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# Sessile algae in European mountain streams

## 2. Taxonomy and autecology

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Abstract — In the streams of the Kebnekaise Mts (Swedish Lapland), the Tatra Mts (Poland), the Alps (Austria), the Fagaras (Rumania), and the Rila Mts (Bulgaria), 380 taxons of algae were found. Among them, diatoms formed the dominant group, 77.2—94.3% of total flora. In the group of diatoms great morphological variations were observed. In the populations of a number of species, apart from typical cells, cells whose dimensions differ from the known diagnosis were found.

Upon examining the autecological characteristics of 48 species and varieties of algae it has been concluded that most of them possess a wide ability of adaptation to various life conditions.

Key words: Phytogeography, algae autecology, diatoms taxonomy.

## 1. Introduction

The object of this investigation consisted of the algae which develop in streams of the Kebnekaise Mts (Swedish Lapland), the Tatra Mts (Poland), the Alps (Austria), the Fagaras Mts (Rumania), and the Rila Mts (Bulgaria). The streams concerned lie between 550 and 2750 m a.s.l. The temperature of the water in these streams ranges from 2.2 to 15°C, and the pH varies from 5.4 to 8.5.

The first part of this paper has described the differentiation of structure of algae communities in relation to the environmental changes along the course of unpolluted and polluted streams and in relation to different habitats, and different seasons. The second part concentrates on the taxonomy of the diatoms and on the autecology of some species of the algae.

## 2. Results and discussion

### 2.1. Taxonomy

In the streams under examination 380 taxons of algae were identified; about 90 per cent of them had already been indicated in previous publications (Kawecka 1965, 1971, 1974a, 1974b, 1976, 1980). The remaining 10 per cent consist of the organisms which appear sporadically and which in most cases have been identified only to the level of genus.

The greatest variety of species was observed in the following streams: Finstertaler-Bach (Alps), Maljovica (Rila Mts), Rybi Potok (Tatra Mts), Arpasul (Fagaras Mts) — 100—200 taxons. The smallest number of species appeared in the glacial streams: Tarfalajåkka (Kebnekaise Mts) and Rotmoos Ache (Alps) — 25—65 taxons.

In every stream diatoms constituted the dominant group (Table I). In the Sucha Woda stream *Cyanophyta* reached a relatively high percentage. In the Maljovica stream, among *Chlorophyta*, desmids were numerous, while in other streams they were rare.

Particular attention was paid to large morphological variations of diatom cells. In the population of species as well as typical cells, cells of different length, width and a number of striae in 10 μm were found. The morphological features of such forms differed to a greater or lesser degree from the known diagnosis of that particular species (Hustedt 1930, 1931, 1932, 1933, 1937), Cleve-Euler (1952, 1953a, 1953b,

Table I. Floristic spectrum
(the percentage share of algae species and of fungus species in the communities)

| Mountains | Kebne-kaise | Tatra Mts | | | Alps | | | | Fogaras | Rila |
|---|---|---|---|---|---|---|---|---|---|---|
| Streams | Tarfala-jåkka | Sucha Woda | Potok Olozy-ski | Rybi Potok | Gurgler Ache | Rotmoos Ache | Finster-taler Bach | Königs-Bach | Arpa-sul | Maljo-vica |
| Cyanophyta | 10.9 | 12.6 | 8.9 | 7.5 | 5.1 | 4.8 | 3.7 | 4.5 | 1.4 | 5.4 |
| Chrysophyceae | 1.5 | 0.8 | 1.1 | 0.7 | 1.1 | 4.8 | 0.5 | 1.1 | 0.7 | 0.5 |
| Bacillariophyceae | 78.1 | 79.4 | 87.8 | 74.8 | 91.8 | 90.4 | 90.7 | 94.3 | 93.0 | 77.2 |
| Chlorophyta | 9.4 | 6.3 | 1.1 | 15.6 | 2.0 | - | 5.0 | - | 4.9 | 16.3 |
| Rhodophyta | - | 0.8 | 1.1 | 0.7 | - | - | - | - | - | 0.5 |
| Fungi | - | - | - | 0.7 | - | - | - | - | - | - |

1955), Siemińska (1964), Patrick, Reimer (1966, 1975). Together with the name of each species discussed, is given the name of the author whose diagnosis has been used by the present author. As a criterion for selection, the smallest variation of the morphological characteristics was taken. As for as the size of the cells is concerned, first the length and then the width is given.

*Achnanthes kryophila* Peters.; Cleve-Euler (1953b); fig. 1

Cell dimensions: 12.1—19.8 × 4.4—8.5 μm, 23—25 striae in 10 μm on both valves. The raphe valve has a narrow longitudinal field and the central field diagonally enlarged reaching almost to the margins of the cell. In the pseudoraphe valve, the longitudinal field is also narrow, and the central one often ellipsoidocircular.

The specimens are to same extent different from the indications of the diagnosis of this species, as, according to Hustedt (1933), Siemińska (1964) pseudoraphe valve possesses a longitudinal field which is lanceolate and narrow, and there is no central field. According to Cleve-Euler (1953b) the central field is narrow, only in the middle somewhat enlarged. However, Schmidt (1937) and Carter (1970) found similar cells of *A. kryophila* with a large central field on the pseudoraphe valve.

In previous investigations this species was not shown. It was later separated from the group of cells described as *Navicula rotaeana* (Kawecka 1971, 1974a, 1974b).

*Achnanthes nodosa* A.; Cleve-Euler (1953b); fig. 2

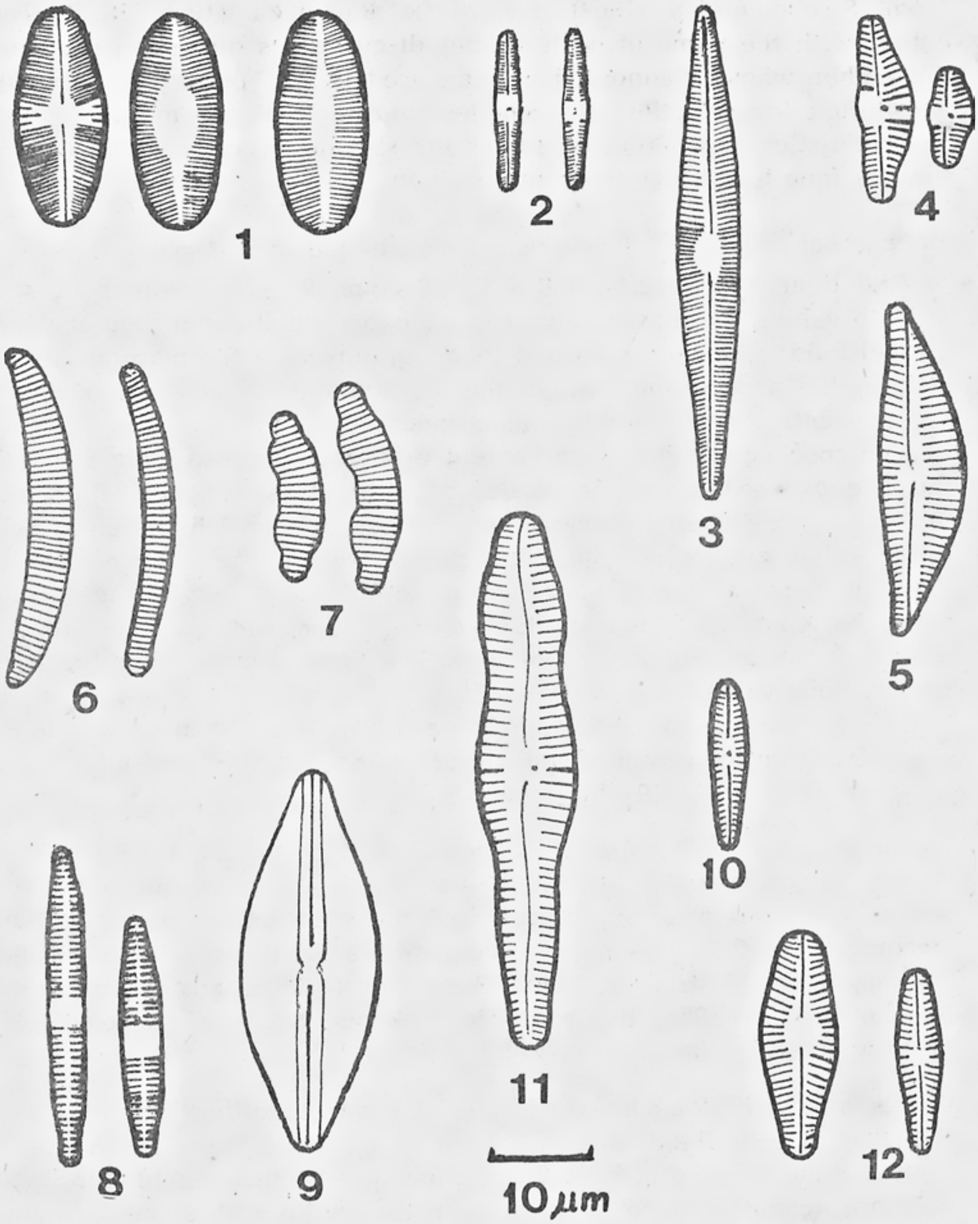
Cell dimensions: 9.9—16.5 × 2.2 μm, 18 striae in 10 μm on both valves. The cells are very narrow and the striae are thickly situated. According to Cleve-Euler (1953b) the width is 2.5—6 μm and they have 14—17 striae in 10 μm. According to Hustedt (1933) and Siemińska (1964) the width is 5—7 μm, striae are also 14—17 in 10 μm.

*Cymbella cesatii* (Rabh.) Grun. ex A.S. var. *cesatii;* Patrick and Reimer (1975); fig. 3

Cell dimensions: 22—25 × 4.8—5.5 μm, 16—20 striae in 10 μm. Some cells are longer and also (regardless of the length) with a smaller number of striae in 10 μm. According to Patrick and Reimer (1975) the length of cells is 21—45 μm, the striae are 18—20 in 10 μm.

*Cymbella sinuata* Greg. var. *sinuata;* Patrick and Reimer (1975); fig. 4

Cell dimensions: 9.9—30.8 × 3.3—7 μm, 9—10 striae in 10 μm. Some cells are small. According to Patrick and Reimer (1975) the length of cells in 11—40 μm, and the width 3.5—9 μm.




