

## **Caddisflies (Trichoptera) of the springs of the Kraków-Częstochowa and the Miechów Uplands (Poland)**

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Manuscript submitted November 2, 1989, accepted July 2, 1990

**Abstract** — The caddis larvae in the examined springs represent impoverished fauna of the surrounding waters. The crenobionts *sensu stricto* are missing. Among the crenophiles the presence of three types of community was recorded: rheophilous crenophiles, originating from the epirhithral and metarhithral, limnophile crenophiles occurring in vernal water bodies, and limnophile crenophiles originating from fens and eutrophic still waters.

**Key words:** sources, caddis larvae, communities.

### **1. Introduction**

Investigations of the fauna of springs have a long tradition in Europe. In Poland only a few studies have been devoted to the caddisflies of such waters: Demel (1922), Michejda (1954), Tomaszewski (1972). Additional information on this subject can be found in other works describing caddisflies in mountain running waters (Riedel 1966, Gląpska 1986, Szczęsny 1986), while lists of some species from the springs of the Kraków-Częstochowa and the Miechów Uplands were presented by Szczęsny (1968), Riedel (1972) and Czachorowski (1986).

The aim of present work was to discuss the species composition and to analyse the ecological distribution of caddis larvae in the springs of the Kraków-Częstochowa and the Miechów Uplands. The paper presents the results of a part of complex investigations on the macrobenthos of the springs in this territory carried out by the Department of Ecology and Environment Protection of the Teacher Training College in Olsztyn.

## 2. Study area

A detailed description of the investigated area can be found in the paper by Biesiadka et al. (1990).

Altogether 75 springs were included in the investigations: 43 stations in the Kraków-Częstochowa Upland and 32 stations in the Miechów Upland (fig. 1). A few samples were also collected from other water

