20 Biological studies of *Palingenia longicauda* (Olivier) (Ephemeroptera: Palingeniidae) in one of its last European refuges — Abiotic characteristics and description of the habitat

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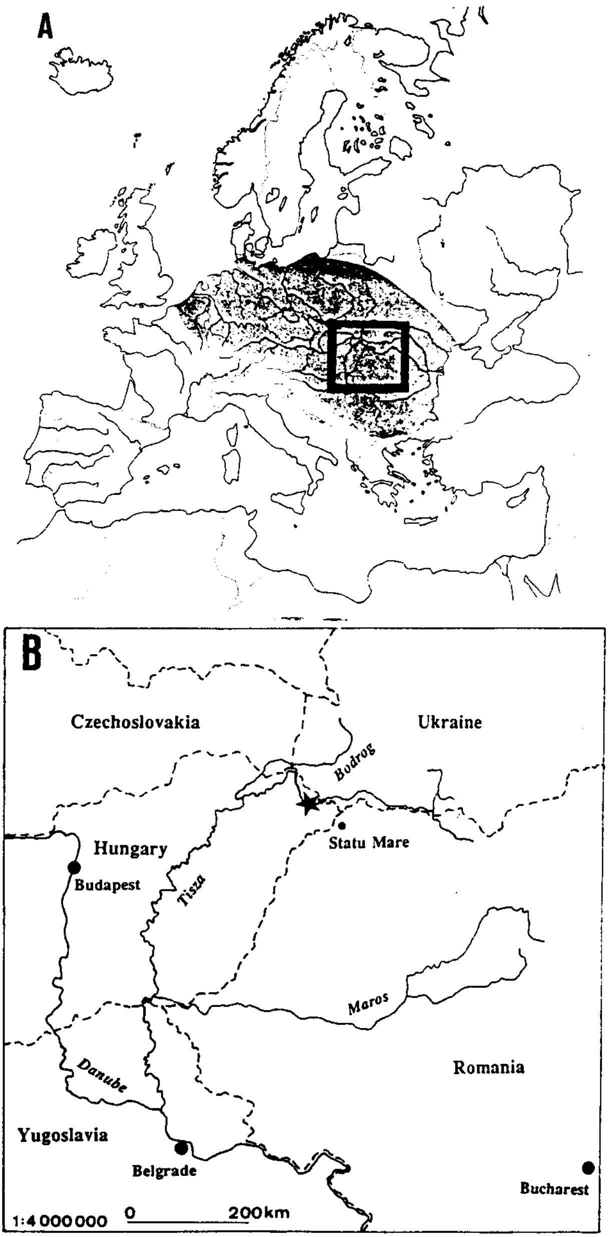
The Tisza River in Hungary is one of the last refuges of Palingenia longicauda *(Ol.). The main characteristics of the habitat are presented, and the physical and chemical parameters are discussed, as well as human impacts on the habitat. The composition of the sediment plays a significant role in the colonization of the larvae. Larvae require a substrate composed of a high amount of clay and fine silt with a particle size less than 20 µm. Sediments with a proportion of more than 20 per cent of coarse silt (particle size 20 - 50 µm) are inadequate for colonization.*

Introduction

Palingenia longicauda (Olivier 1791) is probably the oldest known mayfly species, since it is already known with certainty by the pioneer works of Clutius (1635) and Swammerdam (1675) (see Arvy and Peters 1975, Francissen and Mol 1984 for more details).

According to Russev (1987), *P. longicauda* is a central European species that was formerly found from Holland to Ukraine (Fig. 1A). Due to human impacts on the environment, the species has progressively disappeared from western Europe since the beginning of the 20th century. Around 1950, the most important populations were found in the Danube and in some of its tributaries. Since 1974, no *Palingenia* populations have been found in the Danube (Russev 1992). Among the last remaining places where this species can still be found is the Tisza watershed, more precisely the Tisza River with some of its tributaries, such as the Bodrog and the Maros rivers (Fig. 1B). The occurrence of a *Palingenia* population in the Tisza has long been known; the first observations were reported by Marsigli in 1726 (Beretzk et al. 1957).

