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The macroinvertebrate fauna of some Byelorussian, Karelian, and Altaian springs and its relation with certain factors

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A b s t r a c t - The species composition of the investigated springs depends on such factors as geographic location, type of spring, and the characteristics of the surrounding ground vegetation. In Byelorussian springs the co-occurrence of species was analysed. On the level of co-occurrence of 50% and over a group of 10 species which can be considered as the most characteristic of Byelorussian springs was distinguished.

Key words: springs, environmental factors, invertebrate communities.

1. Introduction

Springs are an interesting subject of ecological and faunal studies owing to their relatively constant temperature regime, which differs from any other water body in the given geographic region. In springs there may occur interstitial species (T e r e k, B r a z d a 1986) and stygobionts (B o u t i n, I d b e n n a c e r 1989, B i e s i a d k a et al. 1990). Moreover, in cold spring ecosystems primary producers, with the rare exception, are practically absent, hence the faunal composition of springs is very distinctive. For this reason studies of spring fauna have a long tradition. However, the majority of papers are devoted to only one several taxonomic groups of invertebrates found here. There are relatively few works dealing with the whole spring community (D a v i d s o n, W i l d i n g 1943, S t e l l a 1958, M o t a s h et al. 1963, M i n s h a l l 1968, W o j t a s 1972, T h o r u p, L i n d e g a a r d 1977, Cowie, Winterbourn 1979, Ward, Dufford 1979, Giudicelli, Dakki 1984, Kownacki 1985, Glazier, Gooch 1987, Nesterovich 1992).

Of late a question under discussion has been: how does the spring invertebrate community depend on the water temperature regime, geographic location, hydrological regime (i.e. current force), chemical composition of the water, surrounding vegetation, and other factors?

The aim of the present work was to determine the main species composition of 31 springs and to attemp to compare it with such factors as type of spring, surrounding vegetation, and geographic location.

2. Study area, material, and methods

Samples were collected from 1987-1992 using a 15 cm wide benthos scraper and/or a 0.025 m^2 Ekman-Berge bottom sampler from 3 different large regions (fig. 1): Byelorussia (temperate zone), Karelia (north-west CIS, taiga zone) and Altai (south-west Siberia, steppe zone).

In Byelorussia 25 springs, in Karelia 3, and in Altai 3 springs were investigated. Within Byelorussia; in turn, samples were collected in 3 areas (fig. 2): the Minsk region (central Byelorussia),

Fig. 1. Location of sampling stations

Vitebsk region (north Byelorussia) and the Grodno region (west Byelorussia). It is interesting to note that all except one of the springs in the Minsk region are located in the Minsk Upland which is the watershed between the Baltic and Black Sea basins. All springs were given conventional numbers, hence Byelorussian ones number from 1-25, Karelian springs from 20-28, and Altaian springs from 29-31. The characteristics of the springs are given in Table I. The springs had a temperature regime not lower than 2°C in winter and not higher than 8°C in summer. Oxygen concentration was fairly high in the examined springs, i.e. 8.5-13.6 ml dm^{-3} (Nesterovich 1922).

The material which formed the basin of the investigation included more than 9000 specimens of invertebrates. To evaluate the faunal similarities between the springs, the Jaccard formula 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.

