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Winter macroinvertebrate investigations along the Bükkös Stream (Visegrádi Mountains, Hungary)

By

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Abstract. The authors conducted winter macroinvertebrate investigations revealing the relationships between the macroinvertebrates and abiotic environmental factors, especially current velocity and dissolved O_2-content.

Investigations of the macroinvertebrate communities of the Visegrádi Mountains (in the Pilis Biosphere Reserve) has been carried out for several years in the Department of Systematic Zoology and Ecology of the Eötvös Loránd University. This study has been coordinated and supported by the Institute of Ecology and Botany of the Hungarian Academy of Sciences within the framework of the UNESCO Program Pilis Biosphere Reserve.

We had stated earlier on the base of Hungarian and foreign researches that appearence of rhitron communities followed the alteration of current velocity in a mosaic-like position. Along the Apátkúti Stream detailed investigations on winter faunistic distribution, especially on orders Ephemeroptera, Plecoptera and Trichoptera, were carried out by ANDRIKOVICS and HADNAGY. Of factors influencing the distribution, current velocity, dissolved O_2-content, water depth, type of substrate and water pollution were examined. Dependence of distribution of larvae on environmental factors mentioned above was examined as well.

On the base of our results it seems desirable to continue winter faunistic investigations along the Bükkös Stream and to reveal in details the relationship between communities and abiotic environmental factors, especially current velocity and dissolved O_2-content.

Of the newer literature connected with this subject works of BENGTSSON (1981), MACAN (1980), SINGH—SMITH—HARRISON (1984) and of Hungarian literature researches of OLÁH (1972) and KISS (1977) revealing the relationship between communities and current velocity are emphasized.

Place, date and method of investigations

Collecting and sampling were made on Bükkös Stream, 8 times, between 15.10.1985 and 04.03.1986. Stream was divided into characteristic parts downstream,

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collecting and sampling were made on one part in each case. Dates and numbers of localities are as follows:

Date	*Part*	*Number of locality*
15.10.1985	Dobogókő—Szurdokvölgy	1—8
29.10.	Quarry of Dömörkapu	20—25
12.11.	Sikáros—Pioneers' Camp	9—13
29.11.	Dömörkapu	26—28
05.12.	Housing Estate	20—34
06.12.	Pioneers' Camp	14—19
13.01.1986	Camp	35—38
04.03	Lajosforrási Road	38—41

Localities of sampling are shown on a block plan (Fig. 1).

