ACTA HYDROBIOL.	36	1	91—101	KRAKÓW 1994

Habitat preferences of invertebrates (especially Oligochaeta) in a stream

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Manuscript submitted November 15, 1993, accepted March 25, 1994

Abstract - The highest density of macrofauna was recorded in a muddy habitat, and the highest biomass (d.w.) in a stony one. Only Naididae, Hydracarina, young larvae of Trichoptera, and large specimens of *Gammarus* spp. preferred a transitional habitat (mud-covered stones). Of the 25 identified species of Oligochaeta especially three dominant species (*Nais bretscheri*, *N. pardalis*, and *N. communis*) were most numerous in the transitional habitat. Downstream the species diversity of Oligochaeta increased and the composition of the community changed.

Key words: streams, macrofauna, Oligochaeta, density, biomass, habitats, preferences.

1. Introduction

The attachment of particular species or even larger taxonomic groups of animals to a particular habitat is well known (Fomenko 1972, Hynes 1972, Starmach et al. 1976). The bottom of mountain streams and rivers is composed of stones, whereas near the banks and in meanders often accumulations of mud are formed whose durability depends on fluctuations in the water level. In this type of stream most numerous are the rheo- and lithophylous forms, while the limno- and pelophilous ones live in stagnant waters. Mud-covered stones represent a transitional zone between the two bottom types. In lowland rivers the transitional habitat is mud-covered sand, but more such habitats can be found, e.g. undercut banks (Rhodes, Hubert 1991), tree roots and emergent vegetation (Ormerod 1988) or surface water/groundwater transition (Vervier, Gibert 1991).

The aim of the present study was to determine the habitat preferences of macrofauna occurring in a stream with a stable water level, and in particular to find out whether there exist groups of fauna occurring most numerously in a transitional habitat. The basis for the study were data concerning the composition, density, and biomass of the fauna of a stony and a muddy habitat and of mud-covered stones. The composition and distribution of Oligochaeta are discussed in greater detail.

2. Study area, material, and methods

The Sąspówka stream was chosen for the investigations on account of the fairly small changes both with respect to the area and location of habitats. The first results of hydrobiological investigations conducted in this stream were published earlier (Dumnicka et al. 1990). Investigations of macrofauna had previously been conducted by Szczęsny (1968).

The stream, 6 km long, with a catchment basin of 13.5 km^2 and a gradient of about 19‰, is a right-bank tributary of the River Prądnik which is turn joins the River Vistula (fig. 1). The stream flows through a valley cut in the Upper-Jurassic limestone of the Częstochowa-Cracow Upland. The springs are located in a village from which a small amount of domestic sewage and agricultural pollutants flow into the stream. In its upper course it is surrounded by arable land and meadows, while in the middle and lower courses mainly by mixed forest.

Hydrobiological investigations were carried out at 4 stations (fig. 1) differing mainly in the magnitude of the water flow and the content of nutrients (Table I). At each station 50-70% of the bottom area consisted of stones, mud occupied 20-40% and mud-covered stones at most 10% of the bottom surface. Samples of macrofauna (each time three) were collected at intervals of about one month, from September 1986 to August 1987. They were collected from a surface area of 225 cm^2 (in the case of a stony bottom the area of the sample as seen from above was taken into consideration). A bottom scraper equipped with an 0.3 mm mesh net was used. After washing, the samples were sorted using a stereoscopic microscope and segregated into taxa for which the density and dry weight (after drying to a constant weight at a temperature of 105°C) were calculated.

Fig. 1. Location of the Ojców National Park (A), Sąspówka stream (B) and sampling stations on the Sąspówka stream (C)

Table I. Characteristics of the water of the Sąspówka stream

Parameters	Station 1	Station 2	Station 3	Station 4
discharge ($dm\ s^{-1}\ km^{-2}$)		7.39		12.65
pH	7.8	7.9	7.4	7.6
oxygen saturation O_2 (%)	100.1	103.6	97.2	95.8
BOD_5 O_2 ($mg\ dm^{-3}$)	1.6	1.9	1.4	1.3
$N\text{-}NH_4$ ($mg\ dm^{-3}$)	0.214	0.198	0.183	0.193
$N\text{-}NO_3$ ($mg\ dm^{-3}$)	6.57	5.87	3.67	3.71
PO_4 ($mg\ dm^{-3}$)	0.231	0.187	0.147	0.132

