

**The Šumava Mountains:
an unique biocentre of aquatic insects
(Ephemeroptera, Odonata, Plecoptera, Megaloptera,
Trichoptera and Heteroptera – Nepomorpha)**

**Šumava: jedinečné biocentrum vodního hmyzu
(Ephemeroptera, Odonata, Plecoptera, Megaloptera, Trichoptera
a Heteroptera – Nepomorpha)**

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Abstract

An extensive program on biodiversity of aquatic insects in the Elbe basin of the Czech Republic has been performed in 1950–1965 and 1970–1985. Due to their geographic, geomorphologic, climatic and other peculiarities, the Šumava Mountains received a particular attention. Altogether 337 species of the insect orders studied have been identified. They represent 64 % of the fauna of the Czech Republic, and 35 to 40 % of the Central European fauna. In spite of the absence of true endemic species (probably a consequence of the post-glacial migrations) the following elements of fundamental importance for biodiversity evaluations have been ascertained: (i) endemites of the Alps + Šumava; (ii) Hercynian species; (iii) Carpathian species; (iv) species with the arcto-alpine disjunction; (v) Atlantic or Atlanto-Mediterranean species; (vi) Pontic or Ponto-Mediterranean species; (vii) Mediterranean elements. Examples of these species are presented and some protective measures are offered. Other species mostly belong to widely distributed montane or submontane elements, comprising also numerous tyrphobionts, and tyrphophilous or creophilous species. Long-term changes of biodiversity, if documented, are discussed as well. Owing to catastrophic acidification in the Sudetes and elimination of numerous species by pollution in lowlands, the Šumava Mountains represent an extremely important and valuable biocentre and refuge or secondary faunistic centre of many endangered species; they deserve a strict protection.

Key words: Biodiversity, biogeography-chorology, faunistic elements, long-term changes

Introduction

An extensive, two-phase entomofaunistic research program has been carried out in the periods 1950–1965 and 1970–1985. More than 300 localities evenly distributed within the whole Labe basin were quantitatively sampled in all seasonal aspects, and their biodiversity and population dynamics was examined (for details see LANDA & SOLDÁN 1989). Similar program is being currently conducted in the same localities in order to assess long-term changes of aquatic insect group in question, with special emphasis on the *Odonata* and *Heteroptera-Nepomorpha*. In the past, these groups were not quantitatively sampled and most data have

been acquired or summarized only recently (AŠMERA & DOLNÝ 1990, PAPAČEK 1991, PAPAČEK & SOLDÁN 1995). Within the framework of this research program, a particular attention has been devoted to the Šumava Mountains, a mountain range showing, besides a very large spectrum of aquatic biotopes, some geographic, geomorphologic, orographic and climatic peculiarities. More than 50 localities were studied regularly, in addition to about 80 localities of occasional sampling (for a complete list of localities and geographic coordinates see LANDA & SOLDÁN 1989, NOVÁK 1996 or PAPAČEK & SOLDÁN 1995).

This paper intends to summarize the biodiversity of 6 insects orders in the Šumava Mountains, to analyse origin, chorology and some ecological attributes of the most valuable faunistic elements, and to emphasize the unique role of the Šumava as a biocentre and refuge of aquatic insects.

Notes on the biodiversity and its long-term changes in particular groups studied

Ephemeroptera (mayflies)