Figure 1. **Historical distribution of *P. longicauda* (from Russev 1987) (A) and location of the study site (B, star). Known populations are restricted to the Tisza watershed.**



Materials and Methods

Two field trips were organized in June 1990 and July 1991 to the Tisza at km 710 in Nagyar near the Ukrainian border (Fig. 1B). Km 710 indicates the distance from the locality to the outlet of the Tisza in the Danube. Sediment samples were transported to the laboratory where the sediment granulometry was determined using standard international methods modified by the use of Robinson's pipet (Duchaufour 1965). Physico-chemical analyses were performed weekly over a period of five years (1987-1991) at Tiszabecs, 47 km upstream of our study site. Data were available through the courtesy of the "Felsö-Tisza-Vidéki Környezetvédelmi Felügyelöség" in Nyíregyháza.

Results

The Tisza

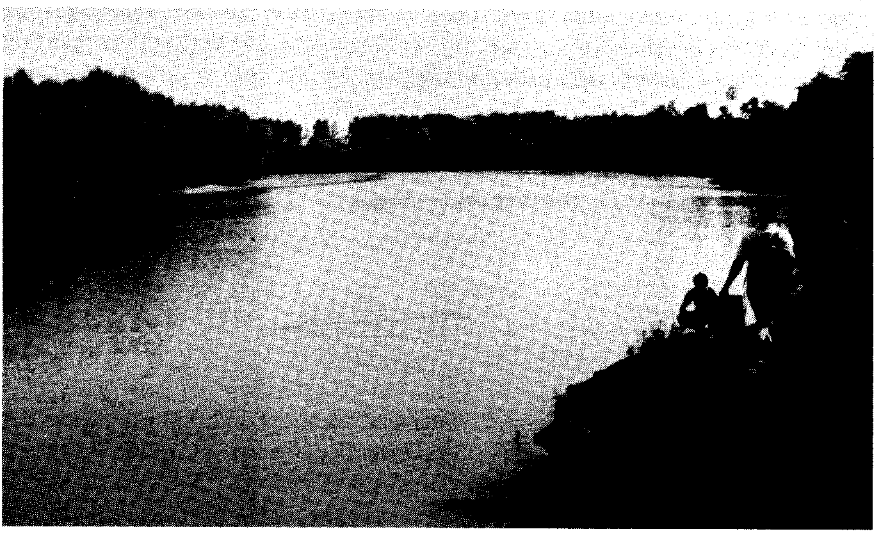
With a length of 960 km and a watershed of about 157,000 km^2, the Tisza River is the most important tributary of the Danube (Uherkovich 1966). Its springs are located in the Ukrainian Carpaths (Bihar area) at about 1500 m a.s.l. and its outlet is situated in the former Yugoslavia or Serbia at ca 80 m. a.s.l. Each year, the Tisza carries about 25 billion m^3 of water (Szépfalusi 1971), and the discharge at its outlet is about 793 m^3/s.

The area investigated (Fig. 2) is situated in the upper part of the river. Here, the Tisza is already a large river flowing on tertiary and quaternary sediments and forming large meanders. The river is approximately 100 m wide and of moderate depth (5-6 m). The slope is gradual (ca. 58 cm/km) and the typical current speed is about 0.6 m/s (Végvári 1976).

Physical and Chemical Parameters of the Water

Table 1 summarizes the main parameters measured over five years (n = 257 weekly measurements). The discharge is typical of a large lowland river: a maximum is observed in March-April during snowmelt and low water levels occur after the summer dry season in September-October (Fig. 3A). The temperature is also characteristic of large rivers in a continental climate with important fluctuations (range over 25°C, see Table 1) from January-February to July-August (Fig. 3B). Parameters such as pH, conductivity and O_2 saturation are quite normal and reflect good water quality. Due to the important concentration of calcium, the Tisza belongs to the waters of positive CO_2 content. The iron content is of mineral origin and its concentration fluctuates as a result of the geochemical characters of the watershed area (Adámosi et al. 1978).

Figure 2. The Tisza River at km 710 (upstream view).



