MAYFLIES (EPHEMEROPTERA) OF THE SANDY BOTTOM OF THE RIVER GRABIA (CENTRAL POLAND)

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The mayfly fauna of a 3 cm thick layer of sandy bottom of the small lowland River Grabia in Poland was studied. This fauna was rather poor. Dominant larvae of Ephemeroptera in the sandy habitat were representatives of *Caenis horaria* and *C. pseudorivulorum*. A rare but characteristic species was *Baetopus wartensis*. A comparatively long list of species was recorded (over 20 taxa) consisting mainly of accidental, drifting or migrating individuals caught in the course of the study.

INTRODUCTION

Hydrobiological studies of the River Grabia have been carried out for more than 50 years. At first thorough, but mainly faunistic and autecological studies were conducted on various groups (PAWŁOWSKI, 1956, 1958, 1972; WOJTAS, 1959,1962; KRAJEWSKI, 1969; PIECHOCKI, 1969; JAŻDŻEWSKA, 1971; TABACKI, 1971; NIESIOŁOWSKI, 1980). Afterwards, only control samplings were carried out. Intensive studies started anew in the early 1990s. Now our studies are aiming at the analysis of the structure of animal assamblages against the background of environmental conditions. The present results are a part of the Polish-Dutch research project «Hydraulics and macroinvertebrates». «Hydraulics» means a wide complex of physical characters connected with running waters flow; hydraulics, exhibiting distinct changes within relatively short stretches of the stream, causes its biological zonation (HIGLER & MOL, 1984; STATZNER & HIGLER, 1986). One of the important abiotic factors immediately connected with hydraulics and controlling the occurrence of macroinvertebrates is the substratum, and in our studies special attention was paid to the sediment structure and its influence upon macrofauna distribution. As an object of study in Polish part of the research program the sandy bottom of the middle course of the River Grabia was chosen. These river stretches displayed much similarity to the streams simultaneously studied in the Netherlands; at the same time the River Grabia is less changed by human activity. In the River Grabia bed sandy bottom predominantes; sand is also the dominant material of the bottom of many European small rivers and streams (TOLKAMP & BOTH, 1978; VERDONSCHOT, 1992). In preparation there is a paper that will present the total macrofauna of the sandy bottom of River Grabia as a typical habitat of small, lowland rivers of alluvial plain not yet seriously influenced by human activity.

The collection of ephemeropteran larvae in this quantitative, regularly sampled material appeared to be very interesting. The present results bring new data to the knowledge of mayfly larvae of the habitat hitherto poorly studied in small rivers in respect to this very insect group.

INVESTIGATED AREA AND METHODS

The Grabia is a secondary tributary to the River Warta (Fig. 1). It is a rather typical, small lowland river with its headwater area situated at an altitude of 228 m a.s.l., a length of 81 km and a slope of 1.06‰. It flows into the River Widawka at an altitude of 142.5 m; at the mouth it is some 20 m wide. The catchment area of the Grabia is situated in a region with an average annual precipitation of 550-650 mm. The water level is rather variable; floods occurring most often in spring and in autumn, rarely in summer, in July. Smaller oscillations of the water level are due to the activity of water mills. The river bed is locally regulated, whereas anthropogenic pollution is relatively low and in general the river can be considered as comparatively little altered by human impact (PAWŁOWSKI, 1958; MAKSYMIUK, 1970).

The River Brodnia, a tributary of the Grabia, is a 12 km long brook meandring strongly at its mouth which is situated near the village of Kolumna.

Research was carried out in the middle section of the Grabia River course in the vicinity of two villages: Zimne Wody (stations 1-4) and Ldzań (st. 5-6) as well as in the mouth section of the Brodnia River, in the village of Kolumna (st. 7-8) (Fig. 1).

In the investigated Grabia section the river bed is bordered by alders and willows. During the vegetation season parts of the river bottom at the banks, and also some parts of the middle of the stream bed are covered by vegetation. Detritus covers the bottom mainly at the banks; the bottom is mostly sandy.

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Ephemeroptera & Plecoptera: Biology-Ecology-Systematics.

The studied section of the River Grabia was on average 7-12 m wide, its depth rarely exceeding 0.7 m and its current velocity rarely surpassing 0.4 m/s. These average values distinctly increase during the spring floods, as was observed in early 1993. The River Brodnia at its mouth was about 0.5 m deep and 3-4.5 m wide (Table 1). Chemical analysis showed the absence of any serious pollution in the investigated rivers. Conductivity varied between 337 and 528 μS being rather typical of Polish natural waters; pH was 7.08 to 8.08; oxygen content was rather high, between 6.66 and 12.97 mg/l. The ranges of the values of some ion concentrations were: SO_4^{--}: 27.9 to 101.5 mg/l, Cl^-: 9.5 to 87.2 mg/l, NH_4^+: 0.064 to 0.404 mg/l, NO_3^-: 1.0 to 23.6 mg/l, Fe^{++}: 0.27 to 1.13 mg/l, Ca^{++}: 50.3 to 80.4 mg/l. Total hardness varied between 2.9 and 4.6 mval/l.