Mayfly species diversity of the Šumava Mts. is characterized, first of all, by these species: *Ecdyonurus austriacus* and *Rhithrogena zelinkai* (*Heptageniidae*) possess conjunctive areas in the Alps, with disjunction to the Šumava. They have never been found elsewhere. *Rhithrogena hercynia* and *Electrogena samalorum* (*Heptageniidae*) are Hercynian endemics of larger areas occurring also in the Sudeten mountain system. *Baetis digitatus* (*Baetidae*), *Arthroplea congener* and *Heptagenia fuscogrisea* (*Heptageniidae*), and *Ameletus inopinatus* (*Siphonuridae*) represent the species with arcto-alpine disjunction, whose southern limits lie in the Šumava (except for widely distributed *A. inopinatus*). Atlanto-Mediterranean species are *Ephemera glaucops* (*Ephemeridae*, earlier data from the Šumava foothills) and *Rhithrogena loyolaea* (*Heptageniidae*) with north-eastern limits of the area of distribution in the Šumava. *Siphonurus alternatus* (*Siphonuridae*) is a Holarctic element with southern limits of its area of distribution here. *Leptophlebia vespertina* (*Leptophlebiidae*), north European species which is very rare elsewhere, showing mass occurrence in all glacial lakes, and high resistance to acidification.

Changes of biodiversity in mayflies within the past 40 years are documented in detail (ŠAMAL 1935, LANDA & SOLDÁN 1982, 1989). One species which lived in the Šumava foothills in the past is evidently extinct (*Prosopistoma foliaceum*, *Prosopistomatidae*), another species is missing since 1935, but has been recollected in South Bohemia recently (*Ephemera glaucops*). Of the 61 species ever collected in the Šumava, we failed to find 6 species in 1970–1985, none of them of special biodiversity importance. In general, mayflies are sensitive to changes of water quality. This changes, however, are still mostly local in the Šumava and their trends are manifested by the decrease of densities of sensitive species population by 20–50 % in favour of species with large ecological range (for details see LANDA & SOLDÁN 1989).

Odonata (dragonflies)

Of the 32 species reported from the Šumava, only 21 species are documented in collections or published after findings (KREJČÍ 1890, ZELENÝ 1960, BOHÁČ 1969, FLIČEK 1971, ALBRECHT 1979, CHÁBERA 1987, AŠMERA & DOLNÝ 1990). The occurrence of remaining 11 species in the Šumava should be re-examined. *Coenagrion hastulatum* (*Coenagrionidae*), *Aeshna subarctica* (*Aeschnidae*) and *Somatochlora arctica* (*Corduliidae*, occurrence uncertain) are species with arcto-alpine disjunction. Ponto-Mediterranean species *Sympetrum pedemontanum* (*Libellulidae*) is reported from the Šumava foothills. Mediterranean species *Cordulegaster*

boltoni (*Cordulegasteridae*) and *Lestes macrostigma* (*Lestidae*) have been found only once (cf. ZELÉNY 1962, PAPÁČEK & SOLDÁN 1995). Hence, incidental migration cannot be excluded. Within the *Odonata*, there are a large number of tyrphobionts like, e.g., *Aeshna subarctica*, *A. juncea* (*Aschnidae*), *Cordulia aenea* (*Corduliidae*), *Sympetrum danae* and *Leucorhynia dubia* (*Libellulidae*). Nothing is known on long-term changes of dragonfly diversity in the Šumava. Extreme vagility, excellent flying abilities and tendency to migration undoubtedly result in incidental occurrence. On the same hand, there are attributes enabling this insect to colonize new habitats, even those of astatic waters. Judging from only moderate long-term changes of usual dragonfly habitats (perhaps except for acidification) biodiversity of this aquatic insect group most probably has not changed so much.

Plecoptera (stoneflies)