Figs 1—12. Species of algae: 1 — *Achnanthes kryophila;* 2 — *A. nodosa;* 3 — *Cymbella cesatii;* 4 — *C. sinuata;* 5 — *C. ventricosa;* 6 — *Eunotia lunaris;* 7 — *E. pectinalis* var. *minor;* 8 — *Fragilaria capucina;* 9 — *Frustulia rhomboides* var. *saxonica;* 10 — *Gomphonema intricatum* var. *pumilum;* 11 — *G. longiceps* var. *montanum;* 12 — *G. olivaceum*

*Cymbella ventricosa* Kütz.: Hustedt (1930); fig. 5

Cell dimensions: 27—38.7 × 5—10 μm, 9—14 striae in 10 μm. There are mostly 14 striae in 10 μm, but one can also find some cells with fewer striae (9—11 striae in 10 μm). According to Hustedt (1930), Siemińska (1964) there are 12—18 striae in 10 μm, while according to Cleve-Euler (1955 — syn. *C. ventricosa α genuina)* about 10—12 striae in 10 μm.

*Eunotia lunaris* (Ehr.) Grun.; Cleve-Euler (1953a); fig. 6

Cell dimensions: 35.2—87.5 × 2.2—5 μm, 13—16 striae in 10 μm. Some cells are narrower than it is indicated in the diagnosis of the species; according to Cleve-Euler (1953a — syn. *E. lunaris α genuina*) the width of cells is 3—5 μm.

*Eunotia pectinalis* (Dillw.? Kütz.) Rabh. var. *minor* (Kütz). Rabh.; Hustedt (1932); fig. 7

Cell dimensions: 16.5—34.3 × 3.7—6.2 μm, 12—15 striae in 10 μm. Some cells are narrow and have a smaller number of striae in 10 μm: According to Hustedt (1932) the width of cells is 5—10 μm and they have about 15 striae in 10 μm. VanLandingham (1967) finds the cells of *E. pectinalis* var. *minor* similar to that described above; width 4.5—7 μm, striae 12—15 in 10 μm.

*Fragilaria capucina* Desm.; Hustedt (1933); fig. 8

Cell dimensions: 22—47.3 × 2.2—3.3 μm, 13—16 striae in 10 μm. Some cells are shorter than indicated by the diagnosis of the species. According to Hustedt (1931), as well as Patrick and Reimer (1966) the lower limit of length is 25 μm.

*Frustulia rhomboides* (Ehr.) De Toni var. *saxonica* (Rabh.) De Toni; Hustedt (1937); fig. 9

Cell dimensions: 35.5—56.8 × 11—14.2 μm, the number of striae was not counted. Some cells are distinctly too short and somewhat too narrow when compared with the diagnosis of the species. According to Hustedt (1937), Siemińska (1964), Patrick and Reimer (1966) the length of cells is 40—70 μm, and their width 12—20 μm.

*Gomphonema intricatum* Kütz. var. *pumilum* Grun.; Siemińska (1964); fig. 10

Cell dimensions: 15—37.5 × 3—5 μm, 10—15 striae in 10 μm. In comparison with diagnosis of species some cells are too long and too narrow, and some small forms have more striae in 10 μm. According to Siemińska (1964) the length of cells is 12—30 μm, and width 5—7 μm, and there are 8—11 striae in 10 μm.

*Gomphonema longiceps* Ehr. var. montana (Schum.) Cl.; Hustedt (1930); fig. 11

Cell dimensions: 57.2—69.3 × 7.7—9.9 μm, 9—10 striae in 10 μm. The number of striae only slightly deviates from the diagnosis of the species. According to Hustedt (1930) there are 10—12 striae in 10 μm, but Patrick and Reimer (1975) give for *G. montanum* Schum. var. *montanum* (syn. *G. longiceps* var. *montana*) 9—12 striae in 10 μm.

*Gomphonema olivaceum* (Lyngb.) Kütz.; Hustedt (1930); fig. 12

Cell dimensions: 11—30 × 4.4—6.2 μm, 10—14 striae in 10 μm. The cells are small. According to Hustedt (1930), Siemińska (1964), Patrick and Reimer (1975) the length of the cells is 15—40 μm, and their width 5—10 μm.

*Navicula contenta* Grun.; Hustedt (1930); fig. 13

Cell dimensions: 8.8—18.7 × 3.3—4.5 μm, striae are very fine, probably about 30 in 10 μm. Some cells are longer and wider in comparison with the diagnosis of this species. According to Hustedt (1930), Siemińska (1964) the length is 7—15 μm, and the width 2—3 μm.

*Navicula cryptocephala* Kütz.; Hustedt (1930); fig. 14

Cell dimensions: 19.7—33 × 5.5—6.6 μm, 14—18 striae in 10 μm. Some cells have less striae in 10 μm than indicated by the diagnosis of the species. According to Hustedt (1930), Siemińska (1964), Cleve-Euler (1953b, syn. *N. cryptocephala α genuina*), Patrick and Reimer (1966) the cells have at least 16 striae in 10 μm.

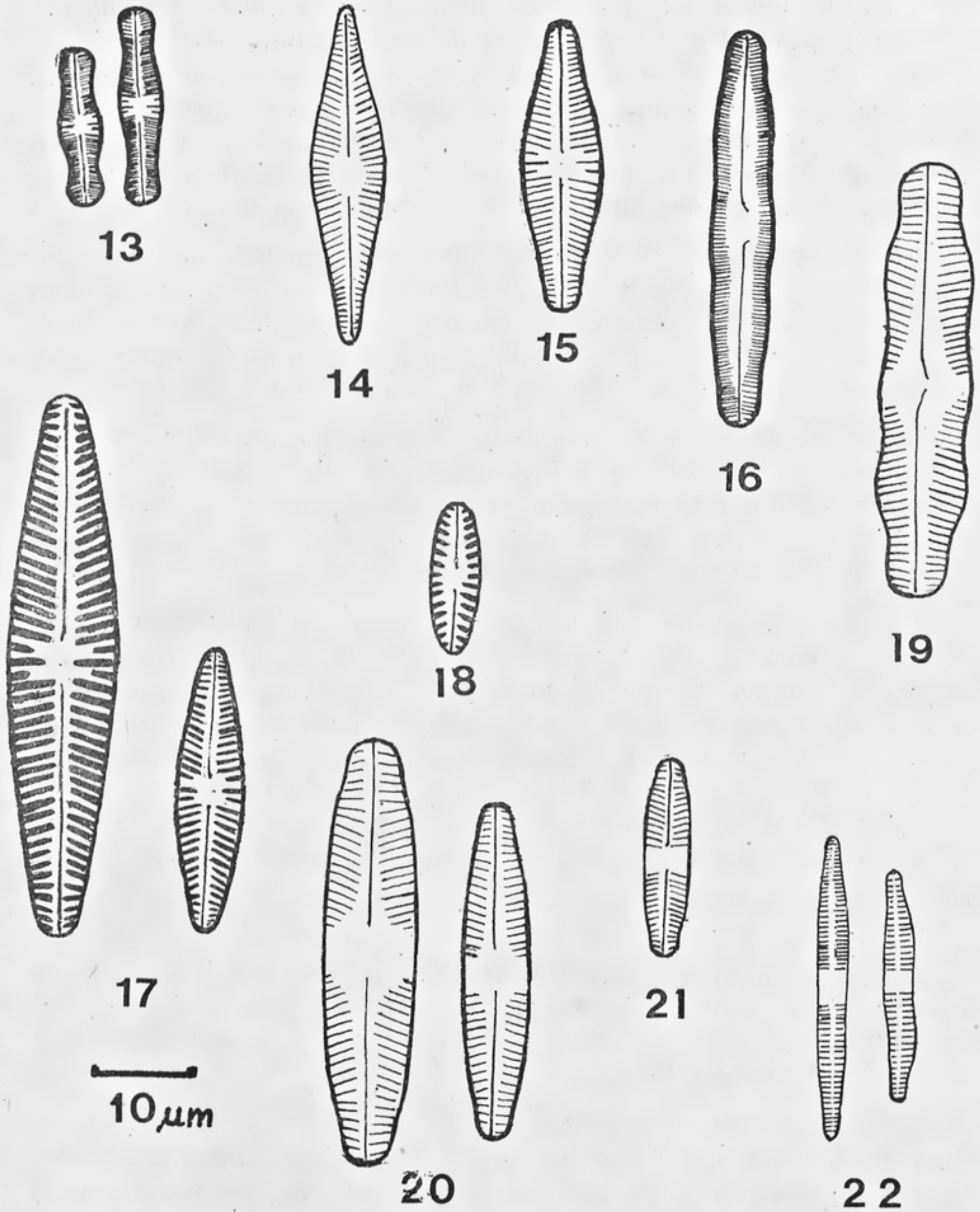
*Navicula* cf. *laterostrata*; fig. 15

Cell dimensions: 26.4—36.2 × 6.6—8.7 μm, throughout the length of cells 12—15 striae in 10 μm.

The cells are similar to *N. laterostrata* Hust., yet their dimensions are not in line with the diagnosis of the species. According to Hustedt (1930), Siemińska (1964), Patrick and Reimer (1966) the length of the cell is 20—30 μm, and its width 8—10 μm; in the middle of the cell there are 15 striae in 10 μm, and near the ends more than 20 striae in 10 μm. Cleve-Euler (1953b) enlarged the range of cell dimensions for *N. laterostrata* (syn. *N. inflata β laterostrata*): 19—32 × × 6—10 μm. Further, he gives 15—19 striae in 10 μm in the centre of the cells and 22—26 near the ends.

*Navicula levanderi* Hust. var. *tatrensis* Bilý et Marvan; Siemińska (1964); fig. 16

Cell dimensions: 25—48.7 × 4.4—6.2 μm, 18—24 striae in 10 μm. Some cells differ from the diagnosis of the species. According to Siemińska (1964) the length is 28—45 μm, the width 4.5—6.5 μm, and there are 20—24 striae in 10 μm.




Figs 13—22. Species of algae: 13 — *Navicula contenta;* 14 — *N. cryptocephala;* 15 — *Navicula* cf. *laterostrata;* 16 — *N. levanderi* var. *tatrensis;* 17 — *N. viridula;* 18 — *Pinnularia Balfouriana;* 19 — *P. mesolepta;* 20 — *P. microstauron;* 21 — *P. subcapitata;* 22 — *Synedra* cf. *minuscula*

*Navicula viridula* (Kütz.) Kütz. emend. V.H. var. *avenacea* (Bréb. et Grun.) V.H.; Patrick and Reimer (1966); fig. 17

Cell dimensions: 33—62.5 × 6.2—12.5 µm, 8—12 striae in 10 µm. Some cells are too long and too narrow, and they have a smaller number of striae in 10 µm than is indicated in the diagnosis of the species. According to Patrick and Reimer (1966) the length is 30—60 µm, and the width 8—10 µm and there are 10—12 striae in 10 µm.

