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VIIVE KOVASK

ON THE ECOLOGY OF DESMIDS. II. DESMIDS AND THE MINERAL CONTENT

The amount of minerals is undoubtedly one of the most essential factors upon which the occurrence and distribution of desmids depends. The mineral content has a selecting influence on the occurrence of certain species of the algae in water bodies with certain mineral concentration (Messikommer, 1928). Desmids are one of the few groups of algae upon which the increase in the amount of minerals in the environment has a selecting influence. The calciphobity of desmids, a fact that has often been pointed out in algological literature, forms a basis for desmids to act as indicators in respect to the mineral content of the environment.

The present article deals with the dependence of the desmid flora on the mineral concentration of the water body. The dependence is expressed in HCO'_3 and $Ca^{\cdot\cdot}$. The work has been done on the materials of Estonian lakes.

Material

The material of the article is based upon data on the desmid flora and mineral content of water of 165 lakes of various types. The material was collected in 1951—1962 during a complex investigation of lakes undertaken by the Institute of Zoology and Botany of the Academy of Sciences of the Estonian SSR. The mineral content of water was assessed by the staff of the laboratory of geobiochemistry of the Institute.

Of the 336 taxonomical units identified in the studied lakes, only 202 desmids will undergo further analysis. A list together with intervals of HCO'_3 of the localities is presented in the following.

	HCO'_3 mg/l		HCO'_3 mg/l
Cylindrocystis Brebissonii	0	*C. lunula*	0—140.3
Netrium digitus	0—61.0	*C. moniliferum*	6.1—181.8
N. dig. var. *lamellosum*	0—20.0	*C. navicula*	0—37.8
Gonatozygon monotaenium	12.2—83.9	*C. navicula* var. *crassum*	0
Penium spirostriolatum f. *amplificatum*	0	*C. parvulum*	12.2—177.0
Closterium acerosum	23.8—207.5	*C. praelongum*	7.9—207.5
C. aciculare	45.8—177.0	*C. prael.* f. *brevius*	51.6—192.8
C. Baillyanum	0—51.6	*C. Ralfsii* var. *hybridum*	7.9—58.0
C. dianae	7.9—123.8	*C. rostratum*	24.4—146.4
C. Ehrenbergii	5.5—177.0	*C. setaceum*	0—24.4
C. intermedium	0—112.9	*C. striolatum*	0—37.8
C. Kuetzingii	5.5—167.8	*C. turgidum*	7.9—126.9
C. lineatum	5.5—126.9	*C. ulna*	0—6.1
		C. venus	0—146.4
		Pleurotaenium coronatum	5.5—91.5

	HCO'_3 mg/l
P. Ehrenbergii	0—126.9
P. eugeneum	5.5—83.9
P. trabecula	0—216.6
P. truncatum	24.4—58.0
Tetmemorus granulatus	4.9—37.8
Euastrum ansatum	3.0—37.8
E. ansatum f. *pyxidatum*	3.1—6.1
E. bidentatum	0—99.5
E. binale f. *Gutwinskii*	0
E. crassum	3.1—13.7
E. denticulatum	3.1—61.0
E. dubium var. *ornatum*	7.9—99.5
E. elegans	3.1—123.9
E. insulare	45.8—279.5
E. insulare f. *silesiacum*	7.9—123.9
E. oblongum	4.9—126.9
E. pectinatum var. *inevolutum*	7.9—135.0
E. pulchellum	5.5—106.0
E. sinuosum	3.1—7.9
E. Turneri	37.8—79.3
E. verrucosum	4.9—94.0
E. verrucosum var. *alatum*	6.1—79.3
Micrasterias americana	11.0—112.9
M. apiculata	0—51.6
M. brachyptera	7.9—48.8
M. crux-melitensis	0—167.8
M. crux-mel. var. *superflua*	39.7—83.9
M. fimbriata	5.5—24.4
M. fimbriata f. *spinosa*	7.9—48.8
M. papillifera	6.1—37.8
M. pinnatifida	36.6—61.0
M. radiata	5.5—126.9
M. radiata var. *dichotoma*	7.9—37.8
M. rotata	0—13.4
M. sol	20.0—100.7
M. Thomasiana	0—58.0
M. Thomasiana var. *notata*	0—112.9
M. truncata	0—126.9
M. truncata var. *bahusiensis*	7.9—58.0
Actinotaenium cucurbita	0
A. palangula	0
A. turgidum	39.7—126.9
Cosmarium abbreviatum	20.1—131.2
C. amoenum	0—20.3
C. annulatum	12.2—58.0
C. bioculatum	7.9—207.5
C. Boeckii	5.5—274.6
C. botrytis	11.0—234.9
C. connatum	5.5—146.4
C. conspersum var. *latum*	12.2—79.3