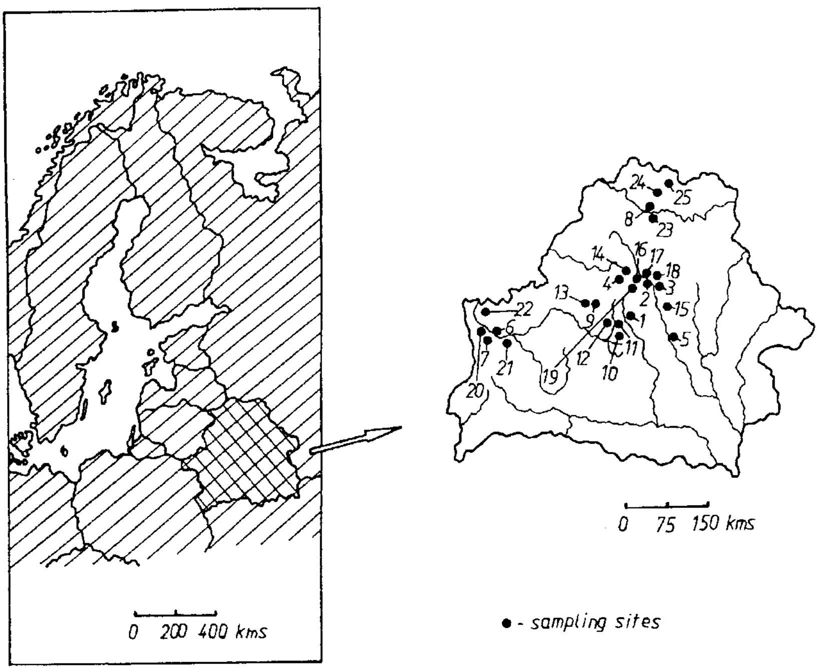

Fig. 2. Location of sampling stations in Byelorussia. 1-25 numbers of springs

Table I. Characteristics of investigated springs. O – open place (free from arboreous vegetation); C – coniferous wood; L – broadleaf forest; L–O – a few decidious trees near the spring; C–L – mixed forest (conifer + decidious)

No	Location	Type of spring	Type of surrounded vegetation
1	Minsk region	helocren	C–L
2	– " –	reohelocren	L
3	– " –	helocren	C–L
4	– " –	helocren	C–L
5	– " –	limnohelocren	L
6	Grodno region	helocren	L
7	– " –	limnocren	O
8	Vitebsk region	limnocren	L–O
9	Minsk region	limnocren	L
10	– " –	helocren	L
11	– " –	helocren	C–L
12	– " –	limnocren	O
13	– " –	limnocren	O
14	– " –	helocren	C–L
15	– " –	helocren	L
16	– " –	limnohelocren	L
17	– " –	limnocren	L–O
18	– " –	helocren	C–L
19	– " –	helocren	L–O
20	Grodno region	limnocren	O
21	– " –	limnocren	O
22	– " –	helocren	O
23	Vitebsk region	limnocren	O
24	– " –	limnohelocren	L–O
25	– " –	limnocren	L
26	Karelia	helocren	C
27	– " –	limnocren	C–L
28	– " –	helocren	C
29	Altai	limnocren	O
30	– " –	limnocren	L
31	– " –	limnocren	O

To estimate the species concomitance an analogous formula was used:

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

where:

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

c - number of springs at which species x and y appeared together,

a - number of stations with species x,

b - number of stations with species y.

The results of computations for faunal similarity and concomitance are given in the form of the shortest dendrite and co-occurrence graph with marked grouping isolines.

3. Results

In the collected material nearly 120 taxa were distinguished. The main taxonomic composition of the spring fauna is given in Table II. It appeared that invertebrates in the springs were represented mainly by larvae of Insects (up to 93% of the species composition).

In fig. 3 the shortest dendrite of similarity between springs belonging to different types is shown. It may be noted that in all of then there was a tendency for a relation between the species composition and the spring type (or hydrological regime, which depends on sping type). Hence, spring numbers 22, 19, 15, 18 and 10, which are helocrens, have a fairly high level of faunal similarity (over 40%) and also helocrens numbered 4, 1, 3 (similarity of over 30%). An analogous relation exist between springs of mixed type, i.e. 24 and 19 (limnohelocren and helocren), 5, 16, and 14 (two limnohelocrens and helocren).

On the other hand, the high level of faunal similarity between spring 17 and springs 14, 2, and 4 is not clear. However, if the faunal similarity of these springs is considered in connection with the character of the surrounding ground vegetation (fig. 4), it can be seen that they are located in woded places. Generally, as in the case of spring type in connection with the surrounding vegetation, there was a relation between these factors and the faunal composition. In fig. 4 the same groups of springs can be distinguished.

