhradí	M	96.6	355	II	Hercynicum	71-59	L
73	TRHONICKÝ BROOK	Jimramov	M	5.0	530	II	Hercynicum	63-63	F
74	SVRATKA	Unčín	M	45.4	515	II	Hercynicum	63-63	K
75	NEDVĚDIČKA	Pernštejn	M	27.6	400	II	Hercynicum	66-64	E
76	LITAVA	Zástřizly	M	3.3	320	IX	Carpathicum	68-69	B
77	JIHLAVA	Horní Ves	M	3.1	615	II	Hercynicum	67-57	F
78	JIŘÍNSKÝ BROOK	Hlávkov	M	8.3	560	II	Hercynicum	65-58	I
79	JIHLAVA	Iváň	M	179.6	185	VIII	Pannonicum	70-65	L
80	KYJOVKA	Staré Hutě	M	2.2	425	IX	Carpathicum	68-69	B

STUDY SITES AND METHODS

There are three main river basins – the Labe (Elbe), the Odra (Oder) and the Morava in the Czech Republic situated in four biogeographic subprovinces (Culek, 1996) and ten orographic subprovinces (Demek, 1987). Altogether, 80 localities of reasonably pristine streams (Tab. 1, Fig. 1) are evenly distributed in all biogeographic subprovinces (Fig. 2) and eight orographic subprovinces (Fig. 3). Reference localities were those sampled during the 1950's (so called Project No. 210) and which in the 1990's did not exhibit any pronounced differences in either species composition or in abiotic variables (for details see Soldán et al., 1998).

Kick samples of larvae were obtained at early spring, spring, summer and autumn during 1994-1997. Equal attention was paid to all types of substratum and pure collection time was restricted to 10-15 minutes at each locality in each season. Main environmental variables (altitude, slope, distance from source, mean stream width and depth, mean current velocity, instantaneous discharge, mean substrate roughness, water temperature, dissolved oxygen, biochemical oxygen demand, pH, conductivity, concentration of total phosphorus, ammonium and nitrate and data on submerged and riparian vegetation were measured. Index of species richness (Margalef, 1958) and index of diversity (Shannon and Weaver, 1963) were calculated.

Table 2. List of species found and abbreviations of species names used in other tables and figures

Species		Species name abbrev.	Species		Species name abbrev.
Ameletus inopinatus	Eaton, 1887	Amel inop	*Heptagenia flava*	Rostock, 1877	Hept flav
Siphlonurus aestivalis	(Eaton, 1903)	Siph aest	*Heptagenia fuscogrisea*	(Retzius, 1783)	Hept fusc
Siphlonurus alternatus	(Say, 1824)	Siph alte	*Heptagenia longicauda*	(Stephens, 1836)	Hept long
Siphlonurus armatus	(Eaton, 1870)	Siph arma	*Heptagenia sulphurea*	(Müller, 1776)	Hept sulp
Siphlonurus lacustris	(Eaton, 1870)	Siph lacu	*Rhithrogena beskidensis*	Alba et Sowa, 1987	Rhit besk
Alainites muticus	(Linné, 1758)	Alai muti	*Rhithrogena carpatoalpina*	Klonowska et al., 1985	Rhit carp
Baetis alpinus	(Pictet, 1843 - 1845)	Baet alpi	*Rhithrogena germanica*	Eaton, 1885	Rhit germ
Baetis buceratus	Eaton, 1870	Baet buce	*Rhithrogena hercynia*	Landa, 1970	Rhit herc
Baetis calcaratus	Keffermüller, 1972	Baet calc	*Rhithrogena iridina*	(Kolenati, 1859)	Rhit irid
Baetis fuscatus	(Linné, 1761)	Baet fusc	*Rhithrogena landai*	Sowa et Soldán, 1984	Rhit land
Baetis lutheri	Müller-Liebenau, 1967	Baet luth	*Rhithrogena loyolaea*	Navás, 1922	Rhit loyo
Baetis melanonyx	Pictet, 1843 - 1845	Baet mela	*Rhithrogena savoiensis*	Alba et Sowa, 1987	Rhit savo
Baetis rhodani	Pictet, 1843 -1845	Baet rhod	*Rhithrogena semicolorata*	(Curtis, 1834)	Rhit semi
Baetis scambus	Eaton, 1870	Baet scam	*Choroterpes picteti*	(Eaton, 1871)	Chor pict
Baetis vernus	Curtis, 1834	Baet vern	*Habroleptoides confusa*	Sartori et Jacob, 1986	Habr conf
Nigrobaetus niger	(Linné, 1761)	Nigr nige	*Habrophlebia fusca*	(Curtis, 1834)	Habr fusc
Centroptilum luteolum	(Müller, 1776)	Cent lute	*Habrophlebia lauta*	Eaton, 1884	Habr laut
Centroptilum pennulatum	Eaton, 1870	Cent penn	*Leptophlebia marginata*	(Linné, 1767)	Lept marg
Cloeon dipterum	(Linné, 1761)	Cloe dipt	*Leptophlebia vespertina*	(Linné, 1758)	Lept vesp
Procloeon bifidum	(Bengtsson, 1912)	Proc bifi	*Paraleptophlebia cincta*	(Retzius, 1783)	Para cinc
Oligoneuriella rhenana	(Imhoff, 1852)	Olig rhen	*Paraleptophlebia submarginata*	(Stephens, 1835)	Para subm
Ecdyonurus aurantiacus	(Burmeister, 1839)	Ecdy aura	*Potamanthus luteus*	(Linné, 1767)	Pota lute
Ecdyonurus austriacus	Kimmins, 1958	Ecdy aust	*Ephoron virgo*	(Olivier, 1791)	Epho virg
Ecdyonurus dispar	(Curtis, 1843)	Ecdy disp	*Ephemera danica*	Müller, 1764	Ephe dani
Ecdyonurus forcipula	Pictet, 1843 - 1845	Ecdy forc	*Ephemera lineata*	Eaton, 1870	Ephe line
Ecdyonurus insignis	(Eaton, 1870)	Ecdy insi	*Ephemera vulgata*	Linné, 1758	Ephe vulg
Ecdyonurus starmachi	Sowa, 1971	Ecdy star	*Ephemerella ignita*	(Poda, 1761)	Ephe igni
Ecdyonurus subalpinus	Klapálek, 1905	Ecdy suba	*Ephemerella mucronata*	(Bengtsson, 1909)	Ephe mucr
Ecdyonurus submontanus	Landa, 1970	Ecdy subm	*Ephemerella notata*	Eaton, 1887	Ephe nota
Ecdyonurus torrentis	Kimmins, 1942	Ecdy torr	*Torleya major*	(Klapálek, 1905)	Torl majo
Ecdyonurus venosus	(Fabricius, 1775)	Ecdy veno	*Brachycercus harrisella*	Curtis, 1834	Brac harr
Electrogena affinis	(Eaton, 1885)	Elec affi	*Caenis luctuosa*	(Burmeister, 1839)	Caen luct
Electrogena lateralis	(Curtis, 1834)	Elec late	*Caenis macrura*	Stephens, 1835	Caen macr
Electrogena quadrilineata	(Landa, 1970)	Elec quad	*Caenis pseudorivulorum*	Keffermüller, 1960	Caen pseu
Epeorus sylvicola	(Pictet, 1865)	Epeo sylv	*Caenis rivulorum*	Eaton, 1884	Caen rivu
Heptagenia coerulans	Rostock, 1877	Hept coer			

TWINSPAN (Hill, 1979) was used to classify the data obtained. No samples were deleted or weighted, no species were deleted, but ubiquitous species (such as *Baetis rhodani* and *Ephemerella ignita*) were downweighted. Pseudo-species (the way of substituting a quantitative variable - abundance - by several quantitative variables used in program TWINSPAN) were defined at 5 cut levels.