	HCO'_3 mg/l
C. contractum	4.9—11.0
C. contr. var. *Jacobsenii*	20.0—106.0
C. contr. f. *ellipsoideum*	12.2—48.8
C. contr. var. *minutum*	5.5—16.0
C. Debaryi	5.5—123.9
C. depressum	7.9—177.0
C. depr. var. *achondrum*	79.3—167.8
C. depr. var. *planctonicum*	20.1—231.9
C. difficile	7.9—279.5
C. formosulum	6.1—289.8
C. form. var. *Nathorstii*	48.8—207.5
C. granatum	13.4—279.5
C. gran. var. *subgranatum*	37.8—247.1
C. humile	0—286.8
C. impressulum	6.1—177.0
C. laeve	88.5—119.0
C. margaritatum	3.1—99.5
C. margaritiferum	4.9—88.5
C. Meneghinii	41.5—177.0
C. Micutowiczii	88.5—130.0
C. obsoletum var. *sitvense*	0—48.8
C. obtusatum	51.6—177.0
C. ornatum	3.1—20.1
C. ovale	7.9—45.8
C. portianum	4.9—112.9
C. protractum	13.4—207.5
C. pseudobroomei	3.1—45.8
C. pseudoprotuberans	5.5—79.3
C. punctulatum var. *subpunctulatum*	4.9—289.8
C. quadratum	9.2—123.9
C. quadrum	13.4—79.3
C. Regnellii	0—186.1
C. Regnesii	13.4—58.0
C. reniforme	5.5—274.6
C. subcostatum	23.8—160.5
C. subcost. f. minor	3.1—207.5
C. subcost. var. *Beckii*	58.6—90.3
C. subprotumidum	23.8—207.5
C. subprot. var. *Gregorii*	37.2—289.8
C. subspeciosum var. *validius*	13.4—112.9
C. subtumidum	23.8—234.9
C. tetraophthalmum	5.5—286.8
C. Turpinii	16.4—181.8
C. Turpinii var. *eximium*	37.8—207.5
C. Turpinii var. *podolicum*	23.8—186.1
C. Wittrockii	37.2—207.5

