THE MORAVA AND ELBE RIVER BASINS, CZECH REPUBLIC: A COMPARISON OF LONG-TERM CHANGES IN MAYFLY (EPHEMEROPTERA) BIODIVERSITY

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The mayfly fauna of more than 200 localities in the Morava basin were sampled, 20 of them in detail in two periods, 1955-1959 and 1994-1995. Based on both the literature and recent faunal data the Elbe and Morava basins are compared. Of the 89 species found in both these areas, 15 occurred only in the Elbe basin and many further species were extremely rare in the Morava basin (enriched, however, by 5 Carpathian/Pannonian elements). Differences were due to more complicated topography and effects of glaciation in the Elbe basin. Indices of biodiversity and saprobity combined with Twinspan classification and ordination of 20 localities show similar trends in long-term changes in both basins.

INTRODUCTION

Except for a small part of North Moravia (Silesia) drained by the River Oder (Odra) and a negligible area belonging directly to the Danube basin in Bohemia, the principal part of Czech Republic is covered by the Morava and Labe (Elbe) river basins. While the Elbe basin in Bohemia has received considerable attention with regards to Ephemeropteran biodiversity (see monograph by LANDA & SOLDÁN, 1989) our knowledge of the Morava basin including the basin of the River Dyje (Thaya) has remained rather fragmentary, directed mostly to some particular watercourses (see e.g. STRAŠKRABA, 1966; ZELINKA, 1969, 1977; TUŠA, 1974; ADÁMEK & RAUŠER, 1977; OBRDLÍK *et al.*, 1979; KRNO, 1994; ZAHRÁDKOVÁ *et al.*, 1995, and others). Despite the intensive sampling programme carried out in 1955-1959 (mayflies collected mainly by M. Zelinka), no quantitative analyses covering the whole Morava basin have been published. To fill this gap, a large-scale programme, focused on biodiversity and changes in mayfly population dynamics, was started in 1993. The objective of this study is to publish initial data enabling detection of long-term changes in selected localities in the Morava basin and to compare species composition as well as trends in the deterioration of aquatic environment in both these principal river basins of the Czech Republic territory.

MATERIAL AND METHODS

In order to investigate species composition and distribution of mayflies more than 200 localities of the Morava basin were sampled in at least one season over the past 35 years (for detailed list of 175 localities see LANDA & SOLDÁN, 1989). Numerous additional localities are currently being sampled (see e.g. ZAHRÁDKOVÁ *et al.*, 1995; S. Zahrádková and J. Helešic, unpublished data). Twenty localities which had been investigated in 1955-1959 were chosen for detailed quantitative analysis. These localities, evenly distributed within the whole Morava basin in all the altitudinal zones of both rhithral and potamal of all bioregions (Fig. 1), were sampled in three seasons (spring, summer, early autumn). Their basic characteristics and location are given in Table 1. Semi-quantitative kicksamples of mayflies, supplemented by the collecting of larvae from submerged stones and vegetation, were taken. Sampling techniques generally correspond to those used previously in the Elbe basin (for details see LANDA & SOLDÁN, 1989).

The following indices were used to define some quantitative and qualitative changes of localities over the whole period (1950-1995) (Table 1): Shanon-Weaver index of diversity, Sörensen similarity index (percentage similarity) and index of saprobity according to SLÁDEČEK *et al.*

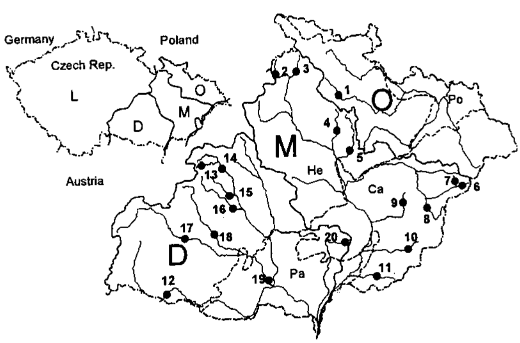

Fig. 1. Map of selected 20 localities of two periods of sampling in the Morava basin. Numbering of localities as in Table 2 and 3. Legend: river basins: L - Labe (Elbe), O - Odra (Oder), M - Morava, D - Dyje (Thaya), bioregions: He - Hercynicum; Ca - Carpathicum, Pa - Pannonicum, Po - Polonicum, lines: solid - watercourse, heavy solid - border of basin, dashed - border of bioregion, dashed/dotted - state border.