Canonical correspondence analysis - (CCA, Ter Braak, 1988) was selected for spatial evaluation of species and environmental data. As basic input for the analysis, the complete data set comprising 80 samples, 71 species and 15 environmental variables was used. No samples were deleted or weighed. No species were deleted, but ubiquitous species were downweighted in the same way as in TWINSPAN. Environmental variables were individually tested by the Monte Carlo permutation test and only significant (p=0.01, 999 unconstrained permutations) outcomes were used for CCA. During the forward selection the

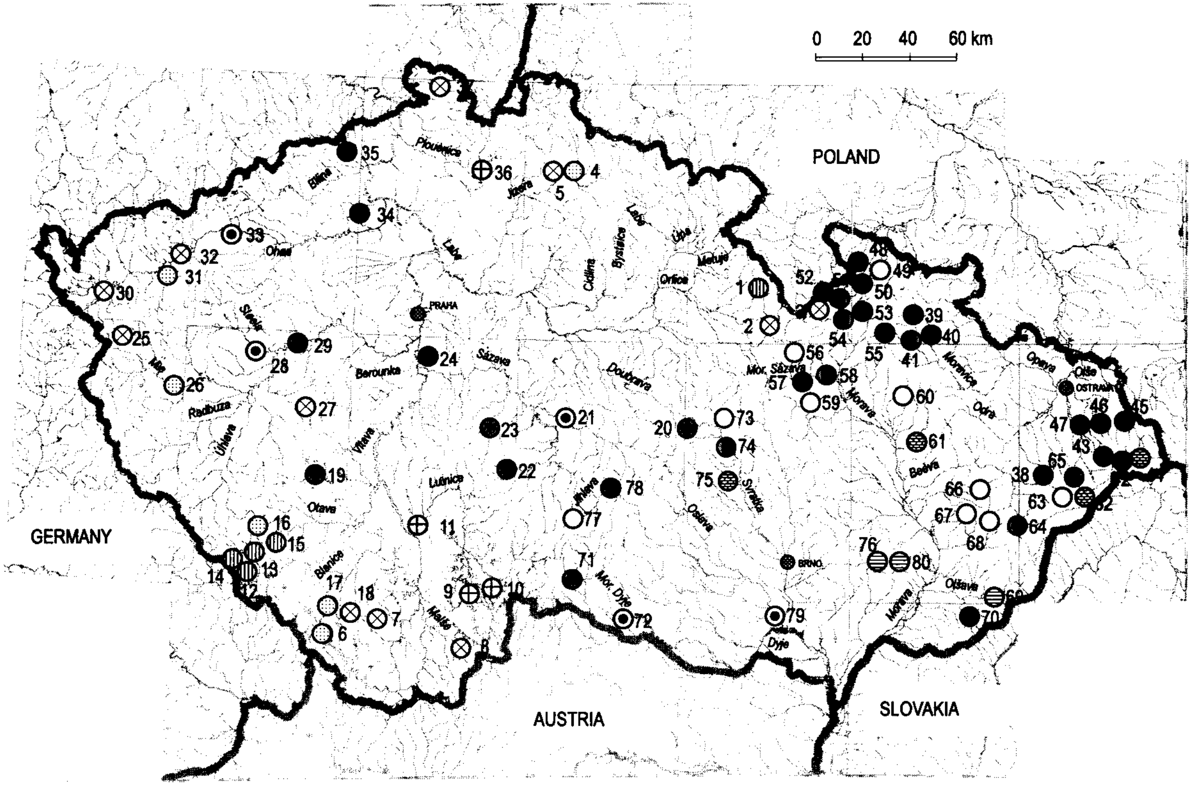

Fig. 1. Map of the Czech Republic showing the investigated localities. Numbers of localities correspond to Table 1. For definition of TWINSPAN groups see text.

TWINSPAN group:	A	B	C	D	E	F	G	H	I	J	K	L
	◍	⊜	●	●	●	○	⊗	▤	▩	◌	◐	◉

variables were used in order to follow their fit. Significance of the first canonical axis was tested by the Monte Carlo permutation test.

The program HOBENT (Kokeš, 1997) used to predict and compare the species composition is based on the procedures as follows: (i) localities of the reference database are classified into individual final TWINSPAN groups, (ii) these are characterised by the set of the most significant environmental variables using Multiple Discriminant Analysis (MDA) (Klecka, 1975), (iii) the locality in question is then classified with respect to its particular environmental variables to belong, with defined probability, into one or more respective group(s) of reference database, (iv) based on these probabilities a list of species expected at this particular locality is defined, (v) this list and real species occurrence are compared to define the coefficient B expressing similarity of real and predicted taxocoene (B = 0: taxocenes completely different, B =1: taxocenes identical). The B values thus enable to evaluate the ecological quality of the locality.

To test the applicability of the model, mayfly species composition at 13 localities (see Tab. 7) was compared to a hypothetical, desired community.

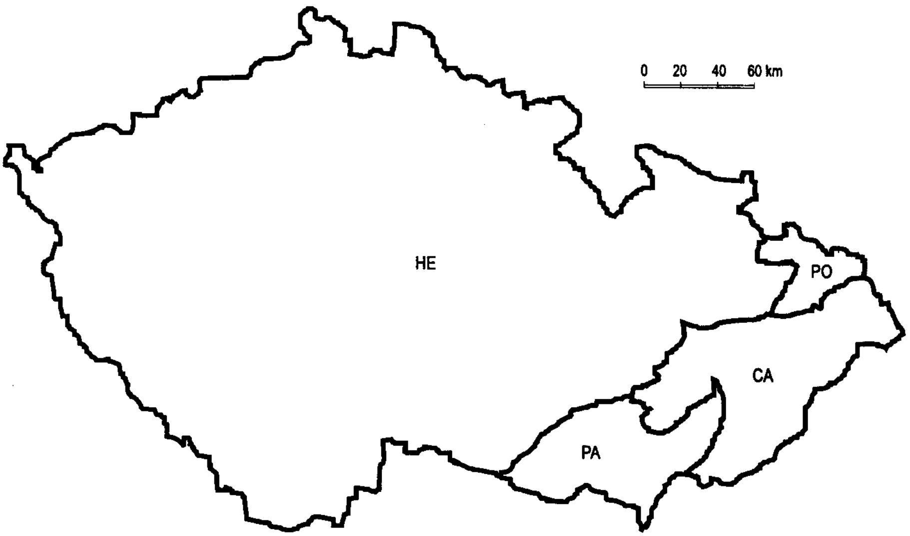

Fig. 2. Map of the Czech Republic showing main biogeographic subprovinces according to Culek (1996). HE - Hercynicum, PO - Polonicum, CA -Carpathicum, PA - Pannonicum. For position of localities studied in individual subprovinces see Table 1.

RESULTS

TWINSPAN Classification

In the first step (D1, Fig. 4), the TWINSPAN principally separated the data into class *0 (i.e. localities of typical rhithral and transitional zone between crenal and rhithral) and class *1 on the other hand (localities of both typical potamal zone and transitional zone between rhithral and potamal). The second division (D2) separated headwater localities (class *00) from other rhithral localities (class *01). Class *00 was divided by the fourth division (D4) into classes *000 and *001. The former class represented final group A, indicator species *Baetis alpinus* (for full scientific names of species and their abbreviations used in Fig. 4 see

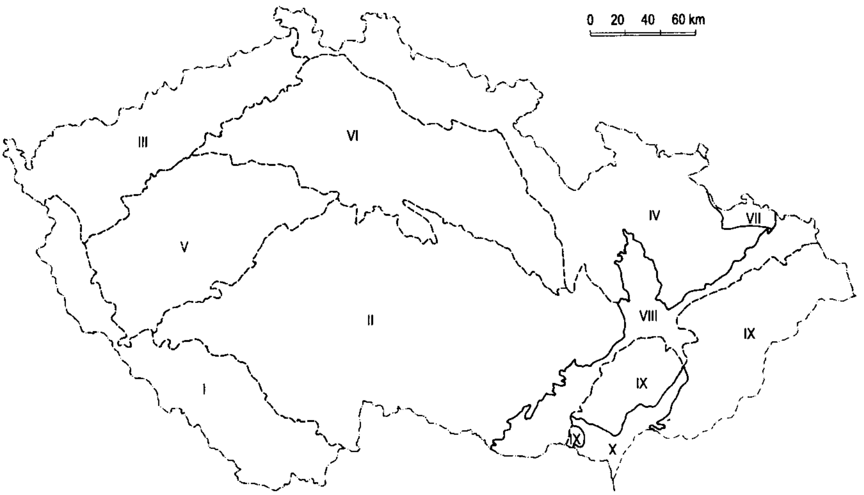

Fig. 3. Map of the Czech Republic showing main orographic subprovinces according to DEMEK (1987). For position of localities studied in individual biogeographic subprovinces see Table 1.
I - the Šumava Mts. system, II - the Czech Moravian Highland System, III - the Krušné Hory Mts. system, IV - the Krkonoše - Jeseníky Mts. system (East Sudete system), V - the Berounka Highland system, VI - the Czech Plateau, VII - the Central Poland lowlands, VIII - depressions of the Outer Carpathians, IX - the Outer West Carpathians, X - the Vienna Basin. Note that no localities in question are situated in the orographic unit No. VII and X.

Tab. 2), largely montane, epirhithral stretches with naturally low pH values (peat-bog water) and lower water temperature, the Labe basin. The latter class (*001) gave rise to final group B (D9 - *0010, no specific indicator, lower elevation brooks of the Carpathians, the Morava basin) and class *0011 with localities of typical epirhithral stretches. Next division of this class (D19) resulted in the class *00110 (final group C, indicators *Habroleptoides confusa, Ecdyonurus subalpinus, Ephemerella mucronata* and *Baetis alpinus*, mostly localities of epirhithral of predominantly higher coline zone, with low distance from source, high slope and lower water temperature) and class *00111 (final group D, without a specific indicator, epirhithral river stretches of middle elevations, more distant from source). Water temperatures were lower and discharges were higher than those at the localities of group C. The fifth division (D5) separated final group G (the class *011, indicators *Ephemera danica, Baetis vernus, Ephemerella ignita, Baetis alpinus*, mainly localities of rhithral of the Labe basin) and followed by division of D10 separated class *010 into two final groups: E (*0100, indicator *Torleya major*, metarhithral stretches of the Morava and Odra basins with higher discharge rates) and F (*0101, indicator *Ephemerella mucronata*, epirhithral stretches predominantly in the Morava basin).

