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# Stream ecosystems in mountain grassland (West Carpathians)*

## 6. Sessile algae communities

**Barbara Kawecka**

Polish Academy of Sciences, Laboratory of Water Biology
ul. Sławkowska 17, 31-016 Kraków, Poland

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Abstract — In the control stream (wooded drainage area) and in the streams situated in the regions of pastures (with a traditional and intensive fertilization) the algal communities were similar from a floristic point of view but fairly distinctly differentiated in the size of the populations of some species. The index of diatom biomass reached the highest values in the stream flowing across the regions of pastures used for traditional sheep grazing, and the lowest ones in the area of the experimental pastures undergoing intensive fertilization.

Key words: stream ecosystems, influence of pastoral economy, the West Carpathians, algal communities, sessile algae, algal ecology, algal periodicity.

## 1. Introduction

The aim of the investigation was to estimate the structure of algal communities developing in the mountain streams flowing through grassland and to observe their growth during the year.

The studies were carried out in the years 1977 and 1978 within the upper Grajcarek catchment basin (maximum altitude 1052 m). A detailed description of the terrain has been given by Kownacki (1982). The subject of the present investigations were the Biała Woda and the Kamionka (Homole) streams. Three stations used to varying degree as

* The investigations were carried out within Project 10.2.

pasture were chosen. The control station, not subjected to pasturing, was situated in the wooded upper course of the Biała Woda stream (BW1). Of the two experimental stations one (BW2) lay in the middle course of the Biała Woda stream, in an area of traditional pasturing, while the other (K2) was situated in an area of experimental pasturing, with intensive fertilization, in the upper course of the Kamionka stream.

## 2. Method

The algae were collected from each station, taking into account the various habitats, such as stones, mud, or mosses. Species abundance of was estimated by the following methods:

1) Estimation of the coverage of algae forming macroscopic aggregations on an area of about 4 sq. m. of the stream bottom. In winter this area concerned those parts of the stream free of ice. The 5-degree scale of coverage was used:

1. 5— 10% of the bottom covered
2. 10— 25% of the bottom covered
3. 25— 50% of the bottom covered
4. 50— 75% of the bottom covered
5. 75—100% of the bottom covered;

2) Microscopic estimation of the abundance of diatoms was carried out according to the method of Starmach (1969). For this purpose the cells of every species were counted in 10 microscope fields and their percentage share in the community was then calculated.

Next the size of the cell was determined by comparing it with the mesh of the micrometric net installed in the microscope eyepiece. The net was composed of 400 square fields, each of an area of 100 $\mu^2$ at a magnification of 12.5×40. The size of the cell was given in multiples or fractions of mesh net always at the same microscopic magnification.

The coefficient of coverage was calculated by multiplying the abundance of the species by its size. The value obtained was then multiplied by 2 in order to get the accepted assimilation surface of agal cells.

By adding the values of the coefficient of coverage of the particular species, the index of diatom biomass was obtained.

The dominants accepted were those species having a coverage of at least 2 and a share in the community of at least 5%. The remaining organismus were treated as adominants.

The seasonal development of algae, with regard to species forming macroscopic aggregations as well as those whose mean annual share in the community amounted to at least 5% is presented.

