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MAYFLY FAUNA (EPHEMEROPTERA) AND THE BIOLOGY OF THE SPECIES POTAMANTHUS LUTEUS (L.) IN A WARMED STRETCH OF THE OSLAVA RIVER

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Abstract

Cooling waters of the Oslavany power station show a depressive effect on the species diversity of mayfly nymphs. Only seven of 35 taxons found in the study area occurred in all localities. In the warmed stretch of the river, the abundance and biomass of mayfly nymphs as well as the production of the most important species *Potamanthus luteus* decreased; a gradual regeneration of the disturbed mayfly population could be observed downstream. In Locality 5, situated 3.5 km downstream from the mouth of cooling waters, the species diversity, abundance, and biomass of mayflies were 69, 30, and 66 per cent, resp., of values found in Locality 1 with natural temperatures; the production of *Potamanthus luteus* was 70 per cent of that found in Locality 1.

Introduction

Mayfly nymphs are an important member of the zoobenthos of running waters. According to Landa (1969) the life of mayflies is influenced by the following factors: water temperature, content of dissolved oxygen, flow rate, water quality, stream character, and nutrition. Ide (1935) also mentioned the water temperature as a limiting factor of mayfly distribution.

Mayflies are a suitable object of studies on effects of cooling waters on natural associations of streams (Langford, 1971; Vojtalik & Waters, 1976). The thermal resistance of nymphs of one species may differ in dependence upon environmental conditions (Whitney, 1939; Kamler, 1971). Langford (1975) found that cooling waters of a power station did not affect or accelerate significantly the emergence of mayflies.

The investigated lower stretch of the Oslava River was affected by cooling water discharged from a power station. The increased water temperatures caused changes in species diversity, distribution, and life cycles of mayflies.

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Localities and methods

In July and August, the natural water temperatures were as high as 20.8° C and dropped to 0.1° C in February. The average annual rate of flow was 3.33 $m^3.sec^{-1}$. The investigated stretch of the river was shallow with a stony bottom covered sporadically with macrovegetation *(Myriophyllum spicatum, Potamogeton pectinatus)* especially upstream the power station. The cooling waters were discharged on the left bank (Fig. 1) and their temperature ranged from 12.0 to 35.6° C.

Under normal flow conditions, the temperatures of the right and left part of the stream were balanced approximately 2.5 km downstream. In this warmed stretch of the Oslava River, biologically treated sewage waters, sedimented water from the hydraulic transport of cinder, and waste waters from ponds were discharged. Their volume and composition affected the benthic association of the Oslava River in a relatively small area situated immediately below their outlets. Analyses of cations, anions, total hardness, pH, alkality, and electric conductivity of samples from the warmed stretch suggested that there were no significant and marked changes in the chemical regime due to the rise of temperature (Kočková, 1975).

Zoobenthos was studied in five localities differing above all in water temperature (Tab. I). With regard to the temperature regime, the associations in Locality 1 were classified as natural (Obrdlík, 1975). Chironomidae, Ephemeroptera, Oligochaeta, Trichoptera, and Mollusca were abundant within the zoobenthos, Hirudinea, Simuliidae, Coleoptera, and Plecoptera were less frequent. The average abundance and biomass of the zoobenthos were 1,267 individuals and 7.2 $g.m^{-2}$, resp. (Adámek & Zelinka, 1973). Periphyton consisted predominantly of diatoms of the genera Synedra, Diatoma, Navicula, and Gomphonema. Green algae were represented mainly by the species *Cladophora glomerata, Ulothrix* sp., and *Stigeoclonium tenue* (Žáková, 1975). *Leuciscus cephalus* was the most frequent fish species. *Chondrostoma nasus, Barbus barbus, Leuciscus leuciscus, Gobio gobio,* and *Rutilus rutilus* were less frequent. In Localities 2 to 5, the temperature regime was affected by cooling water discharged from the power station. Although the rise of temperature was high especially in Locality 3, there was no decrease in the concentration of dissolved oxygen below 7 $mg.l^{-1}$. In warmed localities, both the qualitative and the quantitative composition of biocenoses was changed (Tab. II). Some representatives of the zoobenthos were absent, e.g. *Ancylus fluviatilis,* Plecoptera and Simuliidae, and the occurrence of other species was markedly reduced. Oligochaeta, Chironomidae, and *Plumatella repens* were the most resistant organisms to high temperatures (Obrdlík, 1977). In Localities 2, 4, and 5, the periphyton consisted of diatoms. *Navicula avenacea* and *N. cryptocephala* were dominating. Green algae: *Cladophora glomerata* and *Stigeoclonium tenue* occurred in Localities 2, 4, and 5. In Locality 4, the species *Spirogyra* sp. occurred in higher amounts. Cyanophyta, especially the thermophilous species *Phormidium ambiguum,* were the dominating component of periphyton in Locality 3 (Žáková, 1975). In warmed localities, the species composition of the ichtyofauna was identical with that observed in Locality 1. *Leuciscus cephalus* was the best adapted species in Locality 3 with extreme temperature conditions and its fry occurred in immense shoals.

In 1970-1974, zoobenthos was sampled once a month with a Surber's net; the area of its front frame and the average mesh size were 1/8 m^2 and 0.75 mm, resp. The material was preserved in 4 per cent formaldehyde and weighed after two months. Before weighing the samples were dried in a battery centrifuge (Kubíček, 1969).