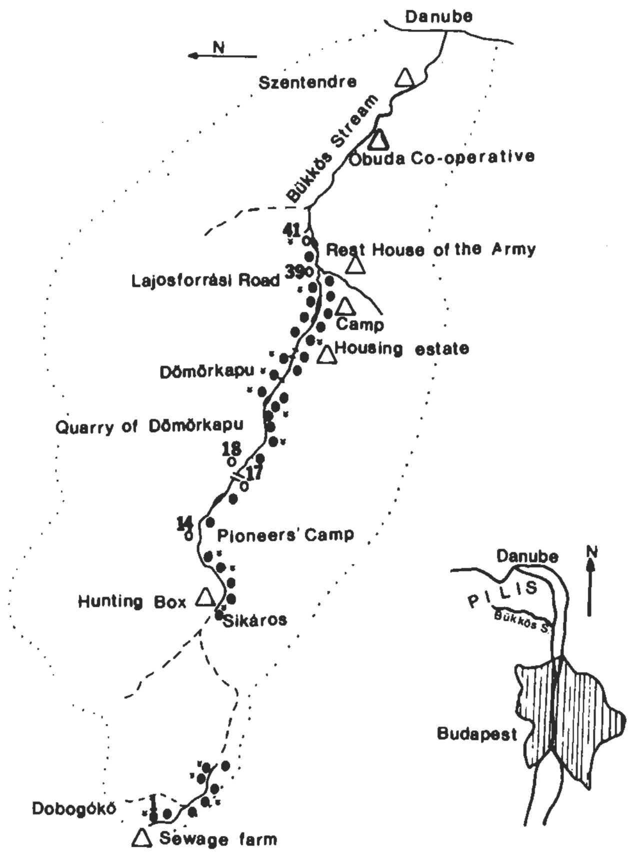

Fig. 1. Plan of Bükkös Stream. 1—41: number of localities; ○ qualitative collections; ● quantitative collections; ✓ Ca^{2+}, total hardness, HCO_3, Conductivity measurements; constant water flow; - - - temporary water flow; —+— water fall; constantly inhabited houses, settlement; ····· boundary of watershed area; —●— part of current velocity less than 0.2 ms^{-1}

Current velocity was measured by a rotor current velocity measuring instrument of A.OTT Current Meter type, in a depth of 0.4 *h* from the surface (*h* means the distance between bottom and surface, namely water depth). This method provide the average current velocity.

Determination of dissolved O_2-content by WINKLER's method was parallel with current velocity measuring.

In addition, total hardness, Ca^{2+} and HCO_3-concentration and conductivity were measured on 17 localities [on the base of COMECON Standard (1968) and FELFÖLDY (1972)]. These places are marked with on the block plan.

Temperatures of air and water were measured by a thermometer of 0.1 graduation. Substrate of stream-bed and polluting effects were investigated as well. Larvae of insects and crawfish were collected by a net of 20×20 cm frame made for this purpose, its material was a sieve with holes of 0.06 mm.

In addition to qualitative collections made on every sampling locality, quantitative collections were made on 5 localities (Fig. 1). These were marked with a circle on the block plan. Quantitative samplings were elaborated statistically. Sum of species, average of scoopings, scatter of values, and percental distribution in comparison to total individual number of sampling places were determined in case of each locality.

In course of collection made by this frame only organisms were captured that lived on stones, under stones, on coating and on aquatic plants, our investigation did not include silt-dwelling members of the fauna.

Results of the investigations

Hydroecological conditions

Total hardness, Ca^{2+}, and HCO_3 concentrations, and conductivity were measured on 17 localities between Dobogókő and the Rest House of the Army. Extreme values of the abiotic environmental factors altered between the values as follows: Ca^{2+}: 50.53 mg^{-1}, HCO_3: 184.27—464.42 mg^{-1}, total hardness: 9.58—30.00 degress.

Values of Ca^{2+}-concentration were higher on the part between Dobogókő—Szurdokvölgy (69.34—73.48 mg^{-1}) than valid in the case of HCO_3 concentration and of total hardness. It probably caused by the sewage farm of Dobogókő as a constant polluting source. The very high values of Sikáros could be explained by the fact that sampling had been made at the source, that was an underground water source. Water seeping through soil was very rich in HCO_3 that might throw the C-forms of the stream out of the balance. Bottom of the source was covered by rotten silt that might cause high value of conductivity.

On the middle part of the Bükkös Stream the four parameters were nearly constant, only values of HCO_3 altered slightly. Water contained less Ca^{2+} here, hardness was of medium value.

After the Rest House of the Army conductivity of water increased owing to the sewage water containing a lot of ions.

A constant inflow was explored at the parting of Lajosforrás. HCO_3 content was constant here, because the supply was soil-water.

The dissolved O_2-content altered between 6.16 and 24.82 mg^{-1}. Curve of dissolved O_2 followed the curve of current velocity, higher values of O_2 content belonged to high current velocity, lower values of O_2 content belonged to lower current velocity (Fig. 2).

This regularity was not observed in some places. When elaborating the results of measurements that had been taken on the 30—36. localities it could be stated that highest values of dissolved O_2 content did not belong to highest values of current velocity, but to values of 0.5—1.5 ms^{-1}. It could be explained by the fact that high current velocity was not the only reason of turbulent flow. Stones, rocks being found on the stream-bed were also necessary to cause turbulency. Such a circumstance could occur most often in case of current velocity mentioned above. In addition the dissolved O_2 content was inversely proportional to water-depth (ANDRIKOVICS—HADNAGY), however localities having current velocity of 0.5—1 ms^{-1} were the most shallow.