The sampling stations were intentionally chosen in evidently sandy sections of the river. Samples were collected at each station at intervals of approximately 2 months along two or three neighbouring transects (Fig. 1). Sampling dates and the number of samples are presented in Table 2. A series of paired samples along the transect were usually taken at a distance of 1 m from each another. In the pair of samples - one sample was taken for macroinvertebrates, the second for granulometric analysis. A shovel sampler with a cutting edge of 10 cm was used (Fig. 2) (TOLKAMP, 1980).

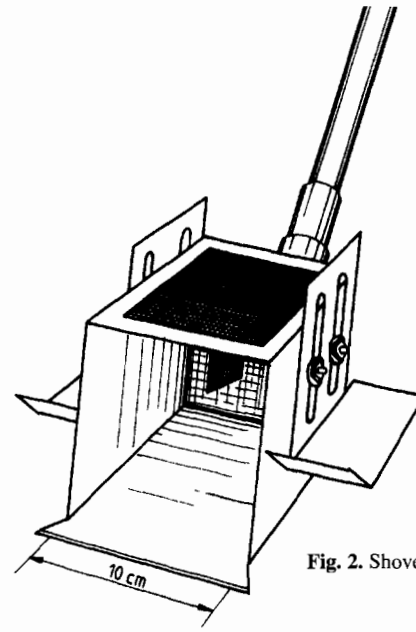

Fig. 2. Shovel sampler.

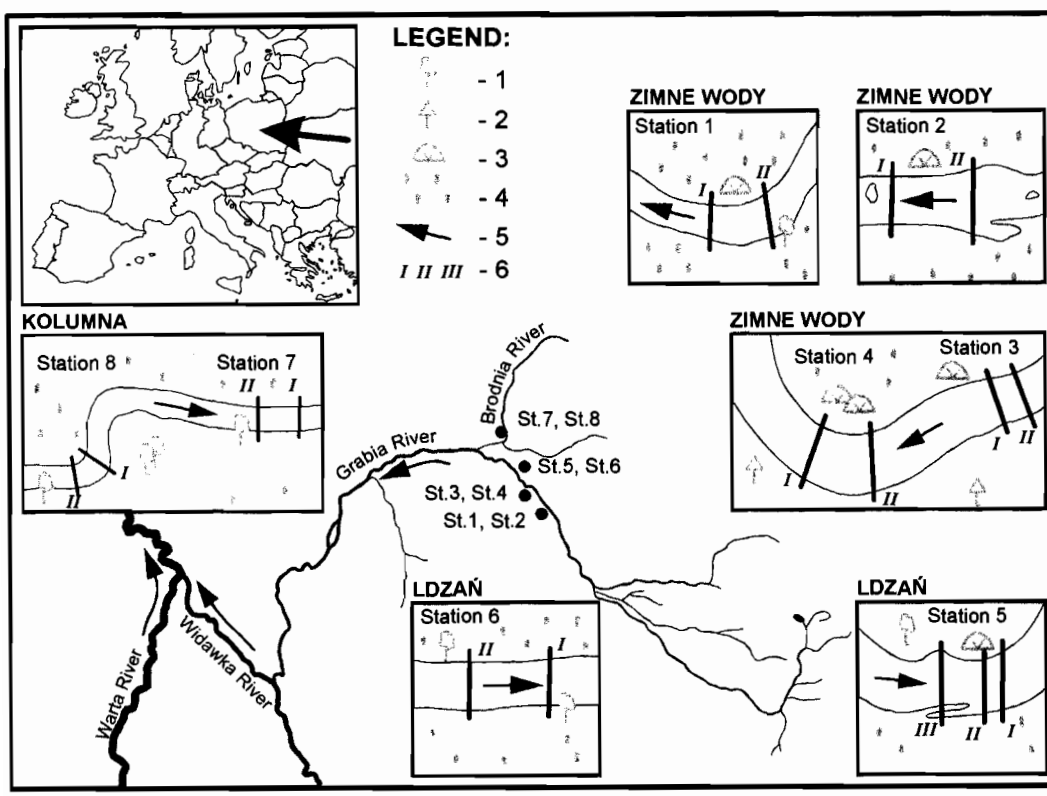

Fig. 1. Investigated area; location of stations and transects in particular river section. 1 - alder (*Alnus glutinosa*); 2 - pine (*Pinus* sp.); 3 - willow (*Salix* sp.); 4 - meadow; 5 - current direction; 6 - transects.

Table 1. Physical characteristics of the environment. *Substrate classification according to TOLKAMP (1980), numerical value: small pebbles - 3, coarse gravel - 4, medium gravel - 5, fine gravel - 6, very coarse sand - 7, coarse sand - 8, medium sand - 9, fine sand - 10, very fine sand - 11.