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Table 1. Basic characteristics of regularly sampled localities in the Morava basin. *Coordinates according to European uniform grid system.

No. of locality	Name of watercourse	Sampling site	Altitude m a.s.l.	Distance from source (km)	River basin	Bio-region	Coordinates *
1	MORAVICE	Malá Šťáhle	540	17.5	Odra	He	60-70
2	MORAVA	Červený potok	500	10 7	Morava	He	58-66
3	BRANNÁ	above Jindřichov	430	15.0	Morava	He	58-67
4	SITKA	above Šternberk	320	19.0	Morava	He	62-69
5	BYSTŘICE	above Hlubočky	335	36.5	Morava	He	63-70
6	VSET. BEČVA	above V. Karlovice	620	3.0	Morava	Ca	66-76
7	JEZERNÍ P.	above V. Karlovice	570	2.1	Morava	Ca	66-76
8	SENICE	above Leskovec	370	27.2	Morava	Ca	67-74
9	TRNÁVKA	Hrobice - Neubuz	290	9.0	Morava	Ca	67-72
10	OLŠAVA	above Pitín	375	2.2	Morava	Ca	69-73
11	VELIČKA	above Louka	260	20.0	Morava	Ca	71-70
12	DYJE	Frejštejn	355	97.5	Dyje	He	63-62
13	FRYŠÁVKA	above Kadov	690	4.0	Dyje	He	63-63
14	SVRATKA	above Unčín	515	45.3	Dyje	He	65-63
15	NEDVĚDIČKA	below Pernštejn	400	27.5	Dyje	He	66-64
16	LOUČKA	above D. Loučky	310	55.1	Dyje	He	68-69
17	JIHLAVA	Třebíč	390	80.0	Dyje	He	67-61
18	OSLAVA	Náměšť	360	65.1	Dyje	He	67-62
19	JIHLAVA	Ivářň	185	179.5	Dyje	Pa	70-65
20	KYJOVKA	above Staré Hutě	425	2.5	Dyje	Ca	68-69

(1981). In order to compare both the phases of sampling two methods of multivariate analysis were used (cf. LEPŠ *et al.*, 1989): (i) TWINSPAN (two-way indicator species analysis: HILL, 1979a) with these parameters: cut-off levels for pseudospecies at 0, 3, 30, 120 and 300; minimum group size for division 5; maximum number of indicators per division 7; maximum level of divisions 6; and (ii) DECORANA (detrended correspondence analysis: HILL, 1979b); data were detrended by the 2nd order polynomials and used as ln-transformations.

RESULTS

During the past 15 years 89 species of the order Ephemeroptera were collected in both Elbe and Morava basins at numerous localities. We failed to find 4 species considered to be extinct (*Isonychia ignota, Prosopistoma foliaceum, Palingenia longicauda* and *Ephemera glaucops). Ephemera glaucops* may well occur but was not recorded in this study. Differences between the two basins regarding occurrence of mayflies are given in Table 2. We wish to emphasize that we only present the differences in occurrence (negative or positive), not differences in abundance or number of localities inhabited.

At 20 selected localities investigated in the Morava basin, a total of 47 species were found during both sampling periods. Of these, 40 species occurred in 1950-1959. *Siphlonurus lacustris, Baetis niger, Centroptilum luteolum, C. pennulatum, Oligoneuriella rhenana, Ecdyonurus insignis, Electrogena lateralis, Heptagenia coerulans, Habrophlebia fusca, Choroterpes picteti, Paraleptophlebia submarginata, Ephemerella notata* and *Brachycercus harrisella* were not collected in the 1994-1995 period. In contrast, *Baetis buceratus, Procloeon bifidum, Ecdyonurus aurantiacus, E. dispar, Electrogena quadrilineata, Rhithrogena hercynia* and *Ephoron virgo* were newly collected in the recent study. Increases/decreases in number of species and specimens at individual localities are apparent from Table 3. The number of species has decreased in about half of the localities, while

Table 2. Mayfly species reported either from the Elbe or the Morava river basin within the past 35 years with notes on extinct species (marked with an asterisk).