In fig. 5 faunal similarity of springs from different region is shown. There is no such relation as in the preceding two cases, except for the Karelian (numbers 26, 27, 28) and Altaian (numbers 29, 30, 31) springs. From the geographic point of view, the relatively high faunal similarity between springs, for example, 24 and 19, 19 and 22, 2 and 6 is not quite clear. Evidently the geographic factor

Table II. The main taxonomic composition of macroinvertebrate fauna in the studied springs. i – interstitial species; e – eurybiont; s – stenobiont; c – creniobiot; r – crenophil

Taxa	Number of springs
1	2
Turbellaria	
e *Dugesia lugubris* S h m i d t	1, 3
e *Planaria torva* M ü l l e r	2, 3, 6, 8, 10, 15, 19, 21, 23
e *Dendrocoelum lacteum* M ü l l e r	1, 2, 4, 6, 25
species 1	29
species 2	31
Nematoda	
species 1	1, 3, 5, 15
species 2	17
species 3	29, 31
Oligochaeta	
s *Nais elingius* M ü l l e r	1, 2, 4, 6, 7, 10, 19, 22, 27, 28
e *Tubiflex tubiflex* M ü l l e r	3, 8
species 1	12, 20, 24
species 2	29, 30
species 3	31
Hirudinea	
e *Erpobdella octoculata* L i n n e	7, 21
e *Helobdella stagnalis* L i n n e	8
Hydracarina	
c *Panisus michaeli* K o e n i k e	3, 4
Zschokkea oblonga K o e n i k e	27
c *Thyas rivalis* K o e n i k e	4
c *Sperchon thienemanni* K o e n i k e	1–4
c *S. resupinus* V i e t s	3
c *S. squamosus* K r a m e r	1, 2, 5, 26
c *Lebertia crenophila* V i e t s	1
c *L. holsatica* P i e r s	2
c *L. sefvei* W a l t e r	1–3, 5
c *L. stigmatifera* T h o r	2, 3
Lebertia sp.	2, 3
c *Hygrobates norvegicus* T h o r	1, 2, 3, 4, 5, 6, 27
r *Arrenurus conicus* P i e r s i g	3
Copepoda	
e *Macrocyclops fuscus* T u r i n e	1, 11, 28, 30, 31
e *Acanthocyclops viridis* T u r i n e	3–5, 7, 9, 12, 14, 16, 19, 21, 24, 31
e *A. vernalis* F i s h e r	1, 10, 11, 13, 15, 18, 19, 22, 24, 30, 31

cont. Table II.

1	2
Cladocera	
Polyphemus pediculus L i n n e	12, 26, 27, 29
e *Scapholeberis murconata* M ü l l e r	22, 27
Ostracoda	
e *Heterocypris incongruens* R a m d.	1–4, 6, 7, 9, 10, 12–17, 19, 20, 22, 24, 25
s *Ilydromus olivaceus* B r a d y et N o r m.	1–4, 5, 6–8, 10–12, 14–18, 20, 21, 23, 25
species 1	29, 30, 31
Herpetocypris reptans B a i r d	2
Isopoda	
e *Asellus aquaticus* L i n n e	1, 3, 7, 9–11, 21
Amphipoda	
e *Gammarus lacustris* S a r s	3
i *Synurella ambulans* M ü l l e r	1, 6
species 1	30, 31
Ephemeroptera	
e *Baetis rhodani* P i c t e t	2, 3, 6, 16, 17, 21
e *Centroptilum luteolum* M ü l l e r	26
e *Cloeon dipterum* L i n n e	8, 23
s *Nigrobaetis muticus* L i n n e	26
Plecoptera	
Leuctra fusca L i n n e	1, 2, 4, 14, 16, 17
s *L. hippopus* K e m p n y	1, 3, 17
Taeniopteryx nebulosa L i n n e	3
s *Chloroperla burmeisteri* P i c t e t	23, 26
s *Amphinemura standfussi* R i s	2, 26
A. borealis M o r t o n	26, 28
A. sulcicollis S t e p h e n s	26, 27
s *Nemoura flexuosa* A u b e r t	1, 3, 8, 14, 17, 23
e *N. cinerea* R e t z i u s	1, 4
Nemurella pictetii K l a p a l e k	1–7, 10–12, 14–20, 22–24
species 1	31
Heteroptera	
e *Nepa cinerea* L i n n e	1, 12
e *Notonecta glauca* L i n n e	9
e *Gerris lacustris* L i n n e	3
Corixa sp.	29

cont. Table II.

