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## A COMPARISON BETWEEN THE PHYTOPLANKTON OF SOME BROWN WATER LAKES ENCLOSED WITH REED-BELT IN THE HUNGARIAN PART OF LAKE FERTŐ

### Introduction

Our knowledge on the phytoplankton of the humic lakes in the Hungarian part of Neusiedlersee is very limited. The seasonal dynamics of the phytoplankton - and also the algal flora - shows great differences in comparison with the phytoplankton of other water types of the lake, namely, a spring minimum seems to be characteristic for these lakes (PADISAK 1981). This phenomenon is itself enough interesting to be the subject of further studies adding that except for floristical studies only few data are available on the brown-water lakes of Neusiedlersee (DOKULIL 1973, 1975, PADISAK 1982).

However, a systematical sampling project on these lakes can hardly be carried out. In winter it might be dangerous or even impossible to reach them. In summer one or another inner lake might not be accessible periodically due to either a low water level or other difficulties (e.g. canals might be impenetrable). That is why we have not yet been able to carry out a sufficiently frequent sampling project on these small lakes.

At this point a new question arises whether the seasonal patterns of phytoplankton in humic lakes are similar or not. In case a close similarity between them is to observe than we could compose a seasonal pattern based on pooled annual data of different small lakes. This approach is not completely correct theoretically, but considering the above mentioned difficulties it might be done supposing a relatively high level of similarity between the lakes.

The problem has theoretical aspect as well, namely, whether a more or less similar environmental background can definitely determine the phytoplankton community structure or there might be different community patterns existing within the water. So the studies on similarities and differences of the phytoplankton communities living in humic lakes have not only practical but theoretical significance as well.

#### Study area, methods

1982 was a fortunate year because the water level was constantly high enough and some old canals were reopened, so 7 inner lakes could be studied on five occasions all them being located in the western part of the Hungarian part (Fig. 1). Herrenlacke is the greatest one with a relatively large open water area. Oberlacke and Small Herrenlacke are similar in that their openwater area is not continuous, but is dissected by many small stands of *Phragmites*. Three other lakes: Lake Hidegségi, Lake Nagyhatár and Lake Átjáró have a smaller but nearly continuous open-water surface. Lake Pitner is an interesting artificial lake - it used to be an open-air bath - with a water depth of 2 meters (all others are between 80 and 100 cm). On April 19<sup>th</sup> four lake were sampled: Herrenlacke, Lake Hidegségi, Lake Nagyhatár and Small Herrenlacke. On May 17<sup>th</sup> and on July 30<sup>th</sup> six lakes (Herrenlacke, Lake Hidegségi, Lake Nagyhatár, Small Herrenlacke, Lake Átjáró and Oberlacke), on June 21 four (Herrenlacke, Lake Hidegségi, Lake Nagyhatár and Oberlacke) and on October 27<sup>th</sup> all the seven lakes were sampled using a glass-tube sampler. The samples were fixed with Lugol's solution and counted with an inverted microscope (UTERMÖHL 1958) to about 400 individuals giving a counting accuracy, expressed in terms of 95 % confidence limits of  $\pm 10\%$  (LUND et al. 1958) Several identification manuals (BARTHA et al. 1976, BOURRELLY 1966, 1968, 1970, FELFÖLDY 1972, 1981, HUBER-PESTALOZZI 1938-1961, HUSTEDT 1930, NEMETH 1980) and other publications (HUSTEDT 1959 a, 1959 b, 1959 c, KUSEL-FETZMANN 1974, 1979 a, 1979 b, PANTOCSEK 1912) were used during identification. Floristical data were analyzed using cluster analysis based on Jaccard's measure of similarity (JACCARD 1908) and WPGMA

fusion algorithm (SNEATH and SOKAL 1973).

## Results

During the whole study 116 species of algae were recorded (Cyanophyta: 16, Euglenophyta: 10, Pyrrophyta: 3, Chrysophyta: 56 and Chlorophyta: 31). The presence-absence data are given in Table 1.

On April 19<sup>th</sup> four lakes were studied. The highest numbers were recorded in Lake Hidegségi, the lowest in Small Herrenlacke (Fig. 2). Rhodomonas predominated the Lake Nagyhatár and Small Herrenlacke while in the two other lakes Rhodomonas was only the second predominant. Quantities of species having a relative frequency of 5% are given in Table 2. Data are expressed in terms of relative frequency.

On May 17<sup>th</sup> six lakes were studied. Herrenlacke had both the greatest numbers of species and number of individuals. Small Herrenlacke was just the opposite. The two variables (numbers and number of individuals) seem to be positively correlated. Small Herrenlacke and Oberlacke are floristically similar based on the cluster diagram and a high predominance of Pyrrophytes occurred in them (Fig. 3). Lake Hidegségi, Lake Nagyhatár and Lake Atjáró were also dominated by Pyrrophytes but not so strongly than the other two lakes mentioned above, there was a good amount of diatoms besides them. The predominant species was Rhodomonas in five cases and it was the second predominant after Campylodiscus in Herrenlacke.