Class *1 (right side of dichotomy, Fig. 4) was divided into class *10 and class *11 (final group L with indicator *Potamanthus luteus*, potamal localities of the Labe and Morava basins).

The division D6 separated classes *100 and *101. Class *100 gave rise to classes *1000 and *1001. The former represents the final group H (indicators *Heptagenia flava, Procloeon bifidum* and *Ephemerella ignita*, localities of specific, nearly potamal character at lower elevations, with low slope), the latter class *1001 included rhithral localities predominantly of lower elevations, situated mostly in the Labe basin. The division D25 separated the final groups I (*10010, no specific indicator, brooks with sandy or gravel bottom,

Table 3. Hierarchic classification (TWINSPAN) of reference localities – two-way ordered table. For number of localities see Table 1, for full species names see Table 2, for characterisation of individual groups (A-L) see in the text.

No. of locality	13	12	14	1	15	69	76	80	38	43	53	50	39	40	46	47	48	52	55	57	70	42	35	34	65	51	41	54	44	62	61	75	60	67	73	49	59	56	66	63	68	77	Class of species
Species																																											
Ecdy suba	-	-	-	-	-	3	2	4	2	2	2	2	-	-	-	2	1	-	1	2	2	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	0 0 0
Rhit irid	2	-	-	-	2	3	-	4	2	3	-	2	1	-	2	3	-	2	1	-	2	3	3	2	1	2	-	2	-	3	-	-	-	-	-	1	-	-	-	3	-	-	0 0 0
Amel inop	-	3	2	-	-	-	-	-	-	-	-	1	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 0
Rhit loyo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 0
Rhit land	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 0
Ecdy veno	-	2	-	-	2	-	-	1	2	3	3	2	2	2	3	2	-	1	-	-	-	2	2	-	1	2	2	-	-	2	-	-	-	-	-	2	-	-	-	-	-	-	0 0 0
Baet mela	-	-	-	-	-	-	-	-	2	2	3	-	1	-	-	3	-	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	0 0 0
Ecdy forc	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 0
Ecdy aust	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 0
Epeo sylv	-	-	-	-	3	-	-	-	2	2	2	2	3	3	2	2	2	2	3	2	2	3	2	-	2	3	2	2	3	3	2	3	1	-	3	2	3	3	1	2	-	-	0 0 0
Rhit carp	-	-	-	-	-	-	2	-	-	3	3	2	2	2	1	3	2	3	-	2	3	2	-	-	2	2	-	1	2	3	-	-	-	2	2	2	3	3	4	3	1	-	0 0 0
Ecdy star	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	3	3	-	0 0 0
Elec quad	-	-	-	-	-	2	2	3	2	2	1	2	-	-	1	-	-	1	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	2	2	0 0 1
Baet alpi	4	4	4	3	5	1	-	-	2	2	2	2	3	3	4	4	3	3	3	-	2	3	4	3	2	2	2	2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1
Ephe mucr	-	-	-	2	3	-	-	1	-	2	-	1	2	1	3	2	2	2	-	3	2	-	-	-	-	-	-	-	1	-	-	-	2	2	2	1	3	2	2	2	-	-	0 0 1
Habr conf	2	-	-	-	2	3	-	2	1	2	1	2	2	2	1	2	3	-	2	2	2	3	3	3	2	-	-	-	-	3	3	2	4	1	3	2	4	3	3	5	2	-	0 0 1
Ecdy subm	-	-	-	-	-	-	-	-	2	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	2	-	0 1 0
Rhit semi	2	-	-	-	-	-	-	-	-	2	-	1	1	-	-	-	1	3	2	-	2	2	4	3	2	2	2	-	-	-	1	2	2	-	3	-	3	-	-	-	-	2	0 1 0
Baet rhod	5	4	3	3	3	3	4	4	3	4	2	3	4	3	3	2	3	2	2	4	3	3	4	3	3	3	2	3	3	3	4	5	4	3	5	4	5	5	4	4	4	3	0 1 0
Alai muti	-	-	-	-	2	2	-	2	2	3	-	2	2	3	5	2	2	2	1	3	2	1	-	2	-	2	2	2	2	2	3	2	2	-	3	2	3	-	-	2	-	-	0 1 0
Siph lacu	-	-	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 1 0
Elec late	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 1 1
Elc affi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 1 1
Caen pseu	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	2	2	-	-	-	-	-	-	-	-	-	0 1 1
Habr laut	-	-	-	-	2	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	2	3	-	-	1	-	-	-	-	2	2	1	2	1	2	2	-	1	1	3	1	2	0 1 1
Baet vern	-	4	3	2	4	-	-	-	-	2	2	2	-	-	-	-	-	2	1	-	-	-	4	-	-	1	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2	-	1 0 0
Ephe dani	-	-	-	-	-	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	1	2	1 0 0
Ephe igni	-	-	-	-	4	-	-	-	-	2	-	-	3	-	-	-	1	-	-	-	1	2	-	-	-	2	-	2	2	2	-	-	3	2	2	2	2	2	1	2	2	1	1 0 0
Torl majo	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	2	-	-	1	2	2	2	2	-	-	-	-	-	-	-	2	-	-	1 0 0
Ecdy torr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	3	1	2	3	2	-	3	-	2	-	-	1	1	2	1 0 0
Ecdy aura	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1 0 1
Baet luth	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	2	-	2	-	-	1 0 1
Habr fusc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1 1 0
Baet bucc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	-	-	-	-	-	-	-	-	-	-	1 1 0
Baet scam	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Rhit herc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Rhit besk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Lept vesp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Rhit germ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Cloe dipt	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Para subm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	1	-	1 1 0
Lept marg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Nigr nige	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Siph aest	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Ecdy disp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Rhit savo	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Siph arma	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Cent lute	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Ephe vulg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Cent penn	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Baet calc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Brac hari	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Hept long	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Para cinc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Ecdy insi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Hept fusc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Chor pict	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Siph alte	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Baet fusc	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	1 1 1
Proc bifi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 1
Ephe nota	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 1
Ephe line	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 1
Hept sulp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 1
Caen rivu	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 1
Olig rhen	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 1
Pota lute	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 1
Caen luct	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 1
Epho virg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 1
Hept coer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 1
Hept flav	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 1
Caen macr	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 1
Group of loc.	A	A	A	A	A	B	B	B	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D	E	E	E	E	F	F	F	F	F	F	F	F	F	F	

Table 3 (cont.)