1	2
Coleoptera	
Hydaticus sp.	4, 27, 28
Agabus bipustulatus Linne	7
Hydroporus striola Gyll.	1, 3, 5, 7, 13
H. erithrocephalus Linne	1, 3, 4, 13
Hydroporus sp.	12
Bidessus pusillis Linne	8
c *Helodes pseudominuta* Klausnitzer	1–7, 10, 14, 16, 17, 26
Trichoptera	
Rhyacophyla sp.	2
r *Plectrocnemia conspersa* Curtis	1–6, 16, 17, 26, 28
r *Silo pallipes* Fabricius	3
c *Crunoecia irrorata* Curtis	1, 2, 5, 16
Apatania hispida Curtis	3
r *Drusus annulatus* Linne	3
c *Potamophylax nigricornis* Curtis	2, 4–6, 8, 12–14, 16, 17
Limnephilus rhombicus Linne	1
Limnephilus sp. 1	1, 13
Limnephilus sp. 2	12
Limnephilus sp. 3	31
Halesus sp.	3
c *Parachiona picicornis* Pictet	1, 2, 18
Notidobia ciliaris Linne	2
r *Sericostoma personatum* Kirby et Spence	3
Beraea pullata Curtis	3, 6
Diptera	
Stratiomyia sp.	2, 4–6, 15, 19, 23
Odontomyia sp.	31
Antherix sp. 1	1, 2, 4–7, 17, 20, 25
Antherix sp. 2	2, 3, 5
Tabanus sp.	2
Ptychoptera sp.	1–4, 7, 10, 15, 17, 19, 20, 22
Dasyhelea sp.	4
e *Odagmia ornata* Mg.	1–5, 10, 15–17, 19, 20, 23, 24
Eusimulium sp.	26
Nevermannia sp.	2, 6, 7, 17, 20
e *Chironomus plumosus* Linne	30
Chironomus sp.	1, 12
Rheotanytarsus sp.	1–3, 9, 13, 23, 26, 28
species 1	31
Aspectrotanypus trifascipennis Zetterstedt	3, 14, 17
species 2	1, 2

cont. Table II.

1	2
Diamesa sp.	1, 3–5, 16, 23, 25
Prodiamesa sp.	2, 6, 9, 26
Dicranota sp.	1, 6
Chaoborus sp.	11
Tipula sp.	2
Telmatoscopus sp. 1	1–3, 6
Telmatoscopus sp. 2	7, 14, 20, 22
Psychoda sp.	2, 4, 6, 8, 17, 23, 31
Pericoma sp.	5, 18, 25
Dixa sp. 1	1–4, 6, 14–19, 24
Dixa sp. 2	3
Culex sp.	3
Bivalvia	
e *Euglesa personata* M a l m.	1–3, 5–9, 10, 12, 14–20, 22, 24
E. buchtarmensis K r i v.	26
E. hoyeri C l e s s i n	26, 28
Euglesa sp.	8
Gastropoda	
Theodoxus fluviatilis L i n n e	6
Lymnaea turricula H e l d	6, 13
e *L. truncatula* M ü l l e r	7
e *L. stagnalis* L i n n e	16

is not essential within Byelorussia because of the too small distance between these springs, in contrast to those between Belorus, Altai, and Karelia.

From the computer data of special co-occurrence in Belorussian springs it may be possible to distinguish the most characteristic spring inhabitants. On the base of the results obtained by computing, a noticeable decline could be observed in the quanzity of co-ocurrent species of about 50% and over, according to J a c c a r d' s formula. Therefore, the group of most characteristic spring inhabitants in Byelorussian springs precisely from this level of co-occurrency may by distinguished (fig. 6).

Except for 5 species of water mite, in no spring in Byelorussia were distinctly crenobiontic species found. However, there are species which in Byelorussia are at present found only in springs, i.e. *Helodes pseudominuta* (Coleoptera), *Synurella ambulans* (Amphipoda), *Drusus annulatus* (Trichoptera), *Taenyopteryx nebulosa* (Pleceoptera), and *Euglesa personata* (Bivalvia).