As to their biodiversity, the following species of stoneflies seem to be most important in the Šumava: *Siphonoperla montana* (*Chloroperlidae*) and *Leuctra alpina* (*Leuctridae*) are species with the area restricted to the Alps and the Šumava only. *Isoperla goertzi* (*Perlodidae*) is a species endemic to the Hercynian system in Bohemia, Germany and Silesia. *Protonemura hrabei* (*Nemouridae*, last findings in 1956–1960). *Isogenus nubecula* (*Perlodidae*, last occurrence in 1937), *Siphonoperla taurica* (*Chloroperlidae*, last occurrence in 1956) and *Leuctra digitata* (*Leuctridae*) show arcto-alpine disjunction of their areas. Mediterranean species are *Nemoura fulvipes*, *Protonemura intricata*, *Amphinemura triangularis* (*Nemouridae*) and *Brachyptera trifasciata* (*Taeniopterygidae*, northern limits of area in the Labe basin in Bohemia). *Amphinemura standfussi* and *Protonemura intricata* (*Nemouridae*) are species apparently preferring creanal habitats. There are no tyrphobionts in *Plecoptera* but shallow peat-bog drains or small brook are frequently inhabited by at least 5–10 species of *Nemouridae* and *Leuctridae*. Stoneflies are specialized aquatic insects with very high oxygen demands and high sensitivity to pollution except for acidification. Altogether 62 species (and further 10 disputable species collected at the beginning of this century (cf. KLAPEK 1905, ŠAMAL 1920), are known from the Šumava. At present, obviously due to their extreme sensitivity, 18 species are missing, further 5 species (i.g. *Taeniopteryx nebulosa*, *Siphonoperla taurica* and *Isogenus nubecula*) are most probably extinct. For instance, after construction of the Lipno dam not only 21 species living within the inundated area (WINKLER 1956, 1963) but also further 6–8 species living downstream disappeared. During the past 20 years, 4 species were newly collected (SOLDÁN 1994). However, these species represent submontane elements with wider ecological range and limited value for the biodiversity spectrum. These change are, naturally, accompanied with quantitative changes of the stonefly representation, which are apparently higher than those in the *Ephemeroptera*.

Heteroptera – *Nepomorpha* (aquatic bugs)

Of the 26 species ever collected in the Šumava Mts., only 6 species seem to be very important from the biodiversity point of view. Other species found in this region represent mostly common or widely distributed elements occurring at numerous further localities of the Labe basin. The following species are worth of our attention: *Glenocoris propinqua propinqua* (*Corixidae*, *Corixinae*) is a species with arcto-alpine disjunction, now occurring only in the Plešné Lake (earlier findings also in other glacial lakes of the Šumava and in the Jeseníky Mts.), *Notonecta reuteri* (*Notonectidae*) represents a relict, glacial element of the tyrphobiotic type; rare species, with the exception of the Šumava known only from 3 localities in the Labe basin. *N. lutea* represents a species with wide, Eurosiberian distribution with disjunction into Central Europe. This species is very rare in this area. *N. obliqua* is an Atlantic element with eastern limits of its area in the Šumava; a species of rare occurrence as well.

N. maculata represents a Mediterranean or Ponto-Mediterranean species which seems to be endangered due to its sparse distribution in Central Europe. *Cymatia bonsdorffii* (*Corixidae*, *Cymatiainae*) is an Eurosiberian element distributed in Western, Northern and Central Europe, very rare in the Labe basin (collected at 6 localities only). The area of the Šumava Mts. represents most probably southern limits of its distribution.

Long-term changes of aquatic bug diversity in the Šumava are poorly known since earlier data are very fragmentary and most species were never collected until recently (PAPÁČEK 1991, PAPÁČEK & SOLDÁN 1995). The only exception is *Glenocoris propinqua propinqua*. Its mass occurrence is reported from the Čertovo Lake in the beginning of century (FRIC & VAVRA 1898). Originally distributed in other glacial lakes as well, it apparently disappeared from these habitats in the late 1950's (last records by ROUBAL 1957). As far as we know, this species is absent in Bavarian glacial lakes, too. We assume that present considerable decrease of *G. p. propinqua* population densities is not simply affected by acidification. It seems to be more likely a consequence of dramatic changes in the food offer (PAPÁČEK & SOLDÁN 1995). On the other hand, some localities are apparently not affected, retaining their original diversity. For instance, in pools and small lakes of the Modrava peat-bog system all 6 species of the genus *Notonecta* have been found (besides 4 species mentioned above, two common species, namely *N. glauca* and *N. viridis* live here).

