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Evaluation of occurrence, density, and biomass of *Ephemeroptera* in the drainage channel near the village of Turew (Region of Poznań)*

Stefan Mielewczyk

Polish Academy of Sciences, Department of Agrobiology, Swierczewskiego Str. 19, 60-809 Poznań, Poland

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Abstract — Five species of mayflies, among which *Baetis vernus* markedly dominated, were found in the channel flowing across agricultural territories. Variations in larvae density and biomass of these insects were presented in the investigation period (May to October) for two sectors of the channel: the meadow and the wooded one, with reference to their value for macrophyte communities, and also for the whole channel. The mean density in the whole sector was 502 individuals $\cdot m^{-2}$, and the mean biomass 658 mg $\cdot m^{-2}$. Values obtained for macrophyte communities were many times higher. Remarks on the development of *Baetis vernus* were also made.

Key words: drainage channel.

1. Introduction

The paper presents some of the results of complex investigations, carried out by the Department of Agrobiology of the Polish Academy of Sciences in Poznań. The research was conducted towards obtaining a synthetic evaluation of energy flow and matter cycling in various ecosystems of the agricultural landscape (Ryszkowski 1980). The drainage channel starting from the Lake Zbęchy, about 46 km south of Poznań, is one of objects under examination. The aim of the author's investigations was to establish the species composition of *Ephemeroptera*

* Investigations were carried out within the project MR. II/15.

larvae and their dominance structure, and above all to evaluate their density and state of biomass in two characteristic sectors of that channel located in the region of intensively conducted investigations near the village of Turew. The absence of that type of estimations for flows of the Wielkopolska Lowland substantiates undertaking these investigations.

2. Characteristics of the investigated object

The channel flowing out of the Lake Zbęchy crosses agricultural territories in which it joins a net of drainage channels. A sector 1063 m long and 4.5 m wide was the object of investigation. The water level in this channel in early spring exceeded 1 m and in summer it sometimes dropped to 10 cm.

The major part of the investigated object (813 m) borders on arable land and a meadow (meadow sector) and the smaller part (250 m) adjoins a densely intrafield wooded area (wooded sector). The borders of the meadow sector are in places overgrown with *Alnus glutinosa* (L). Gaertn, with participation of *Frangula alnus* Mill., *Sambucus nigra* L., and *Humulus lupulus* L. At spots exposed to sun radiation *Sparganium simplex* Huds., and *Elodea canadensis* Rich. occurred abundantly in this sector of the channel, and sporadically *Butomus umbellatus* L., *Nuphar luteum* (L.) S., *Sagittaria sagittifolia* L., and *Phragmites communis* Trin. were also found (Gołdyn 1981, unpublished data). The bottom was, as a rule, muddy, being sandy only in the middle course.

In the wooded sector the bottom was very muddy and the vegetation very scarce, below 5 per cent of the cover, represented by *Nuphar luteum* and *Sparganium simplex*, and at the banks by *Berula erecta* (Huds.), *Coville*, and grasses.

3. Investigation method

It resulted from preliminary examinations carried out in 1978 that larvae of mayflies occurred in the investigated channel only at spots overgrown with macrophytes. Therefore in 1979 quantitative samples were collected regularly, exclusively within the range of plant patches. Simultaneously estimations of the macrophyte bottom cover of the channel were carried out, with reference made to unpublished data obtained by Gołdyn (1981).

For catching larvae of mayflies a high metal frame of cross section area 225 cm^2, stuck into the bottom and a sampler with a net of 0.3 mm

mesh size were used. The material fished out was rinsed on a net of equal mesh size, i.e. 0.3 mm and segregated in vivo in a dish filled with water. This operation was always performed in situ.

Investigations were carried out in the meadow and in the wooded sector. In each of them 6 series of samples (4 samples in each series) were taken from May till October 1979. In all 48 samples were collected and 2488 larvae, belonging to *Baetis vernus* (2466 individuals), were obtained. For the 4 size classes of larvae of that species (body length without caudal setae), distinguished according to the number of measurements, mean values of fresh weight were determined with accuracy to 0.01 mg. They were used for calculating mean values of fresh weight (in $mg \cdot m^{-2}$) at particular investigation dates in the two sectors of the channel; these were based on the obtained mean values of density of the distinguished size classes of *B. vernus*. For other species mean biomasses found for *Baetidae* (mainly *Cloeon* sp.) and *Caenidae* (Mielewczyk 1981) were adopted.