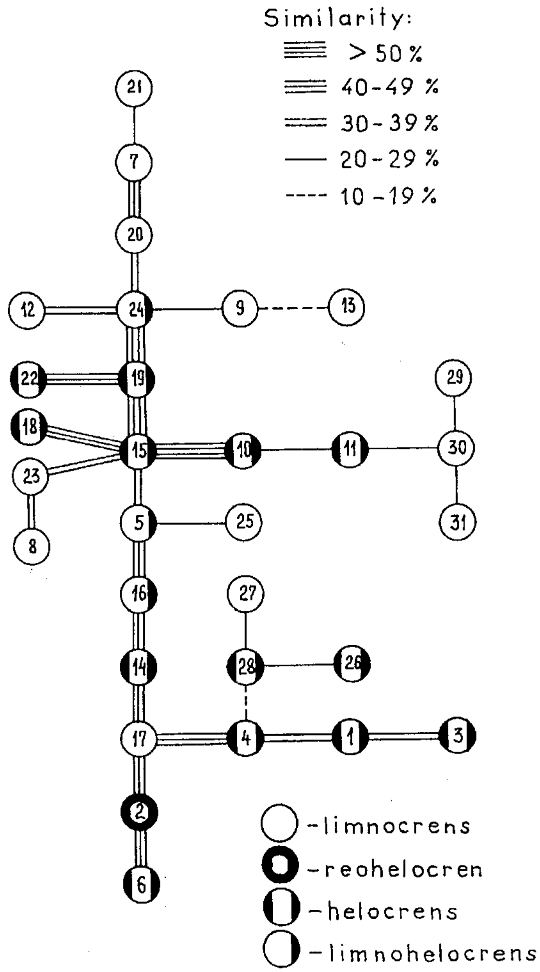

Fig. 3. Faunal similarities between springs of different type. Spring numbers as in Table I

4. Discussion

In the investigated springs were found species belonging to different ecological types - eurobionts, stenobionts, and underground species. At all the springs the faunal composition differed from those of other water bodies in the same locality. The main distinctive feature of springs as water bodies - low temperature of the water throughout all the year - is the main factor in forming the spring invertebrate community. However, as was shown above, there were also differences between spring communities. Obviously, these differences could be caused by biotic as well as abiotic factors.

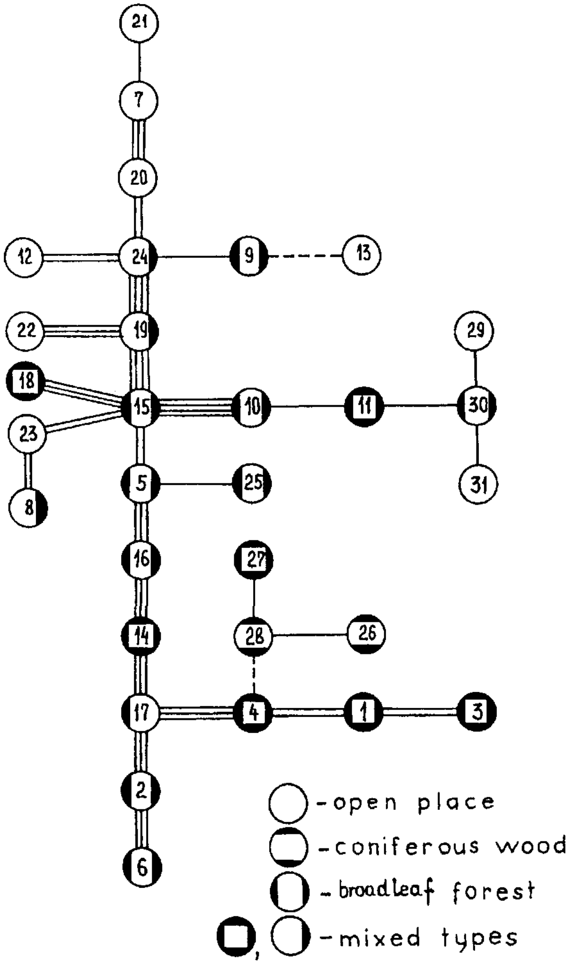

Fig. 4. Faunal similarities between springs with different surrounding vegetation. Spring numbers as in Table I; conventional signs of the similarity level

Glazier and Gooch (1987) investigated the faunal composition of more than 20 springs and compared it with 21 different factors. They concluded that environmental conditions determine assemblage composition rather than inter-species interactions, and the present authors agree with this conclusion.