O_2-content decreased on parts having low current velocity, but this decrease was not proportional to that of current velocity. Dissolved O_2-content came close to or reached saturation point.

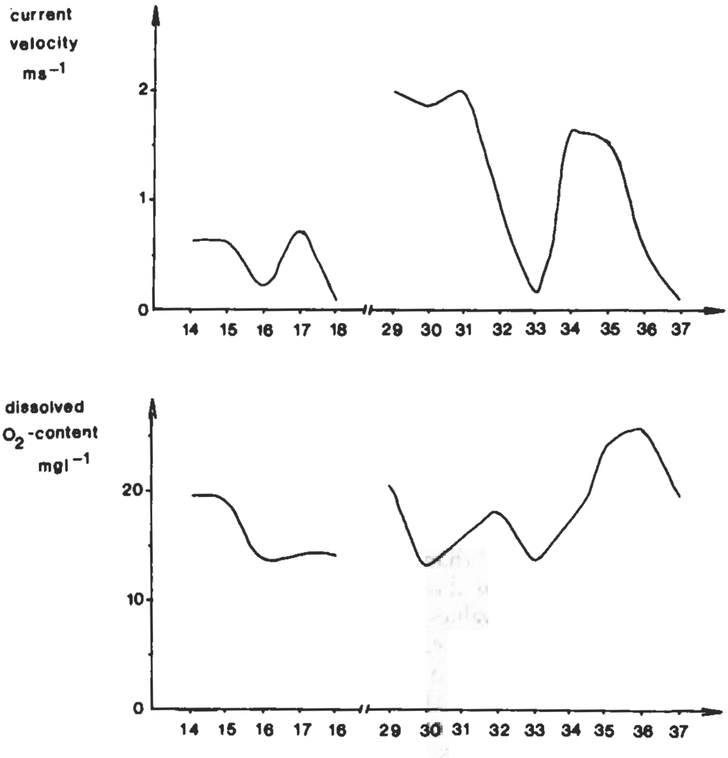

Fig. 2. Simultaneous alteration of current velocity and dissolved O_2. 14—37: number of localities

Thus on the middle part of the Bükkös Stream winter period provided favourable conditions even for rhitron organisms in point of O_2-supply. The higher dissolved O_2-content was "inherited" from parts of higher current velocity, because "slow" and "fast" parts were alternating with each other. This phenomenon might especially be realized where the "slow" part was short, only some ms long.

Decrease in dissolved O_2-content was mainly caused by water-pollution. It could be observed on parts between Dobogókő and Szurdokvögy, and considerable decrease in O_2-content after the Housing Estate also indicated a slight water pollution. Values of current velocity altered between 0.04 and 4.74 ms^{-1}. These were high values compared to those of other publications, but average current velocity was 0.8 ms^{-1} that corresponded values published in other papers. Current velocities depended mainly on falling gradient, water output and cross-section of the steam-bed. In winter the main factor depending current velocity was falling gradient in the Bükkös Stream that had a constant water output from sikáros to the estuary.

Highest current velocity was measured between Sikáros and the Housing Estate (between 1.65 and 4.1 ms^{-1}). This part had a falling gradient of 2.9%. At Dömörkapu where numerous waterfalls had been found, and that had a high falling gradient, current velocity was not lower that 1 ms^{-1}. After the Housing Estate falling gradient decreased (average was 1.5%) here lower current velocity was dominant (0.15—1.66 ms^{-1}). In addition to the average falling gradient grade differences of 1—2 ms and benches had a considerable role as it could be proved by the type of part between Sikáros and Quarry of Dömörkapu where "slow" and "fast" parts were alternating with each other, corresponding to the sudden changes in grade difference. This phenomena could be caused by the different types of rock. At the foot after Dömörkapu the erosion formed a bed with constant falling gradient so values of current velocity were lower here.