Species	Collected only in the Morava basin	Collected only in the Elbe basin	Note
Siphlonurus alternatus	–	+	arcto-alpine disjunction
Baetis calcaratus	–	+	
B. digitatus	–	+	arcto-alpine disjunction
B. gemellus	–	+	
B. tracheatus	+	–	
Centroptilum nana	–	+	
**Isonychia ignota*	–(+)	–(+)	extinct (last record 1965 and 1898, respectively)
Arthroplea congener	–(+)	+	extinct in the Morava basin (last record 1965) arcto-alpine disjunction (?)
Ecdyonurus austriacus	–	+	
E. carpathicus	+	–	Carpathian element
E. starmachi	+	–	Carpathian element
Electrogena samalorum	–	+	
Heptagenia longicauda	–	+	
Rhithrogena landai	–	+	
R. puytoraci	+	–	Carpathian element (?)
R. zelinkai	–	+	
Ephemerella mesoleuca	+	–	South-Central European element or Pannonian (?)
Brachycercus harrisella	–	+	
Caenis pusilla	–	+	
**Proposistoma foliaceum*	–	–(+)	extinct, last record 1923
Leptophlebia vespertina	–	+	
**Palingenia longicauda*	–(+)	–	extinct, last record 1923 Pontic, eremial (?)
**Ephemera glaucops*	–	–(+)	extinct or probably so last record 1933 Atlanto-Mediterranean
E. lineata	–	+	
Total	5	14	plus 3 extinct species in each basin

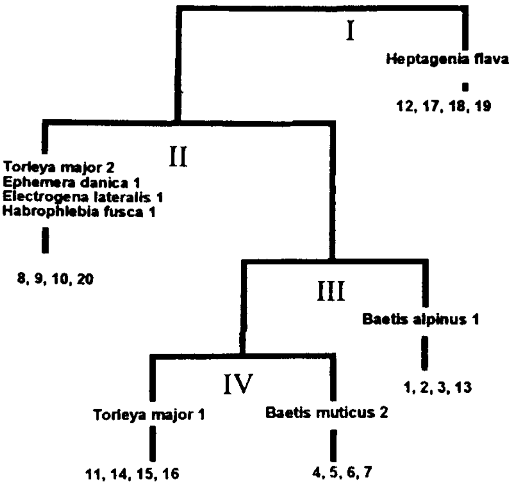

Fig. 2. Divisive hierarchic classification (TWINSPAN) of selected 20 localities in the Morava basin, based on data collected in 1955-1959 with indicator species shown.

Table 3. Principal qualitative and quantitative changes of mayflies at localities of the Morava basin (data from the second period of sampling, 1994 - 1995, in parentheses).

No. of locality	No. of species found	Decrease (-) or increase (+) of species	No. of individuals	H' Shannon-Weav. Ind. of diversity	P.S. similarity (%)	Si index of saprobity
1	8 (8)	0	159 (215)	2.15 (2.17)	62.5	0.9 (1.2)
2	9 (10)	+1	233 (158)	2.14 (2.62)	84.2	0.6 (0.8)
3	10 (10)	0	121 (154)	2.25 (2.28)	80.0	0.5 (1.1)
4	12 (10)	-2	342 (205)	2.37 (2.49)	63.6	1.4 (1.2)
5	10 (11)	+1	152 (369)	2.78 (2.61)	66.7	1.2 (1.4)
6	10 (14)	+4	135 (529)	2.74 (2.67)	66.7	1.3 (0.5)
7	8 (14)	+6	15 (769)	2.67 (2.65)	63.6	1.2 (1.0)
8	10 (16)	+6	437 (513)	1.64 (3.15)	46.2	1.3 (1.6)
9	9 (8)	-1	173 (238)	2.22 (2.17)	47.1	1.4 (1.3)
10	12 (8)	-4	338 (225)	2.33 (2.47)	60.0	1.1 (0.8)
11	6 (9)	+3	83 (112)	2.22 (2.44)	26.7	1.7 (1.8)
12	15 (7)	-8	405 (219)	2.95 (1.73)	54.5	1.8 (2.0)
13	8 (4)	-4	79 (104)	2.31 (1.38)	50.0	1.5 (2.0)
14	13 (11)	-2	136 (257)	2.27 (2.85)	66.7	1.3 (1.4)
15	8 (10)	+2	190 (494)	1.76 (1.86)	55.6	1.6 (1.4)
16	9 (13)	+4	162 (550)	2.57 (1.92)	36.4	1.5 (1.3)
17	7 (2)	-5	146 (59)	1.10 (0.99)	0.0	1.9 (2.1)
18	13 (10)	-3	336 (188)	2.55 (2.46)	34.8	1.9 (1.8)
19	17 (12)	-5	309 (325)	2.95 (2.30)	48.3	2.0 (2.1)
20	10 (10)	0	346 (788)	1.55 (2.10)	70.0	1.4 (0.9)

the number of specimens is higher than previously at approximately 75% of localities. However, diversity remained at the same level or slightly decreased at most localities. At four localities (12, 13, 16, 17) a dramatic decrease was observed, in contrast to a single locality (No. 8) which displayed considerable increase in diversity. The saprobity index exhibited a similar change, decreasing at 13 localities (especially 3, 13; see Table 3).

