OPERA CORCONTICA 37: 369–375, 2000

BIODIVERSITY OF MAYFLIES (*EPHEMEROPTERA*) IN THE KRKONOŠE MOUNTAINS: A HISTORICAL AND PRESENT STATUS OVERVIEW

Biodiverzita jepic (*Ephemeroptera*) v Krkonoších: historický a současný přehled

SOLDÁN TOMÁŠ

Entomologický ústav Akademie věd České republiky, Branišovská 31, 370 05 České Budějovice, CZ, e-mail: <soldan@entu.cas.cz>

Na základě literárních údajů a dlouhodobého faunistického výzkumu bylo v Krkonošském národním parku doposud nalezeno 31 druhů jepic (18 rodů a 7 čeledí, 32,9 % celkové druhové diverzity České republiky). Poprvé jsou publikovány nálezy druhů *Centroptilum luteolum, Nigrobaetis niger, Leptophlebia marginata* a *Ephemera danica.* Většina těchto druhů (21) patří k arboreálním faunistickým prvkům s evropským nebo submediteránním rozšířením, 6 druhů představuje oreotundrální prvky většinou s holoarktickým nebo euroasijským areálem. Byly nalezeny pouze 3 oreotundrální druhy, arkto-alpinské nebo boreomontánní druhy se však v Krkonoších zjevně nevyskytují. Dva endemické druhy, *Rhithrogena corcontica* a *R. zelinkai* (druh v současnosti nezvěstný) vyžadují určitou ochranu. Na základě pravidelných (od počátku 50. let) semikvantitativních odběrů ve všech sezónních aspektech jsou hodnoceny dlouhodobé změny abundance jednotlivých druhů ve vztahu k jejich celkovému rozšíření v povodí Labe. Relativně nízká biodiverzita jepic v Krkonoších je hodnocena z hlediska historických i specifických faktorů (geomorfologie, postglaciální migrace, vagilita a ekologická valence) i některých faktorů prostředí (substrát a jeho pufrační schopnosti a acidifikace).

Based on literature data and long-term faunistic research altogether 31 species (32.9 % of mayfly species diversity of the Czech Republic) belonging to 18 genera and 7 families have been collected so far in the Krkonoše Mts. National Park. *Centroptilum luteolum, Nigrobaetis niger, Leptophlebia marginata*, and *Ephemera danica* are recorded for the first time. Most species (21) belong to arboreal faunistic elements with central european and submediterranean distribution, 6 species with large areas show mostly holarctic or eurasian distribution. There are only 3 oreotundral species but none arcto-alpine or boreo-montane specie has been found. Two endemic species, *Rhithrogena corcontica* and *R. zelinkai* (the latter missing at present) deserve some protective measurements. Abundance of individual species found is compared to that in the whole Labe basin in the Czech Republic and long-term changes in their ocurrence from early 1950's are discussed on the basis of all-season semiquantitative samples. Relatively lower biodiversity of mayflies in the Krkonoše in comparison with other Hercynian mountains and its changes (decrease to the end of the eighties showing apparent recovery tendencies) are discussed with regards to historical factors and specific factors (geomorphology, postglacial migrations, vagility and ecological range) and some environmental variables (substrate conditions, buffering capacity and acidification).

Klíčová slova: Krkonošský národní park, *Ephemeroptera*, druhová diverzita, rozšíření, faunistické prvky, abundance, vertikální zonace, dlouhodobé změny, faktory prostředí

Keywords: Krkonoše national park, *Ephemeroptera*, species diversity, distribution, faunistic elements, abundance, vertical zonation, long-term changes, environmental factors

INTRODUCTION

Since a great attention has been paid to mayflies of the Krkonoše (Giant) Mountains, this area belonged to relatively well-known ones from this point of view. For the firs time, mayflies (most probably *Ameletus inopinatus*) are mentioned by ZACHARIAS (1884) from glacial lakes in the Polish part of the mountains. PAX (1921) and TOMASZEWSKI (1932) recorded, besides some unclear data, some current species (e.g. *Baetis alpinus* or *Serratella ignita*) from the same area. However, our present knowledge is based mostly on long-term faunistic research carried out by the Institute of Entomology of the Czech Academy of Sciences at more than 30 selected localities from early fifties till the present. Based on all-season semiquantitative samples the long-term changes in occurrence of 19 species have been documented and mayfly diversity has been compared to other areas of the Czech part of the Labe basin with respect to bioindication of water quality (for details on methods and lists of localities see LANDA, 1969, LANDA and SOLDÁN, 1982a,b, 1989 and SOLDÁN et al., 1998). Some data were published also by WINKLER (1977, 1979) on the basis of occasional samples and by other authors (TONNER et al., 1983, TONNER and SYROVÁTKA, 1984) in connection with insecticide application to control *Zeiraphera diniana,* a pest of spruce cultural forest in the 1980's.

