

Annual cycle of mayflies (*Ephemeroptera*) in a karstic stream

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Up to the present, data about mayfly (*Ephemeroptera*) numbers in Czechoslovak streams are relatively scarce (PEŇÁZ, 1968; SEDLÁK, 1969; ZELINKA, 1969) and, therefore, this article represents a contribution to our knowledge of this problem.

BIOTOPE AND SAMPLING METHODS

Studies on annual changes in numbers of mayflies were carried out at two stations on the rocky bottom of Křtiny river in the Moravian Karst. The stream rises at an altitude of 455 metres, it is 14 kilometres long, and its catchment area covers 31 square kilometres. Below Křtiny village the brook reaches the limestone bedrock and goes underground, emerging approximately 2.8 kilometres away and continuing in the direction of a small town called Adamov where it empties into the left bank of the Svitava.

Sampling was carried out at two stations: the upper one (No. 1) was situated approximately 400 metres below the place of reappearance of the underground stream, near the rock called Býčí skála (Bull's Rock). The lower station (No. 2) was situated approximately 500 metres upstream from Adamov.

The Křtiny river is a typical karstic stream. At the end of the karst region the hardness of the water increases to 6.95° (according to the German scale). The lowest temperature of the water is 2° C and for that reason this stream does not get ice-bound.

There was a predominantly stony bottom at both stations investigated. Stones were often covered with diatoms and filamentous algae. For more details about individual stations see Tab. 1.

Quantitative samples were taken by means of a water net from the stony bottom. The area of the sampled substrate was determined according to the method described by SCHRÄDER (1932) and it was greater than 2000 square centimetres in every sampling. Samples were fixed immediately under field conditions with 4 per cent formaldehyde; weighing was carried out after three months. Prior to weighing the material was dried according to the method described by ALBRECHT (1959) and KUBÍČEK (1969).

RESULTS

Eighteen species of mayfly were found in the Křtiny river. A massive occurrence was registered in the case of some species only, the rest of them occurred only sporadically. The most frequent were the following: *Bactis alpinus*, *Bactis rhodani* and *Rhithrogena semicolorata*. A survey of species observed in individual stations is given in Tab. 2.

The abundance of mayflies in the Křtiny river at stations Nos 1 and 2 resulted mainly from the occurrence of the *Bactis* genus. The most frequent species were *Bactis alpinus*, *Bactis rhodani* and, during the spring months, *Rhithrogena semicolorata*. Total numbers of mayfly quantities depended, besides abiotic factors (ZELINKA, 1969), on the mutual combination of life cycles of species mentioned. In the Křtiny river changes in quantitative values were complicated as the principal mayfly species produced two generations within one year.

LANDA (1968) studied developmental cycles of mid-European mayfly genera. *Rhithrogena semicolorata* and *Ecdyonurus venosus* belong to "winter" species

TABLE 1

Basic data of both stations

Station	No. 1	No. 2
Height above sea level	315.00 m	265.00 m
Width	2.50 m	4.50 m
Depth	0.15 m	0.25 m
Stream speed (min. - max.)	0.6--1.2 m/sec	0.5--1.2 m/sec
Discharge (min. - max.)	0.1--0.5 m ³ /sec	0.2--0.9 m ³ /sec
pH (min. - max.)	6.7--7.5	7.3--7.5
Water temperature	3--9° C	2--11° C

of mayflies; their larvae develop also during the winter and the main growth period takes place in spring months. *Rhithrogena semicolorata* occurred in the Křtiny river more frequently during the spring months and its larvae contributed to the increase of mayfly biomass during this season. Larvae with black wing bases occurred from April to June. No larvae with black wing bases were found in the *Ecdyonurus* species; older larvae occurred from April to September. *Ephemerella ignita* belongs to a "summer" species. After oviposition in the autumn eggs remain in diapause until the spring or even the summer of the following year. Larvae with black wing bases were found in the Křtiny river in June and July. The most frequent species on the river investigated, *Baetis alpinus* and *Baetis rhodani*, produced two generations a year. According to LANDA (1969) older larvae of *Baetis alpinus* (1st generation) occur from October to June, larvae of the 2nd generation in August

TABLE 2

List of species found at both stations

Species	Station	
	No. 1	No. 2
<i>Baetis rhodani</i> PICT.	+	+
<i>Baetis vernus</i> CURT.	+	+
<i>Baetis lutheri</i> MÜLL.	+	+
<i>Baetis alpinus</i> PICT.	+	+
<i>Baetis pumilus</i> BURM.	+	+
<i>Rhithrogena semicolorata</i> CURT.	+	+
<i>Heptagenia lateralis</i> CURT.	+	-
<i>Ecdyonurus venosus</i> FABR.	+	+
<i>Ephemerella ignita</i> PODA	+	+
<i>Ephemerella notata</i> ETN.	+	-
<i>Ephemerella krieghoffi</i> ULM.	+	+
<i>Ephemerella major</i> KLP.	-	+
<i>Caenis macrura</i> STEPH.	-	+
<i>Paraleptophlebia submarginata</i> STEPH.	-	+
<i>Habroleptoides modesta</i> HAG.	-	+
<i>Habrophlebia fusca</i> CURT.	-	+
<i>Habrophlebia lauta</i> ETN.	-	+
<i>Ephemera danica</i> MÜLL.	-	+

+ present; - absent

and September. In the Křtiny river larvae of the 1st generation of *Baetis alpinus* with black wing bases occurred from March to June, larvae of the second generation (before the fly) from August to November. During winter months only juvenile larvae of this species were found. In the species *Baetis rhodani* larvae with black wing bases (1st generation) occurred in April and