	HCO'_3 mg/l
Xanthidium antilopaeum	0—130.0
X. ant. var. *dimazum*	5.5—58.0
X. ant. var. *laeve*	0—106.0
X. ant. var. *planum*	0—7.9
X. ant. var. *triquetrum*	0—58.6
X. armatum	0—13.7
X. cristatum	0—48.8
X. cristatum var. *leiodermum*	5.5—12.2
Arthrodesmus octocornis	5.5—112.9
Staurodesmus brevispina var. *Boldtii*	12.2—45.8
S. convergens	5.5—51.6
S. cuspidatus	3.1—238.8
S. dejectus	7.9—51.6
S. extensus	0—48.8
S. glaber	4.9—51.6
S. leptodermus	20.0—45.8
S. sellatus	3.1—37.8
S. smolandicus	37.8—48.8
Staurastrum acestrophorum var. *subgenuinum*	0
S. aciculiferum	0
S. anatinum var. *longibrachiatum*	0—14.0
S. arachne	3.1—24.4
S. arctiscon	4.9—79.3
S. avicula	23.8—106.0
S. avicula var. *subarcuatum*	37.2—58.0
S. bicorne	45.8—106.0
S. brachiatum	0—6.1
S. brasiliense var. *Lundellii*	5.5—45.8
S. Brebissonii	37.8—79.3
S. Bullardii	25.6—155.6
S. chaetoceras	37.2—197.1
S. cingulum	3.1—231.9
S. cingulum var. *obesum*	20.1—207.5
S. eurycerum	58.0—112.9
S. furcatum	0—123.9
S. furcigerum	12.8—155.6
S. furc. f. *eustephana*	12.8—79.3
S. inconspicuum	0—6.1
S. inflexum	24.4—155,6
S. lapponicum	3.1—146,4
S. Luetkemuelleri	45.8—183.1
S. lunatum var. *planctonicum*	4.9—37.8
S. Manfeldtii var. *annulatum*	12.2—123.9
S. margaritaceum	0
S. Messikommeri	5.5—61.0
S. muticum	25.6—79.3
S. navigiolum	24.4—48.8
S. orbiculare var. *depressum*	20.1—79.3
S. pelagicum	91.5—197.1
S. pingue	20.1—216.6
S. planctonicum	79.3—207.5
S. polymorphum	11.0—186.1
S. polym. var. *divergens*	0
S. pseudopelagicum var. *tumidum*	11.0—207.5
S. Sebaldi var. *ornatum*	37.8—177.0
S. Seb. var. *ornatum* f. *planctonica*	12.8—197.1
S. setigerum var. *apertum*	23.8—155.6
S. striolatum	61.0—164.0
S. teliferum	0—123.9
S. tetracerum	7.9—239.8
S. tetrac. f. *trigona*	9.2—164.8
S. tohopekaligense	4.9—45.8
S. vestitum	0—48.8
Cosmocladium pusillum	0—112.9
C. saxonicum	7.9—12.2
Sphaerozosma Aubertianum var. *Archeri*	37.2—51.6
S. excavatum	7.9—106.0
S. granulatum	5.5—79.3
Spondylosium panduriforme	12.2—167.8
S. planum	0—112.9
S. pulchellum	0—3.1
Hyalotheca dissiliens	0—167.8
H. mucosa	0—112.9
Desmidium aptogonum	12.2—48.8
D. cylindricum	0—12.8
D. Swartzii	3.0—51.6
Bambusina Borreri	0—29.3
B. Borr. var. *gracilescens*	0

Discussion and results

As the Estonian lakes belong to the hydrocarbonate class according to H. Simm (Симм, 1963), HCO_3' is one of the most essential hydrochemical indicators in our lakes. Simultaneously, HCO_3' is a reflector of the buffer capacity of the water, taking an active part in the formation of pH.

On the basis of the amount of hydrocarbonate, H. Simm (Симм, 1963) divides the Estonian lakes into four groups: 1) lakes with a very low mineral content (<0.5 mg-eq./l or <30.5 mg/l HCO_3'), 2) lakes with a low mineral content (<1.3 mg-eq./l or <79.3 mg/l HCO_3'), 3) lakes with an average mineral content (1.3—2.6 mg-eq./l or 79.3—158.6 mg/l HCO_3') and 4) lakes with a high mineral content (>2.6 mg-eq./l or >158.6 mg/l HCO_3').

In the grouping of diatoms, M. Pork (1967; Порк, 1970) has made use of the scale of alkalinity by F. Hustedt (1937/1939) (with some modifications) and divided diatoms into 1) calciphobes (HCO_3' 0—60 mg/l) which are further divided into two subgroups, 2) indifferents (three subgroups) and 3) calciphiles (HCO_3' up to 300 mg/l), with two subgroups.

In the present article, the HCO_3' intervals which were separated at the charting of the mineral content of the localities of 202 species were taken for the basis of grouping (Fig. 1). In general, the limits of the intervals coincide with the division suggested by the above authors. In Fig. 1 the ecological character of desmids is well revealed: 60 per cent of almost 2,000 localities are concentrated in the HCO_3' interval of 0—60 mg/l, while only 10 per cent falls into the interval of 150—240 mg/l. The biggest number of the localities — 236 — in the case of equal intervals falls into the HCO_3' interval of 0—10 mg/l.

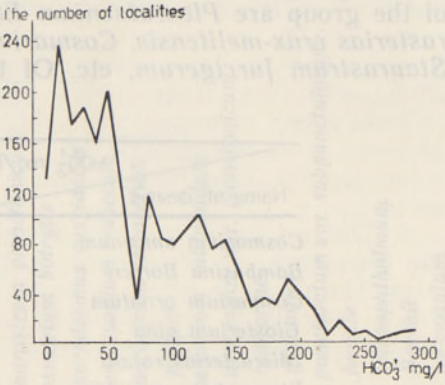

Fig. 1. Distribution of the localities of desmids at different HCO_3' values.