*Pinnularia Balfouriana* Grun.; Siemińska (1964); fig. 18

Cell dimensions: 8.8—16.2 × 3.2—4 µm, 10 striae in 10 µm. In comparison with the description of the species some specimens are too long. According to Hustedt (1930) and Siemińska (1964) their length is 8—12 µm, according to Cleve-Euler (1955) 8—15 µm.

*Pinnularia mesolepta* (Ehr.) W. Sm.; Hustedt (1930); fig. 19

Cell dimensions: 41.8—62.5 × 7.7—12.5 µm, 10—12 striae in 10 µm. Some cells have non-typical width dimensions. According to Hustedt (1930), Siemińska (1964), the width is 9—11 µm, according to Patrick and Reimer (1966) 9—12 µm.

*Pinnularia microstauron* (Ehr.) Cl.; Hustedt (1930); fig. 20

Cell dimensions: 26.2—68.7 ×6.2—11 µm, 10—15 striae in 10 µm. Some cells are too narrow in comparison with the description of the species. According to Hustedt (1930), Siemińska (1964), Patrick and Reimer (1966) the width of cells is 7—11 µm. Yet Starmach (1973) also found (in Tatra Mts) narrow cells of *P. microstauron* (width 5.6—7 µm), Foged (1964) gives a description of *P. microstauron* forme similar to that described above with width 5.3 µm.

*Pinnularia subcapitata* Greg. var. *subcapitata;* Patrick and Reimer (1966); fig. 21

Cells dimensions: 17.5—32.5 × 3.7—5.5 µm, 12—13 striae in 10 µm. Some cells are small. According to Patrick and Reimer (1966) the length of cells is 24—50 µm and their width 4—6 µm.

*Synedra* cf. *minuscula;* fig. 22

Cell dimensions: 13.2—39.6 × 2.2—3.7 µm, 16—20 striae in 10 µm. The central field is present on both sides, and reaches almost to the margin of the valve. The organism lives as epiphyte forming rosette conglomerations on thalli of filaments of other algae.

The shape of the specimens is similar to that of *S. minuscula,* also their dimension only slightly differs from the description by Patrick and Reimer (1966). They differ, however, by the presence of a central field. According to Hustedt (1930), Cleve-Euler (1953a), Siemińska (1964) *S. minuscula* has no central field, or it is marked only by slighter striae. Also according to Patrick and Reimer (1966) usually is no central field and, if it is present, it is small.

### 2.2. Autecology

In this section, the autecological data for 48 species and varieties have been put together. The taxons chosen were stable[1] in ten described communities characteristic for mountain streams (K a w e c k a 1980, fig. 16).

Together with the name of each taxon, the name of the author of its diagnosis is given. Asteriks denote the species whose morphological features differ from the recognized diagnosis and which have been described in the previous chapter. For other species, the cell dimensions are listed in the order: first length, then width.

*Chamaesiphon polonicus* (Ro s t a f.) H a n s g i r g; S t a r m a c h (1966)

Cell dimensions: 5.5—7 × 4.4—5.5 μm.

Altitude: 2600—800 m.

A fairly common species. It is particularly numerous in the outflow of lakes in Tatra Mts and in Rila Mts during the autumn when the level of water is low (K a w e c k a 1980, fig. 2, 14). It is stable in the sector of streams flowing across the forest zone (community VI, pH of 6.2—7.5). Other than in the Tatra Mts *Ch. polonicus* is present in the streams of the Pyrenees Mts (B a c k h a u s 1976), and in the Alps (K a n n 1978). It develops on damp rocks (S t a r m a c h 1929), J a a g (1945; pH of 5.8—7.4).

*Gloeocapsa magma* (B r é b.) H o l l e r b a c h; S t a r m a c h (1966)

Cell diameter: 5.5—8.8 μm, the thickness of cover around the cells about 1 μm.

Altitude: 2750—1600 m.

It is not a common species, while it abounds in Königsbach stream. It is stable in community III at a pH of 6.2.

*G. magma* commonly appears on moist rocks and sometimes in completely dry places (S t a r m a c h 1966). J a a g (1945) includes *G. magma* with *G. ralfsiana* and *G. alpina* in the collective species *G. sanguinea*. The author states that the differences between species mainly concerning the colour of the cover, depend on the environmental conditions (insolation, pH of water) in which this organisms live.

*Homoeothrix janthina* (B o r n e t et F l a h a u l t) S t a r m a c h; S t a r m a c h (1966)

Width of filaments by the base 2.2 μm, in the middle 1.5—2.2 μm.

Altitude: 2750—800 m.

This species is widely distributed, and particularly abundant in the

[1] Stable species — occurring in 70—100% the investigated samples.

sector of the streams flowing across the forest zone, but it has not been found in the forest zone of Arpasul stream. In the High Tatra Mts it develops in abundance throughout the year. According to Backhaus (1968a) it belongs to organisms of low periodicity. It is stable in unpolluted as well as polluted environments (communities III, V, VI, VIII, IX) at a pH of 6.2—7.8. This species is found almost in all the Tatra Mts streams on granite and limestone base (Starmach 1959). Backhaus (1968b) states that the species is characteristic of the oligotrophic acid and fast flowing streams.

*Phormidium favosum* (Bory) Gomont; Starmach (1966)

Cell dimensions: 5 × 2.5 μm.

Altitude: 2750—800 m.

It is a widely distributed species with no clear periodicity during the year. It is stable in unpolluted as well as in polluted environments (communities III, V, VIII—X) at a pH of 6.2—7.8.

This species lives in several types of waters. It is common in running water (Starmach 1966), on moist soil, in puddles, on the banks of eutrophic water reservoirs (Behre, Schwabe 1970), and on moist rocks (Jaag 1945).

The best development is reached in the polluted environment of Rybi Potok stream at a pH of 6.4—6.9. One can find it at a pH of 6.5—7.5 (Geitler, Ruttner 1935/1936), at a pH of 5.7—7.9 (Jaag 1945). It belongs to saprophilous organisms (Fjerdingstad 1965).

*Hydrurus foetidus* (Villars) Trevisan; Starmach (1968)

Altitude: 2750—600 m.

It is frequent both in streams flowing out from mountain lakes and in glacial streams. It is stable in glacial streams as well as in the area of streams flowing through the forest zone (communities I, IV—VI, X). Morphologically the thalli of *Hydrurus foetidus* vary. Most often it forms a gelatinous cover on stones. In rapids the thalli are short; in the parts of streams with a slow current they reach up to 1 m in length. Backhaus (1968c) observes that the thalli assume the form of gelatinous lines when the current is 1 m/second. Czosnowski (1951) observes a shortening of the thalli when the speed of the current increases. McIntire (1966) writes about the effect of the current speed on the character of the thalli of the algae. When the current is swift the algae form felt-like agglomerations; when the current is slow they have long filaments.

*Hydrurus foetidus* needs good and long illumination (Hovasse, Joyon 1960). Most probably its mass development in Lapland streams during the summer is due to the stimulating action of light (the day lasts about 18 hours there). On the other hand, Squires et al. (1973) found *H. foetidus* also in ice covered streams.

*Hydrurus foetidus* belongs to stenothermic cold water organisms. The optimal development is reached at a temperature of 2—12°C (Bursa 1934). In the streams examined it develops best at a temperature of 0.2—13.3°C. Maximum development during the winter and spring is probably also connected with temperature. According to Backhaus (1968a) *H. foetidus* belongs to organisms with strong periodicity; it obtains maximum development in March and April.

*Hydrurus foetidus* does not survive drying up (Kann 1978). It is possible that its absence in parts of Tatra's streams below their outflows of the lakes, is connected with the drying up and freezing of this area.

Backhaus (1968b) includes *Hydrurus foetidus* in the group of organisms typical of oligotrophic and acid waters. In the streams investigated the negative effect of domestic sewage on its development has not been observed. It develops well e.g. in the polluted Finstertaler-Bach stream (Kawecka 1980, fig. 13). The absence of *H. foetidus* in the Rybi Potok stream below the sewage outflow is not the result of pollution, but is rather due to silty sediments on the bottom of the stream in this sector. It does not develop well on the silty mountain platform in the course of Arpasul stream (station 3) and in Finstertaler-Bach (station 1 and 2), or in Maljovica stream (station 3) (Kawecka 1980, figs. 9, 13, 14).

Present investigations show that *Hydrurus foetidus* develops best at a pH of 6.2—6.8. Wasylik (1971) found it in the West Tatra Mts at a pH of 6.9—8.1. According to Hovasse, Joyon (1966) it occurs mostly in acid water at a pH of 5—6.5, but it can also develop in streams based on limestone.

*Achnanthes ilexella* (Kütz.) Brun.; Hustedt (1933)

Cell dimensions: 20—32.5 × 10—17.5 μm, 22 striae in 10 μm on both valves.

Altitude: 2600—980 m.

It occurs sporadically, most frequently in streams of Rila Mts and Fagaras Mts. It is stable in Rybi Potok stream in the zone of final mineralization of sewage (community IX; pH of 6.6—7.8). It is also a stable species in pelorheophilous communities (Kawecka 1980, Table IV).

Optimum pH of about 6 (Cholnoky 1968), it occurs en masse at a pH of 6.3—7 (Hustedt 1944), pH indifferent (Foget 1964).

* *Achnanthes kryophila* Peters.; Cleve-Euler (1953b)

Altitude: 2750—550 m.

The species is widely distributed but not numerous. It is stable in communities II—IV, VI—X at pH of 5.4—8.5.

H u s t e d t (1944) describes it as a boreo-alpine species and S i e m i ń s k a (1964) as a nord-mountain species.

For normal development it requires a constant and high concentration of oxygen and pH below 7 (Ch o l n o k y 1968). F o g e d (1964) states that it is pH — indifferent.

*Achanthes lanceolata* (B r é b.) G r u n.; H u s t e d t (1933)

Cell dimensions: 11—22 × 5.5—6.6 μm, 13—14 striae in 10 μm on both valves.

Altitude: 2750—550 m.

This is a common and abundant species. It develops throughout the year with a tendency to increase in number in the summer. C h u d y b a (1965) observes its maximum development in the autumn (IX—XI). According to B a c k h a u s (1968a) *A. lanceolata* belongs to a group of organisms with middle periodicity. F r i e d r i c h (1973) does not observe a distinct maximum of abundance during the year, yet he supposes that it can be described as summer species.

*A. lanceolata* favours unpolluted water (S c h o e m a n 1973). It is common in mountain streams (B a c k h a u s 1968c, W a s y l i k 1971, W a r d 1979), and is one of the most common species of spring area of European streams (S c h m i t z 1961).