Stations and transects		Width [m] min.-max.	Depth [m] min.-max.	Velocity [m/s] min.-max.	Discharge [m^3/s] min.-max.	Sediment numerical value*	Organic matter in % min.-max.
Station 1	I	7,0-11,7	0,10-1,10	0,10-0,43	0,27-1,9	8-11	0,04-4,27
	II	7,5-13,2	0,08-1,05	0,08-0,38	0,24-2,37	6,8-11	0,26-6,6
Station 2	I	8,1-9,5	0,11-1,25	0,08-0,4	0,42-2,31	8-10	0,02-3,02
	II	5,2-12,0	0,28-1,27	0,12-0,49	0,50-2,53	8-9	0,02-3,57
Station 3	I	8,0-10,1	0,29-0,95	0,03-0,39	0,33-1,25	8-10	0,26-1,16
	II	8,1-10,4	0,09-0,90	0,05-0,4	0,38-1,63	8-9	0,25-7,42
Station 4	I	6,3-11,8	0,07-0,90	0,04-0,48	0,25-1,78	4,7,8-10	0,19-9,81
	II	6,3-10,0	0,15-0,95	0,02-0,36	0,24-1,84	8-11	0,31-4,02
Station 5	I	13,2-14,7	0,07-1,16	0,0-0,40	0,20-2,2	8-9	0,20-3,14
	II	14,2-16,4	0,05-1,60	0,0-0,33	0,15-1,42	5,8-10	0,18-4,24
	III	15,0-19,3	0,15-1,50	0,02-0,31	0,18-1,36	8-10	0,18-7,26
Station 6	I	8,6-12,5	0,03-0,66	0,0-0,38	0,18-1,28	3,4,6,8-10	0,20-2,99
	II	9,9-14,0	0,01-0,58	0,0-0,38	0,23-1,18	6,8-10	0,38-3,74
Station 7	I	2,8-4,6	0,01-0,32	0,05-0,31	0,04-0,15	8-9	0,21-2,52
	II	2,8-3,3	0,1-0,3	0,03-0,28	0,05-0,14	8-11	0,25-3,90
Station 8	I	2,3-3,6	0,03-0,49	0,11-0,34	0,04-0,14	8-10	0,24--8,69
	II	2,6-3,1	0,03-0,40	0,06-0,29	0,06-0,15	7-11	0,19-8,40

The shovel was moved along the stream bed for 20 cm thereby scraping away a 200 cm^2 area of surface layer sediments (1/50 m^2). The layer of sediment was approximately 3 cm thick.

Samples were brought fresh to the laboratory and immediately (i.e. 1-3 hours after collecting) sieved with 0.5 mm mesh size sieves. Material was sorted fresh, mostly alive; sometimes samples were too numerous or rich and then they were kept in a refrigerator at 6°C for sorting the next day. According to the program assumptions our stations were intentionally chosen in sandy sections of the rivers where the organic matter content was usually low, rarely surpassing 1% (only occasionally as high as several percent). Granulometric analysis was carried out in the laboratory according to the methods proposed by TOLKAMP (1980). Substrate types in his classification were numbered from 1 to 11 (Table 1). Table 1 demonstrates that the substrate in our stations usually consisted of coarse, medium or fine sand. In these sediments grain sizes with diameters ranging from 1.0 to 0.125 mm prevailed.

Table 2. Field program, sampling dates and numbers of benthos samples collected, presence of Ephemeroptera nymphs in the series of samples indicated. Numerator: total number of samples; denominator: number of samples with Ephemeroptera; shading shows samples where Ephemeroptera were lacking.

Year	1992															1993												1992
Month	05	06			07		08		09	10			12			01	02		03		04		05		06		07		-
Day	25	01	08	11	22	30	19	26	28	06	13	20	01	07	15	04	10	16	02	09	20	26	04	17	21	30	12	26	1993
Station 1	21/13				11/6				11/4				10/1				8/0				9/0				8/3				78/27
Station 2	10/6				9/7				10/5				9/4				9/0				10/0				9/3				66/25
Station 3		7/1				5/2				9/5				4/2				7/3				6/0				6/3			44/16
Station 4		15/4				9/3				9/6				7/3				9/1				10/0				10/6			69/23
Station 5			16/9				13/0				13/3				9/4				17/5				12/3				13/1		93/25
Station 6			21/5				10/1				8/3				8/3					9/4			9/2				9/1		74/19
Station 7				8/0				8/1				8/0				7/0				7/0				9/4				7/1	54/5
Station 8				11/0				7/1				7/0				6/0				6/0				7/4				5/0	49/5

RESULTS

The characteristics of the stations (Table 1) and the research program (Table 2) show that samplings were carried out regularly in all seasons in a rather homogenous habitat. Therefore low diversity of fauna was observed. All macroinvertebrates were hitherto counted and classified to higher taxa only for samples of station 1. In Fig. 3 the changes of the total abundance of macrofauna and Ephemeroptera in this station in the yearly cycle are presented against the background of changes in discharge. The negative effect of the flood is evident between February and May.