Concerning the human impacts on the environment, some parameters have been studied in more details. The potassium (K^+) content between 1987-1990 is rather stable and shows a mean amount of 3.45±1.20 mg/L. However, in 1991 a significant and drastic increase of potassium up to 8.25±6.35 mg/L was recorded (ANOVA: $F_{4,252} = 26.25$, $p<0.001$). Fig. 4A illustrates the evolution of ammonium concentration in relation to discharge. This parameter tends to increase with increasing discharge. The chloride evolution is completely different since this parameter decreases with increasing discharge (Fig. 4B).

Granulometry

Palingenia larvae are restricted to the outer bank of the meander consisting mainly of clay and silt. The patchy distribution of the holes dug by the larvae let us compare in more detail the composition of the sediment in colonized and uncolonized substrates. There are significant differences between the two types of sediment (Fig. 5). Colonized sediments consist of more than 30 per cent clay (size 2 µm) and 55 per cent fine silt (size 20 µm). The proportion of clay in uncolonized sediment was reduced to <20 per cent and fine silt to <40 per cent.

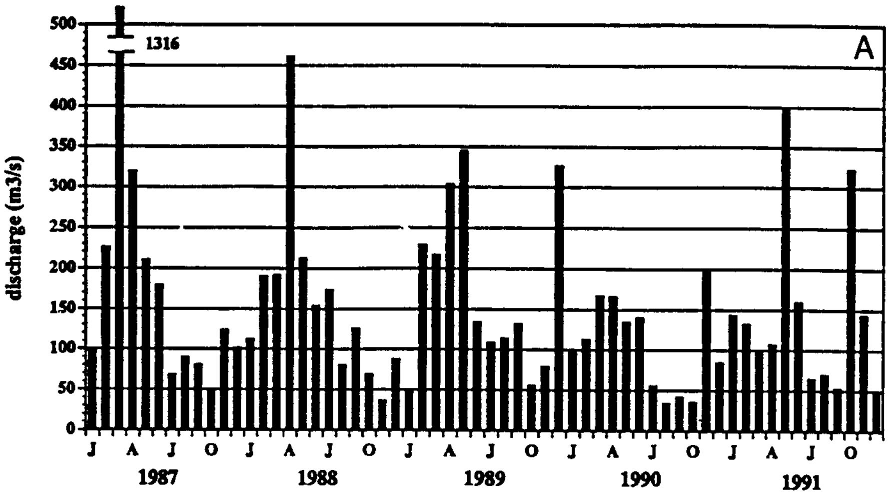
Table 1. Main physical and chemical parameters of the Tisza measured weekly between 1987-1991.

Parameter	mean	min.	max.
discharge (m^3/s)	164	16	5680
temperature (°C)	10.1	0.1	25.5
pH	7.5	6.7	8.3
conductivity (µS/cm)	268	145	590
O_2 saturation (%)	104	46	163
total hardness (CaO mg/L)	56	32	82
Ca^+ (mg/L)	32.25	8.82	80.16
Fe^+ (mg/L)	0.48	0.02	3.93
K^+ (mg/L)	8.25	1.41	19.01
Na^+ (mg/L)	14.6	3.6	51.9
Mg^+ (mg/L)	5.61	1.94	20.36
NH_4^+ (mg/L)	0.34	0	3.76
NO_3^- (mg/L)	4.66	0.26	29.76
NO_2^- (mg/L)	0.044	0.007	0.106
Cl^- (mg/L)	23.41	7.09	85.08
SO_4^- (mg/L)	13.79	0.96	65.11
PO_4^- (mg/L)	0.11	0	1.03

Discussion

The evolution of some chemical parameters allowed us to anticipate the influence of human activities. The rapid increase of the potassium concentration in 1991 should be confirmed by further sampling. The high concentration may be due to an increasing agricultural runoff. Another influence of agricultural land use can be seen in the evolution of ammonium concentration. The increase of this parameter with discharge can be explained by soil washing during high water periods. In contrast, decreasing chloride concentrations in relation to increasing discharge

Figure 3. **Monthly discharge (m^3/s) (A), and temperature (°C) (B) of the Tisza between 1987-1991.**