It is stable in the low parts of the streams and in the sector directly below the outflow of domestic sewage (community VII, VIII). It is found in polluted environments (S c h r o e d e r 1939, W e h r l e 1942, S ö r e n s e n 1948), in water with a relatively high amount of mineral matter and a rather low amount of organic compounds (B a c k h a u s 1968b).

It is stable at a pH of 6.5—8.5 and reaches the highest abundance in Olczyski stream at a pH of 7.4 and calcium content 16.44—20.1 mg/l Ca (P a s t e r n a k unpublished). According to H u s t e d t (1957), J ø r g e n s e n (1948) it belongs to alkaliphilous species. It favours neutral to slightly alkaline waters (S c h o e m a n 1973). It lives at a pH of 6.9—8.5 (W e h r l e 1942). It obtains its optimum development at a pH of 7.2—7.5 (C h o l n o k y 1968), and at a pH of 6.3—8.2 (S c h e e l e 1952).

*Achnanthes minutissima* K ü t z.; H u s t e d t (1933);
*Achnanthes microcephala* (K ü t z.) G r u n.; H u s t e d t (1933)

Cell dimensions: *A. minutissima* — 12—17.5 × 2.2—3.3 μm, striae very delicate, about 30 in 10 μm on both valves. *A. microcephala* — 15.4—20 × 2.2—3 μm, striae very delicate, about 30 in 10 μm on both valves.

Altitude: 2750—550 m.

Both species are the most common and abundant. They are stable in community II—X and in all habitats examined. They conglomerate on mosses and in muddy sediments (K a w e c k a 1980, Tables III, IV).

*A. minutissima* is often found in mountain streams, e.g. in the West Tatra Mts (Wasylik 1971), in the Schwarzwald Mts (Backhaus 1968c), and in the Pyrenees (Besch et al. 1972a).

Both species develop throughout the year with a tendency to increase in number during the winter and spring seasons. Wasylik (1965) found the maximum development of *A. minutissima* in spring, Backhaus (1968a) in spring and in summer (May, August).

It seems that *A. minutissima* is more sensitive to pollution than *A. microcephala*. In the streams examined *A. minutissima* shows a tendency to decrease in number below the outflow of sewage. Backhaus (1968c) did not find any *A. minutissima* in the polluted sector of the streams, and Besch et al. (1972b) noted it only sporadically. On the other hand, *A. microcephala* is a species characteristic of unpolluted (Venkatesvarlu 1970) as well as polluted water (Besch et al. 1972b).

Both species prefer oxygen-rich water; *A. minutissima* is known as an indicator of waters rich in oxygen (Cholnoky 1968, Archibald 1971, Schoeman 1976).

Both species are stable and abundant at a pH of 5.4—8.5. *A. minutissima* develops en masse at a pH of 6.2—7 (Hustedt 1944), it is frequent at a pH of 7.2—7.4 (Hustedt 1943), also at a pH of 6.3—8.2 (Sheele 1952), it is indifferent to pH (Jørgensen 1948, Backhaus 1968b). *A. microcephala* reaches its maximum at a pH of 6.4—6.6 (Cholnoky 1968).

*Anomoeoneis exilis* (Kütz.) Cl.; Hustedt (1959)

Cell dimensions: 18.7—24.2 × 4.4 μm, c. 32 striae in 10 μm.

Altitude: 2750—550 m.

It appears sporadically mostly in the streams of the Tatra Mts, and the Alps. It is stable in the sector of streams polluted with domestic sewage (communities VIII, IX) and in the Finstertaler-Bach stream at the time when the lake (from which it flows) was experimentally fertilized (community X); pH range from 6.2—7.8.

It develops en masse at a pH of 6.8—9 (Hustedt 1944), reaching an optimum development at a pH of 6.7—7 (Cholnoky 1966, Archibald 1971); alkaliphilous species (Niessen 1956, Hustedt 1957, Schoeman 1973).

*Anomoeoneis serians* (Bréb. ex Kütz.) Cl. var *brachysira* (Bréb. ex Kütz.) Hust.; Patrick and Reimer (1966)

Cell dimensions: 13.7—28.4 × 5—7.1 μm, 25—30 striae in 10 μm.

Altitude: 2750—550 m.

This variety is widely distributed, but nor numerous. It is stable in the outflow of lakes (community II), and in the Finstertaler-Bach stream flowing from the experimentally fertilized lake (community X); pH of 5.4—6.8.

It develops well at a pH of 6—7 (Niessen 1956), and en masse at a pH of 6—6.8 (Hustedt 1944); acidophilous species (Jørgensen 1948, Foged 1964).

*Ceratoneis arcus* Kütz.; Hustedt (1932)

Cell dimensions: 27.5—100 × 5—5.5 μm, 15—16 striae in 10 μm.

Altitude: 2750—550 m.

This species is widely distributed and numerous. It is stable in communities II—X, and in all habitats; in thalli of Hydrurus foetidus it forms concentrations of cells (Kawecka 1980 Tables III, IV).

It develops all the year round with a tendency to increase during winter and spring. Wasylik (1971) does not observe distinctive quantitative variations during the year; according to Squires et al. (1973) it is a species of late spring and early summer, according to Scheele (1952) the maximum development takes place during the late spring.

The enrichment of the environment in biogene compounds stimulates its development, that is the reason a large number were observed in the experimentally fertilized Finstertaler-Bach stream and in the Rybi Potok stream in the zone of self-purification (Kawecka 1980, figs 2, 13).

It develops best at a pH of 6.2—6.8 (community X). It is numerous at a pH of 7.2—8 (Scheele 1952), pH optimum at a pH of about 7, probably at a pH of 7.2—7.3 (Cholnoky 1968).

*Cocconeis placentula* Ehr.; Hustedt (1933);
*Cocconeis placentula* Ehr. var. *euglypta* (Ehr.) Cl.; Hustedt (1933)

Cell dimensions: *Cocconeis placentula* — 28.4—34 × 17.7—32 μm, 23 striae in 10 μm on both valves. *Cocconeis placentula* var. *euglypta* — 13.2—33 × 7.7—16.5 μm, on the raphe valve 23 striae in 10 μm, on the pseudoraphe valve 19 striae in 10 μm.

Altitude: 2750—550 m.

The species and variety are widely distributed and they appear in similar habits which indicates similar ecological needs. They develop in great numbers throughout the year. Wasylik (1971) does not see, either in *C. placentula* var. *euglypta* any distinctive quantitative change during the year. The maximum development in summer was observed in *C. placentula* by Butcher (1932), Chudyba (1965 — Juni, August), Squires et al. (1973 — August), and in autumn by Raabe (1951).

The species and variety are stable in streams unpolluted (communities IV—VII) as well as in polluted waters in final phase of self-purification (community IX). According to Schoeman (1973) *C. placen-*

*tula* prefers oligotrophic water, it appears also in oligo- to β-mesosaprobic water (Friedrich 1973). Butcher (1947) finds *C. placentula* var. *euglypta* in the final self-purification zone of the streams, and according to Wehrle (1942) it is resistant to pollution.

They are most frequently at a pH of 6.2—7.2 (community IV). According to Jørgensen (1948), Scheele (1956), Hustedt (1957), Schoeman (1973) *C. placentula* prefers alkaline waters. It develops en masse at a pH of 7.2—7.4 (Hustedt 1943), is numerous at a pH of 7.8—8.5 (Scheele 1952), and at a pH of 8 (Cholnoky 1968), it is pH — indifferent (Foged 1964).

* *Cymbella cesati* (Rabh.) Grun. ex A. S. var. *cesatii;* Patrick and Reimer (1975)

Altitude: 2750—1100 m.

The species is widely distributed, but not numerous. It is stable in the stream polluted with domestic sewage, and in the Finstertaler-Bach stream flow from the experimental fertilized lake (community VIII, X); pH range from 6.2—6.9.

It appears en masse at a pH of 6.7—7.2 (Hustedt 1943), its optimum development is at a pH of about 6 (Cholnoky 1968), indifferent to pH (Jørgensen 1948, Foged 1964).

* *Cymbella sinuata* Greg. var. *sinuata;* Patrick and Reimer (1975)

Altitude: 2750—550 m.

It is widely distributed. It is stable both in unpolluted and polluted streams (communities V, VII, VIII). It appears numerous in low parts of the streams (community VII, pH of 7.2—8.5) especially in Arpasul stream.

*C. sinuata* develops optimally at a pH of about or above 8 (Cholnoky 1968), it is numerous at a pH of 6.8—8.2 (Scheele 1952), indifferent to pH (Hustedt 1957, Foged 1964).

* *Cymbella ventricosa* Kütz.; Hustedt (1930)

Altitude: 2750—550 m.

It is widely distributed, and belongs to the group of the most abundant species. It is stable in communities II—X, and develops all year round with a tendency to reach a maximum of abundance during winter and spring. Similarly Scheele (1952) observes the maximum development in winter.

*C. ventricosa* has a wide ecological spectrum. It develops numerous in unpolluted streams, but below the outflow of sewage number of cells distinctly increase. It lives in oligotrophic waters (Cholnoky 1970b), and belong to indicators of oxygen rich and poor in mineral compounds waters (Schoeman 1976). On the other hand it is a species typical of small current streams with high amount of mineral, and decay organic matter, but with relative high oxygen saturation (Backhaus 1968b).

*C. ventricosa* is most abundant in the polluted sector of the streams (community VIII) at a pH of 6.5—6.9. It is numerous at a pH of 6.8—7.2 (Hustedt 1943), also at a pH of 6.5—8.2 (Scheele 1952), develops optimally at a pH of 7.7—7.8, but it is able to survive fluctuations of pH of water to slightly acid (Cholnoky 1968). It is indifferent to pH (Jørgensen 1948, Scheele 1956, Hustedt 1957, Foged 1964).

*C. ventricosa* is resistant to toxic substances. It appears at concentrations of 3.9 mg/l $H_2S$, and 2.1 mg/l Cu (Schroeder 1939).

In the High Tatra Mts it developed in great numbers on the moist mosses at altitude about 1700 m. Behre and Schwabe (1970) found it to be the most abundant species in the new environment of the volcanic island Surtsey.

*Denticula tenuis* Kütz. var. *crassula* (Näg.) Hust.; Hustedt (1930)

Cell dimensions: 12.5—23 × 3.3—5.5 μm, 7 striae in 10 μm.

Altitude: 1960—800 m.

This variety is widely distributed, but not abundant. It is stable in the polluted parts of the streams (communities VIII, IX) at a pH of 6.5—7.8.

It develops optimally at a pH of about or above 8 (Cholnoky 1968), alkalibiontic (Foged 1964).