No. of locality	3	30	18	25	5	2	7	27	37	32	8	9	11	10	36	19	20	24	22	23	29	71	78	4	16	17	31	6	26	64	74	45	58	33	21	28	72	79	Class of
Species																																							
Ecdy suba	-	2	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 0
Rhit irid	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	0 0 0
Amel inop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 0
Rhit lovo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 0
Rhit land	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 0
Ecdy veno	-	-	2	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	0 0 0
Baet mela	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 0
Ecdy forc	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 0
Ecdy aust	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 0
Epeo sylv	-	2	2	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	3	2	-	-	-	-	-	-	2	-	-	-	-	-	-	0 0 0
Rhit carp	2	-	-	3	2	2	2	2	-	2	-	-	-	-	1	2	-	-	-	-	-	-	2	-	-	-	-	-	-	3	-	-	1	-	-	-	-	-	0 0 0
Ecdy star	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	0 0 0
Elec quad	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1
Baet alpi	4	3	3	3	3	-	-	-	-	3	2	-	-	-	-	-	-	-	-	-	-	-	-	3	4	4	4	4	-	-	-	-	-	-	-	-	-	-	0 0 1
Ephe mucr	-	2	3	2	2	2	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2	2	2	2	2	1	-	-	-	-	-	-	-	0 0 1
Habr conf	-	3	3	2	2	3	3	2	3	3	2	-	-	-	3	3	3	-	3	3	3	3	-	2	2	2	3	2	-	3	1	3	-	2	-	-	-	-	0 0 1
Ecdy subm	-	-	-	-	-	-	-	1	-	2	2	-	-	-	-	2	-	-	2	-	-	-	-	-	-	-	2	-	-	-	2	-	-	-	-	-	-	-	0 1 0
Rhit semi	-	3	3	2	3	2	3	-	2	-	-	-	-	2	2	4	2	3	-	-	2	3	-	2	3	2	3	2	2	-	3	-	1	-	-	-	-	-	0 1 0
Baet rhod	3	5	4	4	4	4	5	3	3	4	5	-	4	4	3	5	4	5	4	4	4	4	5	5	4	-	4	5	4	3	4	2	3	3	-	4	2	2	0 1 0
Alai muti	2	-	2	-	2	2	-	2	-	2	2	-	3	-	2	3	2	4	2	3	2	-	-	-	3	2	3	-	2	-	-	-	-	2	-	2	-	-	0 1 0
Siph lacu	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2	-	-	-	-	-	-	-	-	-	-	0 1 0
Elec late	-	-	-	-	-	2	3	2	-	-	2	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	2	-	-	-	-	1	-	-	-	-	0 1 1
Ele affi	-	-	-	-	2	-	-	2	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-	-	0 1 1
Caen pseu	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	-	-	-	2	2	-	-	-	0 1 1
Habr laut	-	-	-	2	2	2	2	2	-	-	3	-	3	-	-	3	-	2	3	2	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	0 1 1
Baet vern	3	3	4	3	-	3	4	3	3	4	-	3	4	4	4	-	4	4	3	4	3	1	-	4	-	-	3	4	-	1	2	-	-	4	2	-	-	-	1 0 0
Ephe dani	4	4	3	3	-	3	3	3	3	4	5	-	4	4	4	4	3	4	3	3	3	2	2	3	4	3	-	3	3	2	-	-	-	-	-	3	-	-	1 0 0
Ephe igni	3	4	-	3	3	3	2	3	2	3	3	4	5	4	4	-	3	5	3	4	3	3	4	4	4	3	3	3	4	2	2	2	2	3	4	4	2	1	1 0 0
Torl majo	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	3	-	-	1	-	-	2	-	-	2	-	2	1	2	-	2	-	-	-	-	-	1 0 0
Ecdy torr	2	-	-	2	1	-	-	-	-	-	-	-	3	-	-	3	3	4	1	2	2	-	2	2	2	1	3	-	2	3	2	3	-	-	-	-	-	-	1 0 0
Ecdy aura	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	1	1 0 1
Baet luth	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	2	1	-	2	2	-	2	2	2	1	1 0 1
Habr fusc	-	-	-	-	-	-	-	2	-	-	-	-	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	1 1 0
Baet buce	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	2	2	2	-	-	-	-	2	1 1 0
Baet scam	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2	-	-	-	-	2	3	3	2	-	-	-	-	-	1 1 0
Rhit herc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Rhit besk	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	2	-	-	-	-	-	-	-	2	-	-	-	-	2	-	-	-	-	-	-	-	-	-	1 1 0
Lept vesp	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	1 1 0
Rhit germ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	1 1 0
Cloe dipt	-	-	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1 1 0
Para subm	2	3	-	2	-	2	2	2	-	-	-	2	4	2	-	3	3	3	3	3	2	2	2	2	2	2	-	3	-	-	-	2	1	-	-	-	-	-	1 1 0
Lept marg	-	-	2	2	-	2	-	-	-	-	-	2	-	-	2	4	-	3	-	-	-	-	-	-	2	-	2	2	2	-	-	-	-	-	-	-	-	-	1 1 0
Nigr nige	2	2	2	2	-	-	-	-	-	-	-	4	-	3	-	2	1	2	-	2	-	3	-	-	3	3	3	3	3	-	-	-	-	-	-	-	-	-	1 1 0
Siph aest	-	-	2	2	-	-	-	-	-	-	-	2	-	2	-	3	3	-	-	-	-	-	-	-	-	3	-	4	2	-	-	-	-	-	-	-	-	-	1 1 0
Ecdy disp	2	2	-	-	-	-	-	2	-	3	-	-	-	-	2	3	3	3	-	2	2	2	2	2	3	2	3	-	2	2	-	2	2	-	-	-	-	-	1 1 0
Rhit savo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	2	-	2	-	-	-	-	-	-	-	-	-	-	1 1 0
Siph arma	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Cent lute	-	-	-	-	-	-	-	-	-	-	3	2	4	2	-	-	3	4	2	3	1	1	-	-	3	-	-	3	2	-	-	-	-	-	2	-	-	-	1 1 0
Ephe vulg	-	-	-	1	-	-	-	-	-	-	-	2	3	-	-	2	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Cent penn	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Baet calc	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Brac hari	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Hept long	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Para cinc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	1 1 0
Ecdy insi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	3	-	-	-	-	-	-	-	-	-	1 1 0
Hept fusc	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	2	2	-	-	-	-	-	-	-	-	-	1 1 0
Chor pict	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	1 1 0
Siph alte	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1 1 0
Baet fusc	-	2	-	2	-	-	-	-	-	-	-	3	3	-	2	2	-	-	-	3	3	-	-	4	3	3	3	-	4	4	2	-	-	4	3	3	3	3	1 1 1
Proc bifi	-	-	-	-	-	-	-	-	-	-	2	2	2	2	-	-	-	-	-	-	2	-	-	-	-	-	-	2	-	-	-	-	-	2	2	-	-	-	1 1 1
Ephe nota	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	1 1 1
Ephe line	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1 1 1
Hept sulp	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	-	-	-	-	2	-	-	2	-	-	-	3	2	2	-	2	-	-	3	3	3	2	3	1 1 1
Caen rivu	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1 1 1
Olig rhen	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-	2	1 1 1
Pota lute	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	2	3	3	4	4	1 1 1
Caen luct	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2	-	-	-	-	-	2	-	2	2	1 1 1
Epho virg	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	2	1 1 1
Hept coer	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	1 1 1
Hept flav	-	-	-	-	-	-	-	-	-	-	-	3	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	3	-	2	1 1 1
Caen macr	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	3	2	3	-	3	-	-	-	-	-	-	-	-	3	-	-	2	-	3	3	3	3	2	1 1 1
Group of loc.	G	G	G	G	G	G	G	G	G	G	G	H	H	H	H	I	I	I	I	I	I	I	I	J	J	J	J	J	J	K	K	K	K	L	L	L	L	L	

mainly of the Labe basin and those of the Morava basin situated close to the watershed) and J (*10011, indicators *B. alpinus* and *E. mucronata*, localities of meta- and hyporhithral of the Labe basin). These two groups differed in discharge rates. The final group K (*101, indicator *B. buceratus*, comprised hyporhithral/epipotamal stretches of the Morava and Odra basins). For detail species composition of individual taxocenes see Tab. 3, for summary of important environmental variables and parameters evaluated with respect to TWINSPAN groups see Tabs. 4 and 5.

Table 4. Summary of important variables evaluated with respect to TWINSPAN groups – environmental variables. Order of values: minimum, maximum, (median), average (if present). L – Labe River basin, M – Morava River basin, O – Odra River basin.

TWIN-SPAN group	No. of localities	River basin	Distance from source [km]	Altitude [m]	Slope [m.km-1]	Mean width [m]	Maximal water temperature [oC]	pH minimal value
A	5	L	2.4, 18.7, (6.8)	490, 1020, (905)	15, 80, (30)	0.9, 7.5, (1.7)	11.8, 15.2, (13.5)	4.7, 6.2, (5.9)
B	3	M	1.7, 3.3, (2.2)	320, 425, (375)	30, 50, (50)	0.7, 1.2, (1.2)	12.9, 15.4, (14.9)	7.4, 7.9, (7.7)
C	16	L,O,M	0.5, 9.9, (3)	225, 770, (618)	20, 90, (55)	0.6, 8.0, (1.9)	10.2, 14.8, (12.2)	6.3, 7.7, (7.2)
D	4	O,M	1.5, 12.5, (8)	510, 620, (560)	20, 40, (30)	3.5, 9.0, (6.5)	11.5, 15.5, (12.1)	6.9, 7.5, (7.1)
E	4	O,M	7.5, 37.4, (17.9)	335, 620, (448)	10, 20, (18)	3.5, 8.0, (6.8)	17.0, 18.2, (17.9)	7.0, 8.1, (7.3)
F	10	O,M	2.1, 20.6, (4.4)	290, 615, (415)	10, 50, (20)	1.8, 5.0, (2.5)	13.0, 16.0, (15.0)	6.8, 8.0, (7.3)
G	11	L	0.5, 11.3, (8.9)	327, 659, (568)	5, 40, (10)	1.0, 5.5, (1.6)	13.5, 22.9, (19.1)	6.1, 6.9, (6.8)
H	4	L	17.7, 55.0, (42.4)	283, 432, (403)	5, 10, (5)	2.5, 6.0, (4.0)	16.2, 20.5, (19.1)	6.7, 7.2, (6.9)
I	8	L,M	1.4, 30.5, (9.9)	225, 650, (455)	5, 40, (10)	1.0, 10.0, (2.0)	16.0, 23.1, (17.2)	6.6, 7.0, (6.9)
J	6	L	14.7, 93.7, (49.9)	279, 748, (464)	5, 20, (8)	3.0, 15.0, (6.0)	15.6, 24.5, (18.9)	5.8, 7.2, (6.7)
K	4	L,O,M	20.8, 45.5, (36.3)	255, 515, (340)	5, 5, (5)	10.0, 20.0, (11.6)	14.8, 23.6, (19.5)	7.2, 8.4, (8.2)
L	5	L,M	72.8, 179.6, (96.6)	185, 355, (348)	5, 10, (5)	9.0, 27.0, (20.0)	18.9, 23.1, (21.6)	6.7, 7.0, (6.9)

Canonical Correspondence Analysis (CCA)

Five statistically significant environmental variables, namely distance from source (correlated with the first ordination axis); minimum pH measured (correlated with the second ordination axis), altitude, slope and water temperature (summer maximum) were found. For general statistical characteristics (eigenvalues and percentage of variance) see Tab. 6.