The share of ephemeropteran larvae in the macrofauna of the sandy bottom in terms of abundance was usually low; in station 1 it was always lower than 5%. Particularly low abundance of ephemeropteran larvae was noted in the Brodnia River.

Ephemeroptera were encountered only in 146 samples of the total 527 samples collected in all stations (Table 2). Therefore the frequencies of particular species, calculated as a relation of the number of samples with this species to the total number of all samples collected in the station (Table 3 - F) or in the chosen river section (Table 3 - F_1), appeared to be low. Altogether in 8 stations 693 larvae of Ephemeroptera were collected composed of 24 identified taxa. Some specimens were very young or damaged and therefore full specific determination was possible for only 15 species. Larvae very

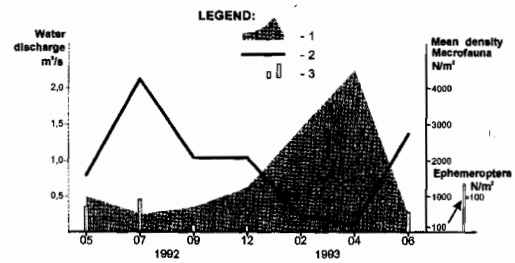

Fig. 3. Seasonal changes of the density of macrofauna and ephemeropteran nymphs alone against the background of seasonal changes in discharge (station 1). 1 - water discharge, 2 - macrofauna, 3 - Ephemeroptera.

Table 3. Abundance and frequency of Ephemeroptera nymphs in the investigated area. N - number of specimens. Frequencies were calculated as a relation of the number of samples with this species to the total number of all samples collected in the station (F) or in river section (F1).

River	Grabia																	Brodnia					
Section	Zimne Wody											Ldzań						Kolumna					
Station/Number of samples	1 / 78		2 / 66		3 / 44		4 / 69		Total 257			5 / 93		6 / 74		Total 167		7 / 54		8 / 49		Total 103	
Taxon	N	F	N	F	N	F	N	F	N	%	F_1	N	F	N	F	N	%	F_1	N	F	N	F	N	F_1
Baetis fuscatus	1	1,3			1	2,3			2	0,35	0,8			2	1,3	2	1,7	0,6						
Baetis fuscatus group			1	1,5			1	1,4	2	0,35	0,8	1	1,1			1	0,9	0,6						
Baetis vernus	1	1,3							1	0,17	0,4										2	4,1	2	1,9
Baetis cf. vernus																			1	1,8	5	6,1	6	3,9
Baetis cf. calcaratus														1	1,3	1	0,9	0,6						
Baetis sp.	4	3,8					1	1,4	5	0,88	1,6			2	2,7	2	1,7	1,2	10	9,3	5	6,1	15	7,8
Baetopus wartensis	6	6,4							6	1,05	1,9	1	1,1			1	0,9	0,6						
Centroptilum luteolum	3	3,8			16	9,1	6	5,8	25	4,38	4,3	1	1,1	1	1,3	2	1,7	1,2						
Pseudocentroptilum sp.							1	1,4	1	0,17	0,4													
Procloeon sp.							5	1,4	5	0,88	0,4	1	1,1			1	0,9	0,6						
Cloeon dipterum group					1	2,3			1	0,17	0,4													
Baetidae	2	2,6			3	6,8			5	0,88	1,9													
Heptagenia flava							1	1,4	1	0,17	0,4													
Paraleptohlebia submarginata					1	2,3	1	1,4	2	0,35	0,8													
Habrophlebia fusca																			1	1,8			1	1,0
Ephemera vulgata	1	1,3	6	6,1					7	1,23	1,9													
Ephemera danica	3	2,6					2	2,9	5	0,88	1,8	1	1,1	1	1,3	2	1,7	1,2						
Ephemerella ignita	7	3,8	3	3,0	7	2,3	9	1,4	26	4,55	2,7	6	4,3	4	4,0	10	8,8	4,2						
Caenis horaria	5	5,1	12	12,1	170	22,7	111	13,0	298	52,29	12,1	33	19,3	24	14,9	57	50,0	17,4						
Caenis robusta												1	1,1			1	0,9	0,6						
Caenis pseudorivulorum	13	10,3	26	16,7	14	9,1	33	10,1	86	15,08	11,7	2	1,1	22	6,8	24	21	3						
Caenis rivulorum	1	1,3	14	12,1	3	6,8	5	5,8	23	4,1	6,2	1	1,1			1	0,9	0,6						
Caenis sp.	10	7,7	6	6,1	8	4,5	13	7,2	37	6,48	6,6	5	4,3	4	4,0	9	7,9	4,2						
Brachycercus harrisellus	8	9	1	1,5	2	4,5	6	8,7	17	2,98	6,2													
	65		69		226		195		555			53		61		114			12		12		24	

similar to *Baetis calcaratus* KEFF. but differing in colour pattern were labelled *Baetis* cf. *calcaratus*. A few individuals of the genera *Pseudocentroptilum* BOGOESCU and *Procloeon* BENGTSSON as well as larvae of the *Cloeon dipterum* group also occurred in the samples.