*Diatoma hiemale* (Lyngb.) Heib.; Hustedt (1931)
*Diatoma hiemale* (Lyngb.) Heib. var. *mesodon* (Ehr.) Grun.; Hustedt (1931)

Cell dimensions: *D. hiemale* 30—100 × 7—12 μm, 2—4 striae in 10 μm. *D. hiemale* var. *mesodon* 12.5—27.5 × 7.5—11 μm, 2—4 striae in 10 μm.

Altitude: 2750—550 m.

This species and variety are widely distributed. They are stable in communities II—X, and also in all the examined habitats: in the thalli of *Hydrurus foetidus* they often form conglomerations of cells (Kawecka 1980, Tables III, IV). They are most numerous in the Königs-Bach stream (community III), and in the sector of streams flowing across a forest zone (community IV).

According to Schmitz (1961) *D. hiemale* var. *mesodon* is one of the most common species in the spring areas of European streams. Siemińska (1964) calls *D. hiemale* a nord-mountain, cold-water species.

This species and variety reach their maximum development during the winter and spring season (XI—VI; water temperature 5.5—13.3°C.

Wasylik (1965) observes maximum development in spring, also Backhaus (1968c) calls the variety a spring species.

In the polluted sector of Rybi Potok stream the species and variety appear sporadically; this can be linked with a negative reaction to sewage. However, in the Finstertaler-Bach stream below the outflow of sewage the number of cells increased (Kawecka 1980, fig. 13B). According to Backhaus (1968b) *D. hiemale* var. *mesodon* belongs to oligotrophic species.

In the examined stream they obtain their maximum at a pH of 6.2—7.2. *D. hiemale* is numerous at a pH of 6.3—8.2 (Scheele 1952), develops optimally at a pH below 7 (Cholnoky 1968). Backhaus (1968c) observes maximum development at a pH of 6.2—6.8.

*Eunotia pectinalis* (O. F. Müll.?) Rabh. var *pectinalis;* Patrick and Reimer (1966)

Cell dimensions: 21.3—95.5 × 4—7.7 μm, 10—14 striae in 10 μm. In side-on view cells are rectangular.

In the streams of Tatra Mts, Alps, and in Fagaras Mts the specimens were often small, and in the stream of Rila Mts and in Kebnekaise Mts they were large from 52.5 μm in length.

Altitude: 2750—980 m.

The species is widely distributed, but not numerous. It is stable in Finstertaler-Bach stream at the time of experimental fertilization of the lake (community X); pH of 6.2—6.8. It develops optimally at a pH of 6.5. (Backhaus 1968c, Cholnoky 1968), acidophilous (Jørgensen 1948).

* *Eunotia pectinalis* (Dillw.? Kütz.) Rabh. var. *minor* (Kütz.) Rabh.; Hustedt (1932)

Altitude: 2750—650 m.

This species is widely distributed but not numerous. It is stable in polluted streams community VIII); pH of 6.5—6.9.

It appears in acid and neutral waters and is tolerant of larger amounts of calcium than other species of *Eunotia* genus (Patrick, Reimer 1966); acidophilous (Hustedt 1957, Jørgensen 1948).

* *Fragilaria capucina* Desm.; Hustedt (1931)

Altitude: 2750—980 m.

This species is widely distributed and relatively common. It develops abundantly all year round with a tendency to increase in number in the autumn-period. Chudyba (1965) noted the maximum development of the species in March, April, and at the beginning of May, and Rice (1938) in the summer. It is a stable species in both unpolluted and polluted streams (communities III, VI, VIII—X), and also in phytorheophilous communities (filaments of *Chlorophyta;* K a w e c k a 1980, Table IV).

It is most numerous in Rybi Potok stream in the area of the final stage of self-purification (community IX); pH of 6.6—7.8.

It develops optimally at a pH of 7.4—7.8 (C h o l n o k y 1968); alkaliphilous (J ø r g e n s e n 1948).

*Fragilaria crotonensis* K i t t.; H u s t e d t (1931)

Cell dimensions: 5.5—11 × 2.2—3.3 μm, 12 striae in 10 μm.

This planktonic organism flows down to the streams from lakes, and hence is fairly frequent below the outflow of the lakes. During the year it does not show periodicity. S q u i r e s et al. (1973) observe its quantitative maximum in October.

It is stable in Rybi Potok stream in the final stage of self-purification of sewage (community IX); pH of 6.6—7.8. According to C h o l n o k y (1968) optimum pH of about 8; according to F o g e d (1964), J ø r g e n s e n (1948) it is an alkaliphilous species.

*Fragilaria pinnata* E h r.; H u s t e d t (1931)

Cell dimensions: 5.5—11 × 2.2—3.3 μm, 12 striae in 10 μm. A widely distributed but not numerous species. It is stable below the outflow of the lakes (community II); perhaps this is connected with the well developed moss communities in such areas. B e h r e and S c h w a b e (1970) also suggest that development of *F. pinnata* in the volcanic island Surtsey is connected with the bryophilous character of this species. According to C h o l n o k y (1968) this species is widely distributed, but reaches its optimum only in well aerated waters, therefore being among the best indicator of such conditions.

It is stable at a pH of 5.4—7.2. Optimum development at a pH of 7.6—7.8 (C h o l n o k y 1968); alkaliphilous (J ø r g e n s e n 1948, F o g e d 1964, H u s t e d t 1957).

*Fragilaria vaucheriae* (K ü t z.) P e t e r s. var. *vaucheriae;* P a t r i c k and R e i m e r (1966)

Syn: *Synedra vaucheriae, Fragilaria intermedia* (K a w e c k a 1965), 1971, 1977), *Synedra vaucheriae* (K a w e c k a 1974b).

Cell dimensions: 20—31.9 × 2.2—4.4 μm, 12—16 striae in 10 μm.

Altitude: 2070—550 m.

The species is locally distributed, mainly in Tatra Mts, and Fagaras Mts and not abundant. It is stable in the lower part of streams (community VII); pH of 7.2—8.5.

It is one of the most characteristic species in moderate alkaline oxygen-rich waters; optimum pH a little above 7 (C h o l n o k y 1968), it occurs at a pH of 7—7.8 (S c h o e m a n 1973).

* *Frustulia rhomboides* (Ehr.) De Toni var. *saxonica* (Rabh.) De Toni; Hustedt (1937)

Altitude: 2750—1100 m.

This variety is widely distributed but limited in number. It is stable in the upper course of streams (community II), and in Finstertaler-Bach stream at the period of experimental fertilization of the lake (community X); pH ranged from 5.4—7.2.

Optimal development at a pH about or below 6 (Cholnoky 1968), it develops en masse at a pH of 5—6 (Niessen 1956); acidophilous (Jørgensen 1948, Foged 1964).

*Gomphonema angustatum* (Kütz.) Rabh.; Hustedt (1930)

Cell dimensions: 22.4—35 × 6.4—7 µm, 10—11 striae in 10 µm.

Altitude: 2750—550 m.

It is widely distributed but not abundant species. It is stable in the sector of streams flowing across forest zones (community V); pH of 6.2—7.2, and in pelorheophilous community (Kawecka 1980, Table IV).

This species is very common at a pH of 6.3—6.8 (Hustedt 1944), also at a pH of 6.5—8.2 (Scheele 1952), optimum at a pH of 7.5—7.7 (Cholnoky 1968), alkaliphilous (Jørgensen 1948, Foged 1964).

*Gomphonema gracile* Ehr.; Hustedt (1930)

Cell dimensions: 22.4—59.4 × 5—11 µm, 9—11 striae in 10 µm.

Altitude: 2750—1000 m.

This species is not common, it mostly occurs in the Alps and in Rila Mts. It is stable in Finstertaler-Bach stream at the time of experimental fertilization of the lake (community X); pH of 6.2—6.8.

It develops optimally at a pH of 7.2—7.4 (Cholnoky 1968). It tolerates a wide spectrum of pH of the water (Patrick, Reimer 1975), pH indifferent (Jørgensen 1948, Hustedt 1957, Foged 1964).

* *Gomphonema intricatum* Kütz. var. *pumilum* Grun.; Siemińska (1964)

Altitude: 2220—550 m.

This variety is widely distributed; it develops throughout the year and does not show any specific increase in quantity. It is stable in lower parts of the streams (community VII) at a pH of 7.2—8.5, where at the same time it is numerous.

It develops optimally at a pH of 7.2—7.3 (Cholnoky 1968); alkalophilous (Jørgensen 1948). Its occurrence in large numbers indicates that waters are rich in oxygen and poor in nitrogen (Schoeman 1976).

* *Gomphonema longiceps* Ehr. var. *montana* (Schum.) Cl.; Hustedt (1930)

Altitude: 2600—550 m.

This variety is widely distributed but not numerous. It is stable in Rybi Potok stream in the zone of self-purification (community IX); pH of 6.6—7.8.

According to Cholnoky (1968) it develops optimally at a pH of 7—7.5, it is indifferent to pH of water (Foged 1964).

*Gomphonema parvulum* Kütz.; Hustedt (1930)

Cell dimensions: 18.7—31.9 × 5—6.8 μm, 13—16 striae in 10 μm.

Altitude: 2750—1000 m.

The species is widely distributed, but not abundant.

*G. parvulum* has a wide ecological spectrum. It is stable in unpolluted as well as in polluted parts of the stream (communities III, VIII, X); pH of 6.2—6.9. Cholnoky (1970a) finds this species in the waters oligo- to mesotrophic. Its abundant development is an indicator of pollution (Cholnoky 1968). It belongs to facultative nitrogen heterotrophic species (Schoeman 1976, Cholnoky 1968).

*G. parvulum* is resistant to toxic pollution (Backhaus 1968c); it appears when the concentration of copper is 1.5 mg/l Cu (Schroeder 1939).

This species is an indicator of an environment where fluctuation of nitrogen takes place (Schoeman 1976). It is able to tolerate slight variations of osmotic pressure, and large fluctuations in pH of water (optimum at a pH of 7.8—8.2), as well as to stand diminution of oxygen (Cholnoky 1968).

*Melosira distans* (Ehr.) Kütz. var. *alpigena* Grun.; Hustedt (1930)

Cell dimensions: diameter of valve 5.5 μm, height of valve 5.6—7.5 μm, 15—16 striae in 10 μm.

Altitude: 2750—1000 m.

This variety is widely distributed but not numerous. It develops the whole year round with a tendency to increase in number during the autumn-winter period. It is stable in polluted streams (communities VIII, IX) at a pH of 6.5—7.8.

It inhibits slightly acid waters (Cholnoky 1968); alkaliphilous (Foged 1964), abundant at a pH of 6.3—8.2 (Scheele 1952).

*Meridion circulare* Ag.; Hustedt (1930)

Cell dimensions: 15—42.5 × 4.4—5.5 μm, 15 striae in 10 μm.

Altitude: 2600—550 m.