Besides the discovery and life cycle studies of two new *Rhithrogena* species at that time (SOWA and SOLDÁN, 1984, 1986, SOLDÁN, 1998) really essential contribution to study of mayfly of this area was published by VÁVRA (1988). He discovered some species new to the Krkonoše Mts. fauna (e.g. *Baetis fuscatus, Centroptilum luteolum, Ecdyonurus subalpinus, Rhithrogena hercynia,* and *Habrophlebia lauta*) and, based on detailed quantitative samples and study of some environmental variables, attempted to explain the phenomenon of conspicuously irregular distribution of some species, called "specific poverty" by WINKLER (1979).

The objective of this paper is (1) to summarize all earlier published data on mayfly fauna of the Krkoše Mts. within the limits of the national park territory and to complete these data with recent knowledge; (2) to analyze mafly diversity from the biogeographic and quantitative point of view; (3) to discuss historical and specific factors affecting the present ocurrence of species found and (4) to characterize the species important from the environmental and species protection point of view.

SPECIES COMPOSITION AND VERTICAL ZONATON

Detailed analysis of diversity of the order *Ephemeroptera* is apparent from Tab. 1. Altogether 31 species of 18 genera and 7 families have been determined to occur in the Krkonoše Mts. National Park. Naturally, this number is not definitive since numerous localities are yet to be sampled, some species mentioned in the literature are to be determined to the species level, and, moreover, further species evidently occur near the national park border. Of the former, e.g. *Ecdyonurus aurantiacus* reported by Tomaszewski (1932: 30) from the Polish part of the Krkonoše is doubtful. *E. aurantiacus* inhabits solely larger lowland river and this record most probably concerns some other species of the *venosus*-group of this genus. Records on *Rhithrogena ferruginea* by Vávra (1988: 64) undoubtedly belong to *R. carpatoalpina* judging from recent taxonomic revision of the respective species complex (distribution of "true" *R. ferruginea* is restricted to the Iberian Peninsula). In addtion to more than 100 earlier ocurrence records published in 23 contributions, four species new to this area, *Nigrobaetis niger*, *Leptophlebia marginata*, *Centroptilum luteolum*, and *Ephemera danica*, are presented. All of them were collected at several places in the basin of the Lysečinský brook near Dolní Lysečiny (tributary of the Úpa River, 680 m alt., distance from source about 3 km, coordinates of the uniform grid system 5261, for details of environmental variables see SOLDÁN, 1998) in 1994–1999. However, this records seems to be rather formal since they refer to abundant species in the whole Labe basin and their occurence just in the area of the national park is highly likely. Moreover, the latter ones (see Tab. 1., "NP new record") have been found by VÁVRA (1988) at localities very close to the park's borders. Similar species representing those with relatively wide ecological range and being evidently distributed very close to the national park territory are e.g. *Siphlonurus aestivalis*, *Baetis scambus*, *Electrogena affinis* or *Torleya major* (cf. LANDA and SOLDÁN, 1989 or SOLDÁN et al., 1998).

Tab. 1. Species of the order *Ephemeroptera* occurring in the territory of the Krkonoše national park, their principal biogeographic characteristics, abundance and references to earlier records