TWINSPAN analysis (Fig. 2) divided the localities studied in 1955-1959 into five groups. The first step (division I) was characterized by *Heptagenia flava* (4 localities with elevations up to 390 m and relatively high species diversity). Of the remaining groups, that with *Baetis alpinus* (division III) represented clean, larger montane streams with high diversity and low index of saprobity. The group with 4 indicator species, *T. major, E. danica, E. lateralis* and *H. fusca* (division II), consisted of localities at middle elevations in the Carpathians. The final groups (division IV) were characterized by species with similar ecological requirements (*Torleya major* and *Baetis muticus*) and included localities of comparable diversity and saprobity.

Grouping of localities based on the recent collections was quite different. The first division clearly separated a large group with the indicator *Rhithrogena semicolorata* (Fig. 3). This group (14 localities) comprises all the rhithral localities including a subgroup (division II) of the indicator *B. alpinus* which roughly corresponds to similar a group apparent in Fig. 2 enriched by 2 localities with *Ecdyonurus subalpinus* as the indicator species (division IV).

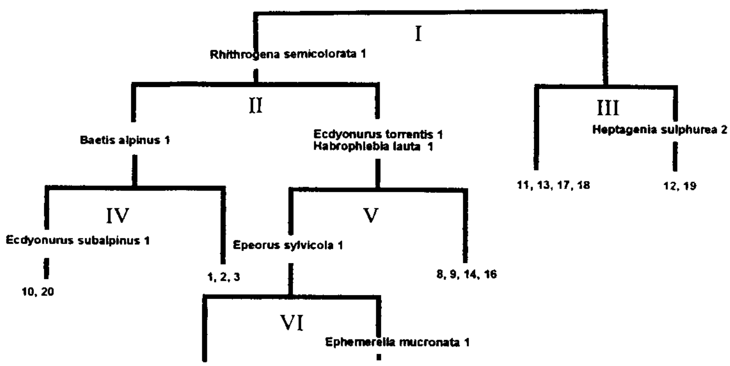

Fig. 3. Divisive hierarchic classification (TWINSPAN) of selected 20 localities in the Morava basin, based on data collected in 1994-1995 with indicator species shown.

Division II also separates a relatively large group characterized by *Ecdyonurus torrentis* and *Habrophlebia lauta* which include only moderately impacted localities at middle elevations. However, the division VI shows more pronounced differentiation of localities. There are only two localities (4 and 7 in a subgroup with the indicator *Ephemerella mucronata*) contrary to the situation in 1955-1959 (see division IV, a group with the indicator *Baetis muticus*, Fig. 2). The remaining 6 localities were separated during the first division. Four of them were characterized by evidently disturbed watercourses. This is clearly apparent in the case of localities 11 and 13 which earlier belonged to the quite different groups (see Fig. 2). Large river localities of this group (Nos. 12 and 19) are, contrary to the first phase of investigation, separated by the indicator *Heptagenia sulphurea* (division III) from remaining localities (11, 13, 17, 18).

Ordination of the localities studied (DECORANA) is illustrated in Fig. 4 (relative length and direction of solid lines represent the intensity of changes at of the individual locality). Locality 19 (the River Jihlava) exhibited the most pronounced changes. These changes can be interpreted as a consequence of the absence of 5 species (including *Oligoneuriella rhenana, Heptagenia coerulans, Choroterpes picteti*) during the 2nd period of sampling. Further pronounced changes occur at the localities 11 and 18. At the former, they were associated with the disappearance of *Oligoneuriella rhenana, Baetis scambus* and *Baetis muticus*, at the latter with the diappearance of *Oligoneuriella rhenana, Baetis fuscatus, Ecdyonurus forcipula, E. venosus, Heptagenia flava*, and *Ephemerella notata*. On the other hand, shifts in ordination diagram apparent at localities 10 and 20 are mainly due to the new occurrence of *E. submontanus* and *Electrogena quadrilineata* at these localities. The horizontal position of shifts in the second quadrant are apparent in localities 1 and 3. These changes can be explained by the increase in saprobity index with approximately the same species composition in both phases of sampling. The same