Megaloptera (dobsonflies)

The *Megaloptera* are a small insect order with about 300 species known up to date. Five of them live in Europe, three occur in Central Europe. *Sialis lutaria* (*Sialidae*) was collected in standing waters mainly at lower altitudes and in the Šumava foothills. *S. fuliginosa* living in lotic habitats occur on the territory of National Park as well. Both species are widely distributed and common at places of their occurrence.

Trichoptera (caddisflies)

Since the number of the *Trichoptera* species collected in the Šumava is very high (Table 1.) only several examples are mentioned here. Other species are treated elsewhere in detail (NOVÁK 1964, 1996). The following species are considered most important ones from the biodiversity point of view: *Hydropsyche silfvenii* (*Hydropsychidae*), *Limnephilus algosus* (*Limnephilidae*) and *Molanna nigra* (*Molannidae*) represent arcto-alpine elements, the former species displaying southern boundaries of its area of distribution just in the Šumava. *Anomalopteryx chauviniana* and *Ecclisopteryx guttulata* (*Limnephilidae*) are Atlanto-Mediterranean species both with eastern area boundaries in this region. *Rhyacophila hirticornis* (*Rhyacophilidae*) is a species with evidently disjunctive area, occurring solely at several Šumava localities within the whole Labe basin. *Acrophylax zerberus* exhibit a very peculiar area: it is distributed, besides the Šumava, only in the Tatra Mts. and some other Carpathian ranges thus representing possible Carpathian faunistics element. *Agrypnia obsoleta* (last occurrence before 1957) and *Hagenella clathrata* (*Phrygaenidae*) are stenotypic tyrphobionts, *Agrypnia varia* (*Phrygaenidae*) and *Grammotaulius nitidus* (*Limnephilidae*) are examples of numerous tyrphophilous species of caddisflies. *Beraea maurus* (*Beraeidae*) is firmly connected with habitats of crenon (the spring area of running water).

Long-term changes in species diversity of the Šumava caddisflies are well documented. In the beginning of this century, 68 species were known here (KLAPÁLEK 1890, 1894, 1902). However, this low number is evidently due to only occasional faunistic research. Detailed investigation of 57 localities in 1955–1993 showed the presence of 137 species (NOVÁK 1964, 1996). Although quantitative presentation changes of most species found are not pronounced, 11 species disappeared before 1920 (e.g. *Rhyacophila vulgaris*, *Hydropsyche saxonica*, *Plet-*

rocnemia geniculata, *Chaetopteryx major* and others), 4 species were never collected after 1950 and 5 species (e.g. *Hydropsyche fulvipes*) disappeared in the 1960's and 1970's (Novák 1996). *Chimara marginata* (*Philopotamidae*) is now extinct in the whole Labe basin (last records from the Šumava foothills in 1939). On the other hand, a certain enrichment of *Trichoptera* diversity have been observed at localities affected by the Lipno dam (emergence of standing water species). Some species originally abundant in fish ponds and other lenitic habitats inhabit mostly peat-bog waters at present (e.g. *Agrypnia spp.*). These ecological changes are probably due to increased eutrophization (fertilization) of fish ponds in the 1970's and 1980's.