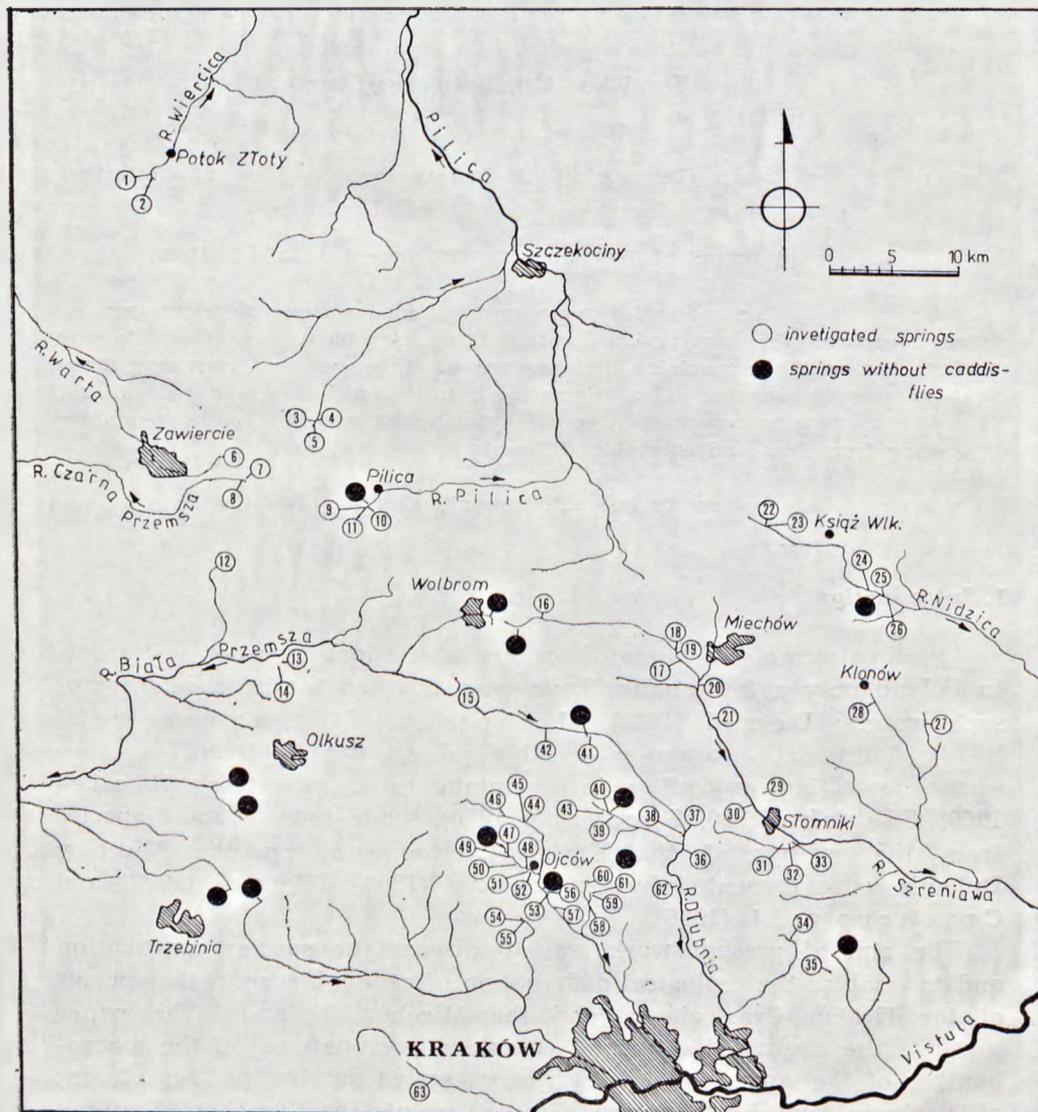


Fig. 1. Map of the study area

bodies i.e. a river and a pond, in direct hydrological contact with the investigated springs.

Among 66 springs in which the presence of caddisflies was observed (fig. 1), 5 principal hydrological types were distinguished: rheocrens, helorheocrens, helocrens, small limnocrens (area up to 5 m<sup>2</sup>), large limnocrens (area 5—400 m<sup>2</sup>).

Stations 1—3, 5—7, 13, 17, 19, 23—25, 27, 28, 30, 38, 44, 45, 47—52, 55, and 62 were considered as rheocrens, Stations 20, 26, 59 as helorheocrens, Stations 8, 12, 22, 56 as helocrens, Stations 16, 18, 29, 31, 32, 39, 40, 53, 54, 60, 61, 63 as small limnocrens, and Stations 4, 9—11, 14, 15, 21, 33, 34, 37, 41—43, 46, 58 as large limnocrens.

A more detailed hydrological and chemical description of the springs can be found in the studies by Dynowska (1979, 1983), Drzał and Dynowska (1982), and Biesiadka et al. (1990).

### 3. Material and methods

Because of the small dimensions of the spring biocoenoses and the possibility of damaging them by too frequent sampling, the field investigations were carried out in August 1985 and in May and October 1987. The larvae were caught using a hydrobiological sampler with a triangular hoop. Near the springs the imagines, which were helpful in determination of the larvae, were caught with an entomological net.

The material which formed the basis of the present investigation included 1436 larvae belonging to 38 taxa.

To evaluate the faunal similarities between the springs, the well-known formula of Jaccard was used

$$P_{xy} = \frac{c}{a + b - c} \times 100\%$$

where:

- $P_{xy}$  — faunal similarity between springs x and y,
- c — number of species common to springs x and y,
- a — number of species in spring x,
- b — number of species in spring y.

To estimate the species concomitance was used Jaccard's formula:

$$W_{xy} = \frac{c}{a + b - c} \times 100\%$$

where:

- $W_{xy}$  — concomitance of species x and y,

- c — number of stations at which species x and y appeared together,  
 a — number of stations with species x,  
 b — number of stations with species y.

To evaluate the concomitance of species the De Camps formula (Szczęsny 1986) was also used, in which besides the occurrence of a species also the statistical probability is taken into account:

$$\emptyset_0 = \frac{(C - P)N - \frac{N}{2}}{\sqrt{A(N - A)B(N - B)}} \times 100\%$$

where:

- $\emptyset_0$  — coefficient of concomitance,  
 A — number of stations at which species x occurred,  
 B — number of stations at which species y occurred,  
 C — number of stations common to both species,  
 N — total number of stations,  
 P — statistical probability of the concomitance of species x and y  
 at N stations:  $P = \frac{AB}{N}$

The results of computations for faunal similarity and concomitance are presented in the form of the shortest dendrite with marked grouping isolines.