## 3. Results

### 3.1. Description of the communities

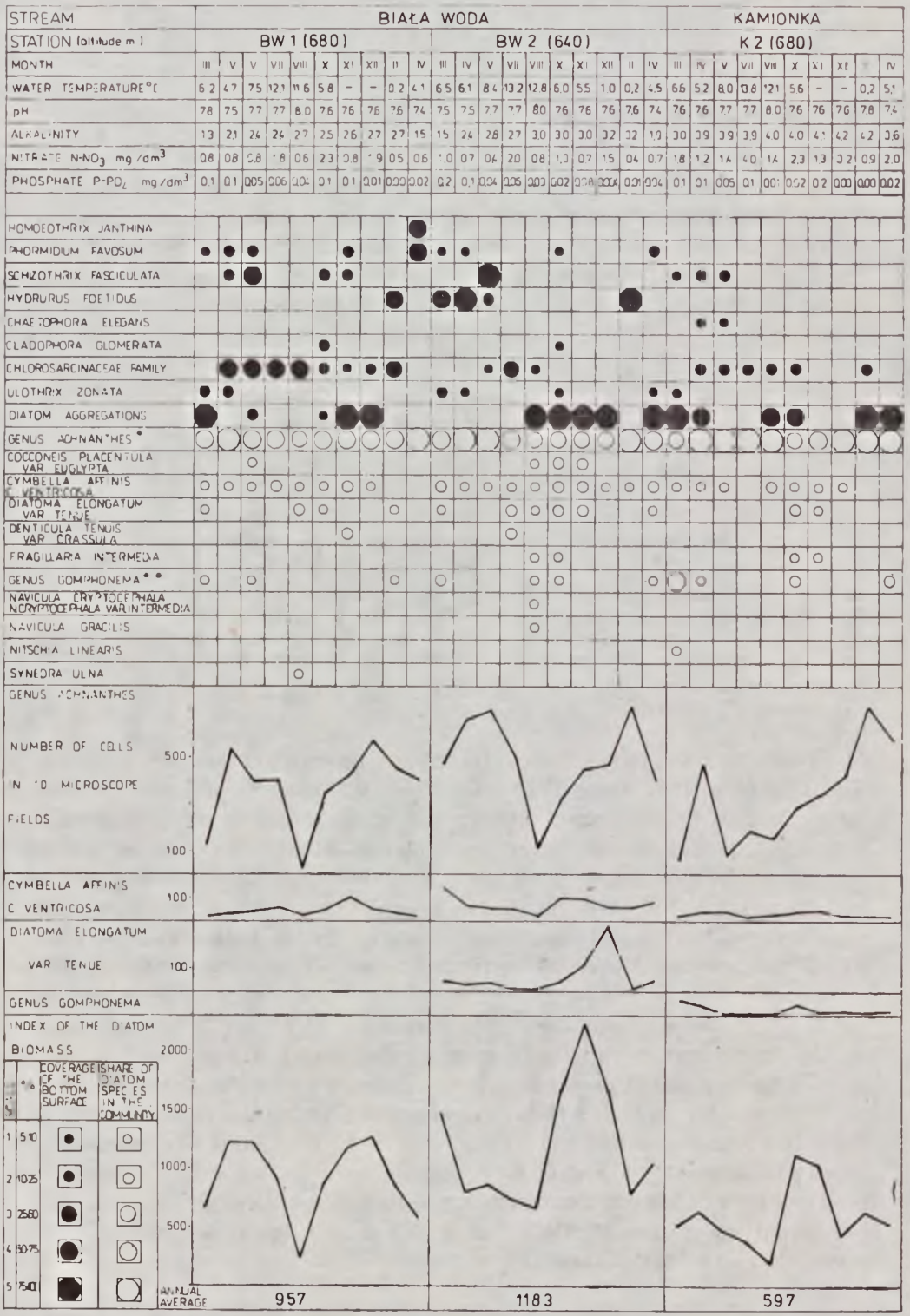
With regard to the number of taxa, the diatom prevailed in the investigated streams. Blue-green, green, red, and golden algae constituted a small percentage (Table I). The total number of species in the Biała Woda (BW1) stream appeared to be the most diferentiated, that in the Kamionka stream (K2) (Table I) showing the poorest differentiation.

Table I. Floristic spectrum. A - number of species; B - percentage share of species in the community

| Stream | Biała Woda | | | | Kamionka | |
|---|---|---|---|---|---|---|
| Station | BW1 | | BW2 | | K2 | |
| | A | B | A | B | A | B |
| Cyanophyta | 3.0 | 3.4 | 3.0 | 3.8 | 2.0 | 2.8 |
| Chlorophyta | 3.0 | 3.4 | 3.0 | 3.8 | 2.0 | 2.8 |
| Rhodophyta | 1.0 | 1.2 | 1.0 | 1.3 | | |
| Bacillariophyceae | 79.0 | 90.8 | 71.0 | 89.8 | 67.0 | 93.0 |
| Chrysophyceae | 1.0 | 1.2 | 1.0 | 1.3 | 1.0 | 1.4 |
| Total number of species | 87.0 | | 79.0 | | 72.0 | |