Discussion and conclusions

The numbers of species of the respective orders collected in the Šumava Mts. are apparent from Table 1. Taking into account total number of species, the Šumava's biodiversity seems to be very high, reaching 50–79 % of the fauna of the Czech Republic and even 35–40 % of the whole Central European fauna. However, the biodiversity should not be evaluated in such a simple way. Total species numbers presented here comprise a great deal of common or widely distributed montane and submontane species. We believe that the unique biodiversity of the Šumava should be characterized, first of all, by extraordinary richness of elements remarkable for their faunistic origin, chorology and/or ecological range or specialization. Although there are no true endemic species (probably a consequence of postglacial migrations) the following valuable elements were ascertained: (i) endemites of the Alps + the Šumava; (ii) Hercynian species; (iii) species of presumable Carpathian origin; (iv) species showing the arcto-alpine (boreo-montane) disjunction of area; (v) Ponto-Mediterranean or Pontic faunistic elements; (vi) Atlantic or Atlanto-Mediterranean faunistic elements; (vii) Mediterranean species. Biodiversity of the Šumava is enriched, contrary to the most other Hercynian mountain ranges, also with numerous creobionts, tyrphobionts and/or creophilous or tyrphophilous species. Most of these species (at least 75 %) were found on the territory of the national park, and it is obvious that they occur on the Bavarian side as well. However, the data concerning aquatic insects of this area are still very fragmentary (e.g. JURITZA 1965, GRIMM 1980 and others). On the aquatic insects treated here, the *Trichoptera* exhibit evidently the highest diversity in the Šumava. This fact seems to be influenced not only by a relatively high global and Central European diversity, but also by a very high vagility and larger ecological range of caddisflies (note semivoltinism, aestivation, flight ability, resistance to acidification and eutrophization – alternative habitats in peat-bogs etc.). Diversity of the *Plecoptera* and *Ephemeroptera* is also relatively high, although their vagility and global biodiversity is obviously much lower. However, contrary to the *Trichoptera*, there are several species endemic to the Alps and the Šumava only (e.g., *Leuctra alpina* or *Ecdyonurus austriacus*). We consider these species as the most valuable elements within the Šumava's biodiversity. As to the *Odonata*, the number of species collected or considered to occur in the Šumava Mts. is evidently not complete or adequate. Since no detailed and systematic faunistic research has been performed, at least further 5–10 species are expected to be collected or verified in the near future.

Although none of the 6 species of the *Heteroptera-Nepomorpha* is included in the Red book (ŠKAPEČ 1992) we believe that all of them deserve strict protection. There is only a single refuge of the once widely distributed *Glenocorisa propinqua*; other species exhibit either disjunctive area or live in pesimum or pejus boundary part of their areas. We suggest to classify them as follows: *G. propinqua* – endangered (E); *Notonecta lutea* – vulnerable (V); *N. obliqua* and *N. maculata* – rare to vulnerable (R-V); *N. reuteri* and *Cymatia bondsdor-*

Table 1. – Biodiversity of selected aquatic insects groups with a special respects to the Šumava Mts. fauna (Megaloptera not included)

Tabulka 1. – Biodiverzita vybraných skupin vodního hmyzu se zvláštním zřetelem k fauně Šumavy (nejsou zde zahrnutý druhy řádu Megaloptera)

Biodiversity/ oder (suborder)	Epheme- roptera	Odonata	Plecoptera	Heteroptera (Nepomorpha)	Trichoptera	Total
Global (estimated)	3,500	5,000	2,500	2,000	8,000	21,000
West Palaearctic (estimated)	350	350	500	90	900	2,190
Central Europe (approx.)	120	120	350	60	450	1,100
Czech Republic (total)	91	64	108	40	220	523
Šumava Mts. (total)	61	32	62	26	156	337
Šumava Mts. (National Park)	52?	25	49	26	124	251
Šumava Mts. (% of European fauna)	51	27	18	43	35	31
Šumava Mts. (% of fauna of the Czech Republic)	69	50	57	65	79	64

fi – rare (R). In addition, 2 species of mayflies (*Arthroplea congener*, *Oligoneuriella rhena-na*), 4 species of dragonflies (*Calopteryx splendens*, *Aeshna subarctica*, *Cordulegaster boltoni* and *Sympetrum pedemontanum*), 2 species of stoneflies (*Isogenus nubecula* and *Capnopsis schileri*), and 3 species of caddisflies (*Chimarra marginata*, *Agrypnia obsoleta* and *A. varia*) which occur or occurred in the Šumava, are comprised in the official „red“ species list (ŠKAPÉČ 1992) and deserve protection of their mostly relict areas. To conclude, the Šumava Mts. represent an extraordinarily important biodiversity centre in Central Europe. Owing to catastrophic acidification of the Sudeten mountains, and elimination of numerous species by pollution of lowland waters, the Šumava is also important and valuable refuge and secondary faunistic centre which deserves a strict protection.

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