Taking into account the amplitude of the occurrence and frequency, desmids of the Estonian lakes may be divided into the following groups:

1. Desmids occurring at a low amount of minerals (HCO_3' 0—60 mg/l). Similarly to diatoms, the group may be further divided into two subgroups:
   a) desmids of water bodies with a very low mineral content;
   b) desmids of water bodies with a low mineral content.

Desmids of the first subgroup occurred at HCO_3' up to 10 mg/l. Such are *Staurastrum brachiatum, S. inconspicuum, Spondylosium pulchellum, Bambusina Borreri* var. *gracilescens*, and others. Desmids with a narrow amplitude in respect to minerals belong to this subgroup; they are mainly bog forms as well as some species of oligotrophic lakes (*Closterium ulna, Euastrum sinuosum*). The subgroup forms only 9 per cent of the studied material since the desmids occurring in smaller bog water bodies (bog-pools, hollows) have not been taken into account. Desmids from nine genera belong to the first subgroup. The richest in species is *Staurastrum*, forming 33 per cent of the number of species. *Staurastrum* also dominated in the group of acidobiontic forms.

The second subgroup is made up of the desmids occurring at HCO_3' up to 60 mg/l. The forms of oligotrophic waters, *Micrasterias apiculata, Xanthidium armatum, Cosmarium ornatum, Staurastrum arachne*, etc. (29 per cent of the studied material) belong to this subgroup. The composition of the second subgroup is more varied. The species of 14 genera are represented, since *Cosmarium* (18%), *Micrasterias* (17%), and *Staurastrum* (15%) are a little richer in species than the other genera.

In the complex of conditions determining the occurrence of desmids of the first group, the mineral component is obviously of the greatest importance; our material, however, is too scanty to fix the limits. The typical bog forms probably do not stand a mineral concentration above 2—3 mg/l. In the case of the forms of oligotrophic waters, the concentration may be somewhat higher.

The optimum areas and amplitudes of the occurrence of 88 desmids are represented in Fig. 2. As the number of lakes in HCO_3' intervals is different, the frequency of occurrence is expressed in per cent. A wider dark area in the figure corresponds to a higher frequency of occurrence.

2. The next group consists of desmids occurring in water with an average mineral content — HCO_3' 150 mg/l, whose frequency of occurrence is mostly higher in waters with a low mineral content. The representatives of the group are *Pleurotaenium Ehrenbergii, Euastrum verrucosum, Micrasterias crux-melitensis, Cosmarium portianum, Xanthidium antilopaeum, Staurastrum furcigerum*, etc. Of the grouped desmids, almost as many

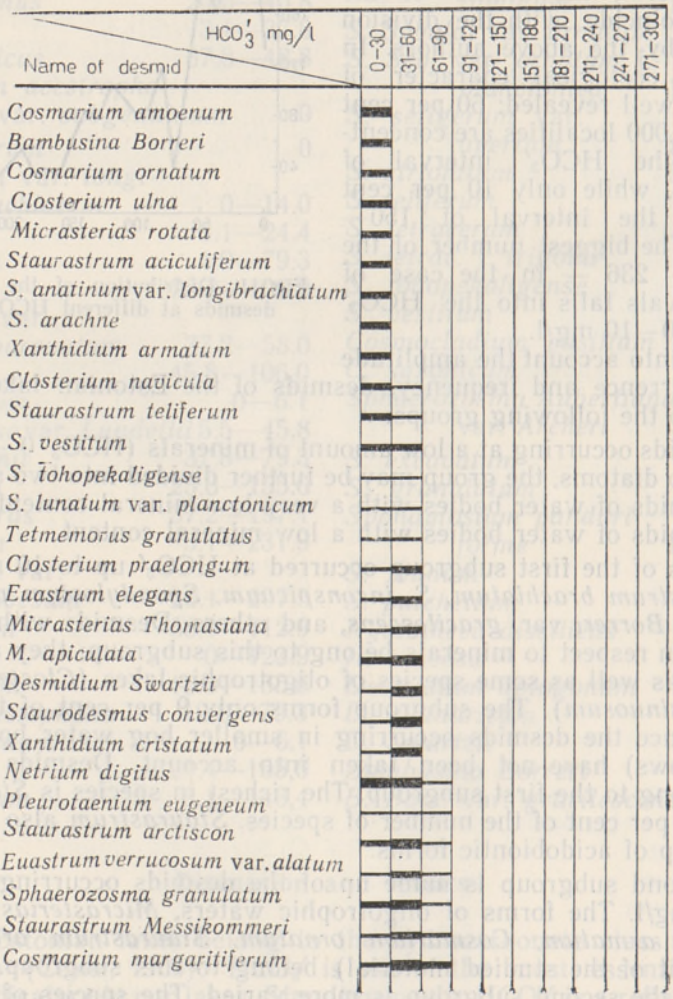

Fig. 2. Ecological amplitudes of desmids according to HCO_3'.