Temperature of water depended on air-temperature, reflecting temperature conditions of places having different microclimate. No relationship was found between temperature and current velocity.

Aquatic plants as substrate seldom occurred in winter in the Bükkös Stream, and riparian vegetation hanging down into the water was also not common. Nevertheless role of riparian vegetation could not be negligible, because there was a considerable mass of litter in the stream-bed. It was mainly composed by hornbeam and oak leaves. Substrate types occurring in the stream are as follows: silt, detritus, litter, sand, gravel, stones of different size and lava-rock with bryum vegetation.

Invertebrates

In course of investigation of quantitative and qualitative distribution of invertebrate macrofaunistic communities 9469 specimens were collected from 42 samplings those could be classed among 42 taxa.

On the upper, astatic parts of the stream no animals were found, and it was the same in temporary inflows. It might be caused by the fact that water could be found only during spring on these parts. From the source at Dobogókő to the gorge only chironomid species, *Lymnaea peregra* and *Chaetopteryx fusca* (Trichoptera) occurred, the two latter species on the same locality.

Among taxa of small individual number members of families Elminthidae, Hydrophilidae and Tabanidae occurred along the whole length of the middle part of the stream, family Simuliidae could be found only at Lajosforrási Road.

Taxa of large individual number consisted of orders Ephemeroptera, Trichoptera, Plecoptera, Amphipoda. Let us explore the distribution of these orders first. Distribution of each order was not uniform. Plecoptera and Ephemeroptera had the smallest individual numbers at Sikáros, but Amphipoda were the most abundant in individual numbers here, curve of distribution was rising at the Pioneers' Camp, it reached the second top in front of Dömörkapu, then individual numbers were decreasing continously. Distribution curve of Ephemeroptera was parallel with that of Amphipoda after the Pioneers' Camp, but at the Lajosforrási Road their distributions were different, individual number of Ephemeroptera was the largest here (Fig. 3).

Alteration of distribution of Trichoptera could be explored only on species level, because distribution of larvae having houses showed the opposite tendency.

80% of Ephemeroptera larvae collected in the Bükkös Stream was composed by 3 taxa: *Rhithrogena semicolorata* group, *Baetis rhodani* and *Epeorus silvicola.* Distribution of these species meant the distribution of the orders. *Baetis rhodani* had a uniform distribution, with slight positive variations. Distribution of *Rhithrogena semicolorata* group showed greater variations, but it was similar to that of the former species. *Epeorus silvicola* had a uniform distribution along the middle part, but individual number considerably increased at the Camp and at the Lajosforrási Road. Of the other Ephemeroptera species *Ecdyonurus starmachi* was characteristic of part at the Pioneers' Camp. *Paraleptophlebia submarginata* was absent between localities 19 and 26 but it had a uniform distribution elsewhere. *Ecdyonurus lateralis* group was rather characteristic of the area between Dömörkapu and the Camp, but it was absent from the area around the Quarry (Fig. 4).

Plecoptera species occurred in quite small individual numbers, they presumably lived along the middle part, but their distribution was not uniform.

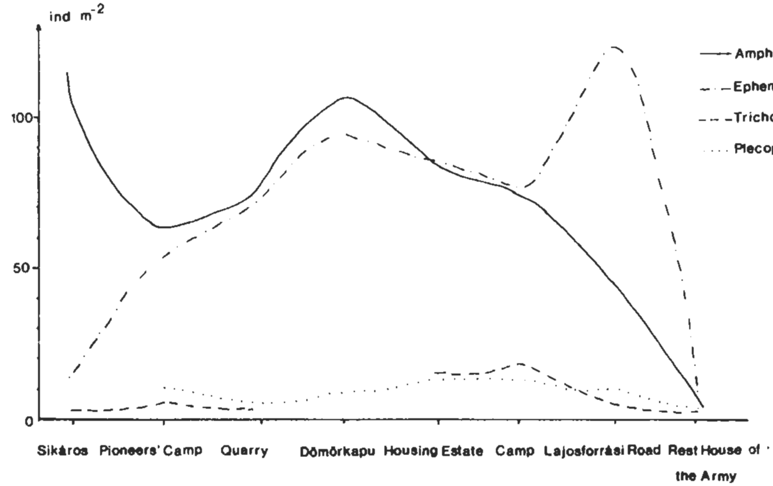

Fig. 3. Distribution of most numerous orders on the middle part of the Bükkös Stream