Data necessary for plotting of a length-mass curve were obtained after measuring and weighting of 112 nymph specimens. The mathematic formulae of this curve were computerized in the computer SAAB 21 for several variants of its possible course and the most probable of them was finally selected.

The production of *Potamanthus luteus* was estimated according to Zelinka's method (Zelinka, 1973) based on '... an individual evaluation of the proportion of individuals of a certain size (length) category which passed into the next size category, to some of the following categories and which were eliminated from the population between the i^{th} and $i^{th}+1$ sampling' (Zelinka & Marvan, 1976).

Table I. The characteristic parameters of localities of the Oslava river.

locality		1	2	3	4	5
dist. along the stream /km/		5,8	3,6		2,9	0,1
water temp. /° C/	average	11,9	17,4	25,8	21,9	18,5
	min.	0,1	3,6	5,6	10,0	9,2
	max.	20,8	31,2	35,4	32,2	29,0
dissolved oxygen /$mg.l^{-1}$/	average	11,98	10,14	8,49	9,27	9,27
	min.	9,67	7,09	6,30	7,48	8,00
	max.	17,14	12,00	11,13	11,49	11,37
content of organic materials in sediment /%/	average	11,9	8,9	7,4	6,9	14,8
area of stones /cm^2/	average	165	158	165	88	116
speed of current /$m.sec^{-1}$/	average	0,80	0,80	0,80	0,55	0,80
depth of stream /m/	average	0,24	0,22	0,33	0,24	0,30
width of stream /m/	average	15	14		17	13

Table II. The average abundance and biomass of zoobenthos in the Oslava river.

locality	1	2	3	4	5
abundance No of animals · m^{-2}	1267	486	274	500	603
biomass $g.m^{-2}$	7,2	2,2	0,7	1,6	5,0

Values of production obtained according to the method mentioned above were compared with values calculated according to Hamilton's method (Hamilton, 1969) and according to a method assuming an exponential growth of biomass (Zelinka & Marvan, 1976) according to the formula:

$$P = \frac{G}{T} \cdot \bar{B} \ \ln \frac{w_t}{w_o} \quad (g.m^{-2}) \qquad [1]$$

where P – production
G – generation interval (one year)
T – time of larval development
$\bar{B}$ – average biomass
w_t – biomass of an individual from the highest size category
w_o – biomass of an individual from the lowest size category (a freshly hatched nymph).

Our calculations were based on Hamilton's assumption that for univoltine species G = T and, thus, $\frac{G}{T} = 1$.

The total annual production of mayflies occurring in individual localities in 1973 was estimated on the base of average biomass B and P/B coefficient (i.e. specific production). In our calculations the value of P/B = 9 was used (Zelinka, 1973; Zelinka & Marvan, 1976; Zelinka 1977).

Results

Composition of the mayfly fauna

The proportion of mayflies in the zoobenthos was high. Identified mayflies corresponded to 20 to 30 per cent of the total number of registered taxa.

Nymphs of 35 mayfly species were found in Locality 1 with the natural temperature regime (Tab. III). Nymphs of *Potamanthus luteus* occurred regularly. Nymphs of the genus Baetis were found at nearly all samplings. The most frequent were nymphs of the species *B. lutheri, B. bioculatus et scambus* and *B. rhodani.* Rather frequent were nymphs of *Ecdyonurus venosus, E. fluminum, E. torrentis, Ephemerella krieghoffi, Caenis macrura,* and *Ephoron virgo.* The other species occurred only sporadically.

In Locality 2, the water temperature was the lowest of all the warmed localities under study; however, the average annual water temperature was higher by 5.5°C than that in Locality 1. This fact affected, together with extraordinary high actual water temperatures (Tab. I), the occurrence of mayfly nymph during the periods of low flow rate. Altogether 20 species were found. *Potamanthus luteus* was found in all cases. *Rhithrogena semicolorata* and *Heptagenia* sp. were completely absent. Nymphs of the genus Baetis, *Ephemerella ignita,* and *Caenis macrura* were found frequently.

A similar species composition and dynamics of the occurrence of mayfly nymphs were observed in Locality 5. Altogether 21 mayfly species were found. In Locality 5, the average annual water temperature was 18.5°C, i.e. it was higher by 1.1°C than in Locality 2 (Tab. I); however, the variance of actual temperatures was lower. Nymphs of *Oligoneuriella rhenana* and *Caenis pseudorivulorum* occurred only in Localities 2 and 5 (Tab. III). The lowest number of mayfly species was found in Locality 3. Only *Potamanthus luteus, Baetis bioculatus et scambus,* and *B. rhodani* were more frequent. Due to high water temperatures (frequently above 30°C during the summer) no species occurring in the Oslava River is able to finish its development in this locality. In Locality 4, fourteen mayfly species were found; however only *Potamanthus luteus* occurred regularly and in a higher abundance. If some sensitive species (e.g. *Ecdyonurus venosus*) were found in strongly warmed Localities 3 and 4 (Tab. III) it is necessary to say that they were classified as younger larval instars which migrated into the right, cold part of the stream or died with the increasing water temperature (approximately after the 15th April). No older larval instar of *Ecdyonurus venosus* was found in Localities 3 and 4.

Only 7 of the total number of 35 identified species of mayfly nymphs occurred in all localities, viz. *Baetis bio-*

Table III. Taxa of mayflies found in the Oslava river.