From a floristic point of view the communities discussed were similar (fig. 1). *Schizothrix fasciculata* was a fairly abundant species of blue-green algae. Predominated among the green algae were not closely identified species of the *Chlorosarcinaceae* family forming a green coating on the stones and particularly abundant in the Biała Woda (BW1) and Kamionka (K2) streams. These green algae were accompanied in shady places by the red alga *Chantransia* sp. In the Biała Woda stream (BW2) the species *Hydrurus foetidus* played an important role in the community. It occurred in lesser abundance at the control station (BW1) but macroscopic aggregations in the Kamionka stream (K2) formed no at all. In the diatom group the species of the genus *Achnanthes*, mainly *A. minutissima* and *A. pyrenaica*, everywhere prevailed decisively. Also fairly numerous were the following species: *Cymbella affinis*, *C. ventricosa*, *Diatoma elongatum* var. *tenue*, species of the genus *Gomphonema*, chiefly *G. angustatum*, and *G. olivaceum*.

The index of diatom biomass reached its highest value at BW2, having a slightly lower one at BW1, but at K2 it was lower by nearly half lesser than at either of them (fig. 1).



### 3.2. Seasonal changes in algal communities

#### 3.2.1. The Biała Woda stream (BW1)

In spring the green algae formed fairly abundant aggregations (among the mainly not closely determined species of the *Chlorosarcinaceae* family and *Ulothrix zonata*) and also blue-green algae (*Phormidium favosum, Schizothrix fasciculata* and *Homoeothrix janthina*). In summer the development of algae was poor, only unidentified green algae still being plentiful. In autumn their coverage diminished, while the species *Schizothrix fasciculata* again increased in abundance. In winter *Hydrurus foetidus* predominated in the community and also the green algae became more abundant.

The index of diatom biomass achieved two peaks of equal value. The first occurred in spring and was chiefly caused by the development of species of the *Achnanthes* and *Cymbella* genera. The second occurred in the autumn and also was caused by the species of the genera *Achnanthes*

Fig. 1. Algal communities in the annual cycle. Selected were species forming macroscopic aggregations and the dominant diatom species. Chemical data according to Bombówna (1982). * Genus *Achnanthes: A. minutissima, A. microcephala, A. pyrenaica, A. amphicephala.* ** — Genus *Gomphonema: G. angustatum* var. *productum, G. olivaceum, G. olivaceum* var. *calcareum, G. intricatum* var. *pumilum.* The adominant diatom species: *Achnanthes lanceolata* (Brèb.) Grun., *A. lanceolata* var. *capitata* O. Müll., *A. lapponica* Hust., *Amphipleura pellucida* Kütz., *Amphora ovalis* Kütz., *A. ovalis* var. *pediculus* Kütz., *Campylodiscus* sp., *Ceratoneis arcus* (Ehr.) Kütz., *Cocconeis placentula* Ehr., *C. placentula* var. *intermedia* (Hérib.) W. Sm., *Cymbella aequalis* W. Sm., *C. aspera* (Ehr.) Cl., *C. Cesatii* (Rabh.) Grun., *C. cistula* (Hempr.) Grun., *C. delicatula* Kütz., *C. lanceolata* (Ehr.) V. H., *C. naviculiformis* Auersw., *C. prostrata* (Berk.) Cl., *C. sinuata* Greg., *C. sinuata* var. *ovata* Hust., *Cymbella* sp., *Diatoma hiemale* (Lyngb.) Heib., *D. hiemale* var. *mesodon* (Ehr.) Grun., *D. vulgare* Bory, *D. vulgare var. capitulatum* Grun., *D. vulgare* var. *Ehrenbergii* (Kütz.) Grun., *Diploneis* sp., *Epithemia zebra* (Ehr.) Kütz., *Eunotia* sp., *Fragilaria capucina* Desm., *F. crotonensis* Kitt., *F. pinnata* Ehr., *F. pinnata* var. *lancettula* (Schum.) Hust., *Frustulia vulgaris* (Thw.) De Toni, *Gomphonema intricatum* Kütz., *G. longiceps* Ehr. var. *montanum* (Schum.) Cl., *Gomphonema* sp., *Gyrosigma* sp., *Hantzschia amphioxys* (Ehr.) Grun., *Meridion circulare* Ag., *Navicula cryptocephala* Kütz. var. *veneta* (Kütz.) Grun., *N. laterostrata* Hust., *N. pupula* Kütz., *N. pupula* var. *capitata* Hust., *N. radiosa* Kütz., *N. rhynchocephala* Kütz., *N. viridula* Kütz., *Neidium alline* (Ehr.) Cl., *N. dubium* (Ehr.) Cl., *N. dubium* var. *constrictum* Hust., *Nitzschia acicularis* W. Sm., *N. angustata* (W. Sm.) Grun., *N. dissipata* (Kütz.) Grun., *N. linearis* W. Sm., *N. palea* (Kütz.) W. Sm., *N. recta* Hantzsch, *Nitzschia* sp., *Pinnularia borealis* Ehr., *P. microstauron* (Ehr.) Cl., *P. subcapitata* Greg., *P. viridis* (Nitzsch) Ehr. var. *sudetica* (Hilse) Hust., *Pinnularia* sp., *Rhoicosphenia curvata* (Kütz.) Grun., *Stauroneis anceps* Ehr., *S. Smithii* Grun., *Surirella angustata* Kütz., *S. ovata* Kütz., *Surirella* sp., *Synedra amphicephala* Kütz., *S. minuscula* Grun., *S. rumpens* Kütz.