Among Trichoptera distribution of species living free was uniform, but they were absent from parts at the Quarry and Dömörkapu. After the Rest House of the Army the species and individual numbers decreased drastically, and after Izbég and around Szentendre only *Lymnaea peregra* could be found. It was caused by the constant, considerable pollution. Distribution of the most common species is shown by Fig. 4.

In course of collection five quantitative collections were made. During them 6844 individuals were collected, that meant 72.3% of the total individual number. 96% of the family Chironomidae, 86% of *Nemoura flexuosa*, 96% of *Nemoura* species, 68% of *Baetis rhodani* and 69% of *Rhithrogena semicolorata* group were collected by this method. Family Chironomidae proved to be the most abundant in individual number among the groups of the Bükkös Stream. Ordo Ephemeroptera was also abundant in individual number, among species investigated *Rhithrogena semicolorata* group and *Baetis rhodani* were the most numerous that could be supported by qualitative samplings. Order Amphipoda was numerous in course of both qualitative and quantitative samplings, but the distribution was not uniform. In the aspect of individual number order Plecoptera was the fourth, among them *Nemoura flexousa* was the third most abundant species of the middle part of the Bükkös Stream. Individual number and percentage proportion of Trichoptera were quite low (Fig. 5).

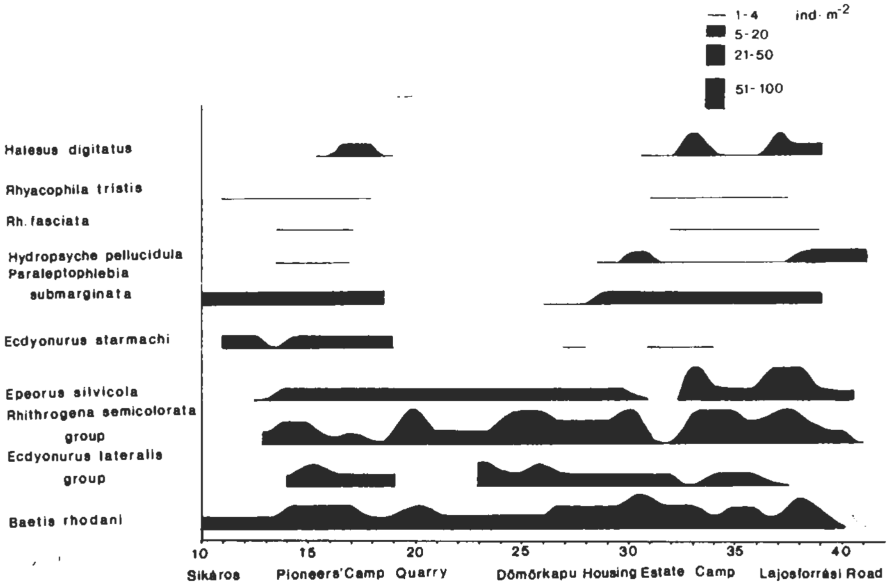

Fig. 4. Distribution of the most common species on the middle part of the stream

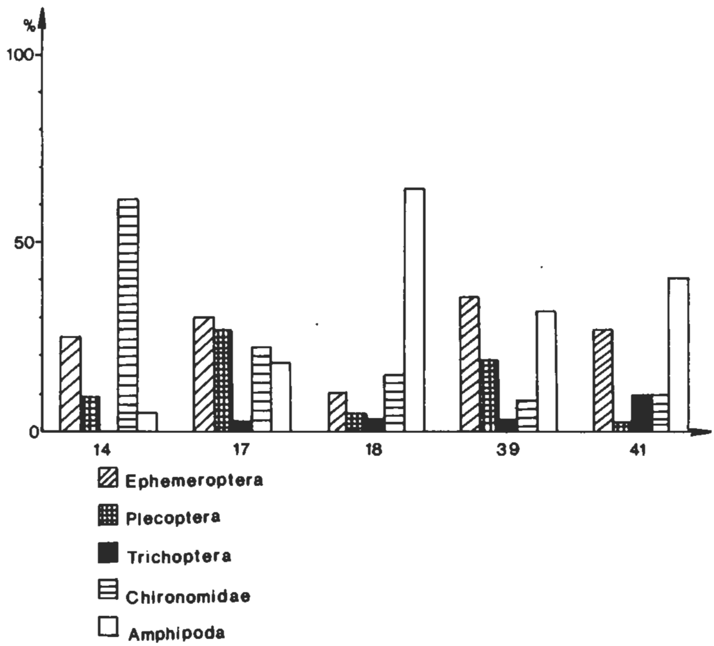

