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The use of chironomid pupal exuviae for ecological characterization of the Upper Vistula (southern Poland)*

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Abstract – Collections of chironomid pupal exuviae and male imagos were made in the Vistula between the reservoirs Wisła Czarne and Goczałkowice and its source spring Biała Wisełka and Czarna Wisełka. 80 species were identified, 6 of which were found to be new to Poland. The presence/absence and relative numbers of the species found in the samples were used to define the chironomid assemblage, that could be applied to evaluate the pollutant effect of sewage effluent, acidification, and "regulated stream" effect in this reach of the river.

Key words: Chironomidae, pupal exuviae, rivers and streams, pollution, acidification, "regulated stream".

Wykorzystanie wylinek Chironomidae do ekologicznej charakterystyki górnej Wisły (południowa Polska). Wylinki poczwarek oraz dorosłe samce Chironomidae zebrano w Wiśle między Zbiornikiem Wisła Czarne i Zbiornikiem Goczałkowickim, i w jej źródłowych potokach Biała Wisełka i Czarna Wisełka. Oznaczono 80 gatunków, z których 6 było nowych dla Polski. Obecność lub brak poszczególnych gatunków oraz ich udział ilościowy w próbach wykorzystano do określenia zespołów Chironomidae, które mogą być wykorzystane do oceny skutków zanieczyszczenia ściekami, zakwaszenia i regulacji w badanym odcinku rzeki.

1. Introduction

The fauna of the invertebrates of the Upper Vistula is poorly known. Apart from the characterization of zoobenthos carried out on the level of higher systematic groups information about the taxa dominating in the region of the reservoirs Wisła Czarne and Goczałkowice (Dumnicka et al. 1988, Kasza and Krzyżanek 1993) there has been no detailed monograph on the entire fauna. On the other hand, there is information concerning Ephemeroptera (Mikulski 1950), Trichoptera (Szczęsny 1986), and Simuliidae (Bokłak et al. 1993). Chironomidae, one of the most important groups of river fauna, has not so far been investigated precisely in the Upper Vistula.

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The main aim of the present work was to determine the qualitative composition of Chironomidae in the Upper Vistula in the reach from the Wisła Czarne Reservoir to the Goczałkowice Reservoir and in its spring streams, the Biała Wisełka and Czarna Wisełka. A second aim was to describe the biocenosis characterizing the investigated reach of the river on the basis of the species and taxa of Chironomidae occurring there.

2. Material and methods

The investigations were carried out at 8 stations (fig. 1). A detailed description of the stations and their physical and chemical characteristics are given in the work of Kasza and Krzyżanek (1995).

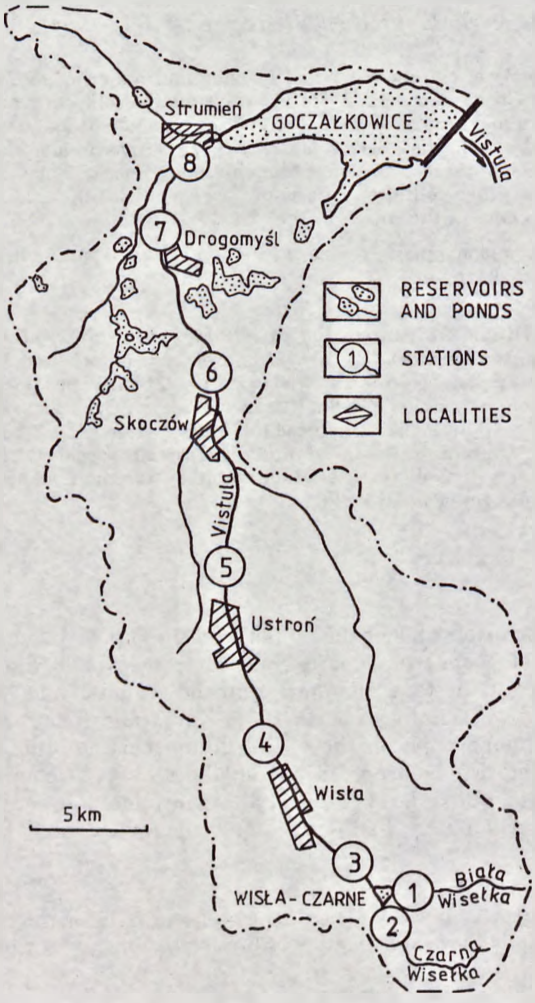

Fig. 1. Location of the sampling stations in the upper reaches of the Vistula.