Name of desmid	1	2	3	4	5	6	7	8	9	10
Cosmarium Debaryi		■	■							
Staurastrum orbiculare var. *depressum*		■	■							
Spondylosium planum	■									
Euastrum verrucosum	■									
E. dubium var. *ornatum*	■									
Hyalotheca mucosa	■	■		■						
Cosmarium portianum	■	■		■						
Euastrum pulchellum var. *retusum*		■								
Arthrodesmus octocornis		■	■							
Xanthidium antilopaeum var. *laeve*										
Micrasterias truncata	■	■		■						
Pleurotaenium Ehrenbergii	■	■	■							
Cosmarium quadratum		■	■							
Closterium venus	■	■								
Euastrum oblongum	■	■								
Xanthidium antilopaeum	■	■		■						
Cosmarium pachydermum										
Staurastrum Manfeldtii var. *annulatum*										
Cosmarium connatum	■	■	■		■					
Staurastrum lapponicum		■			■					
Hyalotheca dissiliens	■	■		■						
Micrasterias crux-melitensis		■								
Closterium Kuetzingii		■	■							
Staurastrum furcigerum		■	■							
S. inflexum		■	■	■	■	■				
Cosmarium depressum		■	■	■		■				
Spondylosium panduriforme		■	■							
Cosmarium Turpinii		■	■			■				

Name of desmid	1	2	3	4	5	6	7	8	9	10
Staurastrum alternans	■		■	■	■	■				
Cosmarium subcostatum			■	■	■	■				
Staurastrum chaetoceras		■	■	■		■				
Cosmarium bioculatum	■	■	■	■	■		■			
C. subcostatum f. *minor*	■	■	■	■	■		■			
C. impressulum	■	■	■	■	■		■			
Closterium Ehrenbergii		■	■	■	■		■			
C. moniliferum		■	■	■		■	■			
C. parvulum		■	■	■		■	■			
Cosmarium protractum		■	■	■	■		■			
C. subprotumidum		■	■	■		■	■			
Staurastrum cingulum var. *obesum*		■	■	■		■	■			
Cosmarium Regnellii	■		■	■			■			
Staurastrum pseudopelagicum var. *turmidum*			■				■			
Closterium aciculare			■	■	■	■				
Staurastrum planctonicum			■			■	■			
Cosmarium botrytis	■				■			■		
Staurodesmus cuspidatus	■	■	■	■			■	■		
Pleurotaenium trabecula	■	■		■				■		
Staurastrum tetracerum		■		■			■	■		
S. pingue						■	■	■		
Cosmarium subtumidum		■	■	■	■	■	■	■		
C. depressum var. *planctonicum*					■	■	■	■		
C. reniforme	■	■	■	■	■	■	■		■	■
C. granatum		■	■	■	■	■	■			■
C. punctulatum var. *subpunctulatum*		■	■	■	■	■	■	■	■	■
C. humile		■	■	■	■	■	■	■	■	■
C. tetraophthalmum	■	■	■	■	■	■	■		■	■
C. Boeckii	■	■	■	■	■	■	■		■	■
C. formosulum	■	■	■	■	■	■	■	■		■
Euastrum insulare			■	■	■					■

belong here — 35 per cent — as to the first group. The composition of the group is varied, containing species from 14 genera. The richest in species are *Staurastrum* (23%) and *Cosmarium* (22%). Some similarity between this group and the second subgroup of the first group, on the one hand, and the group of acidophilous forms, on the other, may be noticed. In the latter the composition was also varied, while dominants were absent.