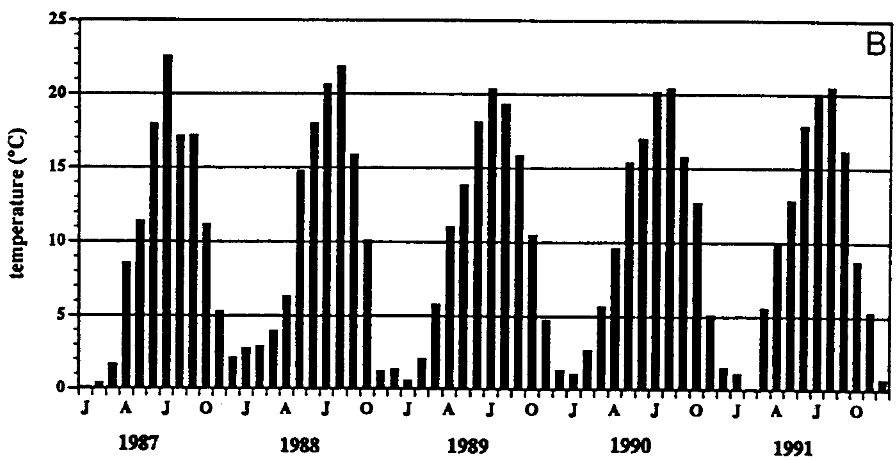
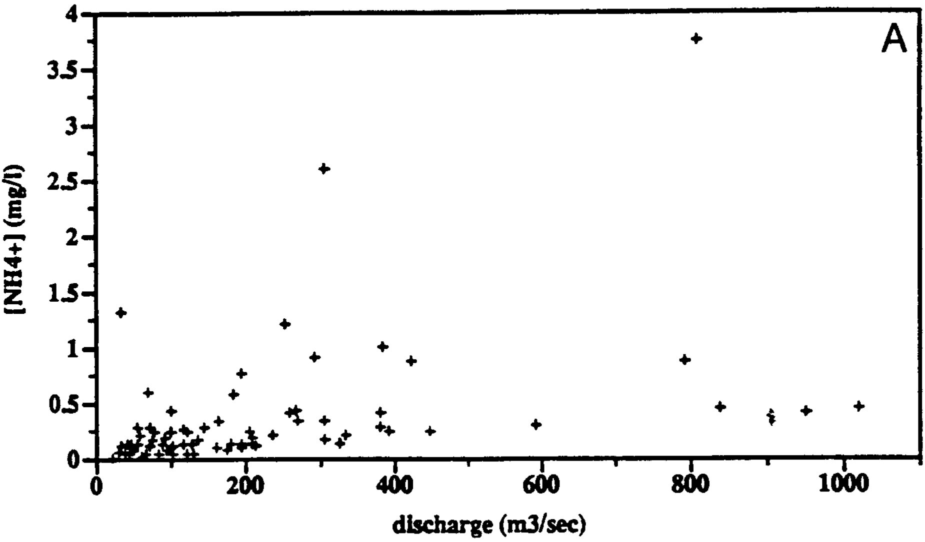


Figure 4. **Evolution of ammonium concentration (NH_4^+ mg/L) (A), and chloride concentration (Cl^- mg/L) (B) in relation to discharge.**