Table 5. Summary of important parameters evaluated with respect to TWINSPAN groups – biodiversity measures. Order of values: minimum, maximum, (median), average (if present). L – Labe River basin, M – Morava River basin, O – Odra River basin.

TWIN-SPAN Group	No. of localities	River basin	No. of species N	Species richness D	Species diversity H'
A	5	L	5, 17 (5) 7.8	1.36, 5.24, (1.81)	1.63, 3.16, (1.96)
B	3	M	4, 9 (8) 7.0	1.21, 2.89, (2.71)	0.88, 2.43, (2.04)
C	16	L,O,M	8, 16 (11) 11.4	2.61, 5.65, (3.29)	1.68, 3.00, (2.46)
D	4	O,M	7, 14 (10) 10.3	3.22, 5.70, (4.10)	2.26, 2.93, (2.55)
E	4	O,M	11, 14 (11) 12.0	3.63, 4.79, (4.07)	1.79, 2.94, (2.64)
F	10	O,M	7, 15 (10) 10.4	2.49, 4.75, (3.41)	1.65, 2.75, (2.20)
G	11	L	6, 21 (13) 13.2	3.13, 6.60, (4.12)	2.62, 3.51, (2.81)
H	4	L	14, 20 (15) 16.0	4.27, 6.20, (4.66)	2.77, 3.38, (3.16)
I	8	L,M	10, 19 (15.5) 14.8	2.99, 6.03, (4.55)	1.16, 3.62, (3.19)
J	6	L	18, 27 (21) 21.3	5.72, 8.47, (6.41)	3.26, 3.82, (3.72)
K	4	L,O,M	11, 16 (12.5) 13.0	4.17, 5.58, (4.96)	2.67, 3.12, (2.94)
L	5	L,M	8, 15 (14) 12.6	2.70, 5.15, (4.71)	1.99, 3.15, (2.79)

Depicting of respective envelopes of the TWINSPAN classification groups of localities (A-L in Fig. 5) shows evident differences in their nature. Rhithral localities (e.g. groups A or C) are situated at the left side of the diagram, potamal one (group L) at the right side. Localities of the rhithral/potamal transition zone (e.g. group K) occupy the central part. Upper part of the diagram (Fig. 6) comprises mainly the Labe basin localities, lower part mainly the Odra and the Morava basins localities. This distribution is due mainly to rather low values of pH in the Labe basin caused by geological conditions and effects of peat-bog waters in comparison with the Morava and Odra basins. Moreover, the localities of TWINSPAN group A (high elevations of the Labe basin, lower pH) are situated in the left upper quadrant. The localities of the groups B (small streams of the Morava basin Carpathians), D (epirhithral of the Morava and Odra basins, higher discharges), F (epirhithral of the Morava basin), and most of localities of the group E (metarhithral of the Morava and Odra basins) are situated in the left lower quadrant. The group C (cold epirhithral brooks of higher coline zone of all basins, but predominantly of the Odra basin) is located on the left side of diagram but just in intermediary position. The group G (consisting of rather not clearly defined rhithral localities of the Labe basin) occurs just in the central part of the diagram. The group H (specific localities of lowland rivers) is situated at the right lower part of the diagram, very closely to groups G and I. The group K (localities of hyporhithral/epipotamal of the Morava and Odra basins) is placed in the same quadrant although more distally owing to its transitional character. Similar localities of the Labe basin (group J) are situated mainly in the right upper quadrant. The group L (typical potamal sites) is located also in this quadrant but shifted positively along the first ordination axis.

Table 6. Eigenvalues and percent variance explained for the first four ordination axes of CCA

Axis	Eigenvalue	% variance
1	0.494	8.4
2	0.352	14.4
3	0.245	18.6
4	0.098	20.3

Sum of all canonical eigenvalues: 1.245
Monte Carlo permutation test, 999 perm.

Differences between the Labe basin on one hand and the Odra+Morava basins on the other hand are very apparent from the ordination the whole set of localities (Fig. 6). The envelope comprising the Labe basin localities is conspicuously shifted to the upper part of the diagram, only partially superimposing those of the Odra+Morava basin localities. Moreover, the position of the Odra basin localities indicated close relationships to the Morava basin.

Ordination of species is apparent from Figs. 7 and 8. The positions of individual species clearly depend on the distribution of environmental variables. For instance, *Electrogena quadrilineata* or *Ecdyonurus subalpinus* are situated at the left lower quadrant preferring places in short distance from source, middle elevations and slope, lower water temperature and higher pH. On the other hand, the potamal species *Potamanthus luteus* is located distally at the right side of diagram. This position means preferences of places at long distance from source, localities at low elevations with minimal slope higher pH and high summer water temperatures.

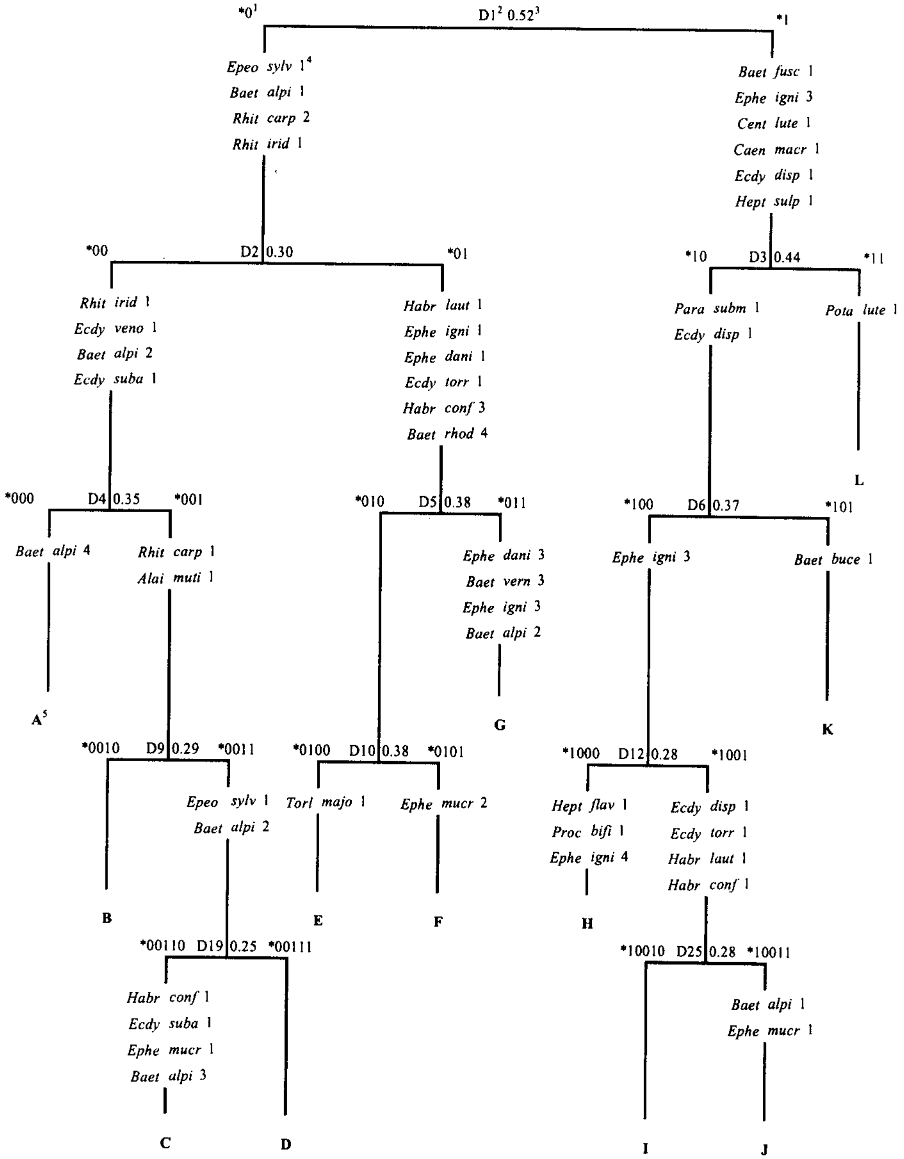

Fig. 4. Hierarchic classification (TWINSPAN) of reference localities and associated indicator species. For abbreviations of indicator species names see Table 2, for definition of individual groups (A -L) see the text.
[1] TWINSPAN class, [2] No. of division, [3] eigenvalue, [4] pseudospecies cut level

HOBENT

The complete data set (80 localities, 71 species) formed the reference database. HOBENT was used to verify that mayfly communities could be predicted from the reference database. Further thirteen rhithral samples taken at the localities different from the above reference data set were tested (No. C1-C13, see Tab. 7). A wide spectrum of information on

Table 7. List of control localities with basic characteristics and results of evaluation of control localities by HOBENT. L – Labe River basin, M – Morava River basin, O – Odra River basin. For definition of individual groups (A - L) see in the text.