This species is widely distributed, but not numerous although the conditions seem suitable for its development. *M. circulare* is a cold water organism. It develops best at a temperature below 15°C (Whitford, Schumacher 1963). It likes well aerated waters (Cholnoky 1968). It is rheobiont (Foged 1948) relatively indifferent to water current (McIntire 1968). It is worth mentioning that *M. circulare* belongs to a group of diatoms which are most numerous in the area of springs of European streams (Schmitz 1961).

Fjerdingstad (1965) includes *M. circulare* into saproxenic species, however, Backhaus (1968c) finds it both unpolluted and polluted environments.

It is stable in the middle and lower sectors of the stream (communities IV—VII) at a pH of 6.2—8.5. Optimum development at a pH of about 8 (Cholnoky 1968), it is numerous at a pH of 6.3—8.2 (Scheele 1952); alkaliphilous (Jørgensen 1948, Foged 1964).

* *Navicula cryptocephala* Kütz.; Hustedt (1930)

Altitude: 2750—550 m.

This species is widely distributed but not numerous. It develops throughout the year with a tendency to increase in numbers in autumn. Wasylik (1971) notes its maximum development in summer-autumn period (August—September).

It is stable in the lower part of streams and in polluted environments (communities VII, VIII, IX), as well as in a pelorheophilous community (Kawecka 1980, Table IV).

This species is able to tolerate many ecological factors (Archibald 1971). It is a fresh-water species (Cholnoky 1970a), but it can well withstand moderate fluctuations of osmotic pressure (Cholnoky 1968). *N. cryptocephala* does not belong to heterotrophic species, but can live in strongly autrophic conditions (Cholnoky 1968). It also tolerates toxic substances in the environment (Cholnoky 1970a, Wehre 1942). Besides, it is an organism characteristic of the soil habitat (Brendemühl 1948).

It is most abundant at a pH of 6.5—6.9. It appears in all kinds of water, especially in neutral to alkaline (Hustedt 1943). The species is common at a pH of 3—8.5 (Wehrle 1942), and 6.3—8.2 (Scheele 1952). It develops optimally at a pH about or little below 8 (Cholnoky 1970a); alkalophilous (Jørgensen 1948, Scheele 1956, Foged 1964).

*Navicula perpusilla* Grun.; Hustedt (1930)

Cell dimensions: 10—20 × 3—5 μm, about 36 striae in 10 μm; in the central part of cell they are thinner.

Altitude: 2750—850 m.

This species is widely distributed but not numerous. It is stable in

Königs-Bach stream (community III) at a pH of 6.2. Optimum development at a pH of 5.5 and 6 (Cholnoky 1968), indifferent to pH of water (Hustedt 1957).

*Nitzschia dissipata* (Kütz.) Grun; Hustedt (1930)

Cell dimensions: 24.8—35 × 3.6—5 μm, 8 keelpunctae in 10 μm.

Altitude: 2750—550 m.

It is widely distributed but does not occur in large numbers. It is stable in lower parts of the streams (community VII) at a pH of 7.2—8.5.

It is frequent at a pH of 6.9—8.2 (Scheele 1952), it reaches its optimum development at a pH about or a little below 8 (Cholnoky 1968); alkalibiontic (Jørgensen 1948); alkalophilous (Hustedt 1957, Foged 1964). It can not stand fluctuations of osmotic pressure or changes of pH of water (Cholnoky 1968).

It is an indicator of waters rich in oxygen and poor in nitrogen compounds (Schoeman 1976). It seems that the development of *Nitzschia dissipata* is inhibited by high amounts of organic phosphate (Bahls 1973).

*Nitzschia linearis* W. Sm.; Hustedt (1930)

Cell dimensions: 85.8—101.2 × 5—5.5 μm, 10 keelpunctae in 10 μm.

Altitude: 1900—550 m.

This species occurs in small numbers, mainly in the lower parts of the streams where also it is stable (community VII); pH of 7.2—8.5.

It develops en masse at a pH of 6.5 (Starmach 1969) it is frequent at a pH of 6.8—8.2 (Scheele 1952), develops optimally at a pH of 7.8 (Cholnoky 1968); alkaliphilous (Jørgensen 1948).

*Nitzschia palea* (Kütz.) W. Sm.; Hustedt (1930)

Cell dimensions: 25.6—62.5 × 3.3—5 μm, 10—16 keelpunctae in 10 μm.

Altitude: 2750—550 m.

The species is widely distributed. It is stable exclusively in the polluted parts of Rybi Potok stream (community VIII), where it is also numerous. It has a tendency to increase in number in the autumn. Blum (1957), Willem et al. (1972) observe maximal development of the species in summer, Squires et al. (1973) from August to October, Scheele (1952) in autumn and winter. Raabe (1951) observes an even level of its development during the year.

*Nitzschia palea* is characteristic of running waters containing a great quantity of organic matter (Backhaus 1968b, Archibald 1971).

It belongs to obligatory nitrogen heterotrophic species (Cholnoky 1968) and hence *N. palea* is dominant in badly polluted waters rich in nitrogen (Schoeman 1976). Liebmann (1962) includes *N. palea* to the group of α mesosaprobic organisms.

In relation to other ecological factors this species is eurytopic (Cholnoky 1968). It is able, e.g., to stand toxic pollution and occurs in waters containing 3.9 mg/l $H_2S$, or 2.1 mg/l Cu (Schroeder 1939). It is also resistant to chromium (Blum 1957). *N. palea* belongs to one of the most common species of soil algae (Brendemühl 1948).

It is most numerous at a pH of 6.5—6.9. It is also abundant at a pH of 6.5—8.2 (Scheele 1952), reaches optimum at a pH of 8.4 (Cholnoky 1968), indifferent to pH of water (Jørgensen 1948, Hustedt 1957).

*Pinnularia borealis* (Ehr.) Cl.; Hustedt (1930)

Cell dimensions: 30—52.5 × 7.5—8 μm, 5 striae in 10 μm.

Altitude: 2750—1000 m.

It is widely distributed but not numerous. It is stable in the highest parts of the streams (community II) and also in pelorheophilous communities (Kawecka 1980, Table IV).

It belongs to ubiquitous species. It lives in standing and running waters (Hustedt 1943). It also belongs to soil algae (Komaromy 1975, Brendemühl 1948). Bock (1963) reported it from extremely dry locations.

It is stable at a pH of 5.4—7.2. It develops at a pH below 6 (Cholnoky 1968), acidophilous (Jørgensen 1948), indifferent to pH (Hustedt 1957).

* *Pinnularia microstauron* (Ehr.) Cl.; Hustedt (1930)

Altitude: 2750—1000 m.

The species is widely distributed but not abundant. It is stable in the highest parts of the streams (community II) at a pH of 5.4—7.2.

It occurs in acid and alkaline waters (Hustedt 1943), at a pH of 3—8.5 (Wehrle 1942). It is numerous at a pH of 6—7 (Niessen 1943), at a pH of 4.3—6.5 (Jørgensen 1948, Hustedt 1957), develops optimally at a pH a little below 7 (Cholnoky 1968).

It can be found in water where a deficit of oxygen provides a limiting factor for the development of other diatoms (Cholnoky 1968).

* *Pinnularia subcapitata* Greg. var. *subcapitata;* Patrick and Reimer (1966)

Altitude: 2750—600 m.

It is widely distributed but nor abundant species. It is stable in polluted parts of the streams (community VIII) at a pH of 6.5—6.9.

*P. subcapitata* occurs in several habitats. It is acidobiont (Jørgensen 1948), numerous at a pH of 6—7 (Niessen 1956). It develops optimally at a pH of 3.4—4.5 (Wehrle 1942), and also at a pH of 5.5—5.8 (Cholnoky 1968), indifferent to pH (Hustedt 1957). It belongs to soil algae (Komaromy 1975). It is supposed to be adapted to live in hot springs (Cholnoky 1966).

*Synedra ulna* (Nitzsch.) Ehr.; Hustedt (1932)

Cell dimensions: 117.5—200 × 5.5—7.5 μm, 10—12 striae in 10 μm.

Altitude: 1980—550 m.

This species is widely distributed. It develops throughout the year with a tendency to increase in numbers in autumn-winter period (Kawecka 1977). Raabe (1951) noted maximum development in March, April, August and September, Rice (1938) in spring and late summer or autumn, Budde (1928) from May to September, Backhaus (1968a) in June and July, Chudyba (1965) in March, April and at the beginning of May, also from June to August and from September to November. Wasylik (1965) and Willem et al. (1972) notice maximum development in the autumn.

*Synedra ulna* is stable in the lower sector of streams and in Rybi Potok stream polluted with domestic sewage (communities VII—IX).

This species has a wide ecological spectrum (Wehrle 1942). Cholnoky (1968) includes it to the oligotrophic species; Besch et al. (1972b), however, found it also in polluted environments. Friedrich (1973) observed *S. ulna* often in β-mesosaprobic zones of streams and Backhaus (1968c) in poly- and α-mesosaprobic zones. It is also resistant to toxic pollution, it occurs e.g., when the concentration of copper is 1.5 mg/l Cu (Schroeder 1939).

It is most numerous at a pH of 6.6—7.8. It develops en masse at a pH of 7—8.9 (Niessen 1956), frequently at a pH of 7 (Besch et al. 1972b), also at a pH of 6.3—8.2 (Scheele 1952). It develops optimally at a pH of 7.8 (Cholnoky 1968), it is alkalophilous (Foged 1964, Jørgensen 1948), indifferent to pH with a tendency to favour alkaline waters (Hustedt 1957).

*Tabellaria flocculosa* (Roth.) Kütz.; Siemińska (1964)

Cell dimensions: 18.7—74.5 × 3.5—7.5 μm, 13—15 striae in 10 μm.

Altitude: 2750—550 m.

It is a widely distributed species, most abundant in outflow of lakes (community II). It gets there from the lakes where it is common, e.g., in Morskie Oko lake (Kawecka 1966), or in lake Vorderer Finstertaler See (Pechlaner 1967).

It is stable in both unpolluted and polluted parts of the streams (communities II, VIII—X), at a pH of 5.4—7.8.

It develops optimally at a pH of about 5 (Cholnoky 1968), at a pH of 6.2—6.4 (Backhaus 1968c), and at a pH of 4 (Knudsen 1954). It is numerous at a pH of 6.2—7 (Hustedt 1943), and also at a pH of 7—8.5 (Niessen 1956).

The organism is sensitive to environmental pollution: directly below the outflow of sewage one can observe a decreasing number of cells (K a w e c k a 1980, figs 2, 13).

*Cosmarium subcreantum* H a n t z s c h; W e s t (1971a)

Cell dimensions: 25—37.5 × 22.5—32.5 μm, width of isthmus 7.5—12.5, thickness 12.5—21.2 μm.