Fig. 5. Percentage distribution of most numerous groups on the five localities

Scatter values comparing to the average values showed that role of micro-environment had increased on parts having low current velocity. In the case of the same species scatter values could be different on two different localities. Best examples were localities 17 and 18 where average values of Amphipoda were near the same, but scatter was different. Reason could be the different environmental factors.

Anthropogenic effects

Anthropogenic effects influencing the stream were significant and could be divided into two groups. Constructive works did not cause any problems, they only might alter the type of the stream-bed. These artificial watergates, rubblestones and concrete dams had faded into the environment of the stream and their effect on the fauna and flora was complicated. It could be explored with the knowledge of the former picture, perhaps they had a modifying effect on the fauna.

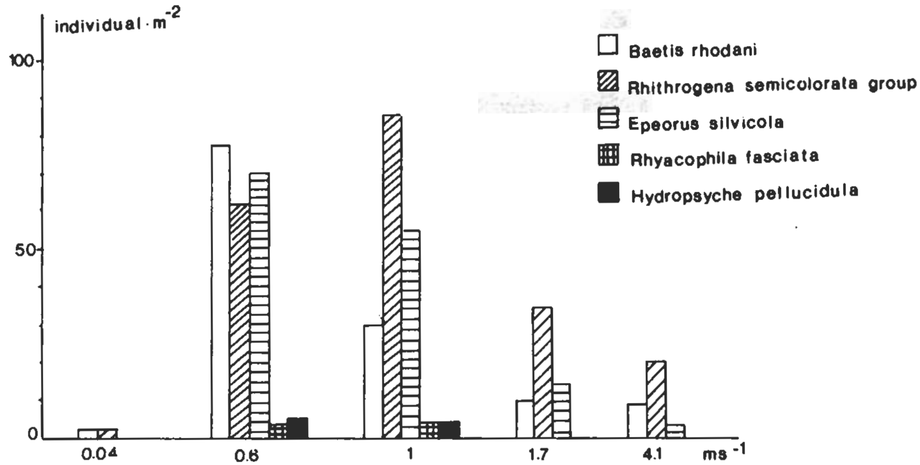

Fig. 6. Quantitative relationships between chracteristic values of current velocity and dominant elements of macroinvertebrates

Consequences of the other factor, namely water-pollution were much more visible. The sewage farm at Dobogókő placed water into the dry bed but this water had a very strong chloric odour, nettle was growing aroud the outlet that indicated N_2 pollution. Water got clean to provide suitable habitat to other macrobenthos in addition to chironomids only after the Chilly Soldier. Here *Chaetopteryx fusca* was found in a low individual number and *Lymnaea peregra* in greater individual number.