/ + present, – absent /

locality	1	2	3	4	5
Baetis bioculatus et scambus	+	+	+	+	+
Baetis lutheri Müll.-Lieb.	+	+	+	+	+
Baetis pumilus /Burm./	+	+	–	–	+
Baetis rhodani /Pict./	+	+	+	+	+
Baetis vernus Curt.	+	+	+	–	+
Baetis sp.	+	+	+	+	+
Centropilum luteolum /Müll./	+	–	+	–	–
Procleon pseudorufulum Kimm.	–	+	–	–	–
Oligoneuriella rhenana /Imhoff/	–	+	–	–	+
Rhithrogena semicolorata /Curt./	+	–	–	–	–
Heptagenia coerulans Rost.	+	–	–	–	–
Heptagenia flava Rost.	–	–	+	–	–
Heptagenia lateralis /Curt./	+	–	–	–	–
Heptagenia sulphurea /Müll./	+	–	–	–	+
Heptagenia sp.	+	–	–	+	–
Ecdyonurus dispar /Curt./	+	+	–	–	+
Ecdyonurus fluminum /Pict./	+	+	–	–	–
Ecdyonurus insignis /Eat./	+	–	–	–	+
Ecdyonurus torrentis Kimm.	+	+	–	+	+
Ecdyonurus venosus /Fabr./	+	+	+	+	+
Ecdyonurus sp.	+	–	–	+	+
Ephemerella ignita /Poda/	+	+	+	+	+
Ephemerella krieghoffi	+	–	–	–	–
Ephemerella notata Eat.	+	+	+	–	–
Ephemerella sp.	+	–	–	–	–
Caenis horaria /L./	+	–	–	+	–
Caenis macrura Steph.	+	+	+	+	+
Caenis moesta Bengt.	+	–	–	+	+
Caenis pseudorivulorum Keffermüll.	–	+	–	–	+
Caenis sp.	+	–	+	–	+
Paraleptophlebia submarginata /Steph./	+	+	–	–	–
Ephoron virgo /Oliv./	+	+	–	+	+
Ephemera danica Müll.	+	+	–	–	+
Ephemera vulgata L.	+	–	–	–	–
Potamanthus luteus /L./	+	+	+	+	+
number of taxa	31	20	13	14	21

culatus et scambus, B. rhodani, B. lutheri, Ecdyonurus venosus, Ephemerella ignita, Caenis macrura, and *Potamanthus luteus.*

Mayfly abundance and biomass

Mayfly nymphs represent an important component of the fish food in the Oslava River. For example in Localities 1 and 5, mayflies and mayfly nymphs amounted to as much as 21 and 24 per cent of the total content of the digestive tract of *Barbus barbus*, resp. (Adámek & Obrdlík, 1977).

The highest abundance and biomass of mayfly nymphs were found in Locality 1. The average annual abundance and biomass were 360 individuals . m^{-2} and 1.2 $g.m^{-2}$ (Tab. IV). Both values fluctuated during the year (Figs. 2 and 3). In Locality 1, these changes resulted from a cyclic development of individual species. The spring maximum of abundance was observed before the emergence of imagines.

The second maximum was observed in September-October when an intensive development of newly hatched nymphs took place. The highest biomass was found in the period of the spring maximum of abundance. This biomass consisted of big mayfly nymphs which were ready to emerge. The deviations of this cycle observed in some years in Locality 1 resulted partly from floods and

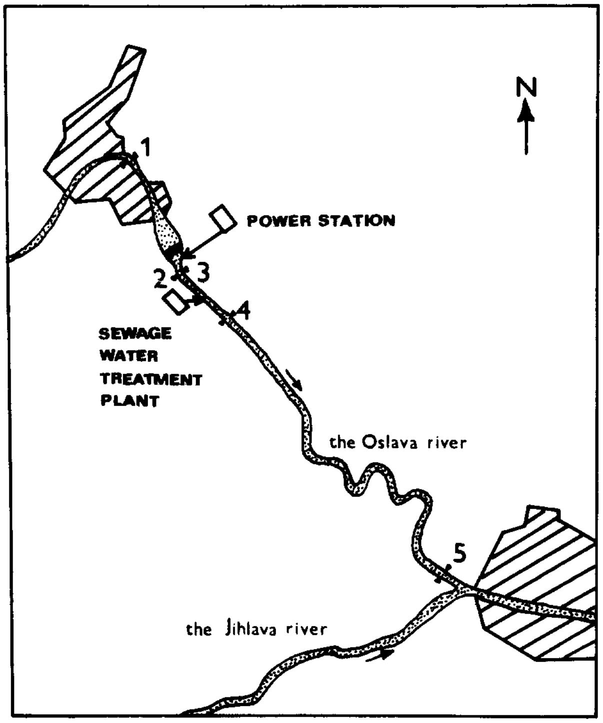

Fig. 1. Situation of localities on the Oslava River.

partly from floating away of floes.

In Localities 2 and 5, the average annual abundance and biomass of mayfly nymphs were very similar (Tab. IV). There was a marked spring maximum in the course of abundance in Locality 2 (Fig. 2). The autumn maximum was inexpressive. This might be caused by high water temperatures.

In Locality 5, samplings of zoobenthos were interrupted approximately from the second half of 1971 to the first half of 1972. In spite of that, however, it may be said that the course of abundance was approximately the same as that observed in Locality 2. In Localities 2 and 5, the highest values of biomass were found during the spring before the emergence of imagines of the major part of species observed (Fig. 3). The lowest abundance and biomass were found in Locality 3 while in Locality 4 these values were slightly higher (Tab. IV). High water temperatures disturbed the developmental cycle of mayfly nymphs (Figs. 2, 3). The low spring maxima consisted of species with a rapid development (e.g. *Baetis rhodani*) which can use lower water temperatures of the period October-April for their nymphean development.