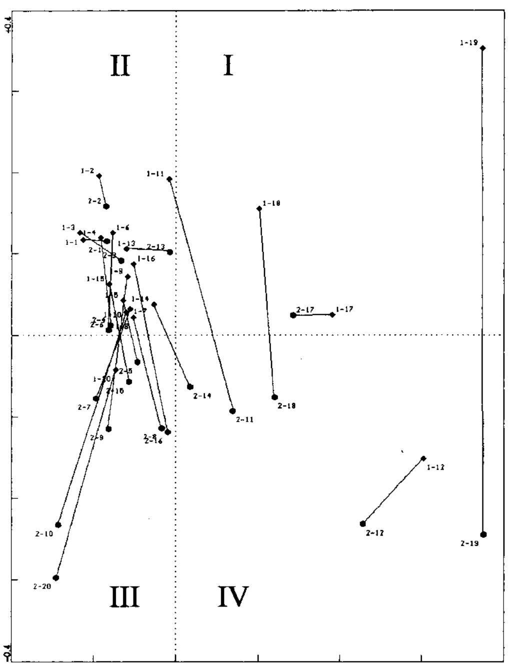

Fig. 4. Ordination shifts of 20 selected localities (DECORANA): ■ - first period of sampling, 1955-1959; ● - second period, 1994-1995; I-IV - number of quadrants.

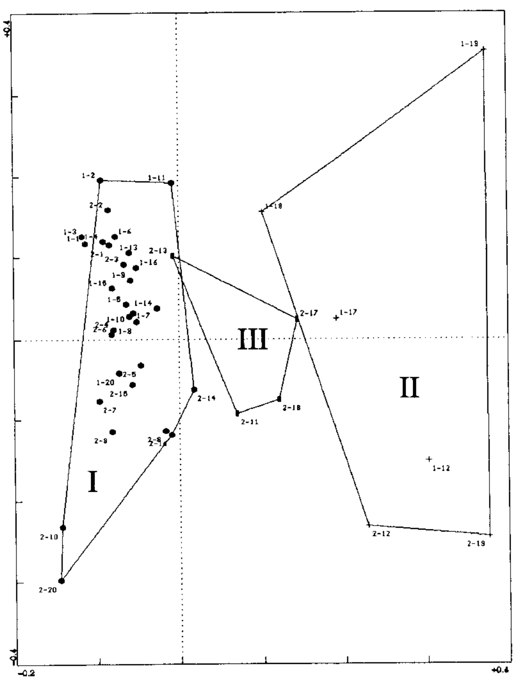

Fig. 5. Projection of the TWINSPAN classification (see Figs. 2-3) to the ordination space of DECORANA classification; I-III - numbers of clusters (see explanation in the text).

situation but with decrease of species diversity by nearly 50% was seen in locality 13. This fact, however, translocates its position towards the vertical axis nearly out of respective quadrant, in which not substantially changed localities are concentrated. The vertical axis seemed to separate localities of rhithral and potamon nature. As to the locality 17, a horizontal shift in ordination diagram (1st quadrant) is apparently due to the replacement of the original species composition (7 species, e.g. *Heptagenia flava, Ephemerella ignita, Caenis luctuosa, Baetis rhodani*) with *Baetis fuscatus* and *B. vernus.*
Comparison of both the above methods of multivariate analysis (Fig. 5) showed three clusters of localities. Cluster I (left) summarizes rhithron localities with little change during the past 30 years. Cluster II (right) consists of potamon localities, its larger size is reflecting more pronounced changes in comparison with cluster I. Cluster III comprises localities with major changes during the period in question. These localities enter this cluster from both clusters I and II regardless of their original position.