Species and taxonomic position of individual genera *)	Global area *)	Faunistic element and origin *)	Abund. **)	References ***)
Ameletus inopinatus EATON, 1887 (A)	NC Europ.	oreotundral	4-5 (3)	1-7, 12,15-22
Siphlonurus lacustris (EATON, 1870) (S)	Eurasian	oreotundral	4-5 (3)	3-6, 12, 19
Alainites muticus (LINNÉ, 1758) (B)	European	large area, Euro-Mediter?	2 (4-5)	6, 19
Baetis alpinus (PICTET, 1843-1845) (B)	C Europ.	arboreal, Euro-Mediter?	6 (6)	4-6, 8-10, 12, 15-20
Baetis fuscatus (LINNÉ, 1761)	Palaearct.	large area	3 (6)	19
Baetis rhodani PICTET, 1843-1845	Eurasian	large area, Euro-Mediter?	6 (6)	4-6, 12, 16, 17, 19
Baetis vernus CURTIS, 1834	Eurasian	arboreal, Euro-Mediter?	6 (6)	6, 12, 16, 17, 19
Centroptilum luteolum (MÜLLER, 1776) (B)	Holarctic	large area	1 (4-5)	NP new record (19)
Cloeon dipterum (LINNÉ, 1761) (B)	Holarctic	large area	2 (6)	6, 19
Nigrobaetis niger (LINNÉ, 1761) (B)	European	arboreal	1 (3)	new record
Ecdyonurus dispar (CURTIS, 1834) (H)	SC Europ.	arboreal, Euro-Mediter	1 (5)	6, 19
Ecdyonurus forcipula (PICTET, 1843-1845) (H)	SC Europ.	arboreal, Atlanto-Mediter	1 (2)	6, 12, 10, 19
Ecdyonurus subalpinus KLAPÁLEK, 1905	C Europ.	arboreal, Euro-Mediter?	1 (3)	19
Ecdyonurus submontanus LANDA, 1970	C Europ.	arboreal, Euro-Mediter?	5 (3-4)	6, 19
Ecdyonurus venosus (FABRICIUS, 1775)	SC Europ.	arboreal, Atlanto-Mediter	5 (4-5)	3, 6, 10, 12, 16, 17, 19
Electrogena lateralis (CURTIS, 1834) (H)	SC Europ.	arboreal, Euro-Mediter	4 (4-5)	3, 6, 10, 16, 17, 19
Epeorus assimilis EATON, 1885 (H)	SC Europ.	arboreal, Ponto-Mediter	6 (4-5)	6, 12, 19
Rhithrogena carpatoalpina KLONOWSKA, OLECHOWSKA, SARTORI et WEICHSELBAUMER, 1985 (H)	C Europ.	arboreal, Atlanto-Mediter	1 (4)	12, (19?)
Rhithrogena corcontica SOWA et SOLDÁN, 1986	C Europ.	arboreal, endemic	1 (1)	11, 12, 14, 19, 23
Rhithrogena hercynia LANDA, 1970	C Europ.	arboreal	1 (2-3)	16, 17, 19
Rhithrogena hybrida EATON, 1885	C Europ.	arboreal, Atlanto-Mediter	1 (1)	16, 17
Rhithrogena iridina (KOLENATI, 1859)	SC Euro.	arboreal, Atlanto-Mediter	4 (4-5)	6, 12, 19
Rhithrogena semicolorata (CURTIS, 1834)	SC Europ.	arboreal, Euro-Mediter	5 (4-5)	3, 6, 12, 16, 17, 19
Rhithrogena zelinkai SOWA et SOLDÁN, 1984	C Europ.	arboreal, endemic?	1 (1)	6, 13
Ephemerella mucronata (BENGTSSON, 1909) (Em)	Eurasian	arboreal	3 (3-4)	6, 12, 15-17, 19
Serratella ignita (PODA, 1761) (Em)	Eurasian	large area	6 (6)	4-6, 8, 9, 12, 16, 19
Habroleptoides confusa SARTORI et JACOB, 1986 (L)	SC Europ.	arboreal, Euro-Mediter	3 (6)	6, 19
Habrophlebia lauta EATON, 1884 (L)	NC Europ.	oreotundral	3 (5)	19
Leptophlebia marginata (LINNÉ, 1767) (L)	Holarctic	arboreal	1 (4)	new record
Paraleptophlebia submarginata (STEPHENS, 1835) (L)	European	arboreal, Euro-Mediter?	2 (4-5)	12
Ephemera danica (MŰLLER, 1764) (E)	European	arboreal, Euro-Mediter?	1 (6)	NP new record (19)

*) Abbreviations used: A – *Ameletidae*, S – *Siphlonuridae*, B – *Baetidae*, H – *Heptageniidae*, Em – *Ephemerellidae*, L – *Leptophlebiidae*, E – *Ephemeridae*, Palaearct. – Palaearctic, C – central, NC – north-central, SC – south-central, Europ. – European, Mediter. – Mediterranean. **) Abundance

(Abund.) of individual species refers to density (relative number) of localities, not to density of speciemens at the localities of occurrence. The six-grade scale by Friederichs quantified by Skuhravá (for details and full references see SOLDÁN et al., 1998) is followed: 1 – solitary, 2 – rare, 3 – medium distributed, 4 – abundant, 5 – very abundant, 6 – common. Density of localities is expressed for the territory of the Krkonoše National Park, density within the whole Labe basin (see also LANDA and SOLDÁN, 1989 or SOLDÁN et al., 1998) in the second one (in parentheses).
***) Full references to earlier distributional records of individial species are listed at the end of this contribution.