Population of Potamanthus luteus

Abundance and biomass

Potamanthus luteus contributed in average with 30 to 40 per cent to the abundance and biomass of all mayfly nymphs in the investigated stretch of the Oslava River. Its proportion was approximately equal in all localities and showed seasonal fluctuations associated with the life cycle of mayflies. In all localities, the highest abundance and biomass were observed during the spring season; later on, at the time of emergence of imagines in summer, it decreased and increased again in August and September.

Normally, values of abundance and biomass ranged from zero (June 1973, 1974) to 504 indiv.m^{-2} (September 1971) and zero (June 1973, 1974) to 0.51 g.m^{-2} (May 1971), in Locality 1.

In warmed Localities 2, 3, and 4, values of both quantitative indices were rather fluctuating. *Potamanthus luteus* was a regular component of mayfly fauna only in spring and it was frequently absent from June to February. In Locality 2, the maximum abundance and biomass were observed, similarly to Locality 1, in May 1971 (344 indiv.m^{-2} and 0.27 g.m^{-2}, resp.). In warmed Locality 3, *Potamanthus luteus* occurred sporadically and its abundance and biomass did not exceed the limits of 8 individuals.m^{-2} (May 1971) and 0.14 g.m^{-2} (April 1973), resp.

In the lowest Locality 5 the occurrence of *Potamanthus luteus* was similar to that in Locality 1. However, the size of its population was considerably smaller and the maximum abundance and biomass were 152 individuals.m^2 and 0.20 g.m^{-2}, resp., in February 1973. Similarly as in

Table IV. The average abundance and biomass of mayflies larvae in the Oslava river.

locality	1	2	3	4	5
abundance No. of animals · m^{-2}	360	90	31	40	106
biomass g.m^{-2}	1,2	0,7	0,2	0,3	0,8

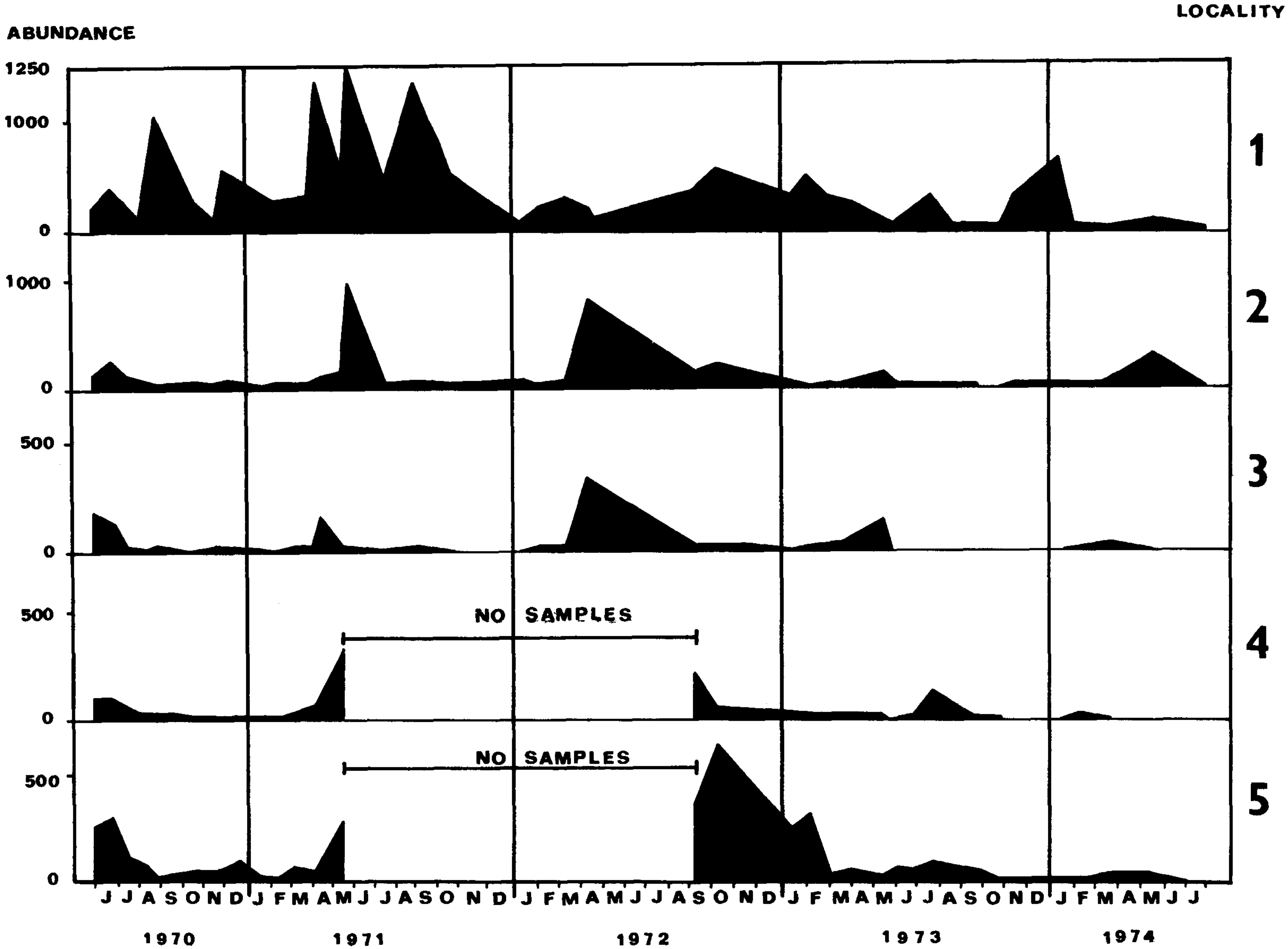

Fig. 2. Abundance (number of animals.m^{-2}) of mayfly nymphs.