3. Results

3.1. General characteristics and habitat diversity of the fauna

The macrofauna of the stream was abundant and diverse. Density varied from 18 000 at Stations 1 and 4 to 27 000 indiv. m^{-2} at Station 3 (Table II). The variation in biomass was slightly different: the greatest biomass was found at Station 3 (about 3.9 g m^{-2}), where also the highest density of macrofauna was recorded; next came Stations 1 and 2, while Station 4 had the lowest biomass (about 2.3 g m^{-2}) (Table III). Among the differentiated taxa Chironomidae had the highest density at all stations, their number being 5 to 15 times higher than that of other taxa. Ephemeroptera and *Gammarus* spp. also had high density along the whole stream; locally, other taxa, such as, e.g., Simuliidae (Station 1), Plecoptera (Station 2), Sphaeridae and *Ancylus fluviatilis* (Station 3)

Table II. Density (indiv. m^{-2}) of macrofauna in different habitats of the Sąspówka stream. s – stones; m – mud. Oligochaeta* – including Tubificidae, Enchytraeidae, Lumbriculidae and Propappidae

Habitat / Taxa	Station 1			Station 2			Station 3			Station 4		
	S	S+M	M	S	S+M	M	S	S+M	M	S	S+M	M
Chironomidae	4596	5485	21834	7000	7812	38927	2163	3102	54529	6385	15175	20763
Ephemeroptera	3852	1652	440	2674	1535	226	2251	1401	326	1214	660	631
Gammarus sp. Fabr.	1668	1755	3197	1022	621	314	895	1217	2438	541	743	899
Simuliidae	2492	342	318	460	152	6	275	322	145	88	49	10
Plecoptera	412	381	601	3681	777	138	675	829	163	317	187	88
Sphaeridae	484	753	1745	49	108	685		367	1681	119	412	640
Trichoptera	228	289	79	616	245	19	264	470	330	397	419	240
Oligochaeta*	136	240	1001	35	219	447	48	146	528	105	685	504
Diptera	52	20	152	303	303	1169	106	29	40	211	457	523
Naididae	16	28	34	343	1117	199	131	162	76	816	1143	138
Coleoptera	16	107	64	1305	777	107	84	51		163	149	29
Sialis sp. Latr.	8	73	176	44	88	239	4		31		6	73
Hydracarina	312	152	151	88	142	44	51	110	22	22	61	
Turbellaria	52	10	15				55	22	4	4	17	
Ceratopogonidae	8	49	220	24		597	4		18			
Isopoda	4	5										
Gastropoda							1115	733	31	277	391	59
total	14336	11341	30027	17644	13896	43117	8121	8961	60362	10659	20554	24597
mean for the station		18343			23380			26818			18110	

Table III. Biomass (mg m^{-2}) of macrofauna in different habitats of the Sąspówka stream. s – stones; m – mud. Oligochaeta* – including Tubificidae, Enchytraeidae, Lumbriculidae and Propappidae

Taxa \ Habitat	Station 1			Station 2			Station 3			Station 4		
	S	S+M	M	S	S+M	M	S	S+M	M	S	S+M	M
Chironomidae	78	136	289	90	188	500	39	77	1595	159	487	988
Ephemeroptera	918	357	94	623	391	72	770	726	95	334	322	66
Gammarus sp. F a b r.	968	1203	1125	589	697	302	838	964	638	255	303	264
Simuliidae	260	59	107	15	20	12	15	22	18	18	6	5
Plecoptera	42	37	50	222	93	25	77	121	18	37	41	22
Sphaeridae	214	279	811	37	44	270		180	988	55	226	244
Trichoptera	938	286	140	2053	648	534	103	195	116	652	606	331
Oligochaeta*	16	37	110	2	22	43	4	37	84	4	55	53
Diptera	6	7	575	32	44	415	321	23	42	57	100	372
Naididae	2	3	6	6	22	3	4	6	2	11	17	3
Coleoptera	8	24	50	164	61	19	15	8		64	41	12
Sialis sp. L a t r.	2	49	44	20	64	85	2		9		55	105
Hydracarina	18	12	11	7	12	3	2	11	9	4	11	
Turbellaria	116	10	12				21	15	1	2	12	
Ceratopogonidae	1	5	11	2		79	1		3			
Isopoda	4	2										
Gastropoda							2112	928	29	394	270	49
total	3591	2506	3435	3862	2306	2362	4324	3313	3647	2046	2552	2514
mean for the station		3194			2886			3865			2338	

or Naididae (Station 4) were abundant. At each station other taxa had the greatest biomass: *Gammarus* spp. (Station 1), Trichoptera (Station 2), *Ancylus fluviatilis* (Station 3) and Chironomidae together with Trichoptera (at Station 4). The faunal composition was consistent along the stream; only a few groups were restricted to particular parts of it: here belonged Isopoda recorded only at Station 1, washed there from springs, or snails (*Ancylus fluviatilis*) which appeared from Station 3.