The present work is chiefly based on the collections of pupae and pupal exuviae. This method is increasingly widely applied in determination of the composition of Chironomidae taxa of running waters (Coffman 1973, Hayes and Murray 1988, Laville 1979, 1981, Wilson 1977, 1980, 1989, Wilson and Bright 1973). The material was obtained from places with a slow current and from stagnant waters, where pupal exuvia gather on the surface, and from midstream by means of drift nets. Additionally, imagines flying above the water or resting on inshore vegetations were caught. The samples were taken in May, July and October 1991.

Solid preparations of the pupae and imagines of Chironomidae were made in the laboratory. The material was identified mainly using the keys for pupae of Lengton (1991), Wiederholm (1986), and special monographs on the following subfamilies: Tanypodinae (Fittkau 1962) or genera: *Cricotopus* (Hirvenoya 1973), *Eukiefferiella* (Lehmann 1972), *Rheocricotopus* (Saether 1985), *Nanocladius*, *Harnischia-complex* (Saether 1977). Imagines were identified using the keys of Pinder (1978), Wiederholm (1989), and individual monographs. The lack of contemporary works on certain genera prevented identification of the whole collected material. For example, the genus *Orthocladius* (s.str.) had not been revised in Europe. In the last compendium of the European Chironomidae (Fittkau and Reiss 1978) 60 species included earlier among genus Orthocladius have uncertain taxonomic position. The key for determine American species *Orthocladius* (Soponis 1977) cannot be applied when identifying the European species. The pupae of Chironomus, one of the genera richest in species, are practically indeterminable. At present, within this genus, systematics is based mainly on the chromosome structure and many new species have been described on this basis.

The obtained results are of exclusively qualitative character. Nevertheless, an attempt was made to isolate and classify the groups of Chironomidae on the basis of concomitance of species. The similarity coefficient of Sørensen

$$S = 100 \times 2c / a + b$$

was applied, where: a, b — number of species at stations A and B,
c — number of species common to both stations.

Then, on the basis of cluster analysis, the interdependences were presented as a dendrogram. Besides, the qualitative composition of the Chironomidae of the Vistula was graphically presented, according to the method suggested by Illies (1953).

3. Results

72 species and 8 taxa were identified, whose systematic classification was not precisely determined (Table I). Some species were reported from Poland for the first time, i.e. *Orthocladius* (*Eudactylocladius*) *olivaceus*, *Orthocladius* (*Euorthocladius*) *ashei*, *Orthocladius* (*O.*) *pedestris*, *Cricotopus* (*C.*) *tristis*, and *C.* (*C.*) *curtus*. Species from the subfamily Orthocladiinae were most numerously represented, 48 taxa, 19 taxa being found within the range of the subfamily Chironominae, 6 of Tanypodinae, 5 of Diamesinae and 1 of Prodiamesinae. Among the identified species or taxa none occurred at all the stations.

On the basis of concomitant species in the investigated reach of the Vistula three distinct assemblages of Chironomidae were distinguished (fig. 2). Those at Stations 4, 5, 6, and 7 had the highest similarity coefficient. They were characterized by a fairly large number of species from 23 to 33 and by relatively high amount of common species from 7 to 16 (fig. 3). However, the number of

Table I. List of taxa found in chironomid exuvial collections from the upper part of the River Vistula.