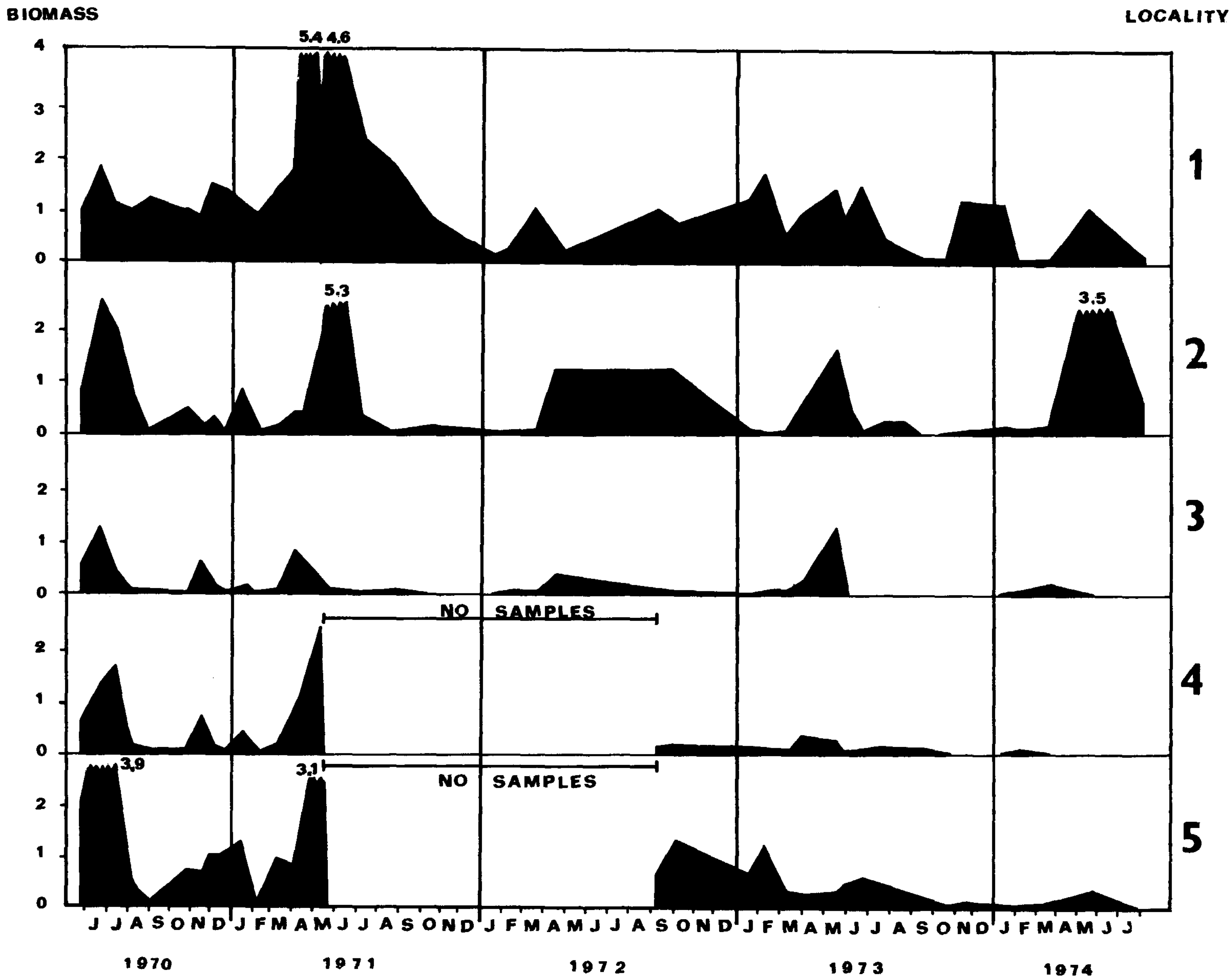

Fig. 3. Biomass ($g.m^{-2}$) of mayflies nymphs.

the whole warmed part of the river, the values obtained in Locality 5 were rather different. In summer and autumn, *Potamanthus luteus* occurred in samples only irregularly.

Growth of Potamanthus luteus nymphs

The maximum body length of nymphs netted in Locality 1, Localities 2 and 4, Locality 5, and the most warmed Locality 3 were 17; 16; 5 to 14 and 3 to 12 mm, resp. (Fig. 4).

There is a certain regularity in average frequencies of individual size categories in Locality 1 during the year. The biggest nymphs occurred from May to August while the highest number of nymphs of lower instars was observed from September to February. In warmed localities, the occurrence of individual size categories rather fluctuated during the year and *Potamanthus luteus* was absent in a number of samples. As compared with Locality 1, the reduction of lower development instars was remarkable, especially in Locality 5.