The studied habitats differed in their population density – the highest being in mud (2-7 times higher than other habitats), while on stones and mud-covered stones the density was similar and, depending on the station, varied from 8000 indiv. m^{-2} on a stony bottom and 9000 indiv. m^{-2} on mud-covered stones at Station 3 to 17 500 and 14 000 indiv. m^{-2} in the same habitats at Station 2. Only at Station 4 was the density of macrofauna in mud and on mud-covered stones similar (20-24 thousands indiv. m^{-2})(Table II).

The greatest biomass was usually recorded in stony habitats (from 4.3 at Station 3 to 3.6 g m^{-2} at Station 1). Again, only Station 4 differed from the others - greater biomass being observed here in a muddy habitat and on mud-covered stones, i.e. in the same habitats where the highest density was recorded. The differences in biomass between the habitats were not so great as those in density (Table III).

The distribution of fauna in the habitats usually corresponded to the preferences of the particular taxa: e.g. Ephemeroptera, Plecoptera or Simuliidae were most numerous on a stony bottom, while Sphaeridae, Chironomidae, Tubificidae, Ceratopogonidae, or *Sialis* sp. preferred a muddy one. At almost all stations the highest density of *Gammarus* spp. was observed in a muddy habitat; only at Station 2 did this taxon occur in the greatest numbers in a stony habitat.

Only a few animal groups prefer to live in habitats consisting of mud-covered stones, among them Naididae and Hydracarina which at Stations 2 to 4 reached their highest density and greatest biomass in this habitat. At Station 1 Naididae occurred in the greatest number on a muddy bottom, but Hydracarina on stones.

Another group comprised 2 taxa (Trichoptera and *Gammarus* spp.), from which one of the examined parameters reached its maximum value in a transitional habitat. Trichoptera were usually found in greatest number on mud-covered stones, but reached their greatest biomass in a stony habitat. Hence, the mean weight of one individual caddis fly found in the mud-covered stone habitat at Station 1 was only 1.0 mg, whereas in a stony habitat it was 4.1 mg. At the other stations the differences were smaller. A reverse relation was found for *Gammarus* spp., which reached its greatest biomass in the habitat of mud-covered stones and its highest density in a muddy habitat. The mean weight of 1 individual of *Gammarus* spp. found in the former habitat varied from 0.5 to 1.1 mg, depending on the station: from 0.3 to 0.5 mg in a muddy habitat, and from 0.6 to 0.8 on stones. This is an indication that individuals of a certain size (small Trichoptera and large *Gammarus* spp.) concentrate in a transitional habitat.

3.2. Characteristics of Oligochaeta of the Sąspówka stream

Twenty-five species of oligochaetes belonging to five families were found in the investigated stream. More than half of them (13 species) belonged to the family Naididae (Table IV), and were mostly representatives of the genus *Nais* (7 species), *Homochaeta naidina* being a rarely encountered species. The family Tubificidae