Taxa	Stations							
	1	2	3	4	5	6	7	8
Tanypodinae								
Procladius (Holotanypus) sigittalis (Kieffer, 1909)								•
Thienemannimyia carnea (Fabricius, 1805)			•	•	•	•		
Rheopelopia ornata (Meigen, 1838)							•	
Conchapelopia pallidula (Meigen, 1818)				•	•	•		
– *melanops* (Wiedemann, 1818)						•		
Nilotanypus dubius (Meigen, 1804)	•							
Diamesinae								
Boreoheptagyia sp.	•							
Diamesa hamaticornis Kieffer, 1924	•							
– *gr. cinerella*	•			•				
Potthastia gaedii (Meigen, 1838)				•				
– *longimana* (Kieffer, 1922)			•		•			•
Prodiamesinae								
Prodiamesa olivacea (Meigen, 1818)				•				•
Orthocladiinae								
Brillia modesta (Meigen, 1830)				•				
– *flavifrons* Johannsen, 1905				•				
Tvetenia calvescens (Edwards, 1929)			•		•	•	•	
– *discoloripes* (Goetghebuer, 1936)					•			
Eukiefferiella coerulescens (Kieffer, 1926)	•							
– *clypeata* (Kieffer, 1922)				•	•		•	
– *claripennis* (Lundbeck, 1898)						•	•	
– *gracei* Edwards, 1929			•				•	
– *minor* Edwards, 1929	•		•					
– *minor* Edwards, 1929 / *fittkaui* Lehmann, 1972							•	
– *devonica* (Edwards, 1929)		•	•					
– *ilkleyensis* (Edwards, 1929)				•		•		
Cardiocladius fuscus Kieffer, 1924				•	•			
– *capucinus* (Zetterstedt, 1850)	•							
Synorthocladius semivirens (Kieffer, 1909)				•	•	•	•	•
Orthocladius (Eudactylocladius) fuscimanus (K., 1908)	•							
– *(Eudactylocladius) olivaceus* Kieffer, 1911					•			
– *(Euorthocladius) ashei* Soponis 1990	•			•	•	•	•	
– *(Euorthocladius) rivicola* (Kieffer, 1911)				•	•		•	
– *(Euorthocladius) rivulorum* (Kieffer, 1909)	•			•				
– *(Symposiocladius) lignicola* Kieffer, 1915				•			•	
– *(Orthocladius) frigidus* (Zetterstedt, 1852)	•	•		•	•	•		
– *(Orthocladius) rivinus* Kieffer				•				
– *(Orthocladius) saxicola* (Kieffer, 1911)	•	•	•	•			•	
– *(Orthocladius) oblidens* (Walker, 1856)				•	•		•	
– *(Orthocladius) pedestris* Kieffer, 1909	•							
Paratrichocladius rufiventris (Meigen, 1830)			•		•	•	•	
– *skirwithensis* (Edwards, 1929)				•	•			

Table I. *Continued*

Cricotopus (Cricotopus) tibialis (Meigen, 1804)								•
– *(Cricotopus) fuscus* (Kieffer, 1909)						•		
– *(Cricotopus) pulchripes* Verral, 1912			•					
– *(Cricotopus) tremulus* (Linnaeus, 1758)				•	•	•		
– *(Cricotopus) tristis* Hirvenoja, 1973							•	
– *(Cricotopus) curtus* Hirvenoja, 1973	•			•				
– *(Cricotopus) triannulatus* (Macquart, 1826)				•			•	
– *(Cricotopus) bicinctus* (Meigen, 1918)				•		•	•	
– *(Cricotopus) vierriensis* Goetghebuer, 1935						•		
Rheocricotopus (Psilocricotopus) chalybetus (Edwards, 1929)					•	•		
– *(Rheocricotopus) effusus* (Walker, 1856)	•							
– *(Rheocricotopus) fuscipes* (Kieffer, 1909)	•		•	•				
Paracricotopus niger (Kieffer, 1913)					•			
Nanocladius bicolor (Zettersted, 1838)						•		
– *parvulus* (Kieffer, 1909)				•				
– *rectinervis* (Kieffer, 1911)					•	•		
Limnophyes sp.					•			
Parametricnemus cf. stylatus				•	•	•		
Heleniella ornaticolis (Edwards, 1929)				•				
Thienemanniella sp.							•	
Corynoneura scutellata Winnertz, 1846						•		
Chironominae								
Chironomus sp.						•		
Cryptochironomus obreptans (Walker, 1856)								•
Demicryptochironomus vulneratus (Zettersted, 1860)						•		
Endochironomus albipennis (Meigen, 1830)								•
Glyptotendipes pallens (Meigen, 1804)								•
– *paripes* (Edwards, 1929)								•
Polypedilum (Polypedilum) convictum (Walker, 1856)				•	•		•	
Phaenopsectra flavipes (Meigen, 1818)								•
Microtendipes chloris (Meigen, 1818)				•	•			•
– *species I*					•			
Paratendipes albimanus (Meigen, 1818)					•		•	•
Tanytarsus brundini Lindenberg, 1963							•	
– *ejuncidus* (Walker, 1856)							•	
– *eminulus* (Walker, 1856)				•				
– *pallidicornis* (Walker, 1856)						•		
Rheotanytarsus pentapoda Kieffer, 1909				•	•			
Micropsectra atrofasciata (Kieffer, 1911)				•	•	•	•	
Paratanytarsus dissimilis Johannsen, 1937							•	
– cf. *dimorphis*					•	•		
Numbers of taxa	16	3	10	33	28	24	23	12