and *Cymbella* as well as by *Denticula tenuis* var. *crassula*. The minimum value of the index of diatom biomass was noted in August (fig. 1).

3.2.2. The Biała Woda stream (BW2)

In spring species such as *Hydrurus foetidus* and the blue-green alga *Schizothrix fasciculata* dominated. In summer the development of algae was poor, only green algae (unidentified species of the *Chlorosarcinaceae family*) being fairly numerous. In autumn the diatoms dominated in the community and in winter *Hydrurus foetidus*.

The index of diatom biomass reached its maximum value in autumn, this resulting from the development of the species of the genera *Achanthes* and *Cymbella* and also of *Cocconeis placentula* var. *euglypta* and *Diatoma elongatum* var. *tenue*. The minimum value of the index of diatom biomass was noted in August (fig. 1).

3.2.3. The Kamionka stream (K2)

The quantitative development of algae here was poor. In spring fairly abundant aggregations were formed by the blue-green alga *Schizothrix fasciculata* and green algae (unidentified species of the *Chlorosarcinaceae* family). In summer and autumn the green algae still survived, but in late autumn the bottom of the stream became very strongly slimed and at that time there was a complete lack of macroscopic algal coatings. The diatoms developed very numerously in winter and the aggregations of green algae again appeared.

The index of diatom biomass reached its maximum value in autumn, this being caused by the growth of species of the genera *Achnanthes* and *Gomphonema* and by that of *Diatoma elongatum* var. *tenue* as well as *Fragilaria intermedia*. The minimum value of the index was noted in August (fig. 1).

The observations carried out allowed certain regularities to be noted in the development of particular species of algae during the year. The spiecies *Phormidium favosum* and *Schizothrix fasciculata* showed a growth tendency in the spring. *Hydrurus foetidus* reached its maximum growth in the winter-spring period. Species such as *Achnanthes minutissima*, *A. pyrenaica*, *Cymbella ventricosa*, and *C. affinis* showed an increase in abundance in spring, autumn, and winter. *Diatoma elongatum* var. *tenue* achieved their best development in late autumn.

## 4. Discussion

The organisms which inhabit the investigated streams are also frequently found in other mountain streams, e.g. *Phormidium favosum*, *Homoeothrix janthina*, *Hydrurus foetidus* (K a w e c k a 1980, 1981), and *Schizothrix fasciculata* (K a n n 1978, K a w e c k a 1965). The species *Achnanthes minutissima* is one of the most numerous organisms occurring in the mountain streams of Europe (K a w e c k a 1980, 1981) and is an indicator of oxygen-rich water (C h o l n o k y 1968). This species is apparently sensitive to organic pollution of the environment since it decreases in abundance below the inflow of domestic sewage to a stream (K a w e c k a 1977, 1980, 1981). The species *Achnanthes pyrenaica* is reported from Tatra mountain streams (K a w e c k a 1965, 1971, W a s y l i k 1971) in which a high content of calcium occurs (B o m b ó w n a 1968, 1971).