Mean values of density and biomass state found among macrophytes at particular dates of investigations were calculated in relation to the degree of the macrophyte cover of the bottom in two sectors of the channel in order to obtain mean values for the whole area of these two sectors. Whereas, in order to obtain mean values of density and biomass states among the plants in the investigation season, the arithmetical mean wighted in relation to the variable degree of the bottom cover with macrophytes was calculated. Finally the mean values calculated for particular investigation dates in both sectors of the channel were calculated for an average square meter of the whole 1063 m long sector under examination. For this purpose the weighted arithmetical means denoting the share of mean densities and biomass states of these two sectors of the channel in the whole investigated sector were calculated. The sum of these values gave the final results.

4. Results

4.1. Species composition and dominance structure

In the investigated sector of the channel, only five mayfly species were found to occur (Table I). It seems that this qualitative scarcity results mainly from a fairly uniform character of that sector, from great variations in the water level in the course of the year, and from autumn water control treatments frequently carried out. *Baetis vernus* dominating markedly and *Procloeon ornatum* associated with it and occurring in small numbers were found there regulary. Other species (Table I) occurr-

Table 1. Domination structure of Ephemeroptera larvae (in %) in the investigated sectors of the drainage channel with reference to number (N) and biomass (B - in $mg \cdot m^{-2}$)

Sector of the channel	Meadow		Wooded	
Mean number and biomass	N 639	B 842	N 57	B 61
Baetis vernus Curt.	98.7	96.9	99.9	99.9
Procloeon ornatum Teher.	0.8	1.4	0.1	0.1
Cloeon dipterum (L.)	0.2	0.6	-	-
Caenis horaria (L.)	0.2	0.1	-	-
Ephemera vulgata L.	0.1	1.0	-	-

ed only in spring at high water levels or in autumn during channel control works. They came from higher situated parts of the channel, where, as shown by preliminary recognition, greater differentiation of the bottom character and plant associations was conduicive to the development of qualitatively richer fauna of mayflies. Apart from the species mentioned in Table I there occurred *Centroptilum luteolum* (Müll.), *Caenis robusta* Etn., and *Habrophlebia fusca* (Curt.). In spite of a qualitatively richer composition of the fauna of mayflies in higher parts of the channel, as for as quantity was concerned it was poorer, according to estimations.

4.2. Density and biomass

The meadow sector of the channel was characterized by high values of density of mayfly larvae among the macrophytes, and by relatively high mean values obtained for this sector (Table II A). The peak of abundance in both cases occurred in the middle of August. A rapid drop of abundance found in October was mainly caused by the completion of the development stage of the second summer generation of larvae of *Baetis vernus*, a species which dominated over all others. It may by also assumed that the partial mowing of aquatic macrophytes in that sector also contributed to the growing intensity of that natural decrease in abundance.

In the wooded sector, the shaded one, the density of mayfly larvae among plants was on the average 1.9 times lower than in the meadow sector, the mean for that sector being even 11.2 times lower. A markedly lower peak of abundance occurred there towards mid — June (Table II B), thus, immediately following the period of poorer foliage of the trees which at the height of the summer almost entirely over shadewed that sector of the channel. It results from the analysis of the size of mayfly larvae density (mainly *B. vernus*) in the two sectors of the channel (Table II A, B) and from the percentage share of four size classes of *B. vernus*

Table II. Density ($N \cdot m^{-2}$) and biomass ($mg \cdot m^{-2}$) of Ephemeroptera larvae in the meadow (A) and wooded (B) sectors of the drainage channel in the year 1979

Factor \ Date	A							B						
	17.V	15.VI	13.VII	15.VIII	13.IX	16.X	Season mean	17.V	15.VI	13.VII	15.VIII	13.IX	16.X	Season mean
Extent of plant cover of the bottom (in %)	6.3	12.5	20.2	26.5	36.5	22.2	20.7	2.0	4.0	1.5	4.0	4.5	4.5	3.4
Density among plants	1689	3166	3122	7855	1633	111	3088	478	4622	2333	1322	667	644	1665
Mean density	106	396	631	2082	596	25	639	10	185	35	53	30	29	57
Biomass among plants	3023	1514	6663	8496	2678	443	4068	990	2827	1793	1803	968	1992	1781
Mean biomass	190	189	1346	2251	978	98	842	20	113	27	72	44	90	61