The estimation of production according to Zelinka's method (Zelinka, 1973) is based on relationships between the lengths and sizes of nymphs of individual size categories. Altogether 112 randomly selected nymphs of different size from Localities 1 and 5 (Fig. 5) were used for the calculation of the dependence of mass of one individual upon the total body length (the total body length was measured from the top of the frontoclypeus to the distal margin of the 10th abdominal tergite). It was found that this relationship may be described by an equation of parabola parallel with ordinata:

$$y = b_0 + b_1 x + b_2 x^2 \qquad [2]$$

where

y = mass of nymph (mg)
x = length of nymph's body (mm)
b_0, b_1, b_2 = regression coefficients
$b_0 = 0.00551$
$b_1 = 0.00188$
$b_2 = 0.00018$

A high correlation coefficient (r = 0.98287) demonstrates a close correlation between body mass and length of nymphs.

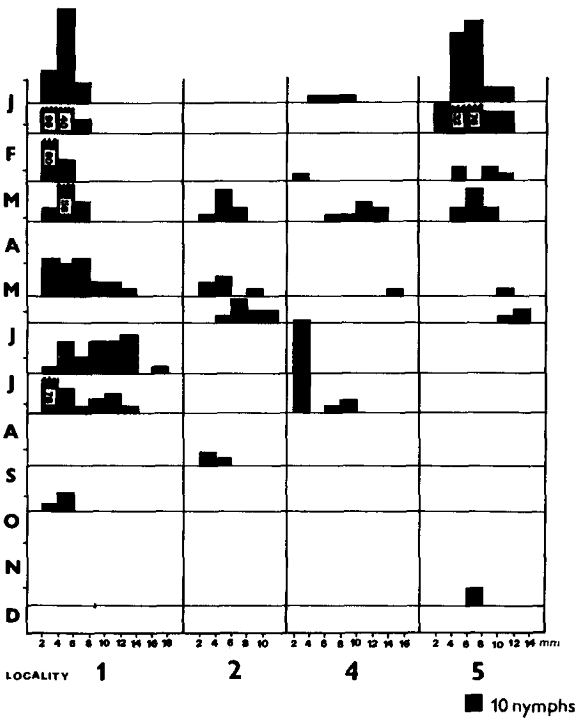

Fig. 4. Size of *Potamanthus luteus* nymphs.

Production of Potamanthus luteus

The thermal pollution of the Oslava River with cooling waters discharged from the Oslavany power station shows a depressive effect not only on abundance and biomass but also on production of mayflies in this stream. Although Localities 1 to 5 were monthly investigated within a period of 5 years, production of *Potamanthus luteus* could be estimated only for 1973 when it was the most frequent species in all samples.

In Locality 1 with a natural thermal regime, production of *Potamanthus luteus* (estimated according to Zelinka's method, 1973) was 0.928 $g.m^{-2}.year^{-1}$; the value of the P/B coefficient (specific production) was 10.92. In this locality, the highest production of *Potamanthus luteus* was observed and the share of this species was as high as 12.2 per cent of the total mayfly production (Tab. VI). The estimation of production according to Hamilton's method (1969) and according to equation [1] gave lower values; 0.378 and 0.515 $g.m^{-2}.year^{-1}$, resp. (Tab. V).

In Locality 2, production estimated according to Zelinka (1973) was more than 6 times lower than in Locality 1, i.e. only 0.151 $g.m^{-2}.year^{-1}$. Estimates according to Hamilton and equation [1] were very low, viz. 0.158 and 0.194 $g.m^{-2}.year^{-1}$, resp. High water temperatures existing in Locality 3 showed such a negative effect