3. Desmids occurring at a high mineral content (HCO_3' up to 240 mg/l) belong to the group under treatment. Such are *Closterium aciculare, C. moniliferum, Pleurotaenium trabecula* and several representatives of *Cosmarium* and *Staurastrum* (*Cosmarium depressum* var. *planctonicum, C. subcostatum* f. *minor, Staurastrum alternans, S. cingulum* var. *obesum, S. pingue, S. planctonicum*). Although the amplitude of occurrence of the mentioned desmids is rather wide, their optimum area of occurrence is mostly at a lower mineral content (see Fig. 2). This quite numerous group — 22% — is poorer in composition. Of the six occurring genera, almost a half are representatives of *Cosmarium*, followed by *Staurastrum* (29%) and *Closterium* (16%). The coincidence with the group of alkalibiontic forms is unexpectedly big: in the latter, the genera occurred in the same order as regards the number of species. Even the percentage is rather similar (see Kõvask, 1971, p. 229). Coincidences in species were fewer.

4. The last group contains desmids indifferent towards mineral content. The frequence of occurrence is higher at lower HCO_3' values in most cases. The group is represented by *Euastrum insulare, Cosmarium granatum, C. humile, C. tetraophthalmum*, etc., amounting to 5 per cent of the desmids examined. Of the genera, *Cosmarium* is prevailing (82%).

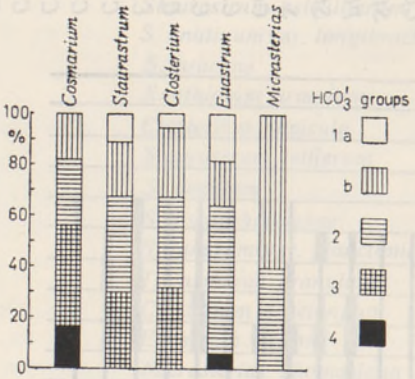

Fig. 3. Relation of HCO_3' groups in several genera of desmids.

Fig. 3 represents the distribution of some genera which are rich in species in HCO_3' groups. The occurrence of the species of *Cosmarium* in the environment rich in minerals is a well-known fact. Our data also prove that *Cosmarium* is rather indifferent to minerals. At a higher amount of minerals the number of its species is even bigger. Most of the desmids with a wide amplitude of occurrence (indifferents) belong to the genus. No species with a narrow amplitude, occurring at HCO_3' 0—10 mg/l were found in this genus. *Closterium* is also a little richer in species at an average or high mineral content. Most of the representatives of *Staurastrum* prefer environments poor in minerals. This genus has more species with a narrow amplitude of occurrence (HCO_3' 0 — 10 mg/l) than other genera. *Micrasterias* and *Xanthidium* are to be found only in water bodies with a low or average mineral content. They are more abundant at HCO_3' <60 mg/l. G. E. Hutchinson (1967) also considers them to be characteristic of soft waters. Some smaller genera, such as *Bambusina, Desmidium, Penium*, etc., occur only in waters with a low mineral content in Estonia.

In comparison with diatoms, the pretensions of desmids to the environment are next to the opposite. For desmids, the optimum mineral content seems to be <100 mg/l. Diatoms are most numerous at HCO_3' 60 — 240 mg/l (Pork, 1967). Among desmids there are practically no

species having a lower limit as regards the mineral content, while among diatoms there exists a whole group of such species.

As calcium salts are the most essential minerals in our lakes, some notes on the connection between the desmids and Ca'' will follow. The dependence of the occurrence of desmids on the calcium content is in general similar to that on all minerals, but it is less obvious. Thus, only *Closterium navicula*, *Cosmarium ornatum* and *Tetmemorus granulatus* occur at a low calcium content (Ca'' up to <10 mg/l) in our lakes. Almost a half of all the studied desmids (calciphobous) occur most frequently at Ca'' 10—20—(30) mg/l, although the amplitude of their occurrence reaches Ca'' 50 mg/l in most cases. *Closterium Kuetzingii*, *Pleurotaenium Ehrenbergii*, *Euastrum elegans*, *Micrasterias crux-melitensis*, *M. truncata*, *Staurastrum arctiscon*, *S. furcigerum*, etc. may serve as examples of such desmids. Taking into account the total mineral content, they belong to the 3rd group of desmids.