## 4. Results

### 4.1. General characteristics of the Trichoptera of the examined springs

In the collected material 38 taxa were distinguished, including 31 found in the springs (Table I). *Hydropsyche instabilis*, *H. pellucidula*, *Potamophylax cingulatus*, *Halesus digitatus*, and *Lasiocephala basalis* occurred only in a river near the hillside springs, while *Holocentropus picicornis* and *Anabolia furcata* were caught in a pond near the spring.

The numbers of the particular taxa ranged from 1 to 306, with *Drusus trifidus*, *Plectrocnemia conspersa*, and *Potamophylax nigricornis* having the highest. Younger larval stages of Chaetopterygini were also numerous. These taxa were also characterized by the greatest frequency.

With respect to frequency structure the sporadic species (found at one or two stations) decidedly prevailed (fig. 2). Species of high frequency were very few. This fact indicates the great individuality of the studied springs.

Table I. Quantitative comparison of the collected caddis larvae nad their distribution in the springs of the Kraków-Częstochowa and Miechów Uplands. N — number of specimens; D — dominance (%); F — frequency (number of stations); R — rheocrens; RH — helorheocrens; H — helocrens; SL — small limnocrens; LL — large limnocrens

Taxa	Springs							
	N	D	F	R	RH	H	SL	LL
1. <i>Rhyacophila fasciata</i> Hag.	24	1.67	8	7				
2. — <i>pubescens</i> (?) Pict.	1	0.06	1	1				
3. — sp. Pict.	4	0.20	3					1
4. <i>Hydroptila</i> sp. Dal.	28	1.95	3					28
5. <i>Plectrocnemia conspersa</i> (Curt.)	217	17.20	45	139	33	12	30	17
6. <i>Holocentropus picicornis</i> (Steph.)	2	0.14	1	2				
7. <i>Tinodes rostocki</i> McLach.	2	0.14	1	20				
8. <i>Hydropsyche instabilis</i> (Curt.)	14	0.97	2	206		41		57
9. — <i>pellucidula</i> (Curt.)	16	1.11	2					1
10. <i>Apatania muliebris</i> (?) McLach.	20	1.39	2				1	
11. <i>Drusus trifidus</i> McLach.	306	21.31	18	88	6	30	14	8
12. — <i>biguttatus</i> (Pict.)	1	0.06	1		4		12	
13. <i>Isonychia dubia</i> (Steph.)	1	0.06	1	1		1	3	3
14. <i>Potamophylax nigricornis</i> (Pict.)	148	10.31	23	7		1	1	14
15. — <i>latipennis</i> (Curt.)	16	1.11	3	59		1	37	82
16. — <i>cingulatus</i> (Steph.)	1	0.06	1				1	
17. <i>Chaetopteryx villosa</i> (Fabr.)	9	0.63	7			1	14	2
18. — sp. Steph.	24	1.67	6			12	2	74
19. <i>Chaetopterygini</i> juv.	268	18.66	24					1
20. <i>Limnephilus rhombicus</i> (L.)	1	0.06	1					2
21. — <i>griseus</i> (L.)	18	1.25	5	1		19		
22. — <i>borealis</i> (Zett.)	88	6.19	6				5	35
23. — sp. I ( <i>borealis</i> ?)	1	0.06	1					26
24. — <i>stigma</i> Curt.	2	0.14	2					13
25. — <i>bipunctatus</i> Curt.	20	1.39	2					1
26. — sp. ( <i>incisus</i> ?)	40	2.79	2	1				
27. — <i>auricula</i> Curt.	26	1.81	3	10		2	2	
28. — sp. ( <i>decipiens-nigriceps</i> ?)	17	1.18	3	1				
29. — sp. II	2	0.14	2	3				
30. — sp. juv.	2	0.14	2	1				
31. <i>Halesus digitatus</i> (Shr.)	3	0.20	2	2				
32. <i>Anabolia furcata</i> Brau	12	0.83	1					
33. <i>Sericostoma</i> sp. Latr.	15	1.04	6					
34. <i>Lithax obscurus</i> (Hag.)	1	0.06	1					
35. <i>Silo pallipes</i> (Fabr.)	52	3.62	3					
36. <i>Lasiocephala basalis</i> (Kol.)	2	0.14	1					
37. <i>Crunoecia irrorata</i> (Curt.)	1	0.06	1					
38. <i>Odontocerum albicorne</i> (Scop.)	2	0.14	1					