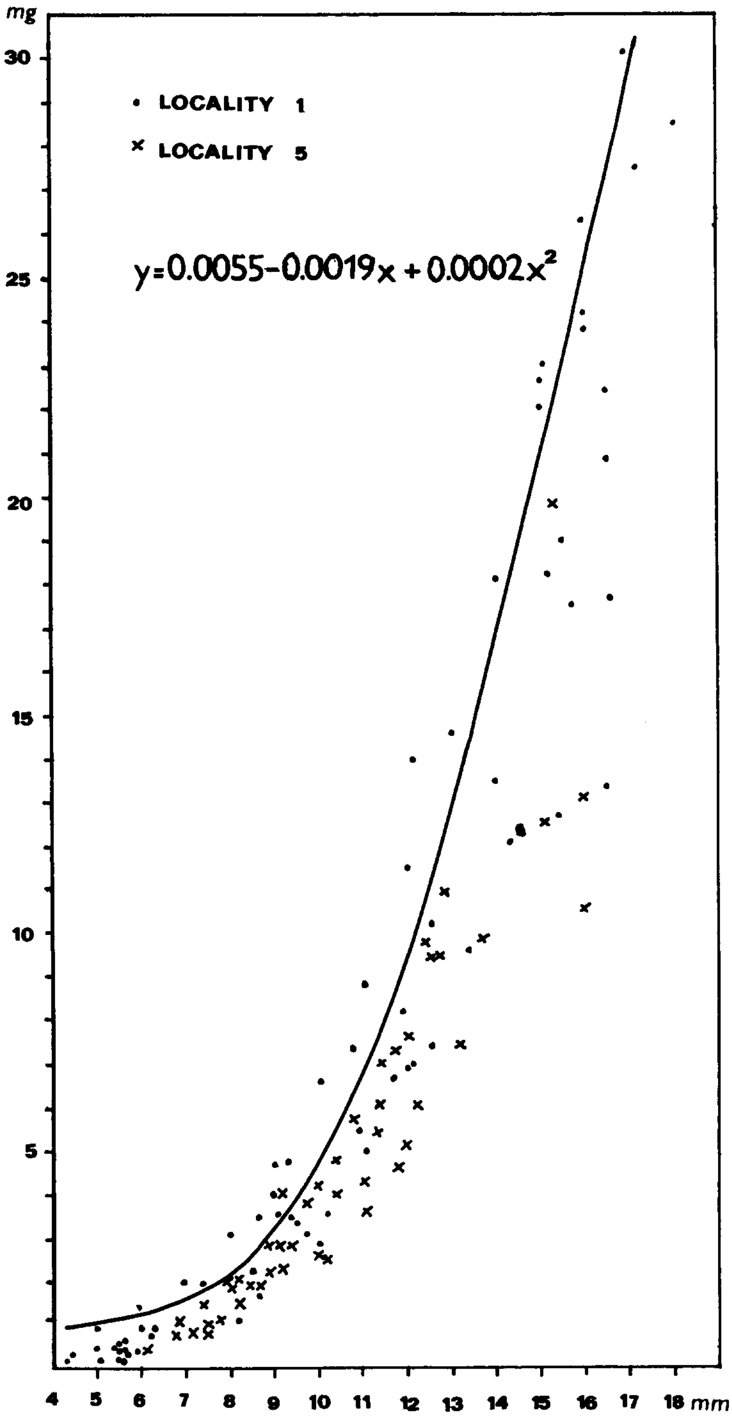

Fig. 5. Relation between body length and mass of *Potamanthus luteus* nymphs.

Table V. Production of *Potamanthus luteus* in the Oslava river in 1973.

locality	$\bar{B}$	P/1/	P/B	P/2/	P/B	P/3/	P/B
1	0,085	0,928	10,92	0,378	4,45	0,515	6,06
2	0,032	0,151	4,72	0,158	4,94	0,194	6,06
3	–	–	–	–	–	–	–
4	0,036	0,335	9,31	0,165	4,58	0,218	6,06
5	0,088	0,655	7,44	0,304	3,45	0,533	6,06

$\bar{B}$ = average biomass /g.m^{-2}/
P = production /g.m^{-2} . year^{-1}/
/1/ according to Zelinka /1973/
/2/ according to Hamilton /1968/
/3/ according to the relation [1] /Zelinka & Marvan 1976/

upon *Potamanthus luteus* that the occurrence of nymphs in this locality may be classified as a random phenomenon. For that reason the actual production of *Potamanthus luteus* was practically zero in Locality 3.

A gradual regeneration of the original biocenosis may be observed in Locality 4; this was indicated not only by increased abundance and biomass but also by an increased production (Tab. V). According to Zelinka (1973) the estimated production was 0.335 g.m^{-2}.year^{-1}, i.e. approximately twice more than in Locality 2 but nearly 3 times less than in Locality 1.

In Locality 5 with the most balanced water temperatures, a new biocenosis was formed adapted to the new thermal regime. This was manifest not only in qualitative and quantitative composition of the zoobenthos but also in production of *Potamanthus luteus* (Tab. V). According to Zelinka (1973) the production was 0.655 g.m^{-2}. year^{-1}, i.e. 1.4 times less than in Locality 1. The share of *Potamanthus luteus* in the total mayfly production was 19.9 per cent (Tab. VI). Hamilton's method gave results more similar to those obtained in Locality 1 and the estimate according to equation [1] was even higher than in Locality 1 (Tab. V). However, only results obtained according to Zelinka's method may be considered as conclusive.

Based on values of average biomass (B) and literature P/B values (Zelinka, 1973; Zelinka & Marvan, 1976) the total annual production of mayflies occurring in individual localities was estimated (Tab. VI). All calculated values indicate that the thermal pollution shows a marked negative effect upon mayfly production. This unfavourable effect was manifest as far as 3.5 km from the outlet of cooling waters (Locality 5), where warmed water was thoroughly mixed with that of the river. In Locality 5, the total production of mayflies was 5 times lower than in unwarmed Locality 1.

Discussion

The share of mayflies in the total number of species of the zoobenthos is relatively high. Peňáz *et al.* (1968), Zahrádka (1978), and Adámek (in press) found considerably lower shares of mayflies in the zoobenthos of this region. This may be explained by the fact that the study in the Oslava River was of long-term nature (five years) and that numbers of findings were sporadic. In addition, the uninvolved stretch of the Oslava River showed a great species diversity and some rare species of water insect, e.g. *Brachyptera braueri* also occurred in this part of the stream (Adámek, 1972).

Langford (1971) found that there were no significant differences in the species diversity of mayfly nymphs upstream and downstream a power station on the river

Table VI. Production of mayflies in the Oslava river in 1973.

locality	average biomass g . m^{-2}	P/B	production g.m^{-2} . year^{-1}
1	0,845	9	7,605
2	0,283	9	2,543
3	0,131	9	1,180
4	0,076	9	0,684
5	0,365	9	3,288

Severn. Thirteen productionally important taxa occurred in all localities. In warmed localities of the Oslava River, the total number of mayfly species decreased (in Localities 3 and 4 below 50 per cent of the original values). Only 7 species of 35 mayfly taxa found in the investigated stretch of the Oslava River occurred in all localities. In both rivers (i.e. Oslava and Severn), species tolerant to the changed thermal regime were as follows: *Baetis bioculatus et scambus, Baetis rhodani, Ephemerella ignita,* and *Caenis macrura.* Both rivers are comparable especially with regard to the quality of water. In both cases the oxygen regime was good and the saturation of water with oxygen did not drop below 70 per cent.