No. of loca-lity	Name of watercourse	Sampling site	Basin	Distance from source [km]	Alti-tude [m]	Slope [m.km^{-1}]	Mean width [m]	Max. water temperature [°C]	pH minimal	Conduc-tivity [μS.cm^{-1}]	No. of species expected	No. of species found	Coeffi-cient B	TWINSPAN Group	TWINSPAN Probability %
C1	Mumlava	Muml. Bouda	L	5.5	705	40	7.5	10.1	5.5	150	3.4	2	0.59	A	100.0
C2*	Chomutovka River	Chomutov	L	12.7	382	15	3.0	16.2	12.7	286	10.2			I	81.4
														G	14.1
C3	Bystřice River	Komárov	L	21.7	235	10	4.0	25.6	21.7	600	8.7	1	0.11	H	91.2
C4	Vltava River	Rožmberk	L	120.6	528	5	8.0	18.9	120.6	225	8.6	1	0.12	L	99.8
C5	brook	Pernštejn	M	1.5	400	30	1.4	14.4	1.5	390	5.6	5	0.89	B	98.0
C6	Bystřice River	Tesák	M	1.7	560	50	1.5	14.9	1.7	186	7.1	9	1.27	F	94.6
C7	Oskava River	Bedřichov	M	4.2	550	50	1.5	12.5	4.2	75	8.6	8	0.93	C	95.0
C8	Habřina Brook	Zastávka	M	6.3	350	20	2.6	14.5	6.3	560	5.7	3	0.53	B	99.9
C9	Gránický Brook	Znojmo	M	7.9	285	15	2.5	16.0	7.9	950	5.7	3	0.53	B	100.0
C10	Luha Brook	Sloup	M	8.6	540	20	3.0	18.0	8.6	250	7.9	5	0.63	E	87.6
C11	Velička River	Louka	M	20.0	260	10	6.0	22.4	20.0	500	8.6	4	0.47	E	93.4
C12	Křetínka River	Letovice	M	29.0	361	10	4.2	16.0	29.0	450	8.7	2	0.23	H	98.8
C13	Oslava River	Náměšť	M	65.1	360	10	16.0	18.0	65.1	410	8.2	6	0.73	K	99.9

* included in 2 TWINSPAN groups

environmental variables (e.g. physico-chemical analyses, discharge rates etc., for the most important variables see Tab. 7) of these control localities was gathered, so that the degree of their denaturalisation could be evaluated independently of species composition. Taxocenes of the two control localities (No. C5 and C7, see Tab. 7) were classified as very similar to the predicted ones (B > 0.8). Favourable results agree with real status - these localities might in fact represent further (not yet used) background localities. Control locality C13 was classified as less similar to predicted one (B = 0.73). The influence of water reservoir and moderate organic pollution influenced species composition of this locality. Control localities No. C3 and C12 represent strongly disturbed river stretches (B < 0.4), e.g. the C12 is influenced by combined effects of extreme discharge rates (situated below dam) and municipal wastewater. Locality C10 represents moderately influenced biotope, localities C8 and C11 heavily influenced ones. Localities C4 and C9 are examples of a certain weakness of the reference database – respective types of these localities are missing from the reference database. For example, the locality No. C9 represents only slightly disturbed lowland brook, a very rare biotope in the Morava basin not yet included into the reference database and thus the value of B coefficient (0.53) does not express the real status. On the other hand, loc. No. C6 is a Carpathian brook of very high species richness even higher than those of localities used. The locality was selected as an example of situation, when value of

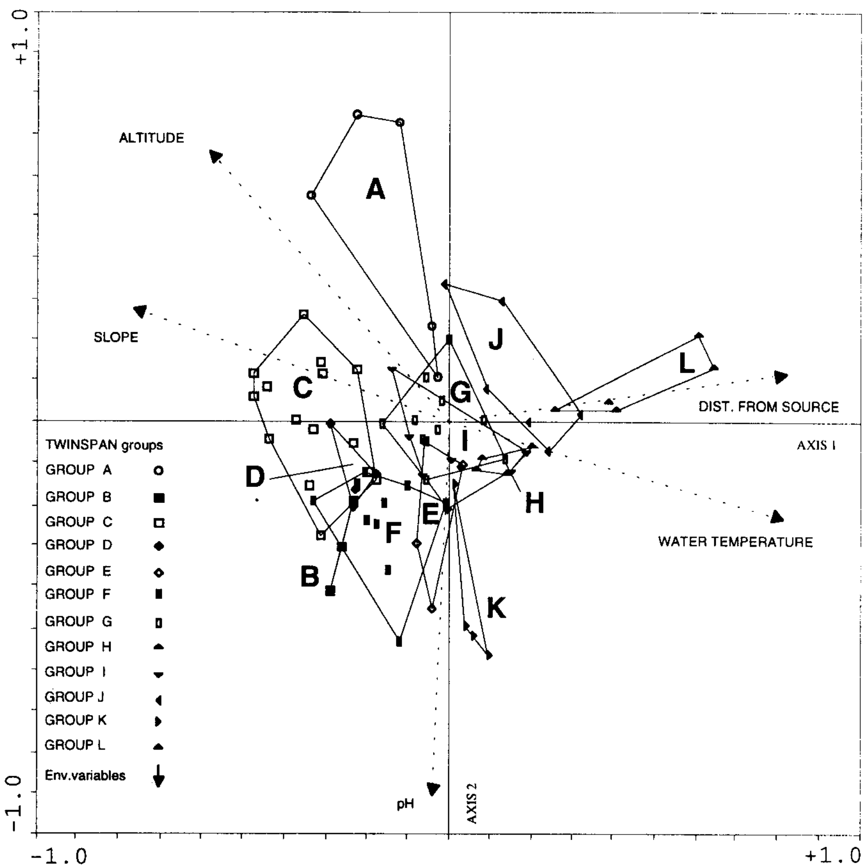

Fig. 5. Canonical correspondence analysis (CCA), ordination plot of localities, species and main environmental variables on the first two CCA axes with envelopes showing TWINSPAN groupings.

coefficient B > 1 can be reached. The localities C1 and C2 are examples of deterioration by acidification. These extremes underscore the necessity of large-scale reference localities, comprising all types of aquatic biotopes actually present in the interest area.

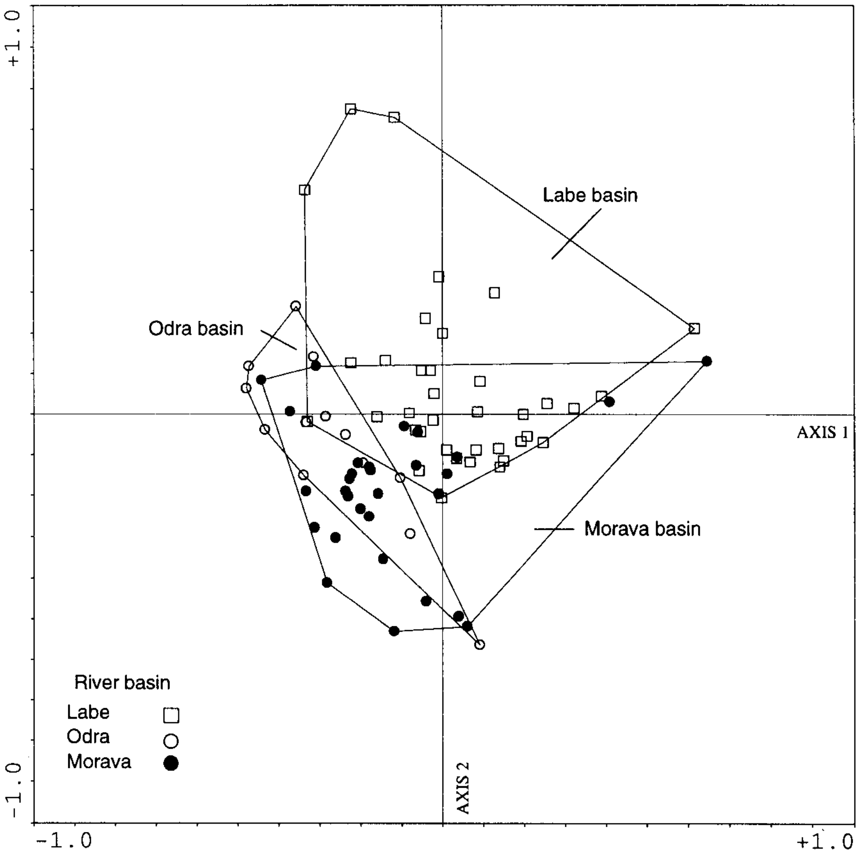

Fig. 6. Canonical correspondence analysis (CCA), ordination plot of localities on the first two CCA axes with envelopes grouping localities of the Labe River, the Morava River and the Odra River basins.