#### 4.2. The occurrence of caddisflies in the particular types of spring

##### Rheocrens

These were represented by 27 stations. 550 larvae belonging to 18 taxa were caught there, the most numerous being *Drusus trifidus* (206 individuals), *Plectrocnemia conspersa* (139 individuals), *Potamophylax nigricornis* (88 individuals), and the tribe Chaetopterygini (59 larvae). The highest frequency was shown by *Plectrocnemia conspersa* (20 stations), *Potamophylax nigricornis* (12 stations), and *Drusus trifidus* (10 stations).

##### Helorheocrens

In the springs of this type 43 larvae belonging to three taxa to 11 taxa were caught. The most frequency occurring were Chaetopte-

##### Helocrens

At four stations 120 larvae belonging to 10 species were caught. The most numerous were *Drusus trifidus* (41 individuals), *Potamophylax nigricornis* (30 individuals), *Limnephilus bipunctatus* (19 individuals), and *L. borealis* and *Plectrocnemia conspersa* (12 individuals each).

##### Small limnocrens

At 14 stations representing this group of springs 121 larvae belonging to 11 taxa were caught. The most frequency occurring were Chaetopterygini (37 larvae), *Plectrocnemia conspersa* (30 larvae), *Potamophylax*

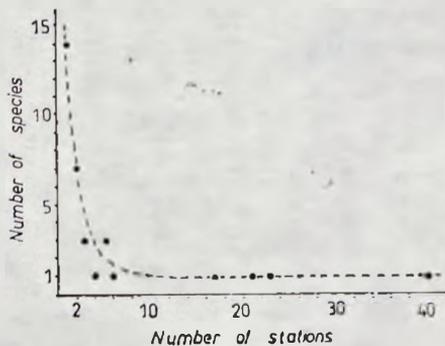


Fig. 2. Frequency structure in the springs

*nigricornis*, and *Limnephilus griseus* (14 larvae each). The highest frequency was that of *Plectrocnemia conspersa* (10 stations), Chaetopterygini (5 stations), and *Potamophylax nigricornis* (3 stations).

#### Large limnocrens

In 15 springs of this type 364 larvae belonging to 17 taxa were collected, the most numerous being *Potamophylax nigricornis* (82 individuals), *Drusus trifidus* (57 individuals), *Limnephilus borealis* (73 individuals), and *Limnephilus* sp. type *incisus* (35 individuals). The highest frequency was shown by Chaetopterygini (8 stations), *Drusus trifidus* (6 stations), and *Plectrocnemia conspersa* (5 stations).

#### 4.3. Comparative analysis of the investigated springs

Faunal similarities between the particular springs varied from 0 to 100%. 7 groups of stations showed similarities greater than 70% (fig. 3). J<sub>1</sub> — 10 stations: 4 large limnocrens, 2 small limnocrens, 3 rheocrens, and 1 helorheocren. In these springs the occurrence of only one species, *Plectrocnemia conspersa*, was observed.

J<sub>2</sub> — 2 stations: large limnocren and a small limnocren. In these springs were found *Plectrocnemia conspersa*, *Drusus trifidus*, *Potamophylax nigricornis*, and Chaetopterygini spp. juv.

J<sub>3</sub> — 8 stations: 3 large limnocrens, 2 small limnocrens, 2 rheocrens, and 1 helocren. Only two species, *Plectrocnemia conspersa* and *Potamophylax nigricornis*, occurred there.

J<sub>4</sub> — two springs: helorheocren and large limnocren. Here occurred: *Plectrocnemia conspersa*, *Drusus trifidus*, and *Potamophylax nigricornis*.

J<sub>5</sub> — two rheocrens in which only one species, *Limnephilus auricula*, was caught. Group J<sub>6</sub> was also made up of two rheocrens.