In Table 3 the dominance Caenidae in this material is evident. The dominant species were *Caenis horaria* and *Caenis pseudorivulorum*. Other frequent and numerous species were *Centroptilum luteolum* and *Ephemerella ignita*. Noteworthy is the first record of two species - *Caenis rivulorum* and *Baetopus wartensis* in the River Grabia, however both occurred in low numbers.

In spite of the proximity of the River Brodnia stations to those of the River Grabia the differences in their ephemeropteran fauna are striking. In the River Brodnia, along with one *Habrophlebia fusca* specimen, only 23 baetid larvae were caught, and *Caenis* larvae were totally absent.

The distribution of all samples according to their granulometric substrate characteristics is presented in Fig. 4a. The sediment of the majority of samples consisted of coarse, medium or, to a lesser extent, of fine sand. The share of samples containing Ephemeroptera in each of these groups was similar amounting to about 30%. Further figures (Figs 4 b, c) suggest that *Caenis horaria* preferred coarse sand (Nr 8), *C. rivulorum* occurred in gravel and in sand of various size (Nrs 5-10), whereas *Baetopus wartensis* was found only in sand in the River Grabia (Nrs 8-10).

Ephemeropteran larvae showed very patchy distribution along the transects and larger concentrations of individuals were rare. Preliminary statistical treatment of our material aiming at the discovery of some relations between habitat characteristics and its ephemeropteran fauna composition failed.

Ephemeroptera larvae were collected in the sandy bottom nearly the whole year; however

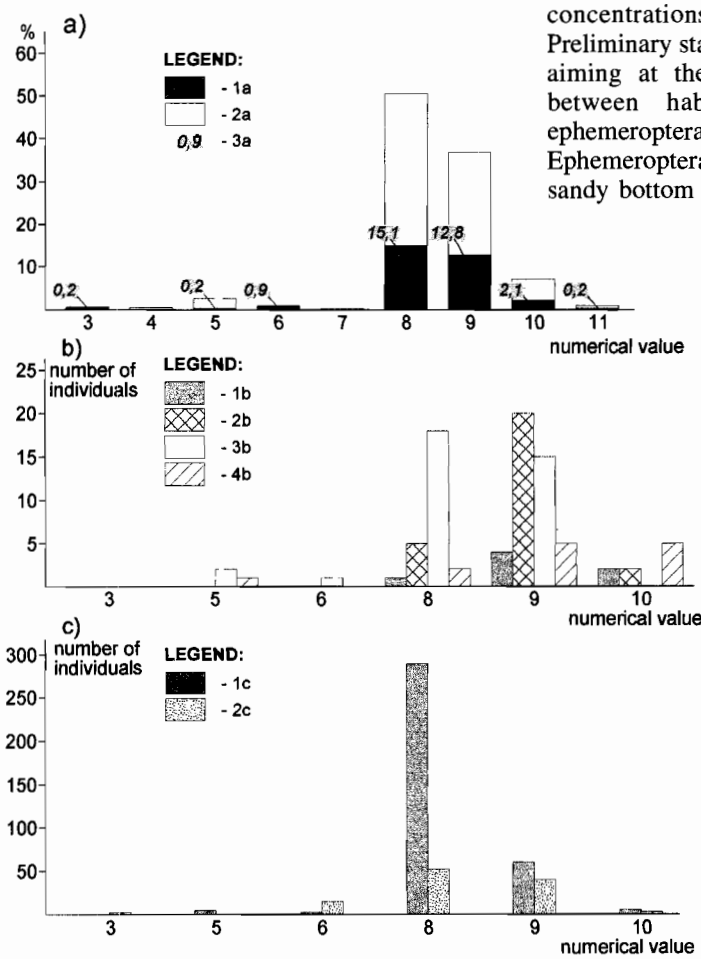

Fig. 4. Occurrence of Ephemeroptera in different kinds of substrate. 3-11 numerical value of sediment: 3 - pebbles, 4 - coarse gravel, 5 - medium gravel, 6 - fine gravel, 7 - very coarse sand, 8 - coarse sand, 9 - medium sand, 10 - fine sand, 11 - very fine sand.
a) The percent share of each kind of substrate in samples. 1a - samples with Ephemeroptera, 2a - samples without Ephemeroptera, 3a - percent of samples with Ephemeroptera.
b) Number of individuals of selected Ephemeroptera species in particular substrates. 1b - *B. wartensis*, 2b - *C. luteolum*, 3b - *E. ignita*, 4b - *C. rivulorum*.
c) Number of individuals of selected Ephemeroptera species in particular substrates. 1c - *C. horaria*, 2c - *C. pseudorivulorum*.

the diversity of this group was clearly lower in autumn and in winter (Fig. 5). On the other hand in autumn the highest abundances were noted. This was due to the population structure of the dominant species, *Caenis horaria* (Fig. 6). This species has a wintering generation and its larvae occurred in samples throughout the year. The high abundance of young larvae in autumn was striking. It can be assumed that larvae of *C. horaria* spent their early development period in the sandy bottom. In summer such aggregations of young larvae were not observed in this sandy habitat. On the other hand *Caenis pseudorivulorum* individuals were caught only in warm months and larvae of various sizes were collected.