The number of 31 species found in the Krkonoše Mts. represents 32.9 % of mayfly diversity of the Czech Republic (94 species, except for 3 evidently extinct, see SOLDÁN et al. 1998). When comparing the number of mayfly species found in this area with other Hercynian mountains of the Czech Republic, this area could be characterized as relatively poor one. The highest diversity of mayflies can be found in the Šumava Mts., 56 species of mayflies were found within the limits of the national park and even 61 species within the limits of the landscape protected area. Other Sudetes mountains exhibit similar species numbers: the Jeseníky Mts. 38 species, the Jizerské hory (Iser Mts.) about 35 ones and the Krušné hory (Ore Mts.) even only about 15 species (cf. LANDA and SOLDÁN, 1982a,b). However, these numbers are apparently orientative undoubtedly depending on the intensity of research and selection of the localities investigated. Even very restricted number of lower altitudes localities enriches total species number extremely (e.g. 35 species in the Krušné hory in this case, see VÁVRA, 1988). Provided that higher elevation localities are investigated only the species number is very low in the Krkonoše, VÁVRA (1988) presents 13 species up to 900 m, 8 species up to 1,000 m and only 2 species above this limit. On the contrary, there are currently at least 10 species living in such elevations (above 1,000 m) in the Šumava Mts. (LANDA and SOLDÁN, 1982b) and fauna of the Krkonoše seems to be really poor at these altitudes. As indicated by VÁVRA (1988) this locality selection led WINKLER (1977, 1979) to erect somewhat confusing “specific poverty” theory for the Krkonoše mayfly fauna.

From the vertical distribution point of view the mayfly species collected in the Krkonoše Mts. can be classified into the following groups: (1) Typical montane species, never or exceptionally descending to lower altitudes below 400–500 m. Most of them prefer streamline habitats of montane streams (*R. corcontica, E. mucronata*), others inhabit places with slow current speed or pools (*A. inopinatus*) or even lenitic habitats (*S. lacustris*); (2) Submontane species with wider ecological range, usually not inhabiting the altitude higher than 500–600 m. However, they sometimes occur at typical montane biotopes, especially in larger streams with rich habitat offer. This concerns, contrary to other representative of the respective genus, mainly *E. forcipula, E. venosus, R. hercynia* and *R. iridina. N. niger* and *E.assimilis* also represent species of the same type of distribution; (3) Species predominantly distributed in the coline zone, from where they are able to colonize lower montane biotopes (or suitable lowland biotopes, too). This is the most numerous species category from the vertical distribution point of view. All species treated in this paper if not mentioned elsewhere belong just to this category; (4) Predominantly lowland species the occurrence of which seems to be incidental at submontane or even montane biotopes. In the case of the Krkonoše Mts., this concerns *C. dipterum* although colonization of such biotopes is enabled by wide ecological valency and relatively high vagility of the latter; (5) Species with extremely high ecological range, the vertical distribution of which almost do not depend on elevation of a locality of occurrence. Eurytopic species *B. rhodani, B. vernus, S. ignita* and perhaps also *E.danica* undoubtedly belong to this category, although they mostly do not inhabit extreme montane biotopes, this concerns mainly *S. ignita* and *E. danica.* However, some evidently stenotopic species (e.g. *B. alpinus*) seem to be almost independent on locality altitude provided that suitable habitats are available (stony bottom and higher current velocity in this case).