The investigated Byelorussian springs owing to the fact that they are all fed by ground water, practically do not differ recognizably in their chemical composition (Bogolubov 1970), this being in contrast with mountain springs (Giudicelli, Dakki 1984, Glazier, Gooch 1987, Roca, Baltanas in press). Consequently, in the Byelorussian springs

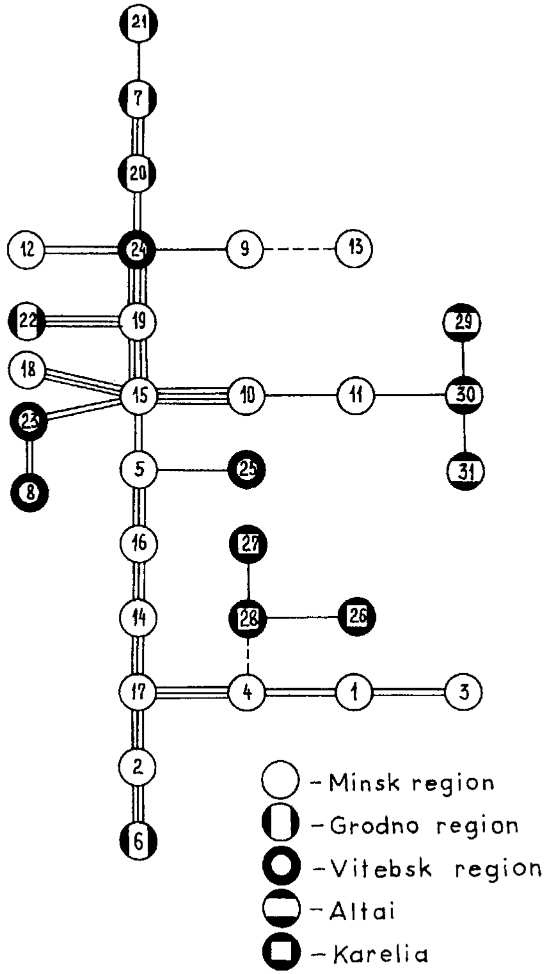

Fig. 5. Faunal similarities between springs from different regions, spring numbers as in Table I; conventional signs of similarity level as in fig. 3

(and perhaps this is true for all lowland springs fed by ground waters) the role of other factors in forming their communities increases. From the results of the present studies it may be concluded that the type of spring and the character of the surrounding vegetation affect faunal composition more or less equally, geographic location being essential only in the case of great distance between the examined springs. This conclusion is consistent with results of other investigations (Czachorowski 1990, 1991, 1993). In general for each species in springs there are factors which can determine its