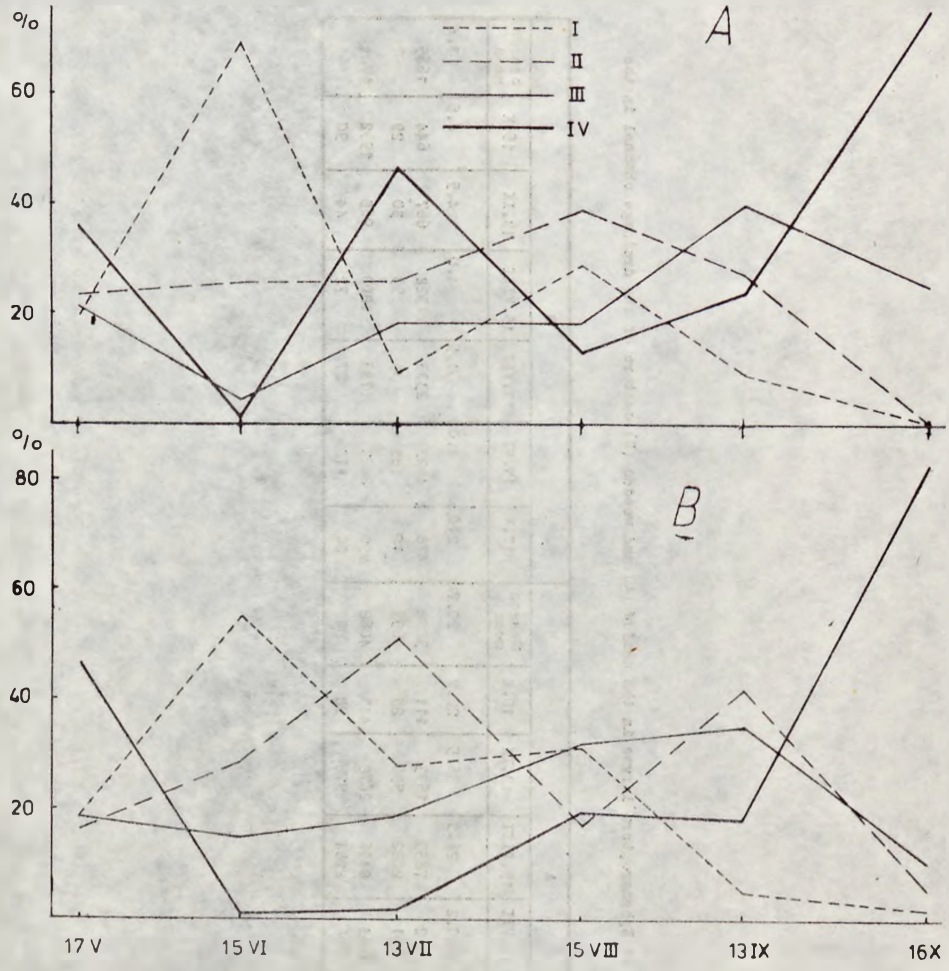

Fig. 1. Course of changes in percentage share of four size classes of *Baetis vernus* in 1979: A — in the meadow, well insolated, sector of the channel; B — in the wooded, shaded sector of the channel, I—IV — size classes: I — ⩽ 2.7 mm II — 2.8—4.0 mm; III — 4.1—5.5 mm; IV — ⩾ 5.6 mm

larvae (fig. 1) that shading during the summer causes, above all, a slower development rate of larvae of summer generations (fig. 1 B), this being also indicated by their relatively high abundance still in October (Table II B). This influenced the decrease in abundance of larvae which was probably still more pronounced because of their greater mortality due to their longer lifetime (a longer period of exposure to the rapacity of other animals).

The values of biomass states were calculated indirectly through mean biomasses determined for four size classes of *Baetidae* (mainly *Cloeon*

sp.) and *Caenidae* (M i e l e w c z y k 1981). On the other hand in view of the absence of respective data, approximate values were to be determined for larvae of *Baetis vernus* which proved markedly lower than for other representants of *Baetidae* (Table III).

Table III. Mean value of fresh weight of distinguished size classes of Beatis vernus larvae

Size class	Body length without setae in mm	Fresh weight in mg
I	≤ 2.7	0.30
II	2.8 - 4.0	0.65
III	4.1 - 5.5	1.50
IV	≥ 5.6	3.50

In the meadow sector the biomass states of mayfly larvae among macrophytes were, as a rule, very high, the highest value being reached in August. On the other hand the average values for this sector were respectively lower, yet still, high (Table II A). Their values depended not so much on the density as on the dominance of larvae of respective size classes. In the wooded sector the biomass states were generally considerably lower, the highest value being found in June (Table II B). Among the macrophytes the biomass values were 2.3 times lower than in the meadow sector, the mean values for this sector being here as much as 13.8 times lower. These differences were here slightly greater than in the case of density values, which was due to a lower development rate of the larvae in the wooded sector and a longer life time of the larvae of smaller size classes (fig. 1 B) than in the meadow sector (fig. 1 A).