The algal communities of the examined streams showed a great floristic similarity, though they differed fairly distinctly from each other as to the quantitative development of particular species. In the Kamionka stream (K2), situated in an area of pastures with intensive fertilization, for example, the algal coatings were formed less distinctly than in the Biała Woda stream at the control station (BW1) or in the area of traditional sheep pasturing (BW2). Also the development of *Hydrurus foetidus* was here very poor, not forming macroscopic aggregations, although it is a species characteristic for mountain streams. It may be that the sliming of the bottom caused a weak coverage of algae. Also in October in the Biała Woda stream (BW1), with almost 100% of bottom slime, the algae formed out small aggregations (fig. 1). It would seem, too, that the poor development of the species *Hydrurus foetidus* was connected with the silty bottom. It has many times been observed that *H. foetidus* disappears or does not develop well in the lenitic slimed parts of mountain streams (K a w e c k a 1981).

In the Kamionka stream (K2) the index of diatom biomass was distinctly lower than that in the Biała Woda stream. It reached values similarly low as those in diatom communities developing in high-mountain streams at altitudes of 1100—2100 m (K a w e c k a 1980). The low value of the index of diatom biomass is caused here by the specific structure of the community. Namely, in the greater part of the year the species of the *Achnanthes* genus have a 75—100% share in the community, thus the remaining species constitute only not a small percentage. The low values of the index of biomass are explained by the fact that species of the genus *Achnanthes* are minute organisms. Why these species should be the most abundant in the community is difficult to say. To find the answer to this questions further investigations on the ecology of organisms are necessary.

## 5. Polish summary

**Ekosystemy potokowe na terenach pastwisk górskich (Karpaty Zachodnie)**

**6. Zbiorowiska glonów osiadłych**

Badania prowadzono w latach 1977—1978 w potokach położonych na terenie Małych Pienin. Górny bieg potoku Biała Woda (BW1) pozbawiony był wpływu pasterstwa, środkowy bieg (BW2) leżał na obszarze pastwisk z tradycyjnym wypasem owiec, natomiast górny bieg potoku Kamionka (K2), zwanego też potokiem Homole, położony był na terenie pastwisk z intensywnym nawożeniem.

Zbiorowiska glonów rozwijające się na badanych stanowiskach były podobne pod względem florystycznym, natomiast dość zróżnicowane w ilościowym rozwoju poszczególnych gatunków (fig. 1). Pod względem liczby taksonów wszędzie przeważały okrzemki (tabela I). Wśród nich dominowały gatunki z rodzaju *Achnanthes* (głównie *A. minutissima, A. pyrenaica*). Wskaźnik biomasy okrzemek osiągnął najwyższą wartość w potoku Biała Woda na stanowisku BW2, nieco mniejszą na stanowisku BW1, natomiast w potoku Kamionka (K2) prawie o połowę mniejszą niż na dwu pozostałych stanowiskach (fig. 1). Z sinic dość obfite skupienia tworzył *Schizothrix fasciculata*, z zielenic dominowały nie określone gatunki z rodziny *Chlorosarcinaceae* (rząd *Chaetophorales*). *Hydrurus foetidus* rozwijał się najliczniej w potoku Biała Woda na stanowisku 2, a w potoku Kamionka w ogóle nie tworzył makroskopowych skupień.

Zaobserwowano pewne prawidłowości w rozwoju gatunków w cyklu rocznym. *Phormidium lavosum* oraz *Schizothrix fasciculata* wykazywały tendencję wzrostu w okresie wiosennym. *Hydrurus foetidus* osiągał masowy rozwój w okresie zimowo-wiosennym. *Achnanthes minutissima A. pyrenaica, Cymbella affinis, C. ventricosa* wykazywały wzrost liczebności na wiosnę oraz w jesieni i w zimie. *Diatoma elongatum* var. *tenue* osiągała najlepszy rozwój w okresie późnej jesieni (fig. 1).

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