J<sub>7</sub> — two rheocrens and a large limnocren, in which only Chaetopterygini spp. juv. was found. However, in group J<sub>8</sub> (2 rheocrens) only *Drusus trifidus* occurred.

Taking into consideration the similarities above 50%, 7 groups of springs, including 3 new ones, were distinguished.

J<sub>9</sub> — was represented by two rheocrens in which the occurrence of *Plectrocnemia conspersa* and Chaetopterygini spp. juv. was determined.

J<sub>10</sub> — comprised the two groups J<sub>2</sub> and J<sub>4</sub> already distinguished and 6 other stations (3 rheocrens, 2 small limnocrens, and 1 helocren). The occurrence of the following taxa in these sources was observed: *Plectrocnemia conspersa*, *Drusus trifidus*, *Potamophylax nigricornis*, *P.*

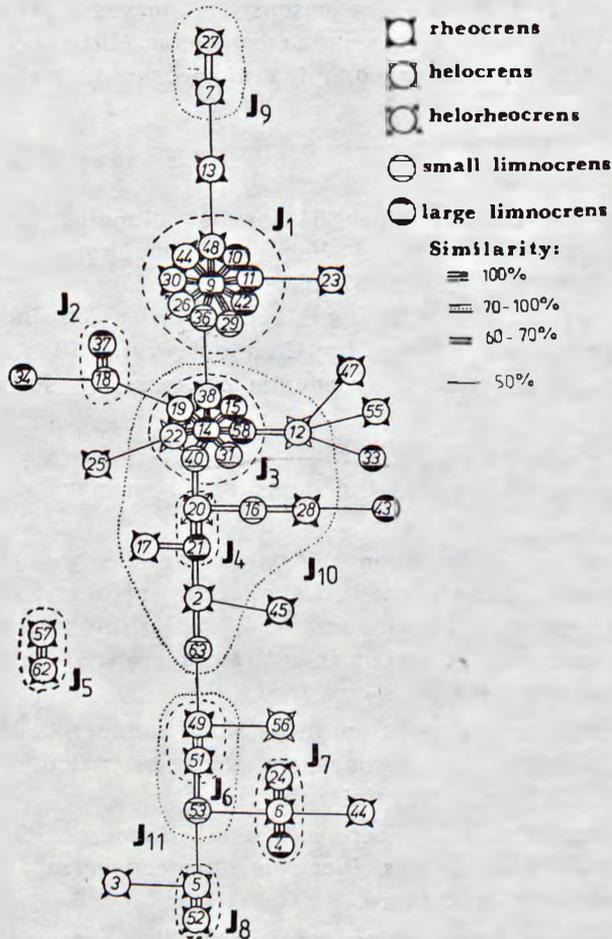


Fig. 3. Faunal similarities between all stations according to the Jaccard formula. Station numbers as in fig. 1

*latipennis*, *Chaetopteryx* sp., *Chaetopterygini* spp. juv., and *Sericostoma* sp.

$J_{11}$  — comprised group  $J_6$  and a small limnocren. The occurrence of *Plectrocnemia conspersa*, *Drusus trifidus*, *Limnephilus borealis*, and *Chaetopterygini* spp. juv. was noted.

The groups of springs distinguished with this method correlate neither with the hydrological types of spring nor with springs belonging to the same catchment area. Moreover, most sources were characterized by a relatively great mutual similarity (above 50%). The dendrite drawn has a gradient (continuous) character. Between the groups a gradient of changes *Plectrocnemia conspersa* — *Potamophylax nigricornis* — *Drusus trifidus* (the main axis of the dendrite, fig. 3) can be observed.

## 4.4. Concomitance of species

After evaluation of concomitance according to the Jaccard formula the distinguished communities were ordered according to the type of habitat in which they occurred.