Several individuals of *Baetopus wartensis* caught in May and June were advanced in their development; four specimens had folded but pale wings in their wing pads. Among the specimens of *Caenis rivulorum* collected in May and June with a length of 3.5-4 mm two individuals had dark wing pads. The remaining individuals of this species caught in autumn were 1.0-2.5 mm in length.

DISCUSSION

In the list of mayfly larvae collected in the sandy bottom of the River Grabia (Table 4) there were representatives of 6 families and 12 genera. Along with their vast systematic spectrum these larvae were rather widely diversified in a morpho-ecological sense.

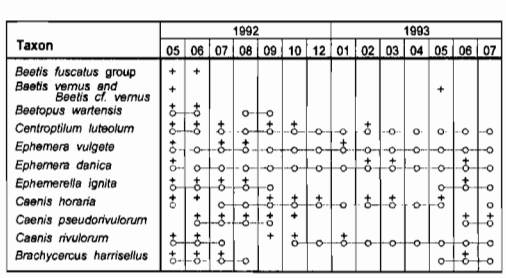

Fig. 5. Seasonal occurrence of ephemeropteran nymphs in the River Grabia sediments in 1992/93 (+++) against the background of their seasonal occurrence in Central-European rivers (literature data) (o-o-o) (KEFFERMÜLLER, 1967; LANDA, 1969: SOWA, 1975).

The abundances of particular species differed widely. The dominant *Caenis horaria* is recognized as an extraordinary eurytopic species; its larvae live in various types of running waters and stagnant basins, of both freshwater and brackishwater (KEFFERMÜLLER 1960, JAŻDŻEWSKA 1971, MALZACHER, 1986). *Caenis horaria* larvae occurred under stones, among vegetation and in the muddy bottom (KEFFERMÜLLER, 1960), on the sandy bottom and among decaying twigs (JAŻDŻEWSKA, 1971). MALZACHER (1986) observed that larvae of *C. horaria* occur both in oligotrophic as well as in meso- and eutrophic water bodies. During earlier River Grabia studies *C. horaria* occurred in samples only from March to mid October (JAŻDŻEWSKA, 1971), however during these investigations winter samplings were conducted mainly at the river banks.

According to KEFFERMÜLLER (1960) and JAŻDŻEWSKA (1971) larvae of the second dominant - *Caenis pseudorivulorum* - occur mainly among stones, twigs, branches, trunks, alder roots, sometimes in decaying alder leaves, less frequently in the phytal.

According to MALZACHER (1986) larvae of *C. pseudorivulorum* are typical potamobionts, i.e., inhabiting medium sized and large rivers, however this author supposes that they can live also in larger streams («Grösseren Bächen»). Earlier studies of the present author in the rivers Pilica, Lubrzanka and Tanew as well as observations carried out in the Carpathian running waters confirm the occurrence of *C. pseudorivulorum* in streams and rivers of various size; these larvae appeared however in these running waters at least a dozen or so kilometers below the sources (JAŻDŻEWSKA, 1971, 1979, 1984; SOWA, 1975; JAŻDŻEWSKA & GÓRCZYŃSKI, 1992).

Among Ephemeroptera found in the present study, besides the dominants, there are two noteworthy species: *Caenis rivulorum* and *Baetopus wartensis. C. rivulorum*, with the exception of one specimen caught in the Drawa River in western Pomerania lowland (GŁAZACZOW, 1994), was hitherto known only from mountainous southern Poland (SOWA, 1975). According to MALZACHER (1986) *Caenis rivulorum* was found in various European regions in small and larger lowland and mountain streams. This author observed *C. rivulorum* larvae pre-

ferring detritus on stony bottom. This species is univoltine with overwintering larvae.

Baetopus wartensis is a very rare species; it was described based on the nymph ready for metamorphosis collected in the phytal, in the middle course of the Warta River (KEFFERMÜLLER, 1960). Later on more larvae of this species were found in the Warta in shallow places with swift current, in the bottom of gravel (KEFFERMÜLLER, 1967).

Two other comparatively abundant species in our material were *Centroptilum luteolum* and *Ephemerella ignita*. Both are very common in Poland (KEFFERMÜLLER, 1960; SOWA, 1975; FALL, 1976; GŁAZACZOW, 1994) and in the River Grabia they belong to the most common and most abundant mayfly species (JAŻDŻEWSKA 1971).

