Proc. IVth Intern.Confer.Ephemeroptera
V.Landa et al.(eds.),317-321,ČSAV,1984

STUDIES ON AQUATIC INSECTS IN CZECHOSLOVAKIA WITH REGARD TO CHANGES IN THE QUALITY OF WATER IN THE LAST 20 - 30 YEARS

V. Landa

Institute of Entomology, Czechoslovak Academy of Sciences,
Na sádkách 702, 370 05 České Budějovice, Czechoslovakia

Abstract. Larves of mayflies were collected quantitatively at spring, summer, and winter seasonal aspects during two research periods /1950-1960 and 1970-1980/ in order to determine distributional changes connected with changes of water quality. Larvae were collected at 150 selected localities evenly distributed in the Labe basin. These localities represent all types of aquatic biotopes and are evenly distributed horizontally. Changes in qualitative and quantitative presentation of individual species were studied by multivariate analysis /cluster analysis, ordination techniques/. Most localities, especially those of greater lowland rivers, show decreasing species diversity and increase in index of saprobity, localities of higher altitudes and pond localities changed only slightly.

Mayflies, Elbe basin, pollution, saprobity

Aquatic insects are one of the most important components of water biocoenoses of continental streams, predominating at many places from the quantitative point of view (abundance and biomass) as well as in the diversity of species. At the present time it is already clear that owing to these circumstances the aquatic insects represent a dynamic system sensitively responding to seemingly negligible changes in water ecosystems, e.g. modifications of the bottom and banks, fluctuation of the water column, or pollution and altered quality of water.

It is well known that pollution considerably interferes with the ecological requirements of many species; this selective pressure may result in their complete eradication. Ecologically specialized species of a narrow ecological range naturally are much more susceptible than those whose requirements

for the biotope are not so higly specialized and whose ecological range is wide. These facts are utilized in a system of saprobity that has been developed into its present form mainly by Zelinka and Marvan (1961), and which is now used in the COMECON countries. It is based on the premise that the quality of water can be assessed by the quantitative and species composition of organisms, because each species is characteristic in a way of a certain saprobic zone. Different ecological ranges are taken into account in the system by establishing a so-called indicative value of each species. This system of bioindication of the quality of water is a part of state norms in Czechoslovakia.

At the present time we must pay more and more attention to the pollution of surface waters caused by industrial development and agricultural mass production as well as by the spreading of housing estates. The purity of water must be constantly watched in order to prevent irreversible changes in the polluted biotopes. Long-term observations are of especial importance, being the only way of distinguishing long-term decisive trends in the historical development of water biotopes and long-term tendencies in the changing quality of water.

I should like to present some results of such studies on water insects in Czechoslovakia. The first phase of an extensive research programme, which was a continuation of the traditional study of these subjects in Czechoslovak territories, was carried out in 1950 - 1965. The originally largely faunistical and biogeographic research gradually expanded into the study of ecology, seasonal cycles, population dynamics and biosystematics of Central European species of the orders Ephemeroptera, Plecoptera, and Trichoptera. Over 2000 Czechoslovak localities have been investigated, evenly distributed in the basins of the Elbe, Visla and Danube in all altitudinal zones and covering all kinds of water biotopes (brooks, rivers, ponds, impoundments, periodical waters, etc.) (Landa, 1964, 1968). One hundred and fifty localities in the Elbe basin in Bohemia were chosen for monthly observations with the exception of December and January (Fig. 1). Sampling was quantitative, supplemented by measurement of temperature and pH, checking of the bottom profile, etc. In this way we obtained a very complete picture of biotopes in the Elbe basin, which can be considered a "zero" state as regards changes in the quality of water in the investigated biotopes. The programme was repeated in the years 1970 - 1982 at the same localities. Sampling was done in the same way, quantitatively, and the physical and chemical characteristics were measured again.

The results of these two phases of intensive research of aquatic insects, carried out within three decades, form not only a unique set of comparative material (over 500,000 specimens) but also a set of data unique in the world considering the size of the territory covered by them. The two phases have been compared from the qualitative (diversity of species), quantitative (abundance and predominance of species) and sap-