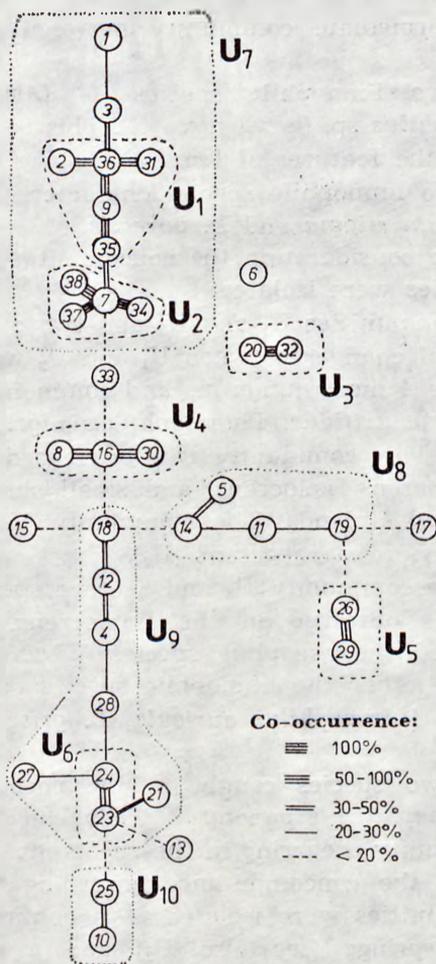


Fig. 4. Concomitance of species according to the Jaccard formula. Numbers of species as in Table I

At the concomitance level above 50%, 6 communities were isolated (fig. 4):

$U_1$  — comprised 5 rheophile species: *Rhyacophila pubescens*, *Lasiocephala basalis*, *Halesus digitatus*, *Hydropsyche pellucidula*, and *Silo pallipes*. They occurred mainly in flows, except *Silo pallipes* which occurred also in springs.

U<sub>2</sub> — comprised 4 species caught in the rheocrens of Wiercica — *Tinodes rostocki*, *Odontocerum albicorne*, *Crunoecia irrorata* and *Lithax obscurus*.

U<sub>3</sub> — comprised two species caught in the pond near the spring. This community was not related to any of the communities of springs.

U<sub>4</sub> — comprised three rheophile species occurring mainly in flows. It represented an intermediate community between rheocrens (U<sub>2</sub>) and limnocrens (U<sub>9</sub>).

U<sub>5</sub> — comprised two limnophile species — *Limnephilus* sp. (type incisus) and *Limnephilus* sp. (larva nova II). This community was found in limnocrens with the features of fens.

U<sub>6</sub> — comprised two limnophile species characteristic of vernal astatic pools — *Limnephilum stigma* and *L. borealis*.

After taking into consideration the concomitance level above 20%, 4 further communities were isolated:

U<sub>7</sub> — comprised communities U<sub>1</sub> and U<sub>2</sub> and two other rheophiles. The gradient character of changes between U<sub>1</sub> and U<sub>2</sub> was evident.

U<sub>8</sub> — comprised the 4 most numerous and common species *Plectrocnemia conspersa*, *Drusus trifidus*, *Potamophylax nigricornis*, and *Chaetopterygini* spp. juv. This community can be regarded as characteristic and typical of rheocrens, helocrens, and small shallow limnocrens of both the investigated Uplands. The community U<sub>8</sub> differed distinctly from those of the Wiercica rheocrens (U<sub>2</sub>).

U<sub>9</sub> — comprised the community U<sub>6</sub> and 6 other species arranged in a continuum and was observed in the limnocrens. One arm of this continuum comprised the rheophile species (*Chaetopteryx* sp., *Drusus biguttatus*), and the other the limnophile species occurring also in the vernal astatic pools (*Limnephilus auricula*, *L. griseus*, *L. borealis*, and *L. stigma*).

U<sub>10</sub> — comprised two species caught in the rheocrens — *Apatania muliebris* and *Limnephilus bipunctatus*. They can be regarded as the third type of community occurring in the rheocrens (besides U<sub>2</sub> and U<sub>8</sub>).

When analysing the concomitance according to the Decamps formula two communities were isolated — a community characteristic for the Wiercica springs (see also U<sub>2</sub>) and a community of the commonest species typical of most springs in the investigated area (see also U<sub>8</sub>) (fig. 5).