DISCUSSION AND CONCLUSIONS

Several attempts to classify the mayfly taxocenes in the area studied have been made. For instance, Zelinka (1953) distinguished 6 running waters zones according to the occurrence of characteristic genera: the *Ameletus* zone (hypocrenal), *Rhithrogena* zone (epirhithral), *Ecdyonurus* zone (meta- and hyporhithral), *Oligoneuriella* zone (epipotamal) and *Ephoron* zone (metapotamal). This classification, although roughly corresponding to that by Illies and Botosaneau (1963), seems to be based mostly on empirical estimations of dominance, and moreover, only at the generic level. Since then a lot of information on mayfly species distribution, life cycles, habitat preferences, interspecific interactions and origin and chorology has been summarised by Landa (1969, 1984), Landa and Soldán (1981, 1982, 1985, 1989, 1995), Landa et al. (1997), Soldán (1992), Zelinka (1953), Zelinka and

Skalníková (1959), Krpal and Zelinka (1990) and an attempt to predict the long-term development of taxocenes has been made (Lepš et al., 1989, 1990) in the Czech Republic. Krno and Šporka (1991), Krno et al., (1994) and Deván and Mucina (1986) studied similar problems in the Danube basin in Slovakia. However, even this large amount of information allows little more than intuitive assessment of taxocoenoses expected at a particular locality. In contrast, we believe the combination of TWINSPAN and CCA classification better defines the differences in taxocenes among river basins. By taking into account principal environmental variables, these differences are clearly seen e.g. from shifts of respective localities envelopes. Apart from several exceptions, TWINSPAN groups presenting rhithral consisted either of the Labe basin localities or of the Morava+Odra basin localities where differences are not so pronounced (cf. Mergl, 1997, Soldán et al., 1998, see also Tab. 3, and Fig. 4). For instance, *Siphlonurus alternatus, Baetis calcaratus* and *Leptophlebia vespertina* are known from the Labe basin only. Quantitative presentation of e.g. *Rhithrogena carpatoalpina, Alainites muticus* and *Habrophlebiá lauta* seems to be higher in the Morava basin, that of e.g. *Paraleptophlebia submarginata* in the Labe basin. Due to a lot of Hercynian mountain system elements in the Czech part and the Carpathian and/or Pannonian elements in the Danube basin, these differences become even more apparent (cf. Krno and Šporka, 1991, Krno et al., 1994, Deván and Mucina, 1986). The variations of the species composition of the Czech rivers were found depending on basin (cf. Tab. 4) and even, within the same basin, on different biogeographic subprovinces (Soldán et al., 1998).

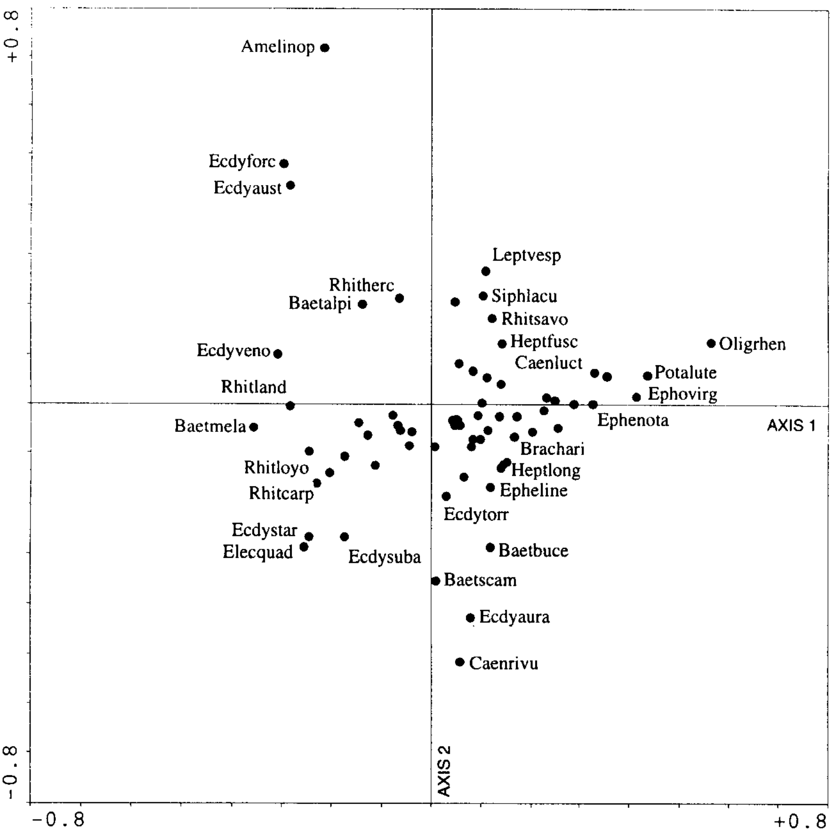

Fig. 7. Canonical correspondence analysis (CCA), ordination plot of species on the first two CCA axes. For full species names see Table 2.

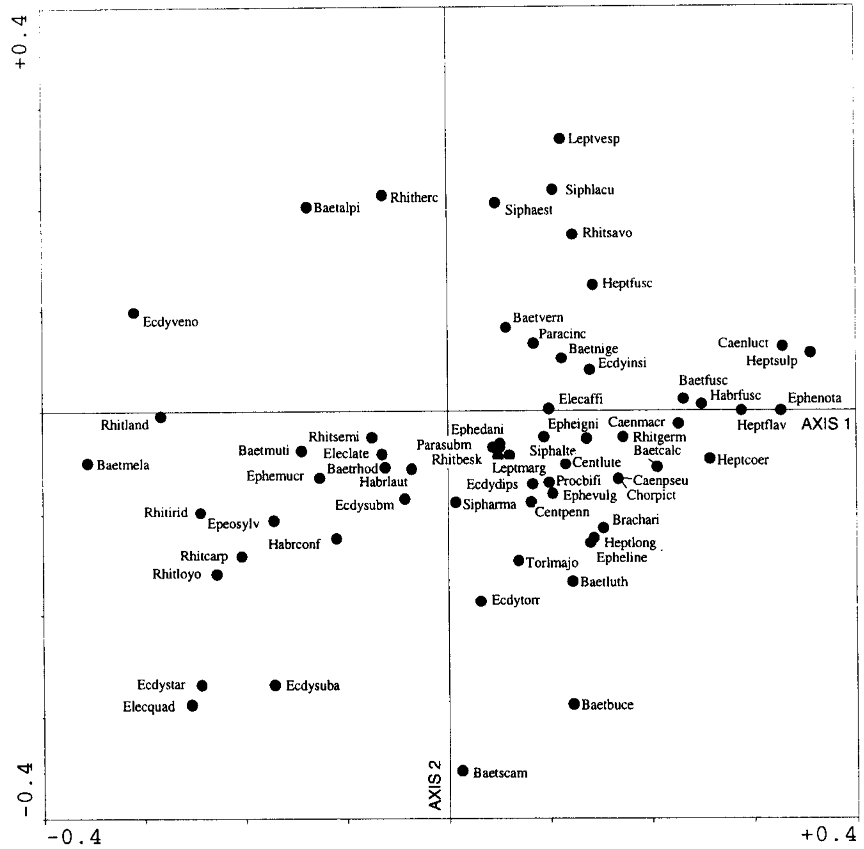

Fig. 8. Canonical correspondence analysis (CCA), ordination plot of species on the first two CCA axes - central part of ordination plot. For full species names see Table 2.

Consequently, an unambiguous ecoregional approach seems to be required for the proposed model because even in such relatively restricted area, as former Czechoslovakia presents. Moreover, lack of some type of biotope may lead to misclassification and the establishment of database of reference localities covering the whole area of investigation and all biotopes types seems to be necessary.

In the Czech Republic, the occurrence of 97 mayfly species has been documented so far (Soldán et al., 1998); however, at least 3 species are considered extinct. Of the remaining 94 species, 71 were found and are contained in this data set. We recommend determination at the species level when differentiating spatial distribution of taxocenes. This enables higher accuracy of predictions, allows more precise definition of locality status and it is also advantageous for environmental conservation management.