Altitude: 2500—1050 m.

This species is uncommon, it occurs mainly in Alpine and Tatra Mts streams. It is stable in Finstertaler-Bach stream flowing from the experimental fertilized lake (community X) at a pH of 6.2—6.8. It has a wide ecological spectrum, and develops at a pH of 5—8.4 (W e h r l e 1942).

*Staurastrum punctulatum* B r é b.; W e s t (1971b)

Cell dimensions: 32.5—40 × 25—35 μm, width of isthmus 12.5—13.5 μm.

Altitude: 2600—800 m.

It is widely distributed but not numerous. It is stable in streams polluted with domestic sewage (community VIII), and in Finstertaler--Bach stream flowing from experimental fertilized lake (community X); pH range 6.2—6.8.

It occurs at a pH of 4.5—8.2 (W e h r l e 1942). Optimum development at a pH of 6.9—7.1. It is a species typical of oligotrophic fast flowing waters which contain a small amount of mineral matter and no decay organic one (B a c k h a u s 1968b). It belongs to oligosaprobic species (L i e b m a n n 1962).

*Chlorhormidium rivulare* (K ü t z.) S t a r m a c h; S t a r m a c h (1972)

Cell dimensions: 7.5—18.7 × 5—10 μm.

Altitude: 2400—1400 m.

This species has a limited range in the upper and middle parts of the streams. It appears there on wet stones. It is stable in the sector of streams flowing across forest zone (community VI); pH of 6.2—7.5.

The organism is resistant to toxic pollution; one can find it, e.g., in streams polluted with zinc (S a y et al. 1977).

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## 3. Polish summary

### Glony osiadłe w potokach wysokogórskich Europy

#### 2. Taksonomia i autoekologia

Badania prowadzono w potokach gór Europy: na północy w górach Kebnekaise (Szwedzka Laponia), w części środkowej w Tatrach (Polska), w Alpach (Austria) oraz na południu w górach Fogaraskich (Rumunia) i w górach Riła (Bułgaria).

W badanych potokach spotkano 380 taksonów glonów. Wśród nich główną rolę odgrywały okrzemki, następnie sinice i zielenice (tabela I). Najbogatsze w taksony były potoki: Finstertaler-Bach, Rybi Potok, Potok Maljovica, najuboższe potoki lodowcowe: Tarfalajåkka oraz potok Rotmoos Ache. Zwrócono uwagę na dużą zmienność morfologiczną komórek okrzemek. W populacji jednego gatunku spotykano oprócz komórek typowych formy odbiegające od nich wymiarami długości, szerokości oraz ilością prążków w 10 μm. Najczęściej obserwowano zmniejszenie długości i szerokości komórek.

Na podstawie dokonanych obserwacji oraz danych z literatury przeprowadzono autekologiczną charakterystykę 48 gatunków glonów, które w wyróżnionych 10 zbiorowiskach osiągnęły stałość (Kawecka 1980, ryc. 16). Zwrócono uwagę na reakcję organizmów na temperaturę wody, jej odczyn, dopływ ścieków organicznych itd.

Organizmy mają duże możliwości adaptacyjne do różnorodnych warunków życia. Szczególnie szerokie spektrum życia posiada *Cymbella ventricosa, Gomphonema parvulum, Navicula cryptocephala, Nitzschia palea* i *Synedra ulna.*

## 4. References

Archibald R. E. M., 1971. Diatoms from the Vaal dam catchment area Transvaal, South Africa. Bot. Mar., 14, 17—70.

Backhaus D., 1968a. Ökologische Untersuchungen an den Aufwuchsalgen der obersten Donau und ihrer Quellflüsse. 2. Die räumliche und zeitliche Verteilung der Algen. Arch. Hydrobiol., Suppl. 34, 24—75.

Backhaus D., 1968b. Ökologische Untersuchungen an den Aufwuchsalgen der obersten Donau und ihrer Quellflüsse. 3. Die Algenverteilung und ihre Beziehungen zur Milieuofferte. Arch. Hydrobiol., Suppl. 34, 130—149.

Backhaus D., 1968c. Ökologische Untersuchungen an den Aufwuchsalgen der obersten Donau und ihrer Quellflüsse. 4. Systematisch autökologischer Teil. Arch. Hydrobiol., Suppl. 34, 251—320.

Backhaus D., 1976. Beiträge zur Ökologie der benthischen Algen des Hochgebierges in den Pyrenäen 2. Cyanophyceen und übrige Algengruppen. Int. Rev. ges. Hydrobiol., 61, 471—516.

Bahls L. L., 1973. Diatom community response to primary waste water effluent. J. Wat. Poll. Control Fed., 45, 134—144.

Behre K., G. H. Schwabe, 1970. Auf Surtsey Island im Sommer 1968 nachgewiesene nicht marine Algen. Schr. Naturwiss. Ver. Schlesw. Holst., Sonderbd., 31—100.

Besch W. K., D. Backhaus, J. Capblanco, P. Lavandier, 1972a. Données écologiques sur les algues benthiques de haute montagne dans les Pyrénées. 1. Diatomées. Ann. Limnol., 8, 103—118.

Besch W. K., M. Ricard, R. Cantin, 1972b. Benthic diatoms as indicators of mining pollution in the Northwest Miramichi River system, New Brunswick, Canada. Int. Rev. ges. Hydrobiol., 57, 39—74.

Blum J. L., 1957. An ecological study of the algae of the Saline river, Michigan. Hydrobiol., 9, 361—408.

Bock W., 1963. Diatomeen extrem trockener Standorte. Nova Hedwigia, 5, 199—254.

Bremdemühl I., 1948. Über die Verbreitung der Erddiatomeen. Arch. Microbiol., 14, 407—449.

Budde H., 1928. Die Algenflora des Sauerländischen Gebirgsbaches. Arch. Hydrobiol., 19, 434—520.

Bursa A., 1934. *Hydrurus foetidus* Kirch. in der Polnischen Tatra. 1. Oekologie, Morphologie. Bull. Intern. Acad. Pol. Scie. et Lettres, Cl. Scie. Math.-Nat., B, 69—84.

Butcher R. W., 1932. Studies in the ecology of rivers. 2. The microflora of rivers with special reference to the algae on the river bed. Ann. Bot., 46, 813—861.

Butcher R. W., 1947. Studies in the ecology of rivers. 7. The algae of organically enriched waters. J. Ecol., 35, 186—191.

Carter J. R., 1970. Diatoms from Andora. Nova Hedwigia Beih., 31, 605—632.

Cholnoky B. J., 1966. Diatomenassoziationen aus einigen Quellen in Südwest-Africa und Bechuanaland. Nova Hedwigia Beih., 21, 163—244.

Cholnoky B. J., 1968. Die Ökologie der Diatomeen in Binnengewässern Weinheim, J. Cramer Verl., 699.

Cholnoky B. J., 1970a. Hydrobiologische Untersuchungen in Transvaal. 3. Die Fischteiche von Marble Hall. Bot. Mar., 13, 5—44.

Cholnoky B. J., 1970b. Bacillariophycées des marais du lac Bangweolo — *Bacillariophyceae* from the Bangweulu swamps. Explor. Hydrobiol. Bassin Lac Bangweolo, Lac Luapula, 5, 1, 5—71.

Chudyba J., 1965. *Cladophora glomerata* and accompanying algae in the Skawa river. Acta Hydrobiol., 7, Suppl. 1, 93—126.

Cleve-Euler A., 1952. Die Diatomeen von Schweden und Finnland. Kungl. Sven. Vet. Handl. Fjärde, 3, 3, 5, 153 pp.

Cleve-Euler A., 1953a. Die Diatomeen von Schweden und Finnland. Kungl. Sven. Vet. Handl. Fjärde, 4, 1, 2, 158 pp.

Cleve-Euler A., 1953b. Die Diatomeen von Schweden und Finnland. Kungl. Sven. Vet. Handl. Fjärde, 4, 5, 3, 255 pp.

Cleve-Euler A., 1955. Die Diatomeen von Schweden und Finnland. Kungl. Sven. Vet. Handl. Fjärde, 5, 4, 4, 232 pp.

Czosnowski J., 1951. Kilka spostrzeżeń nad *Hydrurus foetidus* Kirchner. Pozn. Tow. Przyj. Nauk, Prace Kom. Biol., 13, 2, 1—9.

Fjerdingstad E., 1965. Taxonomy and saprobic valency of benthic phytomicro--organisms. Int. Rev. Ges. Hydrobiol. System. Beitr., 4, 475—604.

Foged N., 1948. Diatoms in water-courses in Funen. 6. Conclusions and general remarks. Dansk. Bot. Ark., 12, 12, 1—110.

Foged N., 1964. Freshwater diatoms from Spitzbergen. Tromsö Mus. Skrift., 11, 1—205.

Friedrich G., 1973. Ökologische Untersuchungen an einem thermisch anomalen Fliessgewässer (Erft Niederrhein). Schr. Landesanst. Gewässerk. Gewässerschutz Land. Nordrhein-Westfalen, 33, 5—125.

Geitler L., F. Ruttner, 1935/36. Die Cyanophyceen der Deutschen Limnologischen Sundaexpeditionen, ihre Morphologie, Systematik und Ökologie. Arch. Hydrobiol., Suppl. 14 (Tropische Binnengewässer), 308—369, 553—729.

Hovasse R., L. Joyon, 1960. Contribution à l'étude de la Chrysomonadine *Hydrurus foetidus*. Rev. Algol., 5, 66—83.

Hustedt F., 1930. *Bacillariophyta*. Pascher's Süsswasserflora Mitteleuropas, 10, 468 pp.

Hustedt F., 1931. Die Kieselalgen Deutschlands, Österreichs und der Schweiz. Rabenhorst's Kryptogamen-Flora, 7, 2, 1, 1—176.

Hustedt F., 1932. Die Kieselalgen Deutschlands, Österreichs und der Schweiz. Rabenhorst's Kryptogamen-Flora, 7, 2, 2, 177—320.

Hustedt F., 1933. Die Kieselalgen Deutschlands, Österreichs und der Schweiz. Rabenhorst's Kryptogamen-Flora, 7, 2, 3, 321—432.

Hustedt F., 1937. Die Kieselalgen Deutschlands, Österreichs und der Schweiz. Rabenhorst's Kryptogamen-Flora, 7, 2, 5, 577—736.

Hustedt F., 1943. Die Diatomeenflora einiger Hochgebirgsseen der Landschaft Davos in den Schweizer Alpen. Part 1, Part 2. Int. Rev. ges. Hydrobiol., Hydrograph., 43, 124—197, 225—280.