On the June 21<sup>rst</sup> only four lakes were sampled. Large differences in numbers and in number of species can be observed and these variables show a negative correlation (Fig. 4). Three lakes were dominated by Pyrrophytes and one by greens. The predominant species varied between the lakes, Lake Nagyhatár was dominated by only Rhodomonas, Oberlacke both by Rhodomonas and Cryptomonas. In Lake Hidegségi three species occurred in large amount: Rhodomonas, Chaetoceros and Cryptomonas while in Herrenlacke Schroederia, Cyclotella, Rhodomonas and Cryptomonas predominated the community.

On July 30<sup>th</sup> large differences in the values of the mentioned variables were also noted (Fig. 5). Oberlacke and Small Herrenlacke proved to be floristically similar, too. The other denser cluster core is formed by the data of Lake Hidegségi and Lake Nagyhatár. All of the lakes were dominated by different species of algae: Lake Nagyhatár by Rhodomonas, Small Herrenlacke by Cryptomonas, Oberlacke both by Cryptomonas and Nitzschia, Lake Hidegségi by Cryptomonas, Crucigenia and Scenedesmus, Herrenlacke by Dactylococcopsis and Schroederia while Lake Átjáró by Peridinium and Rhodomonas. On October 27<sup>th</sup> large differences in numbers and in number of individuals also appeared, they show roughly a negative correlation (Fig. 6). We cannot observe such large differences considering the predominant species. Five lakes were dominated by Cryptomonas. In Lake Hidegségi both Cryptomonas and Rhodomonas were predominant. A rather different pattern was found in Lake Pitner: the community was predominated by Ankistrodesmus and Chlamydomonas and only the third predominant species was Cryptomonas.

As a summary of the studies it can be stated that not exclude two same quantitative seasonal patterns were found amongst the seven studied lakes, although, if we sampling only once Lake Pitner from consideration the phytoplankton abundance shows a summer maximum. The principle species in the spring phytoplankton is Rhodomonas, that of the autumn phytoplankton is Cryptomonas. Besides them, few other species of algae may be only occasionally predominant. The summer phytoplankton of the humic lakes shows a high diversity the predominant species.

### Discussion

It is not too easy to give any adequate explanation of the results, however, it is clear without doubt that the data of different lakes must not be pooled in order to obtain any seasonal cycle, due to the high level of dissimilarities in abundances and in predominance relations as well. And at this point a new question arises, and it is concerned with the theoretical aspect of this study, namely, why these great differences may occur.

Species dominating in the lakes on different occasions can be divided

into three groups. The first contains the flagellates. *Cryptomonas*, *Rhodomonas* and *Peridinium* are often found in lakes which have a brown water colour and are protected against the stirring-up effect of wind. Their ability to choose a narrow water layer in which they live may be a great advantage in those water types. The situation is just the same in the enclosed lakes of Neusiedlersee. Moreover, the two largest lakes - Herrenlacke and Lake Hidegségi - are especially dominated by other groups of algae and they are the ones that are supposed to be the most disturbed by wind. There are data on the high growth rates of the species belonging to the genera *Rhodomonas* and *Cryptomonas* in other Hungarian shallow lakes (PADISAK et al. 1982, TOTH unpublished). In certain studies they are stated to be r-selectionists due to their small cell sizes and/or to their ability for active movement (Sommer 1981). Large *Chlamydomonas* dominance is often observed in small, nutrient-rich astatic waters which are very suitable for r-selectionist species (KISS 1958) Members of the second group: *Schroederia*, *Scenedesmus*, *Ankistrodesmus* and *Dactylococcopsis* may reach a large predominance in shallow lakes (even in nutrient rich fish-ponds) as well as in the other parts of Neusiedlersee (DOKULIL 1979, TEVANNE BARTALIS 1980, PADISAK 1981). They all have small body sizes so that the phenomenon of r-selection can also be expected. The third group, the diatoms can reach a large level of predominance in other lakes but for example *Campylodiscus* and *Chaetoceros* can hardly be considered as r-selectionists. Meanwhile, in our study the dominance of diatoms was observed only in exceptional cases and there was not one sampling site or date when diatoms predominated only.

Though these brown water lakes are protected against the incessant stirring-up effect of wind, they are under the effect to other water movements. In cases of winds blowing in a north-northwestern direction, the water moves into the southern reed-belt from the open areas. This movement may have the effect on the brown water content (or a large amount of it) moves off towards the southern part of the lake together with the phytoplankton community living in it. The basin of the small lake fills up with the interstitial water of the reed belt located

north from it. In cases of wind having a southern direction, or even after the wind from the opposite direction stops, the water movement reverses. Neusiedlersee from time to time shows these movements in ice-free periods.

Based on the Phenomena discussed above it can be easily imagined that such types of water movements provide a permanent environmental background for species having an r-selectionist character, adding that the relatively small sizes of the basins of the brown-water lakes may make possible phenomenon of "ecological drift". So the large differences in numbers and in predominance relations might be explained in these ways. The explanation outlined above can only be proved by carrying out day to day studies not only on the phytoplankton structure but on meteorological conditions and water chemistry as well.