On the middle part the Housing Estate was a local polluting source, but the stream got clean after some hundred ms. Unfortunately after the Rest House of the Army, that caused eutrofication in the stream (diatoms covered the whole streambed), newer and more significant pollution influenced the stream around Izbég, where the Poultry-processing Plant of Óbuda Co-operative placed the sewage water without clearing. Lower part of the Bükkös Stream, that should have been habitat of a special fauna, have become the sewer of Izbég and Szentendre.

On the base of the aquatic macrofauna ARMITAGE et al. (1982) prepared a new biological system to qualify waters. This carefully elaborated system is valid for the inner waters of British Islands. Now we tried to adapt it to the Bükkös Stream. Because distribution of pollution was irregular, stream was divided into characteristic parts. These parts and total points belonging to them were as follows:

1. Dobogókő—Szurdokvögy	12
2. Sikáros—Dömörkapu	216
3. Dömörkapu—Housing Estate	130
4. Housing Estate—Camp	173
5. Camp—Rest House of the Army	190
6. After the Rest House of the Army	55
7. After the Co-operative	3

Pollution altered the composition of the fauna. Sensitive species with higher points disappeared and percent of resistant taxa with lower points increased, communities became poor in species number.

According to ARMITAGE's system quality of the water can be characterised by sum of taxa living there. In the Bükkös Stream results of classifications made by dissolved O_2 and other chemical methods were completely the same. It indicated the effect of the Rest House of the Army and that of pollution because after it the sensitive Plecoptera species, *Perla burmeisteriana*, *Leuctra* sp. and *Isoperla grammatica* disappeared. *Baetis rhodani* despite its being considered as a quite resistant species, and it has had low points in ARMITAGE's system, was absent here, in contrast to *Rhithrogena* sp. and *Epeorus silvicola*, both with high points. This fact would need further envestigation, absence of *Baetis rhodani* might be caused by other environmental factors not studied here.

ARMITAGE's method to qualify waters, disregarding some exceptions, can be used well in Hungary. It reflected well the status of different part of the heavily polluted Bükkös Stream.

Consequences

Because pollution altered the fauna considerably, we looked for areas of minimal pollution to study the relationship between abiotic environmental factors and species communities. The part between Sikáros to the Lajosforrási Road was suitable in this aspect.

Ca^{2+}, HCO_3, total hardness and conductivity altered only slightly on this part, it was usually characteristic of our mountains.

O_2 supply was favourable, so it could not be a limitating factor, as it was shown by results of sampling made on localities 17 and 18. On both places the dissolved O_2-content was almost the same, but the two faunas were completely different. There were differences only in velocities and sizes of stones on the two localities. Localities 32 and 33 were also adjacent to each other, O_2 supply was very good even on parts of low current velocity. The only difference was the current velocity. On locality of high current velocity (0.98 ms^{-1}) the dominant species among Ephemeroptera was *Rhithrogena semicolorata* group and *Epeorus silvicola*, among Trichoptera these were *Rhyacophila tristis* and *Rh. fasciata*. In contrast to it on localities of low current velocity (0.15) *Epeorus silvicola*, *Rhithrogena semicolorata* and *Rhyacophila fasciata* were completely absent, and individual number of Plecoptera decreased considerably. Individual number and percentage of *Ecdyonurus starmachi* increased.

These facts corresponded the Polish results where larvae of *Ecdyonurus starmachi* had been found at moderate current velocity (SOWA, 1971).

It could be explained by the next way: current velocity was the abiotic environmental factor that could influence almost exclusively distribution of larvae. Biotops of high current velocity were characterised by *Rhithrogena semicolorata* group, *Epeorus silvicola, Rhyacophila fasciata, Hydropsyche pellucidula.* These speices occurred on biotops of high current velocity. Distribution of *Baetis rhodani* showed similar tendency, but this species could not be involved in this community, because it often occurred on biotops of low current velocity.