There are several species undoubtedly in need of treatment in the frame of some protective measurements, and I feel that their proper identification is needed. From the formal biodiversity protection point of view, I suggest to classify the following species into the following respective “red list” categories (for categories definitions in mayflies see e.g. SOLDÁN et al. 1998): (1) *R. zelinkai* should be placed among extinct, missing or critically endangered species (EX, CR). This species seems to be endemic to the Krkonoše Mts., Tatra Mts., and the Alps. It was described according to the holotype (larva) collected just in the Labe River in Labský Důl (Dívčí Lávky) in 1975 (SOWA and SOLDÁN, 1984). Since then this species has never been found in the Krkonoše Mts., despite a very high sampling activities at the type locality; (2) *R. corcontica* should be placed among vulnerable species (VU). It seems to be endemic at least within the Hercynian mountain system in central Europe being collected only at several localities in the Krkonoše and Jeseníky Mts. (Zahrádková and Soldán, 1999); (3) *R. hercynia*, although showing relatively high number of localities of occurrence in the Labe River basin, generally represents a rare species preferring mostly metarhithral biotopes particularly exposed to certain deterioration pressure. It should be classified among the susceptible species (SU) category; (4) *R. hybrida* and *E. subalpinus* could be considered in the low risk category (LR). The former is a rare montane species with specific requirements for high quality water habitats. Although being abundant in the Alps and still inhabiting relatively large number of localities in central Europe, number of places of its occurrence decreased within the past decades and its quantitative presentation is now much lower than earlier. The latter, *E. subalpinus*, is relatively abundant submontane species in Central Bohemia and also in the Polish Carpathians. However, it seems to be rare in the Sudete mountain system and the Morava and Odra basins in general, probably due to lack of suitable biotopes – larvae prefer submontane streams with frequently alternating pools and riffles and their quantitative presentation is very low in this area.

BIOGEOGRAPHICAL ANALYSIS AND QUANTITATIVE DISTRIBUTION

Detailed biogeographic analysis is apparent from Tab. 1. The species composition from this point of view generally follows the situation in the whole central Europe, with a typical dominance of arboreal elements (more than 70 %) and species with central or south-central European distribution. However, a very peculiar phenomenon can be observed in the Krkonoše Mts. in general: Except for *A. inopinatus*, there is neither arcto-alpine nor boreomontane species ever collected in this area. Of the former, it is e.g. *Siphlonurus alternatus* or *Leptophlebia vespertina* (this species is, moreover, extremely acidotolerant), of the latter it is *Heptagenia fuscogrisea, Electrogena affinis* and, first of all, *Arthroplea congener*. Contrary to the Krkonoše Mts. (and, in lesser extent, to the Sudetes mountains in general), all these species are currently distributed in other Hercynian mountain ranges, especially within the Šumava (cf. LANDA and SOLDÁN, 1989).

As far as quantitative distribution is concerned, the Krkonoše Mts. exhibit relatively pronounced differences in density of localities of occurrence of most species compared to general conditions within Central Europe (see Tab. 1., the column "Abundance"). In this respect, several species groups can be defined: (1) Abundance is approximately the same. This concerns generally solitary, specialized species (e.g. some species of *Rhithrogena* or *E. forcipula*) on one hand and very common species with wide ecological range (*B. alpinus, B. rhodani*, or *S. ignita*) on the other; (2) Abundance is much lower than usual – this can be explained by different biotopes available for species living or even being common at lower elevations (*B. fuscatus, C. dipterum, H. confusa, E. danica*); (3) abundance is much higher than usual as seen e.g. in *A. inopinatus* and *S. lacustris*. Most probably, this phenomenon depends on free or not fully utilized ecological niches, contrary to e.g. the Šumava Mts. For instance, quantitative occurrece of larvae of *S. lacustris* is influenced by presence of those of *L. vespertina* and other *Siphlonurus* species here (cf. LANDA and SOLDÁN, 1982a,b). Larval densities were not studied in detail but according to VÁVRA (1988) they did not substancially differ from the values measured in other Hercynian mountains or even in the Carpathians. This undoubtedly agrees at least for not acidified streams. However, these values (10–165 ind.m^{-2}) are sometimes by an order lower than at other places except for comparable values (320–1,115 ind.m^{-2}) concerning common species (*B. alpinus, B. vernus R. semicolorata*) at acidified localities with extremely low diversity (cf. VÁVRA, 1988: 68).