TABLE 3

Abundance, biomass and percentage of mayflies in total quantitative values (Station No. 1)

Day 1970-71	Number of individuals n/sqm	Biomass g/sqm	Share in the total abundance (%)	Share in the total biomass (%)
3.V.	336	4.04	16.2	29.4
31.V.	256	3.86	12.2	19.9
27.VI.	56	1.49	1.3	5.1
19.VII.	367	0.73	6.2	2.5
8.VIII.	317	1.16	8.4	4.4
13.IX.	426	0.65	18.5	5.8
18.X.	519	1.77	20.9	11.2
7.XI.	139	0.48	3.9	2.4
13.XII.	347	0.66	15.8	6.0
9.I.	874	1.60	31.0	12.6
13.II.	854	2.65	20.1	10.1
20.III.	1352	10.29	24.4	25.5
18.IV.	600	6.62	22.6	22.7
15.V.	600	7.96	17.0	24.6
X	503	3.14		

May. No larvae of this species were found in June. Larvae of the 2nd generation with black wing bases occurred in July, August and October. During winter months mostly juvenile larvae were found. In the species *Baetis pumilus* larvae were found before the fly in May and June.

The effect of life cycles of the most frequent mayfly species on the total values of mayfly biomass is presented in Tabs. 3 and 4. During the spring months values of the biomass increased in relation to the maturation of larvae. A decrease in the biomass due to a lower occurrence of larvae of the most frequent species was observed in June and July. At locality No. 2 the decrease in the abundance was not so noticeable as that at locality No. 1 because in this locality a greater occurrence of the "summer" species *Ephemera ignita* was registered. A considerable increase in the abundance due to the frequent occurrence of the 2nd generation larvae of *Baetis alpinus* was observed at locality No. 2 during August and September. During the winter months mostly juvenile larvae showing lower values of the biomass (Tab. 4) were sampled.

DISCUSSION

Only certain species played an important role in total values of abundance and biomass. In the Křtiny river the most numerous species were *Baetis alpinus*, *Baetis rhodani* and *Rhythrogena semicolorata*. The other mayfly

TABLE 4

Abundance, biomass and percentage of mayflies in total quantitative values (Station No. 2)

Day 1970 - 71	Number of individuals n/sqm	Biomass g/sqm	Share in the total abundance (%)	Share in the total biomass (%)
10.III.	1066	2.43	26.0	14.9
3.V.	489	4.11	16.9	23.3
31.V.	427	5.38	21.3	30.2
27.VI.	476	2.95	8.9	6.9
19.VII.	636	2.45	14.2	6.8
8.VIII.	1187	2.21	14.9	7.7
13.IX.	1754	6.04	28.6	23.8
18.X.	100	0.48	2.2	2.4
7.XI.	159	0.43	3.4	1.9
13.XII.	122	0.23	4.0	1.1
9.I.	173	0.27	4.9	1.4
13.II.	349	0.92	11.6	4.6
20.III.	534	3.14	14.8	9.9
18.IV.	1472	9.89	31.4	26.3
15.V.	1889	12.61	23.3	28.3
X	722	3.57		

species occurred only sporadically and their occurrence showed no significant effect on the quantitative values. ZELINKA (1969) obtained similar results in trout streams in the Beskydy Mountains; in this region 90 per cent of total quantitative values were represented by five species: *Baetis rhodani*, *Rhithrogena semicolorata*, *Ecdyonurus* sk. *venosus*, *Epeorus asimilis* and *Habroleptoides modesta* (the share of the first three species was 75 per cent).

When comparing individual Moravian trout streams no considerable differences in numbers of species can be observed. In the Křtiny river 18 species

TABLE 5

Average abundance and biomass of mayflies in investigated streams

Stream	A n/sqm	B g/sqm	Author
The Svatka above			
the Vír dam	703	1.265	Peňáz, 1968
The Svatka below the Vír dam	1.323	2.209	
The Loučka	691	2.970	Sedlák, 1969
The Lušová	670	3.438	Zelinka, 1969
The Brodská	547	2.278	
The Bobrava	587	2.06	Sukop, 1970
The Křtiny stream	612	3.35	Sukop, 1971

were observed. LORENČÍK (1969) recorded some other species in the same stream, so that the total number of mayfly taxa was 19 species. ZELINKA (1969) found 19 species in both the Lušová and Brodská rivers. SEDLÁK (1969) recorded 25 species in the Loučka river. A survey of mayflies quantitative values observed in Moravian streams is presented in Tab. 5.

When comparing quantitative values presented in Tabs. 3 and 4 one can see that the greatest abundance of mayflies occurs usually during the spring months (March, April, May). In this period the biomass of mayflies increases, too. The number of mayflies occurring in streams during a certain period is also determined by the species composition. Besides abiotic factors mayfly numbers are partly influenced by the fish consumption. The most frequent fish species of the Křtiny river are the trout (*Salmo trutta*) and bullhead (*Cottus gobio*). According to available data (HOCHMAN, 1957; STRAŠKRABA et al., 1965; TUŠA, 1968; SEDLÁK, 1969) fish, especially trout, prefer the easily available components of the food, so that mayflies are consumed to a lower degree than could be expected according to their percentage in the benthos. The share of mayflies in the food of fish, however, should not be neglected. According to LANDA (1969) the proportion of mayflies in the feed of small trout was as much as 40 per cent. The total quantitative numbers of mayflies can also be influenced by the occurrence of parasites. In the Křtiny river the infestation of mayfly larvae (esp. *Baetis rhodani*) by parasitic worms, probably belonging to the family *Mermitidae*, was observed.

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