DISCUSSION

Taking into account literature data concerning the occurrence mayflies in Central Europe (for full bibliography see LANDA & SOLDÁN, 1989) as well as records a total of 110 species of mayflies are recorded from this area (or, more precisely, from the former Czechoslovakia). Of these, 16 species (14.5%) have so far never been found in the Elbe or Morava basin. Seventy (63.7%) species were collected in both these areas, 18 (16.3%) only in the Elbe basin and 6 (5.5%) only in the Morava basin. The 71 species common to both basins mostly represent abundant and widely spread elements of different origins (cf. LANDA & SOLDÁN, 1989) although some of them (e.g. *Ecdyonurus insignis, Rhithrogena germanica, Heptagenia coerulans, H. fuscogrisea, Ephemerella notata* and *Choroterpes picteti*) seem to be rare in the Morava basin or even missing in samples from the last 3-5 years. Certainly at least the above species are much more endangered in the Morava basin than in the Elbe basin. Some other species, like *Rhithrogena hybrida* or *R. hercynia*, although not endangered due to their occurrence in rhithral sites, are extremely rare in the Morava basin (1-2 localities) but more frequent in the Elbe basin. One species, formerly distributed in both these areas, namely *Isonychia ignota* is evidently extinct. The last record in the Elbe basin is based on the pinned specimen in the Klapálek's collection in Prague dated 1898 (LANDA, 1969). However, unpublished data by BRABEC (1965b) show this species survived for much longer time in the Morava basin, but due to its very narrow ecological range its present occurrence here does not seem possible. Of the remaining species common to both the areas studied, only *Metreletus balcanicus* and *Caenis rivulorum* are worthy of attention since they were recently found in the Morava basin for the first time.

There is probably no doubt that *Prosopistoma foliaceum* and *Palingenia longicauda* are extinct, since the last records by ŠTĚPÁN (1923) and ZAVŘEL (1905), date from more than 70 years ago. On the other hand, *Ephemera glaucops*, contrary to the relatively old last record from the Elbe basin (PAWLIK, 1933), may still be present. There are several recent records from Germany (Saxonia) (BLANKE *et al.*, 1993) and this species undoubtedly lives in the Danube basin in Slovakia (LANDA, 1969; GAJDŮŠEK & KUBČEK, 1970; SOLDÁN, 1981).
The differences in the fauna of the Elbe and Morava basin are due, primarily, to oscillation of front portions of continental and/or alpine graciers during the last 2-3 glaciations. At that time the glaciers spread deeply into the Morava river valley clearly separating the Hercynian and Carpathian mountain systems. The fauna of different origin (Thieneman's «Mischfauna») was concentrated in a band between glacial masses. Eurytherm species adapted to such conditions survived but most species withdrew into western or eastern refugia. We can suppose that the present fauna comprises the species which withstood the glaciation, species which returned from refugia and «newly» evolved and evolving future species. Global warming may play a role in present distribution of mayflies, too. The species occurring either in the Elbe or in the Morava basin (Table 2) can be divided into the following groups:

(i) Species with the arcto-alpine disjunction. This group consists of *Siphlonurus alternatus, Baetis digitatus, Leptophlebia vespertina* and *Arthroplea congener* (cf. LANDA & SOLDÁN, 1985) although the latter species can inhabit quite atypical habitats (lowland ponds). The last record from the Morava basin (BRABEC, 1965a) refer to this type of biotope. The wide ecological range of *Arthroplea congener* (apparent in the Elbe basin, too) is probably due to its extremely long embryonal diapause (10 months) and very rapid larval development before the spring rise in water temperature. The absence of the above species in the Morava basin can be explained by different effects of the last glaciation (Würm). After the withdrawal of the continental glacier to the north, many biotopes suitable for «northern» species arose in the upper Elbe basin in Bohemia. However, some boreal species, like *Caenis lactea* or *Heptagenia fuscogrisea*, also managed to enter the Morava basin although they are much less frequent here.

(ii) Carpathian species comprising *Ecdyonurus carpathicus* and *E. starmachi*. These species distributed in the Carpathians and their foothills enter the Morava basin from the east and the western limits of their area are roughly identical with those of the Carpathicum bioregion in Moravia. The same can be applied to *Rhithrogena puytoraci* known from Poland. However, this species shows somewhat a different distribution also occurring in France and Germany (SOWA & DEGRANGE, 1987). *R. puytoraci* is recorded from the Czech Republic territory for the first time (imagoes collected at locality Morava riv., Doln (Morava).

(iii) Mediterranean species entering the Morava basin from the south and absent in the Elbe basin. Only *Ephemerella mesoleuca* falls into this group, the distribution of which can be explained by effects of the last glaciation (see above) which eliminated «southern» species in the areas influenced by the continental glacier. The extinct species, *Palingenia longicauda* also certainly belonged to this group (LANDA & SOLDÁN, 1985, 1989).