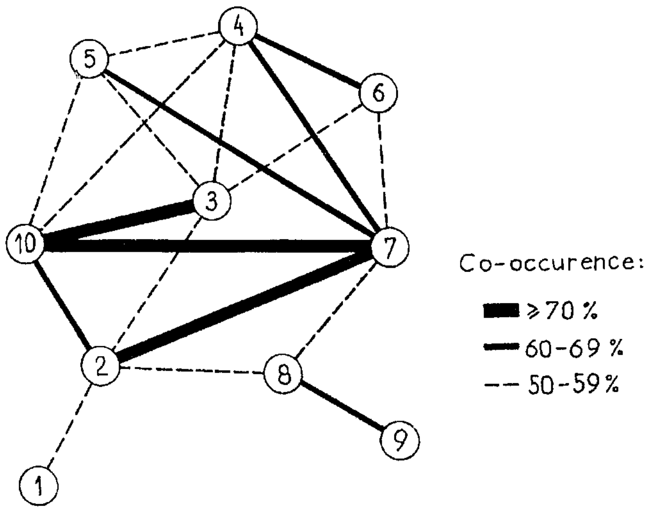

Fig. 6. Concomitance of the most common species in Byelorussian springs: 1 - *Hygrobates nrvegicus;* 2 - *Ilyodromus olivaceus;* 3 - *Heterocypris incongruens;* 4 - *Odagmia ornata;* 5 - *Dixa* sp.; 6 - *Ptychoptera* sp.; 7 - *Nemurella pirctetii;* 8 - *Helodes pseudominuta;* 9 - *Plectrocnemia conspersa;* 10 - *Euglesa personata*

occurrence there (G l a z i e r, G o o h 1987), and these factors act in combination (K h m e l e v a 1988).

It may be noted that environmental factors are interdependent. For example, the bottom composition in the spring depends on such factors as type of spring (current velocity), surrounding vegetation (amount of fallen leaves and needles in the spring basin), dept of the spring, and so on. Therefore, when investigating any spring, it all the environmenta factors must be carefully taken into account.

The group of most characteristic spring inhabitants in Byelorussia consists of species of differeing ecology. For example, *Heterocypris incogruens* (Ostracoda) occurs in water bodies of very different type: from West Africa's temporary pools (B e n z i e 1984) to springs (present paper): *Hygrobates norvegicus* (Hydracarina) is a crenobiont (B i e s i a d k a, K o w a l i k 1978); *Nomurella pictetii* is a common species in various European water bodies (E l l i o t t 1984, L i l l e h a m m e r 1985); *Euglesa personata* can populate springs as well as lakes (H u k a s y a n 1990).

Species which are not regarded as distinctly crenobionts but in Byelorussia at present are found only in springs, may be considered as "regional crenobionts" (C z a c h r o w s k i 1991, C z a c h r o w s k i, N e s t e r o v i c h 1992).

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5. Polish summary

Fauna bezkręgowców wybranych źródeł Białorusi, Karelii i Ałtaju oraz jej związek z niektórymi czynnikami środowiskowymi

Badania były prowadzone w latach 1987-1992 w 25 źródłach Białorusi (strefa klimatu umiarkowanego), 3 Karelii (strefa tajgi) i 3 Ałtaju (Syberia, strefa stepu) (ryc. 1, 2, tabela I). Łącznie zebrano ponad 9000 osobników zaliczanych do 120 gatunków (tabela II). Analizowano skład gatunkowy oraz podobieństwa faunistyczne pomiędzy źródłami z uwzględnieniem położenia geograficznego, typu źródeł oraz charakteru otaczającej roślinności (ryc. 3-5).

Na skład gatunkowy bezkręgowców podobny wpływ miały: typ limnologiczny źródła oraz charakter otaczającej źródło roślinności. Wpływ czynnika "regionalnego" - położenia geograficznego miał istotne znaczenie tylko dla dużych odległości. W obrębie jednego regionu (Białoruś) czynnik ten nie miał istotnego znaczenia. Na podstawie współwystępowania gatunków na poziomie powyżej 50% wyróżniono grupę gatunków najbardziej charakterystycznych dla źródeł Białorusi (ryc. 6). Są to: *Hygrobates norvegicus* (Hydracarina), *Ilyodromus olivaceus*, *Heterocypris incongruens* (Crustacea, Ostracoda), *Odagmia ornata* (Diptera, Simuliidae), *Dixa* sp. (Diptera, Dixidae), *Ptychoptera* sp. (Diptera, Ptychopteridae), *Nemurella picteti* (Plecoptera, Nemouridae), *Helodes pseudominuta* (Coleoptera, Helodidae), *Plectrocnemia conspersa* (Trichoptera, Polycentropodidae) i *Euglesa personata* (Bivalvia, Pisidiidae). Zwrócono także uwagę na fakt "regionalnej krenobiontyczności", gdyż niektóre gatunki są typowe tylko dla źródeł w Białorusi, w innych regionach zasiedlają głównie inne typy wód.

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