This fact is very important because increased temperatures are associated with increasing requirements for oxygen content in water (Kamler, 1969) and its availability (i.e. saturation under a given temperature).

It is obvious that the species diversity of the Oslava River was disturbed more than that of the river Severn. One of the causes of this situation was a higher water temperature in the Oslava River. In the Oslava River, there were also numerous cold stenotherm species of the family Heptageniidae upstream the power station. Whitney (1939), for example, found that temperatures about 24°C killed 50 per cent of nymphs of *Rhithrogena semicolorata* at concentrations of 8.4 mg $O_2.l^{-1}$.

Nymphs of *Baetes rhodani,* which showed lethal temperatures about 24°C (Whitney, 1939), occurred in all localities also in the period of high summer temperatures (i.e. above 26°C). The occurrence of nymphs of *Ecdyonurus venosus* in heavily warmed Localities 3 and 4 during the cold part of the year (at temperatures ranging from 20 to 22°C) corroborates the finding that the lethal temperature of developed nymphs was about 28°C at 7.6 mg $O_2.l^{-1}$ (Whitney, 1939). This means that these nymphs could not occur during summer when water temperatures reached 30°C or more.

Nebeker (1971) and many others showed that various water temperatures affected individual developmental stages of aquatic invertebrates and fish as well as their reproductive potencies in a different manner. This fact must be manifest also in the production of zoobenthos in warmed localities. In unwarmed Locality 1, the course of abundance and biomass of mayfly nymphs corresponded with conditions existing in the barb zone of rivers in this region (Peňáz *et al.,* 1968; Zahrádka, 1978). In the warmed part of the Oslava River, both values are decreased compared with the river Severn (Langford, 1971). This is associated with a great change in the species diversity of mayflies due to high water temperature. There may be numerous causes of changes in abundance upstream and downstream the power station. In addition to the high temperature which could induce changes in developmental cycles of aquatic insects (Ruprecht, 1975) an increased drift of zoobenthos from the thermally endangered zone must be also taken into account (Durret & Pearson, 1975). If a clean stream of the oligo-beta-mesosaprobic zone is warmed up to 26 to 28°C for a short period, the emergence of mayfly imagines is not affected (Langford, 1975).

As mentioned above, *Potamanthus luteus* is the most important species which tolerates not only a considerable water pollution (Landa, 1969) but also, as indicate our results, high temperatures (about 30°C and even more). We have no literary data available about production of *Potamanthus luteus* in barb zones. One of us (Zahrádka, 1978) calculated the average production of *Potamanthus luteus* in the barb zone of the Jihlava River as 11.097 $g.m^{-2}.year^{-1}$ according to Zelinka's method (1973). This value is more than 10 times higher than the average production of *Potamanthus luteus* found in Locality 1 of the Oslava River. This difference may result from differences in weighing of mayfly nymphs, number of samples and frequency of sampling. In Locality 1 of the Oslava River, sampling was carried out once a month. According to Zahrádka (1978) it is necessary to sample zoobenthos of the barb zone twice a month in spring and summer seasons and once every three weeks in the remaining part of the year.

Regarding the great time intervals between individual samples the obtained values of annual production of *Potamanthus luteus* may be evaluated only as preliminary data, because none of the methods used did give reliable results expressing the actual annual production of this species under conditions mentioned above.

Another reason of a more than 10-times-higher annual production of *Potamanthus luteus* in the Jihlava River is the fact that localities in the Jihlava River were classified as epipotamon while those in the Oslava River as metarhitron (Illies & Botosaneanu, 1963).

Conclusions

In this paper the results are presented of studies on mayfly fauna from warmed and unwarmed parts of the Oslava River carried out in 1970-1974 (Fig. 1). It was found that:

(1) Natural water temperatures of the Oslava River ranged from 0.1 to 20.8°C. In Locality 3, situated immediately below the outlet of warmed waste water, the water temperatures ranged from 5.6 to 35.4°C (Tab. I).

(2) The content of dissolved oxygen was 9.67 $mg.l^{-1}$ in Locality 1. In warmed Localities 2-5 this value ranged from 6.30 to 12.00 $mg.l^{-1}$. The saturation of water with oxygen did not drop below 70 per cent (Tab. I).

(3) Altogether 35 taxa of mayfly nymphs were found in the investigated stretch of the Oslava River (Tab. III). Seven of them were common in all localities.

(4) In Locality 1, abundance and biomass of mayflies were in average 360 $individuals.m^{2}$ and 1.2 $g.m^{-2}$, resp. In warmed localities both values decreased and reached a minimum in Locality 3 (31 $individuals.m^{-2}$ and 0.2 $g.m^{-2}$, resp. (Tab. IV).

(5) In warmed Localities 2 to 5, the seasonal changes in abundance and biomass were affected by high water temperatures (Figs. 2, 3).

(6) *Potamanthus luteus* was the most important species as far as the production is concerned. Equation [2] illustrates the relationship between the total body length and mass of nymphs.

(7) In Locality 1, the annual production of *Potamanthus luteus,* estimated according to Zelinka (1973), was 0.928 $g.m^{-2}.year^{-1}$. In warmed localities, the obtained values were lower (Tab. V).

(8) The highest estimate of total production of mayfly nymphs by means of P/B coefficient was obtained in Locality 1 (7.605 $g.m^{-2}.year^{-1}$). In warmed localities lower values were recorded (Tab. VI).

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