species common to the Stations 1, 2, and 3 varied from 1 to 4, and at Station 8 from 1 to 3. The leading species of these stations were *Synothocladius semivirens, Orthocladius (Euorthocladius) ashei, Paratrichocladius rufiventris*, and *Micropsectra atrofasciata*.

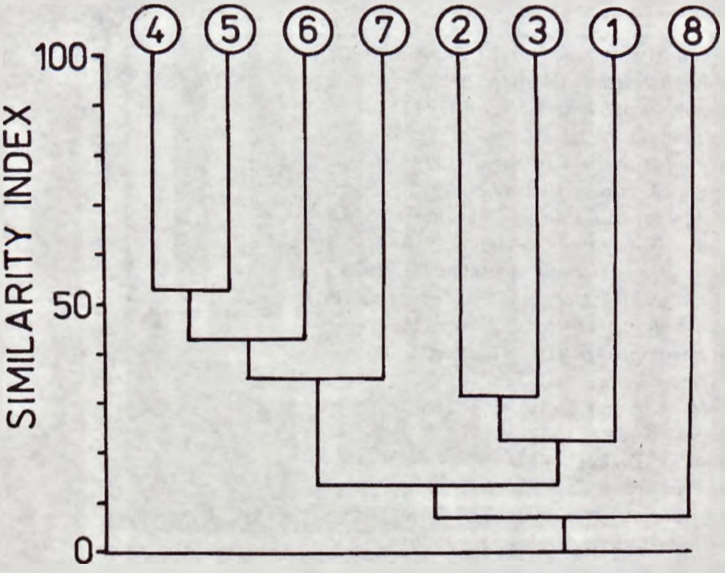

Fig. 2. Dendrogram showing similarity between stations, based on the Sørensen coefficient.