Table IV. Percentage share of oligochaete taxa in the Sąspówka stream

Taxa	Station 1	Station 2	Station 3	Station 4
Tubificidae gen. spp. juv.	82.7	7.0	30.0	19.3
Nais bretscheri M i c h.	0.6	44.7	21.1	50.9
Enchytraeidae gen. spp. juv.	4.6	14.9	1.3	5.3
Nais alpina S p e r b e r	0.3	0.8	4.2	2.3
– *variabilis* P i g u e t	0.3	6.7	1.3	1.6
– *communis* P i g u e t	1.0	2.4	1.7	0.9
Cernosvitoviella atrata (B r e t.)	1.0	1.6	6.0	3.0
Lumbriculidae gen. spp. juv.	0.3	0.3	1.3	0.7
Tubifex tubifex (M ü l l.)	5.2		2.1	0.3
Amphichaeta leydigii T a u b e r	0.6			0.3
Pristina idrensis S p e r b e r	1.9	0.5		
– *amphibiotica* L a s t.	0.6	0.3		
Aulodrilus limnobius B r e t.	0.6			
– *pluriseta* (P i g.)	0.3			
Nais pardalis P i g u e t		13.5	7.7	5.4
– *elinguis* M ü l l.		2.2	0.8	0.1
Chaetogaster diastrophus (G r u i t.)		0.8	3.4	0.7
Rhyacodrilus falciformis B r e t.		2.4	2.6	0.6
Stylodrilus spp. juv. C l a p.		0.8	0.4	1.3
Nais pseudobtusa P i g u e t		0.5		0.9
Marionina riparia B r e t.		0.3	0.8	
Enchytraeus buchholzi V e j d.		0.3		
Cernosvitoviella spp. juv. Niel. & Christ			14.5	5.2
Propappus volki M i c h.			0.4	0.1
Stylaria lacustris (L.)			0.4	
Cernosvitoviella carpatica Niel. & Christ				0.4
Moraviodrilus pygmaeus H r a b e				0.3
Pristina spp. E h r.				0.3
Homochaeta naidina B r e t.				0.1

was represented by 5 species only, including two (*Rhyacodrilus falciformis* and *Moraviodrilus pygmaeus*) rarely found in Poland. It is interesting fact that no representatives of *Limnodrilus*, a genus common to very many different environments, were found. Other families were represented by a few species often found in clean waters.

Species diversity increased down the stream. Only 11 species were identified at Station 1, at Station 2 there were 15, further down the increase in species number being only slight - up to 17 species at Station 4.

The species composition of Oligochaeta changed along the course of the stream. At Station 1 all habitats were dominated by Tubificidae, Naididae constituting only a small percentage of the Oligochaeta fauna. Among the latter, taxa preferring lenitic water (*Pristina* spp.) prevailed. They were more numerous in a muddy habitat (fig. 2), while small numbers of *Nais bretscheri* and *N. alpina* were found in a transitional one only. From Station 2 downstream Naididae dominated, the most numerous being *Nais bretscheri* and *N. pardalis*. These species were especially abundant in the habitat of mud-covered stones, being accompanied by the less numerous *N. communis*. On the other hand, *Nais alpina* did not show any distinct preference for a mud-covered stony habitat. The species listed above are small forms, common in streams with a stony bottom, especially the first two mentioned species. Tubificidae and Enchytraeidae occurred in their greatest numbers in a muddy habitat, only at Station 4 they being more numerous on mud-covered stones.

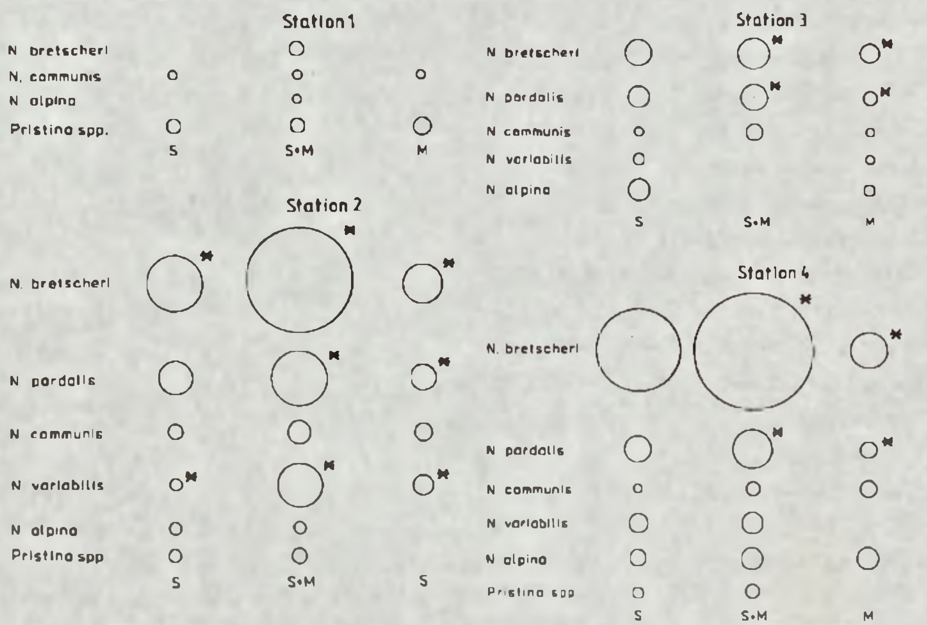

Fig. 2. Habitat preferences of some Naididae species in the Sąspówka stream.
* - the differences in density between transitional habitat (s + m) and stones (s) or mud (m) are significant ($p < 0.05$)