C. luteolum was encountered in running waters of various sizes as well as in old river beds and lakes, in vegetation, under submerged objects and among decaying alder leaves. *E. ignita* usually occurs in larger running waters, where it often belongs to the dominant species. Its larvae occur on the stones, twigs, branches and in vegetation in rather swift current.

The psammophilous fauna, understood not as the micro-metazoan community but as macroinvertebrates, mostly insect larvae, burrowing in the sandy bottom, is usually not very abundant and diversified (WARD, 1992). A few genera of various groups of water insects belong here. Only Chironomidae are more abundantly represented. This fact results, among others factors, from the low amount of organic matter in the sandy bottom. The European mayflies to be mentioned in this context are *Behningia* ULM., *Ametropus* ALBARDA and *Ephemera* L. WESENBERG-LUND (1943) has mentioned the genus *Centroptilum*

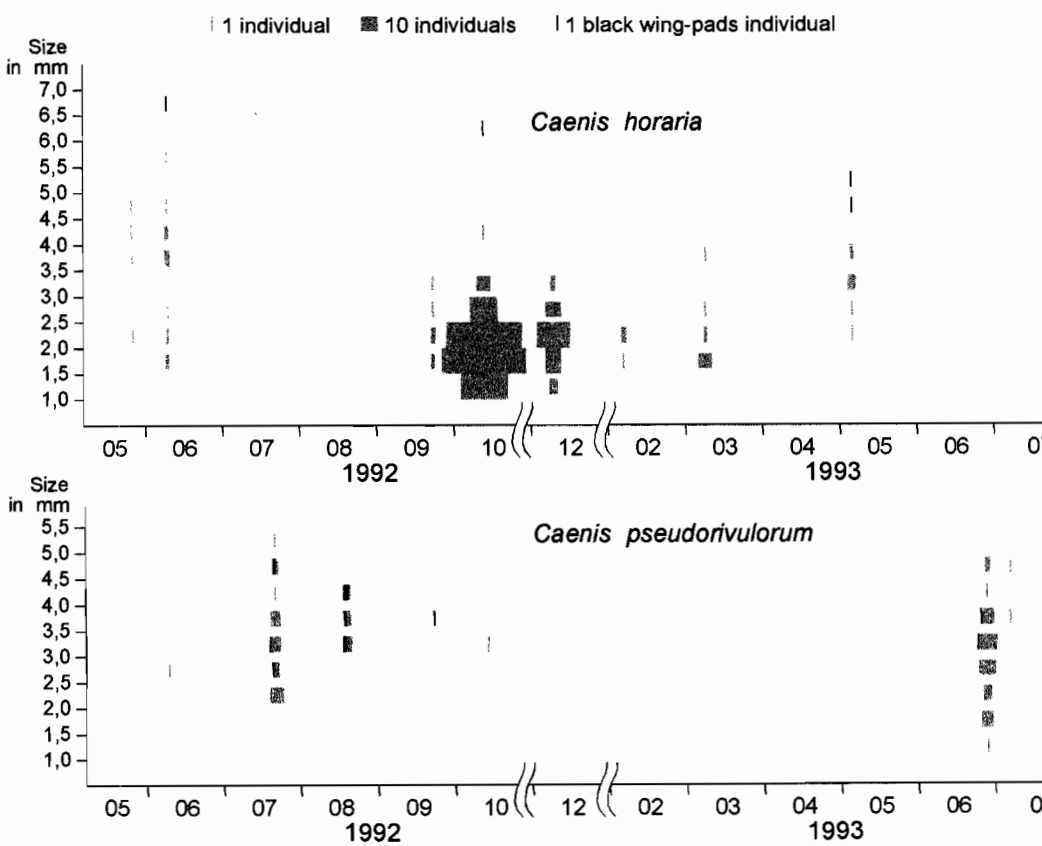

Fig. 6. Population structure of the dominant species.

EATON along with the caddis-fly *Molanna* CURTIS for shallow sandy bottoms of lakes.
The mayfly assemblage of the sandy bottom of the River Grabia seems to be a rather peculiar one. Species commonly recognized as characteristic of such habitat are lacking or not numerous. It seems that only *Baetopus wartensis*, despite its low abundance, can be classified as a species characteristic of sandy bottom. This assumption is justified by observations of KEFFERMÜLLER (1967) as well as the fact that this species was found in the River Grabia after decades of study only in this habitat that was now so thoroughly sampled.

Table 4. Ephemeroptera of the River Grabia in Zimne Wody section in last 30 years. + scarce (<10% of the material), ++ abundant (10-50% of the material), +++ very abundant (>50% of the material).