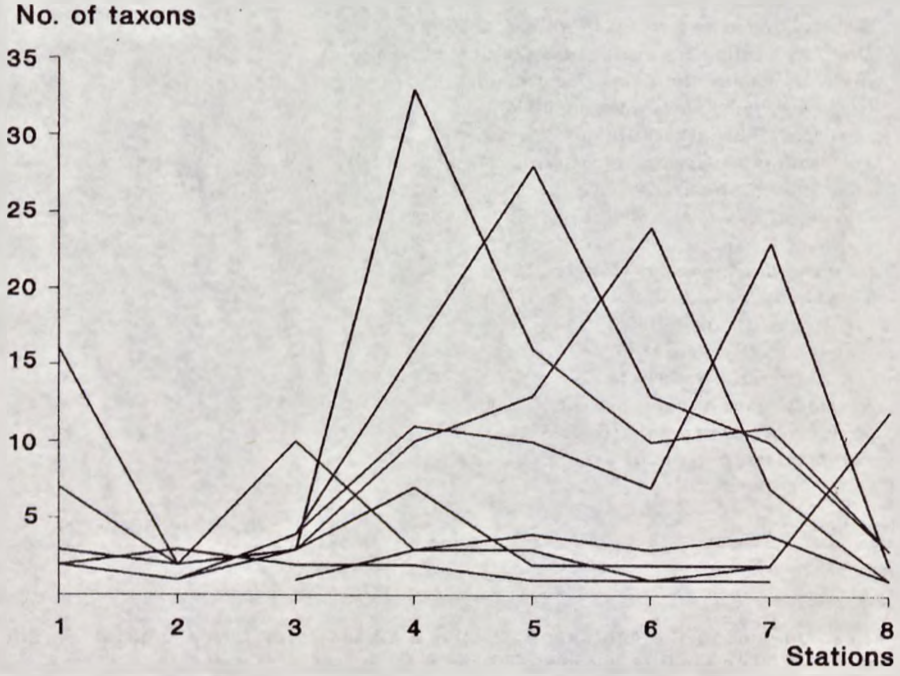

Fig. 3. Graphic presentation on the species structure of Chironomidae of the Vistula.

The next assemblage constituted those from Stations 1, 2, and 3. Their similarity coefficient was considerably lower. The common feature of the assemblages at these stations was the small number of species and few species in common with the Chironomidae fauna at the other stations. However, on the basis of the quality composition, it seems that each of these three stations should be considered separately and that each of them represents a different ecological zone. Only the assemblages at Station 1 can be viewed as being connected with the next part of the river (fig. 3). At Station 1, in the Biała Wisełka, 16 species were identified. 8 of which were found only at this station, while the remaining 8 had a wider range. At Station 2, in the Czarna Wisełka, only 3 species were found. 2 of them, *Orthocladius* (*O.*) *saxicola* and *Orthocladius* (*O.*) *frigidus* belonging to the species with a wide range and *Eukiefferiella devonica* being found also at Station 3. Below the Wisła Czarne Reservoir, at Station 3, 10 species were found, all of them with a very wide range. Only *Cricotopus* (*C.*) *pulchripes* was found exclusively at this station.

The assemblage of Chironomidae at Station 8, situated just above the Goczałkowice Reservoir, differed most from the other assemblages. 12 species were found here, 7 of them belonging to the subfamily Chironominae, 2 to Orthocladiinae, and 1 each to Tanypodinae, Diamesinae, and Prodiamesinae. The occurrence of 7 species was noted only at this station.

4. Discussion

The species *Orthocladius* (*Euorthocladius*) *ashei*, reported from the Upper Vistula as new for Poland was separated from *Orthocladius* (*O.*) *rivicola* (Soponis 1990) only a short time ago. In this situation all the former identifications of *O.* (*O.*) *rivicola* from Poland require revision. The presence of *Orthocladius* (*O.*) *rivinus* was signalled from the Prądnik stream (Dratnal 1976), but, the identification was given as a probable one, and not certain, hence it is missing in the register of the Chironomidae of Poland (Kownacki 1991). The occurrence of *Paratrichocladius skirwithensis*, which is chiefly known from streams and the headwater zone (Fittkau 1954, Hirvenoja 1973), and not from large submontane rivers, at the Stations 4 and 5 deserves attention.

On the basis of hydrobiological investigations of zoobenthos carried out in this region of the River Vistula (Dumnicka et al. 1988, Kasza and Krzyżanek 1993) the presented list of Chironomidae can be enlarged by 3 taxa, i.e. *Cricotopus* (*Isocladius*) sp., *Psectrocladius* sp., and *Dicrotendipes* sp. The *Ablabesmia* sp. found in the Vistula above Goczałkowice is probably a larval stage of some genus indistinguishable in this stage from the subfamily Tanypodinae. Altogether, in the investigated reach of the Vistula, 83 taxa of Chironomidae were found. This number is not complete. Further collection and better cognition of this fly (Diptera) family (new works) may contribute to a considerable increase in the number of species of Chironomidae in this reach of the Vistula. In the best known river of Europe with regard to fauna, the Fulda, 246 taxa of Chironomidae were recorded (Lehman 1971). In the Polish rivers, the greatest number, 148 taxa, of Chironomidae were found in the River Nida (Srokosz 1980). Taking into account those investigations with a comparable degree of precision in determination, 82 taxa were found in the River Pilica, only 19 of them being the same as in the investigated reach of the Vistula (Siciński 1990). In the River Lubrzanka 65 taxa were found, 16 species is common in it (Siciński 1982). The fauna of the

Chironomidae of the Upper Vistula is most similar to that of the River Dunajec in the reach between Nowy Targ and Szczawnica (Dratnal et al. 1979, Kownacki unpubl.). Out of 85 taxa found in the River Dunajec 45 taxa are common to the two rivers.