## 5. Discussion

In 17 springs in the Carpathian Mountains the occurrence of 40 species of caddisfly were determined (Szczęsny 1986). In the Pieniny Mountains, near the springs, imagines of 12 species of caddisfly were

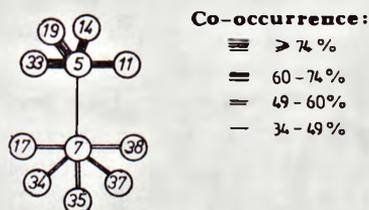


Fig. 5. Concomitance of species according to the Decamps formula. Numbers of species as in Table I

caught (Riedel 1978). Glapska (1986) caught 12 species of Trichoptera larvae in two headwater sections of rivers in the Holy Cross Mountains. In some springs in the Table Mountains Michajda (1954) observed the occurrence of larvae of 15 species. The presence of 15 species was also observed in more than a dozen springs in the Karkonosze Mountains (Czachorowski, in press). In the studied springs of the Kraków-Częstochowa and the Miechów Uplands 28 species of Trichoptera were caught (out of the total number of 38 taxa, 7 were caught beyond the springs, and three taxa were determined as belonging to a rank higher than species). Against the quoted data from other springs in Poland it seems that in the investigated springs a comparatively large number of Trichoptera species were found. However, in the present investigations a great number of springs (75) were examined, hence most probably many incidental species were caught. This assumption may also be supported by the fact that a distinct majority of the species caught was characterized by very low frequency (fig. 2). Another cause of increasing the polarization of the frequency structure may be the lack of stability of some springs, which was manifested in the fauna of water mites (Biesiadka et al. 1990).

In the springs of the River Saspówka (a tributary of the Prądnik) Szczęsny (1968) noted the numerous occurrence of *Drusus annulatus*, *D. biguttatus*, and *D. trifidus*. Less numerous were *Plectrocnemia conspersa*, *Potamophylax nigricornis*, and Limnephilidae indet. In the present investigations *Drusus annulatus* was not observed, while *D. biguttatus* was caught in very small numbers. On the basis of data obtained so far it is not yet possible to establish unequivocally whether the above facts are the results of an impoverishment in the Trichoptera fauna in the Prądnik Valley (as well as in the other springs) or whether they result from the seasonal changes in settling the springs by the rheophile species originating from the epirhithrone.

The springs of the Wiercica may be regarded as those with the unchanged Trichoptera fauna. In the investigations of Riedel (1962) the same species as in the present study were listed. Both the protective

zone of vegetation around the area of these sylvan springs and the springs themselves have preserved their original character, unaltered by man.

The hydrological types of spring were relatively poorly differentiated. The groups of stations differentiated on the basis of faunal similarity comprised springs belonging to different limnological types and those belonging to different catchment areas (fig. 3). Similar results were obtained in the investigations on water mites in the springs of the Kraków-Częstochowa and the Miechów Uplands (Biesiadka et al. 1990). This may be due to the small dimensions of the examined springs, their poor hydrological differentiation, insufficiently clear boundaries between the rheocrens, helocrens, and limnocrens and a possibly destructive effect of human activity (economic utilization of the protective zone of vegetation around the area of the springs and the springs themselves). Moreover, it seems that among caddisflies there are no crenobionts *sensu stricto*.

It would appear that the Trichoptera fauna of rheocrens and helocrens is represented by impoverished fauna of the epirhitral, being at the same time a element initiating succession in the stream. This is confirmed by a comparison of the species composition of the caddisflies in the springs and streams of the Carpathian Mountains (Szczęsny 1986). The great number of caddisflies occurring in the springs of these mountains may be associated with the great number of species occurring in the Carpathian streams. On the other hand, the small number of Trichoptera in the springs of the Sąspówka may be related with the relatively small number of species occurring in the Sąspówka stream itself (Szczęsny 1968). The four most numerous and commonest species of the springs of the investigated Uplands (community  $U_8$ , fig. 4) were found in the springs and in the upper sections of the Carpathian streams (Szczęsny 1986). The second community ( $U_2$ ) found in the rheocrens was distinctly associated with the communities of the streams ( $U_1$ ,  $U_4$ ). *Odontocerum albicorne*, *Crunoecia irrorata*, and *Lithax obscurus* occurred in the headwater zone (crenon) and the upper zone of the stream (epirhitron) in the Carpathian Mountains, whereas *Tinodes rostocki* and *Silo pallipes* were elements of the communities of the middle and their lower sections (Szczęsny 1986).