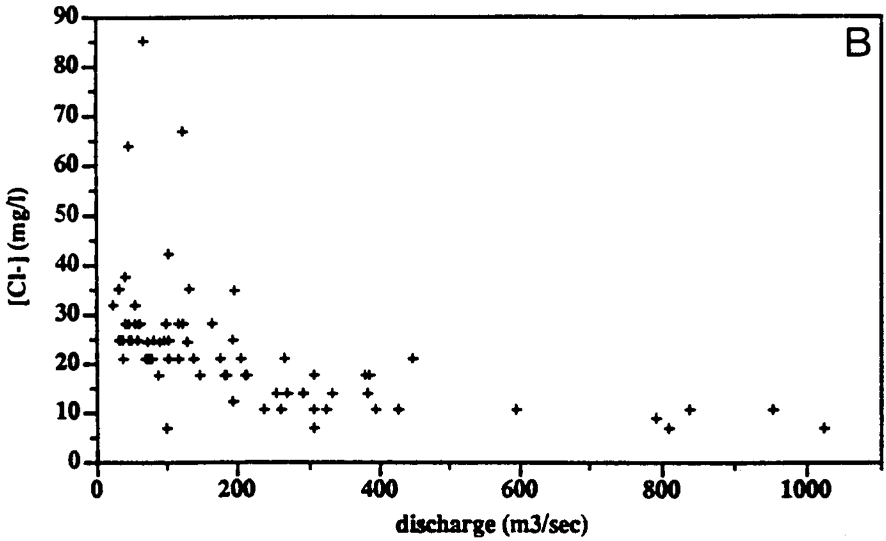
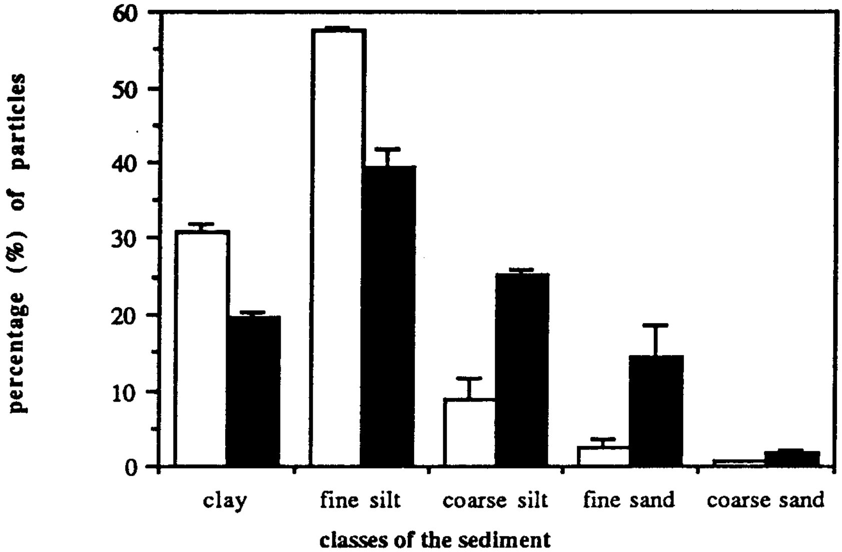


Figure 5. Composition of sediment in colonized (white bars) and uncolonized (black bars) samples. Percentages of clay (≤ 2 μm), fine silt (≤ 20 μm), coarse silt (≤ 50 μm), fine sand (≤ 200 μm) and coarse sand (> 200 μm) are indicated.



probably reflects regular pollution with constant stress, as industrial runoff. An analogous situation was observed in France when paper mills used chlorine in the bleaching operation of paper pulp (Thomas 1981).

Sediment composition plays a significant role in colonization by *Palingenia* larvae (Russev 1968; Csoknya and Ferencz 1972; Csoknya and Halasy 1974; Csoknya and Ferencz 1975). From our results, we can conclude that a proportion of more than 20 per cent of particles over 20 μm, i.e., especially coarse silt, is inadequate for colonization by *Palingenia* larvae. The granulometry of the sediment seems to be the most important parameter affecting the microdistribution of *Palingenia* larvae.

Large lowland rivers have been strongly affected during the past decades by human impacts on the environment. The highly specialized inhabitants restricted to these ecosystems were among the first ones to disappear when global conditions drastically changed. In this sense, the evolution of *Palingenia longicauda* distribution over this century is indicative of the dangers of extinction that threaten these populations (Fig. 1A).

Careful attention must be paid in the future to the evolution of the environmental conditions of the Tisza. This river is the last important refuge for *Palingenia longicauda*. The degradation of the habitat has already been indicated by several authors (Szépfalusi 1971; Végvári 1976; Adámosi et al. 1978) and will have dreadful consequences on the viability of this species. The next years will tell us if what happened to the Danube River in the 1970s will also occur to the Tisza.

Acknowledgements

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