Before the building of the Goczałkowice and Wisła Czarne reservoirs Starmach (1956) distinguished the following ecological areas in the Upper Vistula: 1) the headwater area: to the confluence of the Biała Wisełka and Czarna Wisełka (a gradient: 52.7‰); 2) the montane area: from the confluence of the two streams Biała Wisełka and Czarna Wisełka to Skoczów (8.3‰); 3) the transitional area: from Skoczów to Drogomyśl (3.2‰); and 4) the plain area: from Drogomyśl to Goczałkowice (0.6‰). With regard to fishery, he distinguished a trout zone extending from the spring to Drogomyśl, passing at once into a barbel zone, and omitting a grayling zone. At present, in the investigated reach of the Vistula, can be distinguished the montane area (Station 1) with the Chironomidae fauna typical of the lower reach of clean montane streams (Kownacki 1971). In the middle reach of the Vistula (Stations 4, 5, 6, and 7) fauna typical of strongly eutrophicated, submontane rivers with a stony bottom occurs (Dratnal et al. 1979; Kownacki 1989). Above the Goczałkowice Reservoir (Station 8) the next Chironomidae assemblage, typical of lowland rivers, can be distinguished. The present ecological classification of the Vistula does not correspond with the one which was observed in the fifties; there is no distinct passage between the areas 2 and 3 in the region of Skoczów. In the reach from Wisła to Drogomyśl the changes take place gradually. The unification of the fauna in this reach is undoubtedly due to the increased pollution in the river and to its regulation. The Chironomidae fauna of Station 8 requires discussion. This assemblage is typical of slow-flowing lowland rivers with a slimy-sandy bottom (Wielgosz 1979), and not of the upper zone of a barbel zone (Lehmann 1971). Probably the change in zone at this station was brought about by the raised water level in the Vistula caused by the Goczałkowice Reservoir.

The fauna of Stations 2 and 3 differs from the above scheme. Only 3 Chironomidae species were found at Station 2. The total number of fauna at this station was also the lowest (Kasza and Krzyzanek 1995) and may be attributed to the increased acidification of the water in the Czarna Wisełka. Early in the eighties at the discussed station the pH varied from 5.8 to 7.0 in the annual cycle (Kwandrans 1989), whereas in the late thirties a pH of 6.5–6.6 was recorded in summer (Mikulski 1950). Comparing the Ephemeroptera fauna of the Biała Wisełka and Czarna Wisełka in the thirties Mikulski (1950) found slight differences in its composition, i.e. 15 species in the Biała Wisełka, and 14 in the Czarna Wisełka. At present the differences for Chironomidae amount to 16 species in the Biała Wisełka and 3 in the Czarna Wisełka. Such a small species diversity is typical of acidified waters (Ward 1992), although Chironomidae are considered to be aquatic insects with a high level of tolerance to changes in pH (Hamalainen and Huttunen 1990).

The Chironomidae assemblage of the Station 3 is typical of "regulated streams" as understood by Ward and Stanford (1979), Craig and Kemper (1987), Lillehammer and Saltveit (1984). It is characterized by a decrease in species diversity (10 species) and a large number of species with a wide range (6 species). In spite of the fact that the distance between Station 3 and Stations 1 and 2 is small, only 2 species typical of montane fauna were found at Station 3, i.e. *Eukiefferiella minor* and *Eukiefferiella devonica*.

In the most polluted reach of the Vistula (Dojlido and Woyciechowska 1983), between Okleśna and Jeziorzany (above Cracow), only 10 taxa were found (Dumnicka and Kownacki 1988). Among them, however, apart from *Parachirono-*

mus arcuatus and the terrestial-aquatic *Bryophaenocladius* sp., there were taxa, which would not be found in the Upper Vistula above the Goczałkowice Reservoir.

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