LONG-TERM BIODIVERSITY CHANGES

Long-term diversity changes of the Krkonoše mayfly taxocenes at some selected localities from the beginning of the 1950's are discussed in detail by LANDA and SOLDÁN (1989) and SOLDÁN et al. (1998). In general, gradual decrease of diversity (if the conditions in the 1950's are considered a certain "zero" state) is apparent till the end of the 1980's, since than a certain recovery of aquatic biotopes seems to be seen. To explain this and the above mentioned phenomena, both historical and present changes of some environmental variables should be taken in account. Besides extremely low vagility of mayflies, it is, first of all, geomorphology of the Sudetes mountains. Vertical zonation in the southern part of the Labe basin (the South Bohemian Highlands and the Šumava) is gradual, with comparatively long watercourses providing a large number of gradually changing aquatic biotopes. Large habitat scale yields suitable environmental conditions for much higher number of mayfly species (cf. LANDA and SOLDÁN, 1982b). On the other hand, relatively sudden elevation of mountain ranges of the Sudete system and, consequently, relatively short watercourses result in rapid alternation of more sharply differentiated aquatic biotopes. This is probably the reason for lower number of species in the Krkonoše Mts. Consequently, there are probably not sufficient refugia enabling survival of nearly all typical boreomontane species, such as *Siphlonurus alternatus, Leptophlebia vespertina* and *Arthroplea congener*. That is why the recent or subrecent immigration of submediterranean species completely dominated to survival of northern species of the last glaciation fauna in this area and just the opposite process (or mixture of both these phenomena) can be seen i.g. in the Šumava Mts. Moreover, the habitat zonation in the Krkonoše seems to be very unfavourable, not permitting to survive even to the most acidotolerant species *L. vespertina.*

As far as recent environmental variables are concerned, the acidification seems to be the most important factor. In fact, some areas of the Krkonoše are without any species of mayflies or with only 1–3 species in relatively low densities. The process of acidification in the Krkonoše, now showing certain decreasing tendencies, is described in detail e.g. VÁVRA (1982, 1988) as far as aquatic insect are concerned. Dominant role of acidification in forming of mayfly taxocenes is documented by differences in localities with granite substrates poor in carbonates and soft water with pH values of 5.0–6.0 dropping under 4.0 in the period of snowmelt and localities with evident buffering effects of limestone substrata.To illustrate this, there are 2–3 species with wide ecological range at the former localities (e.g. the Úpa River, Pec pod Sněžkou) contrary to 12 species including acidosensitive ones at the latter (e.g. Lysečinský brook, Dolní Lysečiny). On the other hand, these differences are much less pronounced (if any) in more acidotolerant stoneflies (*Plecoptera*), the taxocenes of which are comparable at both types of localities (cf. SOLDÁN et al., 1998).

ACKNOWLEDGEMENTS

This research was supported by Research Project No. S5007015 "Biodiversity of Entomofauna of and its Significance for Bioindication of Ecological Changes" of the Grant Agency of the Academy of Sciences of the Czech Republic.

REFERENCES

ČERNÝ, W. (1948): Zvířena Krkonoš. In: Klika J. et al.: Příroda v Krkonoších. (Fauna of the Krkonoše Mts. SZN, Praha, pp. 191–220. (in Czech). **(1)**

ČERNÝ, W., DOSKOČIL, J. (1969): Zvířena Krkonoš. In: Fanta J. et al.: Příroda Krkonošského národního parku. (Fauna of the Krkonoše Mts.). SZN, Praha, pp. 161–178. (in Czech). **(2)**

LANDA, V. (1969): Jepice - Ephemeroptera. Fauna of Czechoslovakia, Vol. 18, Academia, Praha, 352 pp. (in Czech, German Summary). **(3)**

LANDA, V., SOLDÁN, T. (1982a): Some faunistic and biogeographic aspects of the mayfly fauna of the Hercynian and Carpathian mountains systems in Czechoslovakia (Ephemeroptera). Acta mus. Reginaehradensis, Suppl., 1980: 58–60. **(4)**

LANDA, V., SOLDÁN, T. (1982b): Changes in distribution of mayflies in Bohemia during the past 20–30 years with regards to the South Bohemian region. Sbor. Jihočes. Muz. v Čes. Budějovicích, Přír. Vědy, 22: 21–28. **(5)**

LANDA, V., SOLDÁN, T. (1989): Rozšíření jepic (Ephemeroptera) v ČSSR a jeho změny v souvislosti se změnami kvality vody v povodí Labe (Distribution of Mayflies (Ephemeroptera) and its changes in the Labe Basin of Czechoslovakia in Connection with Changes of Water Quality). Academia, Praha, Studie ČSAV, 17, 171 pp. (in Czech, English Summary). **(6)**

OBENBERGER, J. (1952): Krkonoše a jejich zvířena (The Krkonoše Mts. and its fauna). Přírodověd. nakladatelství Praha, 325 pp. (in Czech). **(7)**