This study illustrates that intensity of river deterioration (and/or restoration) can be evaluated by the prediction model HOBENT, i.e. by comparison of target and actual status, even by using only mayflies rather than the entire macroinvertebrate community. Naturally, like in other macroinvertebrate groups, mayflies cannot be used to evaluate spring areas (crenal), peat bogs water, and acidified and heavily polluted stretches because these biotopes usually lack mayflies. Hence, we expect that complete macroinvertebrate community composition will be preferred for practical application. The necessity of a large-scale database of localities comprising all main types of biotopes and covering the entire interest area was demonstrated. Despite some reservation, we believe the total number of 400 background localities (planned to be evaluated during the first and second phase of the project in 1997 - 2001) will be sufficient for successful application of this prediction model in the Czech Republic.

ACKNOWLEDGMENTS

This research was supported by the grant of the Council of the Government of the Czech Republic for Research and Development No. 510/2/96 and partly by the Research Project No. S5007015 of the Grant Agency of the Academy of Science of the Czech Republic. We would like to sincerely thank Prof. J. Stanford, Flathead Lake Biological Station, The University of Montana, for critical review of the manuscript. Our thanks are due to Prof. F. Kubícek and Prof. R. Rozkošný for encouragement and consultations and Dr. E. Domínguez who carefully revised final version of manuscript. We wish to thank also Dr. A. Mergl for data from the Odra river basin, and Dr. J. Schenková for technical assistance.

REFERENCES

Armitage, P. D., D. Moss, J. F. Wright and M. T. Furse. 1983. The performance of a new biological water quality score system based on macroinvertebrates over a wide range of unpolluted running-water sites. Water Res. 17 (3): 333-347.

Culek, M. 1996. (Ed.) Biogeographical classification of the Czech Republic. Enigma, Praha, 347 pp. (in Czech, English summary)

Demek, J. 1987. Geographical lexicon of Czech Republic. Mountains and lowlands. Academia, Praha, 584 pp. (in Czech)

Deván, P. and L. Mucina. 1986. Structure, zonation and species diversity of the mayfly communities of the Belá basin, Slovakia. Hydrobiology, 135: 155-165.

Hill, M. O. 1979. TWINSPAN - A FORTRAN program for arranging multivariate in an ordered two-way table by classification of the individuals and attributes. Cornell University Press, Ithaca, N. York, 99 pp.

Illies, J. and L. Botosaneanu. 1963. Problèmes et méthodes de la classification et de la zonation écologique des eaux courantes, considerées surtout du point de vue faunistique. Mitt. Int. Ver. Limnol. 12: 1-57.

Klecka, W. R. 1975. Discriminant analysis, pp- 434-467. In: N. H. Nie, C. H. Hull, J. G. Jenkins, Steinbrenner and D. H. Bent (eds.). SPSS Statistical Package for Social Sciences. McGraw-Hill, New York.

Kokeš, J. 1997. Evaluation of the influence of anthropogenic factors on chosen components of biocoenoses of running waters. Report, Water Research Institute T.G.M. Prague, Dept. Brno, 32 pp. (in Czech)

Krno, I. and F. Šporka. 1991. Some notes on hydrobiological investigations in the Turiec river basin. Acta Fac. Rerum nat. Univ. Comenianae - Zoologia. 35: 71-76.

Krno, I., D. Illéšová and J. Hagaloš J. 1994. Temporal fauna of the Gidra Brook (Little Carpathians, Slovakia). Acta Zool. Univ. Comenianae. 38: 35-46.

Krpal, J. and M. Zelinka. 1990. Statistical evaluation of some effects on distribution of macrozoobenthos of running water. Scripta Fac. Sci. nat. Univ. Purk. Brun., Biologia, 20 (9-10): 451-460.

Landa, V. 1969. Jepice - Ephemeroptera. Fauna of Czechoslovakia, Vol. 18, Academia Praha, 352 pp. (in Czech, German Summary)

Landa, V. 1984. Studies on aquatic insects in Czechoslovakia with regard to changes in the quality of water in the last 20-30 years, pp. 317-321. In: V. Landa, T. Soldán and M. Tonner (eds.). Proc. IVth Int. Conf. Ephemeroptera Bechyne, Czechoslovak Academy of Sciences, Ceské Budejovice.

Landa, V. and T. Soldán. 1981. Some faunistic and biogeographic aspects of the mayfly fauna of the Hercynian and Carpathian mountain systems in Czechoslovakia (Ephemeroptera). Acta Mus. Reginaehradecensis, Suppl. 1980: 58-60.

Landa, V. and T. Soldán. 1982. Changes in distribution of mayflies (Ephemeroptera) in Bohemia with regards to the South Bohemian region during the past 20-30 years. Sbor. Jihoces. Muz. C. Budejovice., Prír. vedy, 22: 21-28 (in Czech).

Landa, V. and T. Soldán. 1985. Distributional patterns, chorology and origin of the Czechoslovak fauna of mayflies (Ephemeroptera). Acta ent. Bohemoslov., 82: 241-268.

Landa, V. and T. Soldán. 1989. Distribution of mayflies (Ephemeroptera) in Czechoslovakia and its changes in connection with water quality changes in the Elbe basin. Studie CSAV, 17, Academia, Praha, 172 pp. (in Czech, English summary).

Landa, V. and T. Soldán. 1995. Mayflies as bioindicators of water quality and environmental changes on a regional and global scale, pp. 21-30. In: Corkum L.D. and Ciborowski J.J.H. (Eds): Current Directions in Research on Ephemeroptera. Canadian Scholar's Press Inc., Toronto.

Landa, V., S. Zahrádková, T. Soldán and J. Helešic. 1997. The Morava and Elbe river basins, Czech Republic: a comparison of long-term changes in mayfly (Ephemeroptera) biodiversity, pp. 219-226. In: P. Landolt and M. Sartori (eds.). Ephemeroptera and Plecoptera: Biology-Ecology-Systematics. Mauron, Tinguely and Lachat, CH-Fribourg.

Lepš, J., T. Soldán and V. Landa. 1989. Multivariate analysis of compositional changes in communities of Ephemeroptera (Insecta) in the Labe basin, Czechoslovakia - a comparison of methods. Coenoses, 4: 39-37.

Lepš, J., T. Soldán and V. Landa. 1990. Prediction of changes in ephemeropteran communities - a transition matrix approach, pp. 281-287. In: I. C. Campbell (ed.). Mayflies and Stoneflies. Life Histories and Biology. Kluwer Academic Publ., Dordrecht.

Margalef, R. 1958. Information theory in ecology. Gen. Syst. 3: 36-71.

Mergl, A. 1997. Characteristic mayfly taxocoenes of epirhithral of the Odra river basin. Diploma thesis, Dept. of Zool. and Ecol., Masaryk Univ. Brno, 81 pp. (in Czech).

Shannon, C. E. and W. Weaver . 1963 Mathematical Theory of Communication. University of Illinois Press, Urbana, 182 pp. Sládecek V. (1973) System of water quality from the biological point of view. Arch. Hydrobiol./Ergebn. Limnol., 7: 1-218.

Soldán, T. 1992. Mayflies - Ephemeroptera. In: Red Book of Endangered and Rare Species and Plants of Czechoslovakia. Príroda, Bratislava, pp. 60-62. (in Czech).

Soldán, T., S. Zahrádková, J. Helešic, L. Dušek and V. Landa. 1998. Distributional and quantitative patterns of Ephemeroptera and Plecoptera in the Czech Republic: a possibility of detection of long-term environmental changes in aquatic biotopes. Folia Fac. Sci. nat. Univ. Masaryk. Brunensis, Biologia 98, 305 pp.

Ter Braak, C. J. F. 1988. CANOCO an extension of DECORANA to analyse species environment relationships. Vegetatio 75: 159-160.

Wright, J. F. 1995. Development and use of a system for predicting the macroinvertebrate fauna in flowing waters. Aust. J. Ecol. 20: 181-197.

Wright, J. F., P. D. Armitage and M. T. Furse. 1989. Prediction of invertebrate communities using stream measurements. Reg. Rivers: Res. Manag. 4: 147-155.

Wright, J. F., M. T. Furse and P. D. Armitage. 1993. RIVPACS - a technique for evaluating the biological quality of rivers in the UK. European Water Poll. Cont. 3 (4): 15-25.

Zelinka, M. and P. Marvan. 1961. Zur Präzisierung der biologischen Klasifikation der Reinheit fliessender Gewässer. Arch. Hydrobiol., 57: 389-407.

Zelinka, M. and J. Skalníková J. 1959. To the knowledge of mayflies (Ephemeroptera) of the Morava river basin. Spisy prír. fak. Univ. Brno, 401: 89-96. (in Czech)

Zelinka, M. 1953. Larvae of mayflies (Ephemeroptera) of the Moravice River and their relationships to water quality. Práce Moravskoslez. akad. prír. ved., 25: 181-200. (in Czech).

Zelinka, M. and P. Marvan. 1961. Zur Präzisierung der biologischen Klasifikation der Reinheit fliessender Gewässer. Arch. Hydrobiol. 57: 389-407.