Hustedt F., 1944. Diatomeen aus der Umgebung von Abisko in Schwedisch-Lappland. Arch. Hydrobiol., 39 (1942), 82—174.

Hustedt F., 1957. Die Diatomeenflora des Flusssystems der Weser im Gebiet der Hansestadt Bremen. Abh. naturw. Ver., 34, 181—440.

Hustedt F., 1959. Die Kieselalgen Deutschlands, Österreichs und der Schweiz. Rabenhorst's Kryptogamen-Flora, 7, 2, 737—845.

Jaag O., 1945. Untersuchungen über die Vegetation und Biologie der Algen des nackten Gesteins in den Alpen, im Jura und im schweizerischen Mittelland. Beitr. Kryptogamenflora Schweiz., 9 (3), 7—560.

Jørgensen E. G., 1948. Diatom communities in some Danish lakes and ponds. K. Danske Vedensk. Sels. Biol. Skr., 5, 2, 3—140.

Kann E., 1978. Systematik und Ökologie der Algen österreichischer Bergbache. Arch. Hydrobiol., Suppl. 53, 405—643.

Kawecka B., 1965. Communities of benthic algae in the river Białka and its Tatra tributaries the Rybi Potok and Roztoka. Limnol. Investig. in the Tatra Mts and Dunajec River Basin, Kom. Zagosp. Ziem Górskich PAN, 11, 113—127.

Kawecka B., 1966. Glony osiadłe na *Potamogeton* sp. w Morskim Oku — Aufwuchsalgen auf *Potamogeton* sp. in See Morskie Oko. Acta Hydrobiol., 8, 321—328.

Kawecka B., 1971. Strefowe rozmieszczenie zbiorowisk glonów w potokach Polskich

Tatr Wysokich — Zonal distribution of alga communities in streams of the Polish High Tatra Mts. Acta Hydrobiol., 13, 393—414.

Kawecka B., 1974a. Effect of organic pollution on the development of diatom communities in the alpine streams Finstertaler-Bach and Gurgler Ache (Northern Tyrol, Austria). Ber. nat. med. Ver. Innsbruck, 61, 71—82.

Kawecka B., 1974b. Vertical distribution of algae communities in Maljovica stream (Rila — Bulgaria). Pol. Arch. Hydrobiol., 21, 211—228.

Kawecka B., 1976. *Eunotia flexuosa* (Bréb.) Kütz. var. *rilensis* n. var. *(Bacillariophyceae)* w potoku Maljovica (Rila — Bulgaria) — *Eunotia flexuosa* (Bréb) Kütz. var. *rilensis* n. var. *(Bacillariophyceae)* in the Maljovica stream (Rila — Bulgaria). Acta Hydrobiol., 18, 425—427.

Kawecka B., 1977. Biocenoza potoku wysokogórskiego pozostającego pod wpływem turystyki. 3. Zbiorowiska glonów osiadłych w Rybim Potoku (Tatry Wysokie, Polska) zanieczyszczonym ściekami bytowymi — Biocenosis of a high mountain stream under the influence of tourism. 3. Attached algae communities in the stream Rybi Potok (the High Tatra Mts, Poland) polluted with domestic sewage. Acta Hydrobiol., 19, 271—292.

Kawecka B., 1980. Glony osiadłe w potokach górskich Europy. 1. Ekologiczna charakterystyka zbiorowisk — Sessile algae in European mountain streams. 1. The ecological characteristics of communities. Acta Hydrobiol., 22, 361—420.

Knudsen B. M., 1954. The ecology of the diatom genus *Tabellaria* in the English Lake District. J. Ecol., 42, 345—355.

Komaromy Z. P., 1975. Algological investigations of Hungarian forest soils. 3. Soil algal surface communities in Mts Mátra. Ann. Hist.-Nat. Mus. Nat. Hung., 67, 19—23.

Liebmann H., 1962. Handbuch der Frischwasser und Abwasserbiologie. 1, München, G. Fischer Verl., 588 pp.

McIntire C. D., 1966. Some effects of current velocity on periphyton communities in laboratory streams. Hydrobiol., 27, 559—570.

McIntire C. D., 1968. Structural characteristics of benthic algal communities in laboratory streams. Ecol., 49, 520—537.

Niessen H., 1956. Ökologische Untersuchungen über die Diatomeen und Desmidiaceen des Murnauer Moores. Arch. Hydrobiol., 51, 281—375.

Patrick R., C. W. Reimer, 1966. The diatoms of the United States. 1. Monographs Acad. Nat. Sci. Philadelphia, 13, 688 pp.

Patrick R., C. W. Reimer, 1975. The diatoms of the United States. 2. Monographs Acad. Nat. Sci. Philadelphia, 13, 2, 213 pp.

Pechlaner R., 1967. Die Finstertaler Seen (Kühtai, Österreich). 2. Das Phytoplankton. Arch. Hydrobiol., 63, 145—193.

Raabe H., 1951. Die Diatomeenflora der ostholsteinischen Fliessgewasser. Arch. Hydrobiol., 44, 521—638.

Rice C. H., 1938. Studies in the phytoplankton of the River Thames (1928—1932). 1 and 2. Ann. Bot., N. S., 2, 539—557, 559—581.

Say P. J., B. M. Diaz, B. A. Whitton, 1977. Influence of zinc on lotic plants 1. Tolerance of *Hormidium* species to zinc. Freshwat. Biol., 7, 357—376.

Scheele M., 1952. Systematisch ökologische Untersuchungen über die Diatomeenflora der Fulda. Arch. Hydrobiol., 46, 305—423.

Scheele M., 1956. Verbreitung und Ökologie der Kieselalgen der Werra mit besonderer Berücksichtigung der Halophyten. Arch. Hydrobiol., 51, 435—456.

Schmidt A., 1937. In: Atlas der Diatomeenkunde 1872—1959. Fortgesetzt durch M. Schmidt, F. Fricke, H. Heiden, O. Müller und F. Hustedt. O. R. Reisland Aschersleben, Leipzig.

Schmitz W., 1961. Fliessgewässerforschung — Hydrographie und Botanik. Intern. Ver. theor. ang. Limnol., Verh., 14, 541—586.

S c h o e m a n F. R., 1973. A systematical and ecological study of the diatom flora of Lesotho with special reference to the water quality. Pretoria, CSIR, 1—355.

S c h o e m a n F. R., 1976. Diatom indicator groups in the assessment of water quality in the Jukskei-Crocodile River system (Transvaal, Republic of South Africa). J. Limnol. Soc. South. Africa, 2, 21—24.

S c h r o e d e r H., 1939. Die Algenflora der Mulde. Ein Beitrag zur Biologie saprober Flüsse. Pflanzenforsch., 21, 1—88.

S i e m i ń s k a J., 1964. *Chrysophyta* 2. *Bacillariophyceae* — Okrzemki. Flora Słodkowodna Polski, 6, 609 pp.

S ö r e n s e n I., 1948. Biological effects of industrial defilement in the river Billebergaan. Acta Limnol., 1, 3—73.

S t a r m a c h K., 1929. Über polnische *Chamaesiphon* Arten. Acta. Soc. Bot. Pol., 6, 30—45.

S t a r m a c h K., 1959. *Homoeothrix janthina* (B o r n. et F l a h.) comb. nova mihi (= *Amphithrix janthina* B o r n. et F l a h.) oraz sinice towarzyszące — *Homoeothrix janthina* (B o r n. et F l a h.) comb. nova mihi (= *Amphithrix janthina* B o r n. et F l a h.) and associating it blue-green algae. Acta Hydrobiol., 1, 149—164.

S t a r m a c h K., 1966. *Cyanophyta* — Sinice, *Glaucophyta* — Glaukofity. Flora Słodkowodna Polski, 2, 807 pp.

S t a r m a c h K., 1968. *Chrysophyta* 1. *Chrysophyceae* — Złotowiciowce oraz wiciowce bezbarwne — *Zooflagellata* wolnożyjące. Flora Słodkowodna Polski, 5, 598 pp.

S t a r m a c h K., 1969. Glony źródeł na wybrzeżu morskim w Chłapowie — Algae of springs on the sea coast at Chłapowo (Northern Poland). Fragm. Flor. et Geobot., 15, 503—511.

S t a r m a c h K., 1972. *Chlorophyta* 3. Zielenice nitkowate: *Ulotrichales, Ulvales, Prasiolales, Sphaeropleales, Cladophorales, Chaetophorales, Trentepohliales, Siphonales, Dichotomosiphonales* (with keys for the identification of filamentous green algae mentioned in the volume). Flora Słodkowodna Polski, 10, 750 pp.

S t a r m a c h K., 1973. Benthic algae of the Great Lake in the Valley of the Five Polish Lakes in the Tatra Mountains. Fragm. Flor. et Geobot., 19, 481—511.

S q u i r e s L. E., S. R. R u s h f o r t h, C. J. E n d s l e y, 1973. An ecological survey of the algae of Huntington Canyon Utah. Brigham Young Univ., Sci. Bull., Biol. Ser., 18, 2, 1—87.

V a n L a n d i n g h a m S. L., 1967. Paleoecology and microfloristics of Miocene diatomites. Nova Hedwigia Beih., 26, 1—77.

V e n k a t e s v a r l u V., 1970. An ecological study of the algae of the River Moosi, Hyderabad (India) with special reference to water pollution. 4. Periodicity of some common species of algae. Hydrobiol., 35, 45—64.

W a r d J. V., 1979. Altitudinal zonation in a Colorado Rocky Mountain stream. 1. Drainage basin, physicochemical condition and macrophytes (in manuscript).

W a s y l i k K., 1965. Communities of algae from the Soła river and its tributaries. Acta Hydrobiol., 7, Suppl. 1, 9—60.

W a s y l i k K., 1971. Zbiorowiska glonów Czarnego Dunajca i niektórych jego dopływów — Algal communities in the Czarny Dunajec River (Southern Poland) and in some of its affluents. Fragm. Flor. et Geobot., 15, 257—354.

W e h r l e E., 1942. Algae in Gebiergsbächen am Südostrende des Schwarzeswaldes. Beitr. Naturk. Forsch. Oberrheingeb., 7, 128—286.

W e s t W., 1971a. A monograph of British *Desmidiaceae*. 3. London, 273 pp.

W e s t W., 1971b. A monograph of British *Desmidiaceae*. 4. London, 191 pp.

W h i t f o r d L. A., G. J. S c h u m a c h e r, 1963. Communities of algae in North Carolina streams and their seasonal relations. Hydrobiol., 22, 133—196.

W i l l e m H. O., De S m e t and F r a n s, M. J. C. E v e n s, 1972. A hydrobiological study of the polluted river Lieve (Chent, Belgium). Hydrobiol., 39, 91—154.

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