Mean values of density and biomass states calculated for the whole investigated sector of the channel show a growth from May till August, this being followed by a rapid decrease lasting till October (Table IV). These values are high, especially when compared with the relatively low degree of covering the channel with macrophytes and the almost exclusive occurrence of phytophilous forms of the family *Baetidae*.

Table IV. Mean density ($N \cdot m^{-2}$) and biomass ($mg \cdot m^{-2}$) of Ephemeroptera larvae in both sectors of the channel in the year 1979

Date	17.V	15.VI	13.VII	15.VIII	13.IX	16.X	Season mean
Density	83	346	491	1605	463	26	502
Fresh weight	150	171	1036	1739	758	96	658

5. Discussion

5.1. Remarks on the development of larvae of *Baetis vernus* Curt.

Larvae of mayflies undergo in their development 20 to 30 developmental stages (Landa 1969) hardly distinguishable. Sowa (1975) who investigated the life cycles of those insects distinguished 12 to 14 size classes of larvae; whereas Jażdżewska (1975) in her investigations on the age distribution of the larvae population of some species distinguished three age groups. The four size classes of *Baetis vernus* larvae, distinguished by the author, in order to determine the mean values of biomass (Table III) were also used for analysis of the collected materials in order to acquire some knowledge on the development of the population of larvae of that species in the investigated season (May till October).

The number of generations in a year can vary even within the same species (Landa 1969) depending on differentiation of thermic conditions not only in a larger area but also within one flow (Sowa 1975). It is generally assumed that *Baetis vernus* has two generations in a year (Landa 1969). Sowa (1975) includes them to multicycle species, hence to those producing at least two generations in a year; some species of that group are assumed to develop even a third generation.

The developmental course of the population of larvae of *B. vernus* in the channel by Turew depicts, to a great extent, the variations in relative abundance (expressed in per cent) of four size classes of larvae of this species found during the investigation season at two stations (fig. 1 A). In the meadow sector exposed to intensive sun radiation the biggest larvae of that species dominated in May, July, and October (fig. 1 A, B), whereas abundance peaks of the smallest larvae were found in June and August. The first peak of abundance of larvae, as resulting from the percentage share of larvae of particular size classes, occurred, without doubt, already in April.

In the densely wooded sector of the channel the first peak of abundance of the biggest larvae was found to take place also in May but the second, marked only slightly, occurred as late as in August. This can be accounted for by the unfavourable influence of shading. The third, very high peak of abundance of these larvae indicating to a seasonal accomplishment of the development of *Baetis vernus* larvae population occurred also in October (fig. 1 B). Two peaks of the smallest larvae abundance occurred there in June and a less pronounced one in August. These data are complemented by the shape of the curve of small larvae abundance (IInd size class) which has two distinct peaks in July and September. It can be concluded from the percentage share of particular

size classes of larvae in May that the first peak of abundance of the smallest larvae must have taken place also in April. In the basis of the quoted data it may also be concluded that in the investigated channel, especially in its meadow sector (fig. 1 A) *B. vernus* produced three generations in a year; this would confirm that its classification as a multicycle species is well-founded (S o w a 1975). However, the absence of relevant observations on the emergence of imagines makes a final formulation of such a statement rather difficult.

5.2. General discussion

The data concerning quantitative estimations of mayfly larvae occurrence and specially their biomass in running waters of our country are extremely scarce and fragmentary. S i e m i ń s k a (1956) gave in her hydrobiological characteristics of the River Brynica results obtained from samples collected only once in June and September or only in September. The greatest abundance of mayfly larvae on a muddy bottom was found by her in the lower course of the River Brynica where it ammounted to 220 and 480 individuals $\cdot m^{-2}$ and their biomass to 748 and 2171 mg $\cdot m^{-2}$ respectively. Whereas, among macrophytes of the middle course of that river the abundance of larvae varied in September within the limits from 100 to 2100 individuals $\cdot m^{-2}$, and their biomass 340 to 6140 mg $\cdot m^{-2}$. G i z i ń s k i (1961) found in the stream Trzebiocha the highest abundance of mayfly larvae in autumn on a gravel bottom (3975 individuals $\cdot m^{-2}$), at a marked dominance of *Baetis* sp. (3655 individuals $\cdot m^{-2}$). The average abundance in four different environments for two autumn periods was here also high (1303 individuals $\cdot m^{-2}$) whereas, for the other periods it was low (100 to 149 individuals $\cdot m^{-2}$). Basing upon these values the real mean value for the stream cannot be, however, calculated when the sizes of the areas of the investigated environments in relation to the whole stream or its appointed sectors are unknown. In comparison with these data the mean abundance of mayfly larvae in a year (55 individuals $\cdot m^{-2}$) in the River Łyna above the town Olsztyn (betamezosaprobic or oligosaprobic zone) is extremely low.