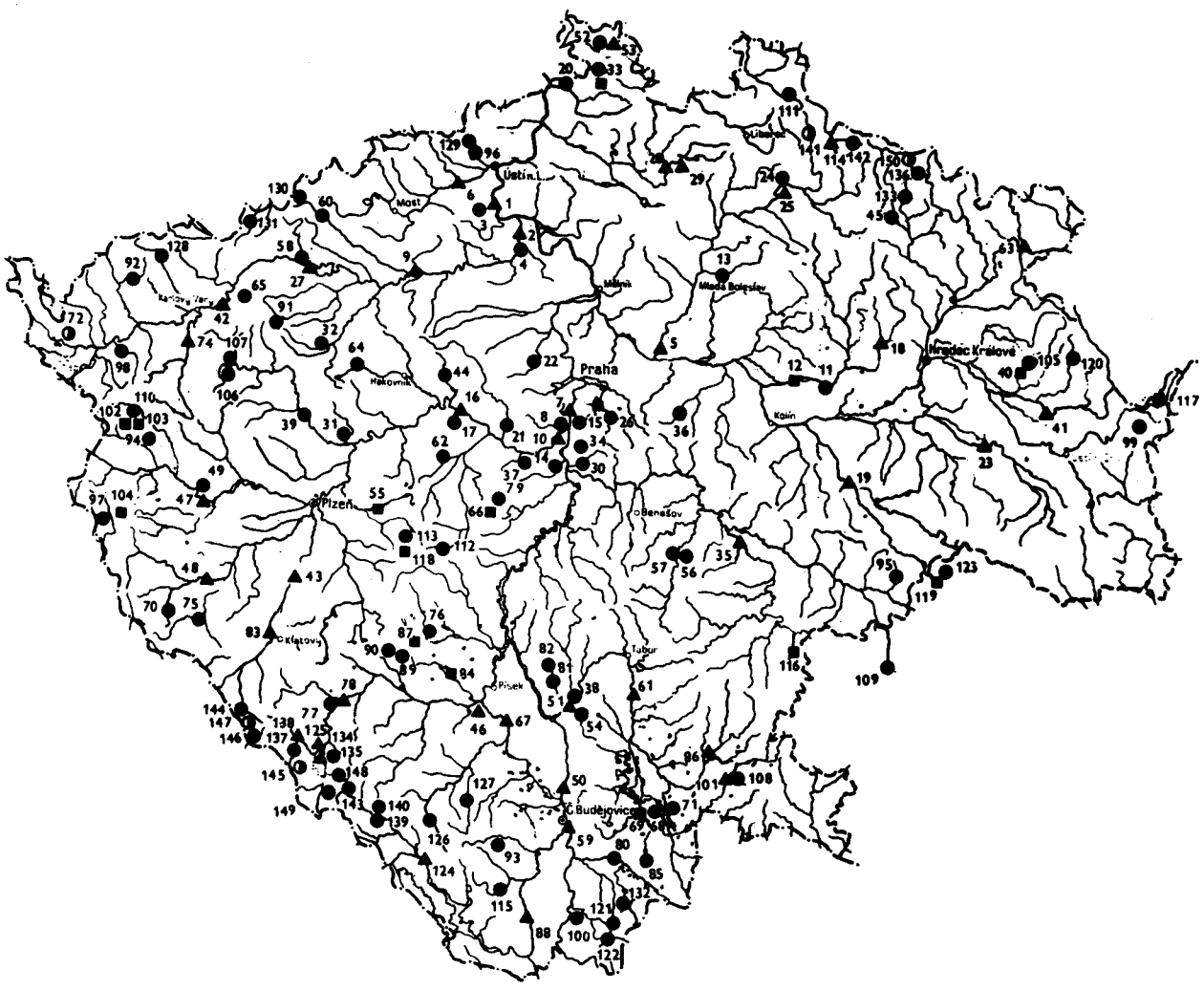

Fig. 1: Localities investigated in the Elbe basin in Bohemia. ▲ - rivers /potamon/. ● - streams /rhithron/. ■ - ponds. ◑ - other biotopes.

robic angles (ensuing saprobity, saprobic index). A large number of mayfly species were found in Czechoslovakia for the first time as well (cf. Landa 1969, 1977; Soldán 1978).

Computer evaluation of the results (more than 50,000 distributional data) was done by the methods of multidimensional analysis (ordination of species, localities, etc.). A useful byproduct of the study is a set of pH values from over 400 localities, giving evidence of the alarmingly increasing acidity (i.e. decreasing pH) of surface waters in Central Europe. Localities where the acidity of water constantly remains below pH 4.5 are no exception, and changes in pH during the last 30 years are statistically significant at many localities.

I shall document our results in mayflies (Ephemeroptera). Though one group of water insects obviously is not enough for assessing changes in biotopes, mayflies are an almost perfect model. They are a group very conservative in its choice of new biotopes, the range of many species is of a relic character, and the relatively narrow ecological range of most species

guarantees considerable sensitivity to changes in the quality of water. Moreover, the taxonomy and ecology of the group have been thoroughly investigated in Central Europe and larvae of all species are well known (in contrast to e.g. trichopteran larvae).