4. Discussion

The investigated stream is a first-order one, hence, owing to its small size and high heterogeneity of habitats, animals can be easily transported from one to another. That explains why they were often found in relatively great numbers in an unsuitable environment, e.g. Simuliidae on a muddy bottom. Also, the larger forms, such as *Gammarus* spp. or Ephemeroptera, could actively move between habitats. Very similar density, biomass, and faunal richness in the riffles and pools in the first-order part of the Illinois River were found by Brown and Brussock (1991).

It is to be supposed that the transitional habitat would be the least populated because its environmental conditions are not suitable for either the litho- or pelophilous animals. Rheophilous forms might be limited by inadequate oxygen concentrations, and the mud covering the stones would make their adherence to them and respiration difficult, while phelophilous forms might find it difficult to find food and to resist the pressure of the current. Some features of a transitional habitat might be favourite for small forms (such as Naididae and Hydracarina), which require a fairly high oxygenation of the water and are not strong enough to resist the current.

Some positive ecological effects, e.g., smaller competition for food or lower predation, may to some extent compensate for unfavourable environmental conditions in a transitional habitat. Ormerod (1988) put forward this explanation for the great frequency of occurrence of certain taxa of macroinvertebrates in transitional habitats of the Wye river system. All these factors may be responsible for the concentration of younger larval stages of caddis flies on mud-covered stones in the Sąspówka stream, while older larvae attach themselves mainly to stones. Also for Naididae, which are often preyed upon (Bouguenec, Giani 1989), mud-covered stones are a relatively safe habitat as their most dangerous predators chiefly forage in other habitats - Turbellaria and Plecoptera on stones, and *Sialis* sp. and Chironomidae in mud. Fomenko (1972) also observed a high occurrence of some species of oligochaetes in transitional habitats.

The distribution of macrofauna in the various habitats of a stream results from a combination of many environmental and ecological factors. A field experiment carried out by Pekarsky (1979) revealed that the density reflects the ability of benthic macroinvertebrates to colonize available habitats and to detect each others' presence. Wright et al. (1983) suggest that selection of microhabitats takes place in association with an ability to maintain station in the preferred biotope. Moreover, many animal species show high plasticity in their adaptations to various environmental conditions and to the utilization of different foods, e.g., Naididae in underground water feed on detritus (D u m n i c k a 1986). All these factors make the composition of macroinvertebrate groups quite variable. Nevertheless, the flow of energy between the main habitats is constantly taking place, although the "energy carriers" change. This flow may be of considerable importance for the ecological links in the stream, balancing the energy budget of individual habitats and making possible better utilization of allochtonous organic matter. The mud-covered stony habitat in the investigated first-order stream shows some features characteristic of the ecotone (greater diversity of species and higher productivity of certain macroinvertebrate groups (K h a r c h e n k o 1991) and thereby fulfils a similar function but on a smaller scale.

5. Polish summary

Preferencje siedliskowe bezkręgowców (szczególnie skąposzczetów) w potoku

Badania prowadzono od września 1986 r. do sierpnia 1987 r. na 4 stanowiskach potoku Sąspówka (ryc. 1) różniących się przede wszystkim wielkością przepływu wody oraz zawartością biogenów (tabela I).

Zagęszczenie makrofauny wahało się od 18 tys. osob. m^{-2} na stanowiskach 1 i 4 do 27 tys. osob. m^{-2} na stanowisku 3 (tabela II). Zmiany biomasy przebiegały nieco inaczej: najwyższa biomasa była na stanowisku 3 (około 3,9 g m^{-2}), potem na stanowiskach 1 i 2, a najniższa na stanowisku 4 (około 2,3 g m^{-2}) (tabela III). Spośród wyróżnionych taksonów największe zagęszczenie na wszystkich stanowiskach miały Chironomidae (5-15 krotnie większe od pozostałych taksonów).