Optimum velocity of this community was between 0.6 and 1.0 ms^{-1}. This values were mainly given by values of *Epeorus silvicola* and *Rhithrogena semicolorata* group. These two species tolerated slightly high current velocity.

For some species current velocity was almost neutral, for example for *Paraleptophlebia submarginata* and *Ecdyonurus lateralis* group. Distribution of *P. submarginata* and *E. lateralis* group were uniform on biotops of different current velocities. Amphipods preferred parts of low current velocities. There were no species occurring only lenitic biotops in winter.

Current velocity had no the same effect on distribution of stream-dwelling rhitron organisms. Individual numbers of some species were primarily determined by current velocity (Fig. 6). We would suggest to introduce the next terms: euryceleric and stenoceleric, on the base of classical ecological terminology (celeris=velocity). In the Bükkös Stream optimum values of euryceleric species were between 0.5 and 1.0 ms^{-1} in winter. These species are as follows: *Rhithrogena semicolorata* group, *Epeorus silvicola, Rhyacophila fasciata, Hydropsyche pellucidula, Nemoura* and *Leuctra* species. *Baetis rhodani* and *Rhyacophila tristis* could be involved as well, though changes in individual number were not so obvious. Individual number of stenoceleric species might decrease at values of current velocity that were different from optimum. Role of the substrate was not so significant but it could not be neglected.

Individual number of euryceleric species did not show any correlation with changes in current velocity. Individual numbers were near the same at different values of current velocity. These species are as follows: *Ecdyonurus lateralis* group, *Ecdyonurus starmachi, Isoperla grammatica.* Distribution of these organisms was primarily effected by the substrate. Their individual numbers did not change with changes in current velocity, only their proportion might alter in comparison with stenoceleric species.

Examining the effect of substrate on distribution of rhitron organisms at same current velocity it could be stated that it had had significant influence only in case of euryceleric species, in other cases current velocity was more important. Members of family Chironomidae were the most abundant in individual number on biotops covered by litter and detritus. Among Ephemeroptera *Ecdyonurus* species were the most numerous at relatively bigger stone size.

REFERENCES

1. Andrikovics, S. & Hadnagy, T. (in press): Winter macrofaunistic investigations along the Apátkúti Stream (Visegrádi Mountains, Hungary). — Annal. Univ. Sci. Budapest, Sect. Biol., 24—25.

2. Armitage, P. D., Moss, D., Wright, S. F. & F. Furse, M. T. (1982): The performance of a new biological water quality system based on macroinvertebrates over a wide range of unpolluted running-water sites. — Water Res., 3: 333—347.

3. Bengtsson, B. E. (1981): The growth of some Ephemeropteran nymphs during winter in a north Swedish river. — Aquatic Insects, 3/4: 190—208.

4. COMECON standard (1986): Kémiai módszerek, 1: 1—264.

5. Felföldy L. (1974): A biológiai vízminősítés. — Vízügyi Hidrobiológia, 3: 1—242.

6. KISS O. (1979): A folyóvízi társulások mozaikelvének értelmezése és az ökoklógiai niche. — Ho Shi Minh Tanárk. Főisk. Füz., 756: 453—465.

7. MACAN , T. T. (1980): The occurrence of Baetis rhodani (Ephemeroptera) in the River Lune. — Aquatic Insects, 2/3: 171—175.

8. OLÁH J. (1972): Aljzatcsere és táplálkozás közötti kapcsolat a Potamophylax rotundipennis Brauer lárvájánál. — Állatt. Közlem., 69/1—4: 106—110.

9. SINGH, M. P., SMITH, S. M. & HARRISON, A. D. (1984): Emergence of some caddisflies (Trichoptera) from a wooded stream in southern Ontario. — Hydrobiologia, 112: 223—232.

10. SOWA, R. (1971): Ecdyonurus starmachi sp. n. et E. submontanus Landa des Carpates polonaises (Ephemeroptera, Heptageniidae). — Bull. Acad. Polon. Sci., Ser. Biol., Cl. V, 19/6: 407—412.