The greatest changes have occurred in stenotopic and specialized species which are unable to tolerate changes in their biotopes. Often they require plenty of oxygen in water, consuming up to 800 - 1000 m^3 per 1 g/hour. They are mostly species whose range was discontinuous and scattered already in the first phase of the research (e.g. Ephoron virgo, Ephemera lineata, Oligoneuriella rhenana) as well as species widely distributed, but specialized in a limited set of habitats (e.g. Choroterpes picteti). Three species were not found again in the second research phase, two species new for Czechoslovakia were discovered. However, some species have markedly enlarged their range, particularly some species of Baetidae and Heptageniidae (e.g. Rhithrogena hybrida, R. germanica, Baetis buceratus, B. lutheri, and others) which because of their expansiveness and wider ecological range have been settling in new biotopes and at new localities, e.g. the sections of rivers under dams where the constantly low temperature of water, intensive flux in the streamline and changes in the profile of the stream cause a certain "montanization" with an often quite unexpected occurrence of mountain and submontane species in lowlands (e.g. in the river Sázava under the Švihov dam on the Želivka, a section of the Ohře under the Nechranice dam, etc.) (cf. Soldán, 1981).

As for quantitative changes, the greatest shift in the representation of individual species (in saprobic characteristics as well) was found at lowland localities up to 250 m a.s.l. The proportion of the resistant species has markedly increased (Baetis vernus up to 15 %, B. rhodani and Ephemerella ignita up to 10 %); these species may be absolutely predominant at seriously polluted places (up to 60 - 70 %). Predominance decreased in species specialized in lowland rivers (e.g. Potamanthus luteus). Similar tendencies occur at highland localities (250 - 700 m), but they are not too conspicuous owing to the wider spectrum of species. The proportion of B. rhodani, Ephemerella ignita, Cloeon dipterum and Ephemera danica has increased at many localities, especially at the altitude of 250 - 500 m, but the percentile representation of the species of Heptageniidae, most of which require more oxygen, has dropped. There has also been a reduction of the number of subdominant species (about 5 - 7 species making up over 5 % of individuals), and the number of species whose representation does not exceed 2 % increased. Almost no changes have been found at mountain localities, despite their colonisation mostly by stenotopic and very fastidious species (the genus Rhithrogena, Ecdyonurus venosus, E. forcipula, Ameletus inopinatus, and others). This can be explained by a limited occurrence of sources of pollution at high altitudes; moreover, the aquatic insects (unlike fish that disappeared from these waters) have not yet been af-

fected by the rapidly progressing acidification.

I wish to emphasize that the quantitative and qualitative changes are closely related, and there is no doubt that they are the result of changes in water biotopes. The occurrence of a given species at a locality is primarily determined by abiotic factors, the most important of which are the oxygen content, water temperature, and profile of the stream. Biotic factors do not seem to have a decisive role in the case of mayflies. Pollution (particularly organic) reduces the oxygen content, and regulation of streams causes changes in their profile. Also thermal pollution, e.g. by the cooling systems of nuclear plants, has recently been on the increase. Bioindication of changes in the quality of water through aquatic insects clearly shows that pollution of the lower sections of rivers and brooks is rapidly increasing. A partial or total breakdown of the selfpurification of water has already occurred at many places (about 10 localities in our sample).

These facts represent a serious danger to water ecosystems which - compared with terrestrial ones - were until lately a relatively less damaged part of environment. Therefore the surface waters, our potential sources of drinking water, ought to be effectively protected from pollution, and their quality should be regularly and consistently checked.

REFERENCES

Landa, V. 1964. Organisation, Ergebnisse und Probleme der faunistische Forschung in der ČSSR. Dtsch. Landw. Berlin, 60: 7 - 18.

Landa, V. 1968. Die faunistische Erforschung der Wasserinsekten in der ČSSR und die Verwertung ihrer Ergebnisse. Abh. Ber. Naturkundemus. Görlitz, 44: 21 - 29.

Landa, V. 1969. Jepice - Ephemeroptera. Fauna ČSSR, 18: 347 pp. Academia, Praha.

Landa, V. 1977. Ephemeroptera. In: Check-list of Czechoslovak insects. Acta faun. ent. Mus. Nat. Pragae, Suppl., 4: 23 - 26.

Soldán, T. 1978. Mayflies (Ephemeroptera) new to the fauna of Czechoslovakia found in 1972 - 1977. Acta ent. bohemoslov., 75: 319 - 329.

Soldán, T. 1981. The effects of dams and river regulation on Ephemeroptera fauna on affected biotopes. Zbor. mat. celošt. zool. konfer., Bratislava, 1981, p. 79 - 83.

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