Much higher values of average annual abundance of mayfly larvae were found by S o w a (1965) at several stations of the stream Wielka Puszcza in the Beskid Zachodni Mts. They varied within the range 133 to 389 individuals $\cdot m^{-2}$ on a stony bottom and 24 to 644 individuals $\cdot m^{-2}$ on a bottom covered with muddy sediments. The highest of these values were found by the author in the middle course of the stream. They are approximate to the results obtained in the channel near Turew (Table IV), especially to its mean value.

Z e l i n k a (1979) investigated the influence of pollution on mayfly

production in a trout stream in the Czecho-Moravian Highlands; in the polysaprobic zone he found very low values of mean annual abundance and biomass (5.8 individuals · m^{-2}, 15 mg · m^{-2}), much higher ones in the betamezosaprobic zone (362.7 individuals · m^{-2}, 802 mg · m^{-2}), and very high ones in the secondary oligosaprobic zone (1400 individuals · m^{-2}, 5044 mg · m^{-2}). Only data from the mezosaprobic zone are approximate to the author's results (Table IV). Average annual abundance of mayfly larvae obtained by Zelinka (1969) for two trout streams in the Beskidy Mts (670 and 547 individuals · m^{-2}) are not much higher than the average value obtained by the author (Table IV), whereas the values of biomass (3.438 and 2.278 g · m^{-2}) calculated by the author are several times higher. Such great differences are due above all, to the montane character of flows investigated by Zelinka (1969) with a qualitatively richer fauna of mayflies with the share of forms of big individual biomass.

The mean values of abundance and biomass of mayfly larvae obtained in the investigated channel by Turew (Table IV) are several times lower than in the litoral of the lake Zbęchy (1445.5 individuals · m^{-2}, 1717.7 mg · · m^{-2}) from which this channel takes its origin, but markedly higher than the mean values calculated for the whole lake (378.3 individuals · m^{-2}, 449.5 mg · m^{-2}) (Mielewczyk 1981). Considering the fact of the almost exclusive occurrence of phytophilous forms in the investigated channel and a relatively small degree of bottom covering with macrophytes the obtained mean values of abundance and biomass for this channel can be regarded as high.

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5. Polish summary

Ocena występowania, zagęszczenia i biomasy larw *Ephemeroptera* w kanale odwadniającym koło Turwi (region poznański)

W wyniku badań przeprowadzonych w roku 1979 w kanale odwadniającym, przepływającym przez tereny użytkowane rolniczo w rejonie Turwi, stwierdzono występowanie larw pięciu gatunków jętek z wybitnie dominującym *Baetis vernus* (tabela I). Przeprowadzona analiza procentowego udziału czterech klas wielkości larw tego ga-

tunku w okresie badań na dwóch różnych stanowiskach (ryc. 1A, B) wskazuje na rozwój prawdopodobnie trzech pokoleń w roku.

Badania przeprowadzono w dwóch różnych odcinkach kanału: łąkowym — miejscami dobrze nasłonecznionym i zadrzewionym — niemal całkowicie zacienionym. Wśród makrofitów odcinka łąkowego stwierdzono znacznie wyższe wartości zagęszczenia i biomasy larw jętek (tabela II A) niż w odcinku zadrzewionym (tabela II B). Różnice tych wartości były znacznie większe dla przeciętnego metra kwadratowego tych odcinków ze względu na bardzo mały stopień pokrycia kanału przez makrofity w odcinku zadrzewionym. Stwierdzono, że zacienienie w odcinku zadrzewionym powoduje zwolnienie tempa rozwoju larw jętek. Dłuższy okres ich życia stanowi jednocześnie dłuższy okres narażenia ich na drapieżnictwo innych zwierząt, co, jak można wnioskować, wpływa też na zmniejszenie liczebności tych larw wśród makrofitów odcinka zadrzewionego w stosunku do łąkowego odcinka kanału.

W porównaniu z wynikami innych autorów uzyskane średnie wartości zagęszczenia i biomasy larw jętek dla badanego kanału (tabele III, IV) oceniono jako wysokie, zwłaszcza ze względu na niemal wyłączne występowanie tu form fitofilnych przy stosunkowo niewielkim średnim stopniu pokrycia dna kanału przez makrofity.

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