PAX, F. (1921): Die Tierwelt Schlesiens. G. Fischer, Jena, 342 pp. **(8)**

SCHNEIDER, W. G. (1885): Verzeichnis der Neuropteren Schlesiens. Z. Entomol., 10: 17–32. **(9)**

SCHOENEMUND, E. (1930): Eintagsfliegen oder Ephemeroptera. Tierwelt Deutschlands, 106 pp. **(10)**

SOLDÁN, T. (1998): Life cycle of Rhithrogena corcontica (Ephemeroptera, Heptageniidae), an endemic species of the Krkonoše Mountains. In: Sarosiek J. & Štursa J. (Eds): Geoekologiczne problemy Karkonszy, Wydavnictwo Acarus, Poznań, pp. 121–125. **(11)**

SOLDÁN, T., ZAHRÁDKOVÁ, S., HELEŠIC, J., DUŠEK, L., LANDA, V. (1998): Distributional and quantitative patterns of Ephemeroptera and Plecoptera in the Czech Republic: A possibility of long - term environmental changes of aquatic biotopes. Folia Fac. Sci. Nat. Univ. Masarykianae Brunensis, Biologia, 98: 1–305. **(12)**

SOWA, R., SOLDÁN T. (1984):Two new species of Rhithrogena Eaton (Ephemeroptera, Heptageniidae) from Central Europe. In: Landa V., Soldán T. & Tonner M. (Eds) Proc. IVth Intern. Confer. Ephemeroptera, Bechyně, 1983, pp. 75–84. **(13)**

SOWA, R., SOLDÁN, T. (1986): Three new species of the Rhithrogena hybrida group from Poland and Czechoslovakia with a supplementary description of R. hercynia Landa, 1969 (Ephemeroptera, Heptageniidae). Pol. Pismo Entomol., 56: 557–572. **(14)**

TOMASZEWSKI, W. 1932 Beitrag zur Kenntnis der Tierwelt Schlesischer Bergbäche. Abh. naturf. Ges. Görlitz, 31: 1–80. **(15)**

TONNER, M., SYROVÁTKA, O. (1984): Einwirkungen der chemischen Luftbespritzung auf die Entomofauna des Rhithrons in Krkonoše (Tschechoslowakei). In: Landa V., Soldán T. and Tonner M. (Eds.) Proc. IVth Int. Conf. Ephemeroptera, Bechyně, Czechoslovak Academy of Sciences, České Budějovice, pp. 229–230. **(16)**

TONNER, M., VÁVRA, V., SYROVÁTKA, O., SOLDÁN, T. (1983): Einfluss der Luftbespritzung gegen den Grauen Lärchenwinckler (Zeiraphera diniana) auf die Entomofauna des Rhithrons in Krkonoše. Věst. Čs. spol. zool., 47: 293–303., 8. **(17)**

VÁVRA, V. (1982): Kyselé srážkové vody a jejich vliv na pH toků v Krkonoších. (Acid precipitation waters and their effects on pH of streams in the Krkonoše Mts.). Opera Corcontica, 19: 65–77. (in Czech, English summary). **(18)**

VÁVRA, V. (1988): Jepice (Ephemeroptera) Krkonoš. (Mayflies (Ephemeroptera) of the Krkonoše Mts.). Opera Corcontica 25: 56–75. (in Czech, English summary). **(19)**

WINKLER, O. (1977): Příspěvek k poznání potoční fauny v Krkonoších. (A contribution to the knowledge of stream fauna in the Krkonoše Mts.). Opera Corcontica 14: 143–153. (in Czech, English summary). **(20)**

WINKLER, O. (1979): Specific poverty of the mayfly fauny of the Krkonoše Mountains. In: Pasternak K. and Sowa R. (Eds.) Proc. 2nd Int. Conf. Ephemeroptera. Panstwowe Wydawnictwo Naukowe, Warszava, Kraków, pp. 39–41. **(21)**

ZACHARIAS, O. (1884): Űber die Fauna des Grossen u. Kleinen Teiches im Riesengebirge. Der Wanderer im Riesengebirge 2, 35: 5–7. **(22)**

ZAHRÁDKOVÁ, S., SOLDÁN, T. (1999): Faunistic records from the Czech Republic. Ephemeroptera, Heptageniidae. Klapalekiana, Praha, 35: 38. **(23)**