Taxon	Early 60-ties	Early 90-ties			
	Jażdżewska (1971, unpubl.) all habitats	Chmielewska unpubl. (phytal only)	Present study	Other samples in various habitats	Total
Baetis rhodani (Pictet)	+	+		+	+
Baetis vernus Curtis	+++	++	+	++	++
Baetis fuscatus (L.)	+	+	+	+	+
Baetis scambus Eaton		+		+	+
Baetis buceratus Eaton		+			+
Baetis cf. calcaratus Keffermüller	+	+	+		+
Baetis digitatus Bengtsson	+				
Baetopus wartensis Keffermüller			+		+
Centroptilum luteolum (Müller)	+	++	+	++	++
Pseudocentroptilum sp.	+				
Procloeon ornatum Tshemova		+		+	+
Procloeon sp.	+	+	+	+	+
Cloeon dipterum (L.) s.s.				+	+
Cloeon dipterum (L.) s.l.	+		+	+	+
Cloeon simile Eaton		+			+
Heptagenia flava Rostock	+	+	+	+	+
Heptagenia sulphurea (Müller)	+			+	+
Heptagenia fuscogrisea (Retzius)	+	+		++	+
Paraleptophlebia submarginata (Stephens)	+		+	+	+
Leptophlebia marginata (L.)	+			+	+
Leptophlebia vespertina (L.)	+			+	+
Habrophlebia fusca (Curtis)	+	+	+		+
Habrophlebia lauta Eaton	+				
Ephemera vulgata L.	+		+	+	+
Ephemera danica Müller	+		+	+	+
Ephemerella ignita (Poda)	+++	++	+	+	+
Eurylophella karelica Tiensuu	+				
Caenis horaria (L.)	+	+	+++		+++
Caenis robusta Eaton			+		+
Caenis luctuosa (Burmeister)	+				
Caenis pseudorivulorum Keffermüller	+	+	++		++
Caenis rivulorum Eaton			+		+
Brachycercus harrisella Curtis	+	+	+	+	+

Caenis horaria known as an eurytopic species can be recognized as a stable element of the River Grabia sandy bottom. It is quite possible that its young larvae of the wintering generation prevailing in this material are in fact psammophilous organisms. *C. pseudorivulorum* and *C. rivulorum* are usually recognized as rheophilous species preferring coarser sediments, also stones, where larger organic particles are deposited. However they can also inhabit sandy sediment as demonstrated by *C. rivulorum* in the River Grabia. *Centroptilum luteolum* can also be included in this assemblage. This species is rather eurytopic but was often found in the sandy bottom.

In earlier studies in the River Grabia and in some of its affluents larvae of *Ephemera danica* and *E. vulgata* were rather commonly recorded; they usually occurred in the bottom of sand and gravel covered with detritus (JAŻDŻEWSKA, 1971). Detailed analysis of substrate inhabited by *E. danica* revealed that the presence of detritus is a very important factor influencing the microdistribution of this species in Dutch streams (TOLKAMP & BOTH, 1978; TOLKAMP, 1980). Low amount of organic matter in the substrate from which present samples were collected would explain the strikingly low number of individuals of Ephemera species commonly recognized as psammophilous. Probably for the same reason the present collection is poor in larvae of the *Brachycercus harrisellus* otherwise very common in the River Grabia. They were usually collected in the bottom covered with detritus and even in muddy bottom (KEFFERMÜLLER, 1960; JAŻDŻEWSKA, 1971).

The remaining Ephemeroptera found in our material were accidental guests in (on) sandy bottom as a result of drift or migration. This is evidenced by the low number of individuals of these species. According to GRZYBKOWSKA *et al.* (1987) Ephemeroptera were a common element of drifting macrofauna. It appears that the poor mayfly fauna, consisting only of baetids in the sandy bottom of the Brodnia River, originates from drift.

Populations of typically psammophilous mayfly species were reported from larger Polish rivers like the Widawka and the Pilica (*Ametropus fragilis* ALBARDA) and the Warta [*A. fragilis* ALBARDA, *Behningia ulmeri* LESTAGE and *Oligoneurisca borysthenia* (TSHERN.)] (KEFFERMÜLLER, 1959, 1964; JAŻDŻEWSKA, 1973).

In Table 4 the species of Ephemeroptera presented were collected in various habitats in the Zimne Wody section of the River Grabia in the course of many years. The mayfly fauna of this short (some 2 km) river section appeared to be a rather rich one. The present thorough study of the sandy bottom in the whole river cross-section has enriched the list by two species - *Baetopus wartensis* and *Caenis rivulorum*. On the other hand, despite special, and often repeated sampling, two formerly reported species - *Baetis digitatus* and *Eurylophella karelica* - have not been found recently.

The main interest of hydrobiologists has most often been focussed on the nearshore zone of the rivers, although in natural non-polluted lowland rivers sand of various grain sizes with an admixture of detritus is the basic bottom substrate in central part of the bed. The present studies supplement our knowledge of the mayfly fauna of this hitherto poorly studied habitat that appeared to be not very suitable for this insect group. Nevertheless interesting information was obtained on the autecology of some mayfly species.

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