Some disturbances in this linear model of succession in a stream may be due to the fact that some springs are in direct contact not with the epirhitron but with the hypo- and metarhitron, and in the lowlands even with the potamone (Biesiadka 1979). This explains why in the springs elements flowing in from the communities of the lower sections of the stream can be found. In some springs in the Carpathian Mountains larvae of the genus *Rhyacophila* and *Hydropsyche fulvipes* were found (Szczęsny 1986).

On the basis of the model of Illies (1955) concerning the zonal division of flows in which the shortening of epirhithrone (and the whole rhithrone) depending on the altitude and latitude is taken into consideration, it may be assumed that in the springs in the uplands and lowlands will be found species of Trichoptera which have been dislodged from the shortening and disappearing apirhithrone and the rhithrone as a whole.

The limnocren community  $U_9$  is very interesting. It is partly associated with rheophile species and at the same time contains many species of the vernal astatic waters (*Limnephilus griseus*, *L. borealis*, *L. stigma*, and *Limnephilus auricula*). In his investigations on the water mites Biesiadka (1977) suggested that the postglacial fauna of these mites was common for astatic waters and springs. As the climate became warmer and in the course of succession from this common group these developed species specific for the springs (crenobionts) and those characteristic of vernal waters. The Trichoptera species found in the limnocrens and typical of the vernal astatic pools (Czachorowski, unpubl. data) may be possibly also regarded as a relict of the postglacial fauna. The question remains open why among the caddisflies typical crenobionts did not develop, and why, contrary to the water mites, no divergence of these species took place.

The third group of crenophiles occurring in the studied springs were species from eutrophic waters and fens (community  $U_5$ , fig. 4) for which the springs are marginal habitats. These limnophile species occurred only in atypical springs resembling fens.

## 6. Polish summary

### Chruściki (Trichoptera) źródeł Wyżyny Krakowsko-Częstochowskiej i Wyżyny Miechowskiej (Polska)

Badania prowadzono w sierpniu 1985, maju i październiku 1987 w 43 źródłach Wyżyny Krakowsko-Częstochowskiej i 32 źródłach Wyżyny Miechowskiej (ryc. 1). Pobierano także próby z cieków i stawów będących w bezpośrednim hydrologicznym kontakcie z badanymi źródłami. Łącznie zebrano w 66 źródłach 1436 larw należących do 38 taksonów (tabela I).

Zbadano strukturę frekwencji (ryc. 2). Analizowano skład gatunkowy w wyróżnionych hydrologicznych typach źródeł: reokrenach, heloreokrenach, limnokrenach małych i limnokrenach dużych. Zbadano podobieństwa faunistyczne w oparciu o faunę chruścików pomiędzy wszystkimi źródłami (ryc. 3), a wyodrębnionym grupom źródeł przypisano występujące tam gatunki Trichoptera. Metodą Jaccarda i metodą Decampsa wyliczono współwystępowanie pomiędzy gatunkami (ryc. 4, 5). Wyodrębnionym zgrupowaniom przyporządkowano siedliska, w których występowały.

Stwierdzono, że hydrologiczne typy źródeł źle się wyodrębniły. W wydzielonych

grupach stanowisk znalazły się źródła o różnym typie limnologicznym i pochodzące z różnych zlewni (ryc. 3).

Wśród chruścików nie ma zapewne typowych krenobiontów. Wśród krenofili wyróżniono trzy typy zgrupowań: reofilne krenofile pochodzące z rhithronu (zgrupowania  $U_2$ ,  $U_9$  i  $U_{10}$ ), limnofilne krenofile z astatycznych zbiorników wiosennych (zgrupowanie  $U_8$  i częściowo  $U_9$ ) oraz limnofilne krenofile pochodzące z torfowisk niskich lub stojących wód eutroficznych (np. zgrupowanie  $U_3$ ).

Występowanie w limnokrenach gatunków wód wiosennych (*Limnephilus stigma*, *L. griseus*, *L. borealis* i *Limnephilus auricula*) można uznać za relikty fauny postglacjalnej.

## 7. References

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