Badane siedliska różniły się gęstością zasiedlenia: najwyższe było w mule (2-7 krotnie wyższe od pozostałych siedlisk), natomiast na kamieniach i kamieniach zamulonych zagęszczenie było podobne (z wyjątkiem stanowiska 4). Najwyższą biomasę notowano zazwyczaj na kamieniach. Różnice biomasy między siedliskami nie były tak duże jak różnice zagęszczenia.

Tylko nieliczne grupy zwierząt wydają się preferować zamulone kamienie jako środowisko życia. Do nich należały Naididae i Hydracarina, które osiągały zarówno najwyższe zagęszczenie jak i biomasę w tym siedlisku na stanowiskach od 2 do 4. Drugą grupę stanowiły 2 taksony (Trichoptera i *Gammarus* spp.), dla których jeden z badanych parametrów osiągnął maksymalną wartość w siedlisku przejściowym.

W badanym potoku znaleziono 25 gatunków skąposzczetów należących do 5 rodzin, z czego ponad połowa (13 gatunków) należała do rodziny Naididae (tabela IV). Różnorodność gatunkowa wzrastała z biegiem potoku - na stanowisku 1 oznaczono tylko 11 gatunków, na stanowisku 2 było ich już 15, potem przyrost liczby gatunków był nieznaczny - do 17 na stanowisku 4. Zmieniła się też struktura ugrupowania skąposzczetów - na stanowisku 1 we wszystkich siedliskach zdecydowanie dominowały Tubificidae, od stanowiska 2 dominację objęły Naididae, wśród nich najliczniejsze były: *Nais bretscheri* i *N. pardalis*. Szczególnie licznie gatunki te występowały w siedlisku zamulonych kamieni (ryc. 2), a w mniejszych ilościach towarzyszył im *N. communis*. Natomiast *N. alpina* nie wykazywał tak wyraźnego przywiązania do siedliska kamieni zamulonych.

6. References

Bougenec V., N. Giani, 1989. Les Oligochètes aquatiques en tant que proies des Invertébres et des Vertébrés: une revue. Acta OEcologica/OEcologia Applicata, 10, 177-196.

Brown A.V., P.P. Brussock, 1991. Comparisons of benthic invertebrates between riffles and pools. Hydrobiologia, 220, 99-108.

Dumnicka E., 1986. Naididae (Oligochaeta) from subterranean waters of West Indian Islands - distribution, taxonomical remarks and description of a new species. Bijdragen tot de Dierkunde, 56, 267-281.

Dumnicka E., J. Sanecki, K. Wojtan, 1990. Hydrobiological studies of the stream Sąspówka in the Ojców National Park "Prądnik". Prace Muzeum Szafera, 1, 153-158.

Fomenko N.V., 1972. Ob ekologicheskikh gruppakh oligokhet (Oligochaeta) r. Dnepra. In: Vodnye maloshchetinkovye chervi. Trudy, Akademia Nauk SSSR, 17, 94-106.

Hynes H.B.N., 1972. The ecology of running waters. Liverpool University Press, 555 pp.

Kharchenko T.A., 1991. Koncepciya ekotonov v gidrobiologii. Gidrobiologicheskiy Zhurnal, 27, 3-9.

Ormerod S.J., 1988 The micro-distribution of aquatic macroinvertebrates in the Wye river system: the result of abiotic or biotic factors? Freshwater Biology, 20, 241-247.

Pekarsky B.L., 1979. Biological interactions as determinants of distribution of benthic invertebrates within the substrate of stony streams. Limnology and Oceanography, 24, 59-68.

Rhodes H.A., W.A. Hubert, 1991. Submerged undercut banks as macroinvertebrate habitat in a subalpine meadow stream. Hydrobiologia, 213, 149-153.

Starmach K., S. Wróbel, K. Pasternak, 1976. Hydrobiologia. Warszawa, PWN, 621 pp.

Szczęsny B., 1968. The bottom fauna of the stream Sąspówka in the Ojców National Park. Ochr. Przyr., 33, 215-235.

Vervier Ph., J. Gibert, 1991. Dynamics of surface water/groundwater ecotones in a karstic aquifer Freshwater Biology, 26, 241-250.

Wright J.F., P.D. Hiley, A.C. Cameron, M.E. Wigham, A.D. Berrie, 1983. A quantitative study of the macroinvertebrate fauna of five biotopes in the River Lambourn, Berkshire, England. Arch. Hydrobiol., 96, 271-292.