(iv) Other species of different origin occurring only in the Elbe basin (Table 2). The distribution of these species with narrow ecological ranges can largely be explained by different orographic conditions. Vertical zonation in the Elbe basin (or at least in its southern part) is gradual, with comparatively long watercourses providing a large number of gradually changing biotopes. Large habitat scale yields suitable environmental conditions for such a sensitive group like mayflies. On the other hand, the relatively sudden elevation of mountain ranges in Moravia and consequently relatively short watercourses result in rapid alternation of more sharply differentiated biotopes. The same phenomenon is seen within the Elbe basin, for example between faunas of the Šumava mountains (more than 40 species) and the Krušné hory (Ore mountains) (about 25 species, LANDA & SOLDÁN, 1989). The only species that has not been found in the Elbe basin so far is *Baetis tracheatus*. It is a lowland species of uncertain origin, known only from Poland, East Slovakia and small brooks in south-east Moravia (ZELINKA, 1977).

A comparison of indices studied shows similar long-term trends in both the areas studied. The diversity index decreased at 105 of 150 localities studied in the Elbe basin and at 9 of 20 localities in the Morava basin. Similarly, an increase of the saprobity index (indicating ng further deterioration of water quality) was observed at 44 localities in the Elbe basin and at 11 localities in the Morava basin. A relative number of localities with changing saprobity index seems to be higher in the Morava basin (about 50%) in comparison to about 30% for localities in the Elbe basin. Regarding diversity indices, the situation is the reverse (about 70% of localities compared to 45% of localities in the Morava basin). However, these changes are still comparable since at most localities they are minor and the relative numbers of localities with dramatic or pronounced changes are approximately the same.

The hierarchical classification also shows similarities in the Elbe and Morava basin. Although it is naturally less complicated in the latter and the indicator species are different the following common features are easily recognizable: (i) conspicuous differences between individual periods of investigation within the first division. In the Morava basin, the group of considerably disturbed localities is well defined and clearly separated from remaining localities (Fig. 3). In the Elbe basin, the first division

even comprised similar localities in a common group with those of stagnant or very eutrophic waters (see LANDA & SOLDÁN, 1989); (ii) further differentiation and decrease in the number of rhithral (or crenal) localities of higher elevations with very good water quality in the second phase of research (compare Figs 2 and 8 and Figs 13 and 14 of LANDA & SOLDÁN, 1989); and (iii) similarities in changes of the individual indicator species both areas. Within the second period certain usually those with specialized ecological requirement, are replaced with species having wider ecological range. For instance, *Rhithrogena semicolorata* is replaced by *Heptagenia sulphurea* (division I) and *Torleya major* by *Baetis alpinus* (division II) in dendrograms of localities in the Morava basin (Figs 2 and 3). Similarly, *Baetis rhodani, B. fuscatus* and *Ephemerella ignita* are replaced by *B. alpinus* and *Ameletus inopinatus*.
The ordination of localities applied to combined samples of two study periods in the Elbe basin (see LANDA & SOLDÁN, 1989) showed four particular clusters of localities (rhithron, potamon, ponds and other localities) distinguished according to the first two axes. These clusters can be easily compared to those apparent in Figs 4 and 5 representing rhithron and potamon localities of the Morava basin (only running waters were studied in this area). However, the length of shifts of individual localities in ordination space are very difficult to interpret and they should be considered strictly individually for each locality. Since the shifts are apparently correlated with the species diversity of particular localities the extinction and/or enrichment of a single (or several) species in extremely species-poor localities causes a long shift which need not be related to environmental deterioration (LEPŠ *et. al.*, 1989). This is the case of for instance in localities 10 and 20 in the Morava basin and numerous rhithral localities in the Elbe basin (LANDA & SOLDÁN, 1989). On the other hand, projection of the TWINSPAN classification to the ordination space for the Morava basin localities shows a high level concordance of both these methods, even enabling explanation of shifts of particular «intermedial» localities.

To conclude, in spite of some differences, long-term changes in both the areas studied follow the same trends, mainly a decreasing species diversity frequently accompanied by an increase in the abundance of several species with wide ecological amplitude. This process, still inconspicuous in the rhithral, is much more apparent in the potamon, mostly due to organic pollution.

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