The other large group of desmids (calciphilous) — over one-third — mostly occurs at a high Ca'' content (40—60 mg/l). Such are *Closterium aciculare*, *Euastrum insulare*, *Cosmarium depressum* var. *planctonicum*, *C. granatum* var. *subgranatum*, *C. humile*, *Staurastrum chaetoceras*, *S. pingue*, *S. planctonicum*. Several of the desmids mentioned (*Closterium aciculare*, *Cosmarium granatum* var. *subgranatum*, *C. humile*) are calciphilous according to the data by E. Messikommer (1928, 1942), too. According to the same author (Messikommer, 1928), *Spondylosium planum*, here mostly occurring in water bodies poor in minerals, is also a calciphilous desmid.

As regards the calcium content of the environments, three desmids — *Cosmarium formosulum*, *C. punctulatum* var. *subpunctulatum*, *C. reniforme* — may be considered as indifferents.

Thus, the number of desmids standing environments rich in calcium is rather big in the Estonian lakes, while those preferring a very low calcium content were few in number. Further data may change the percentage to some extent, but still it seems that the amount of calcium (at least in our lakes) is no limiting factor in the occurrence of desmids. On the basis of Estonian material, it is rather the total mineral content that may have such an influence.

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Academy of Sciences of the Estonian SSR,
Institute of Zoology and Botany

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VIIVE KÕVASK

IKKESVETIKATE ÖKOLOOGIAST. II. IKKESVETIKAD JA VEEKOGU MINERAALAINETESISALDUS

Resümee

Mineraalainete hulk veekogus on kahtlemata olulisemaid tegureid, millest sõltub ikkesvetikate esinemine ja levik.

165 mitmesuguse Eesti järve materjali põhjal jaotati 202 ikkesvetika liiki mineraalainete üldhulgast (HCO_3') lähtudes järgmistesse rühmadesse:

1) madala (HCO_3' 0—60 mg/l),
2) keskmise (HCO_3' kuni 150 mg/l) ja
3) kõrge (HCO_3' kuni 240 mg/l) mineraalainete sisaldusega veekogude ikkesvetikad ning
4) HCO_3' suhtes indiferentsed ikkesvetikad.

Ikkesvetikate kõigist leiukohtadest kuulub 60% nende hulka, kus HCO_3' on 0—60 mg/l, ja ainult 10%-l on HCO_3'-sisaldus 150—240 mg/l. Väiksema mineraalainetesisaldusega järvedes on mitmekesisem ka ikkesvetikate liigiline koostis ja suurem perekondade arv. Ühiseid jooni domineerivates perekondades ja nende liikide rohkuses võib sedastada nii HCO_3' kui ka pH järgi eristatud rühmades.

Ikkesvetikate sõltuvus $Ca^{\cdot\cdot}$-st sarnaneb nende sõltuvusega HCO_3'-st, kuid on vähem ilmne. Kaltsiumirohkust taluvaid ikkesvetikaid esineb Eesti järvedes küllalt palju. Ikkesvetikate esinemist mõjutab pigem üldine mineraalainete- kui kaltsiumisisaldus.

Eesti NSV Teaduste Akadeemia
Zooloogia ja Botaanika Instituut

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ВИЙВЕ КЫВАСК

К ЭКОЛОГИИ КОНЪЮГАТ. II. КОНЪЮГАТЫ И МИНЕРАЛЬНЫЕ ВЕЩЕСТВА ВОДОЕМОВ

Резюме

На основе исследования материала из 165 различных озер Эстонии выделены следующие группы конъюгат по отношению к минеральным веществам (HCO_3') : 1. Встречающиеся при 0—60 *мг/л* HCO_3' составляют 38%. Различаются конъюгаты, распространенные в водоемах с очень низким и низким содержанием минеральных веществ. 2. Встречающиеся при HCO_3' до 150 *мг/л* — 35%. 3. Встречающиеся при HCO_3' до 240 *мг/л* — 22%. 4. Индифференты составляют 5%.

60% местонахождений конъюгат сосредоточены в пределах 0—60 *мг/л* HCO_3' и только 10% — при 150—240 *мг/л* HCO_3'. В водоемах ,где содержатся малые количества минеральных веществ, больше также видов и родов.

Зависимость конъюгат от содержания $Ca^{\cdot\cdot}$ в озерах менее выражена. Распространение конъюгат может зависеть больше от общего количества минеральных веществ, чем от количества кальция.

Институт зоологии и ботаники
Академии наук Эстонской ССР

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