### Zusammenfassung

Im ausgedehnten Schilfbestand des ungarischen Teiles des Fertö (Neusiedlersee) sind mehrere, vom offenen Wasser abgeschlossene, schwarzwässrige Kleingewässer zu finden. Im Winter sind diese Teiche gänzlich unerreichbar, aber auch im Sommer nur schwer zu erreichen (die Kanäle verschließen sich, oder andere Hindernisse verbauen einem den Weg). Eben deshalb ist es äußerst schwierig, über die saisonale Sukzession ihres Phytoplanktons Daten-Serien von genügender Daten-Häufigkeit zu gewinnen. Wenn wir die mehr oder weniger gleichartige Zusammensetzung und quantitativen Verhältnisse des Phytoplanktons dieser kleinen abgeschlossenen Teiche beweisen könnten, dann wäre es möglich, einzelne saisonale Daten-Serien von Teilergebnissen mehrerer kleiner Teiche zusammenzustellen. Während des Jahres 1982 ist es uns gelungen bei fünf Gelegenheiten insgesamt aus sieben solchen, sich im Schilfbestand befindenden Kleingewässern parallel Proben zu entnehmen. Von den Proben konnten insgesamt 101 Arten, bzw. subspezifische Taxa festgestellt werden. In beiden, aus dem Frühling stammenden Proben waren die Algen-Arten der Gattungen Rhodomonas und Cryptomonas dominant. In einer

der Teiche war *Campylodiscus clypeus* var. *bicostate* in größeren Mengen anzutreffen. Im Herbst war bei sechs Teichen die Dominanz von *Cryptomonas* kennzeichnend, im siebenten konnte dagegen die Dominanz von *Ankistrodesmus* und *Chlamydomonas* festgestellt werden. Im Sommer waren die Dominanz-Verhältnisse sehr abweichend, in den verschiedenen Teichen konnten größere Mengen der Artengruppen *Peridinium*, *Rhodomonas*, *Cryptomonas*, *Chaetoceros*, *Cyclotella*, *Schroederia*, *Nitzschia*, *Scenedesmus* und *Dactylococcopsis* angetroffen werden. Dabei konnten auch größenordnungsmäßig verschiedene Individuenzahlen des Phytoplanktons festgestellt werden. Die erhaltenen sehr abweichenden Angaben machen es unmöglich, aus den Daten-Serien der einzelnen Teiche irgendein gemeinsames saisonales Gesamtbild zu schaffen. Außer der oben angeführten Feststellung hat das Problem noch eine theoretische Beziehung, nämlich: Warum gestaltet sich das Phytoplankton der einzelnen Teiche derart verschieden in einem in physikalisch- und chemischer Hinsicht in großen Zügen ähnlichen Umgebung. Über die in größerer Zahl angetroffenen Arten kann - anhand von Literaturangaben - festgestellt werden, daß sie mit großer Wahrscheinlichkeit r-strategische Arten sind, deren Vermehrung durch die sich oft verändernden Umgebungsverhältnisse gefördert wird. Es kann angenommen werden, daß bei Nordwind vom offenen Wasser durch das Schilf in Richtung südliches Ufer, beim Aufhören des Nordwindes bzw. bei Südwind aber in entgegengesetzter Richtung, mit einer bedeutenden Wasserströmung zu rechnen sei, und in dieser Weise das Wasser der schilfumschlossenen Teiche sich im ständigen Austausch befindet. Das Einströmen des interstitiellen Wassers des Schilfbestandes in die Becken der einzelnen Kleingewässer bedeutet eine ständige Nährstoffzufuhr. Es wird angenommen, daß diese Wasserbewegung den fortwährenden umweltlichen Hintergrund für die Anwesenheit der r-strategischen Arten bildet. Die Frage könnte nur mit Hilfe täglicher algologischer, meteorologischer und wasserchemischer Meßwerte eindeutig geklärt bzw. bewiesen werden.

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sampling site/date	I.					II.					III.					IV.					V.					VI.					VII.				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	4	5	1	2	4	5	1	2	3	4	5	5						
<b>CYANOPHYTA</b>																																			
1. <i>Anabaena constricta</i>				+												+	+	+						+											
2. <i>Aphanocapsa delicatissima</i>																			+																
3. <i>Chroococcus minutus</i>					+					+										+															
4. <i>Chroococcus turgidus</i>		+																																	
5. <i>Coelosphaerium kuetszingianum</i>																			+																
6. <i>Dactylococopsis raphidioides</i>	+	+	+	+					+					+	+				+																
7. <i>Lyngbya cryptovaginata</i>																								+											
8. <i>Lyngbya limnetica</i>					+	+				+						+	+	+	+										+	+	+				
9. <i>Merismopedia punctata</i>		+																	+																
10. <i>Microcystis flos-aquae</i>			+	+	+																														
11. <i>Oscillatoria acutissima</i>						+													+										+						
12. <i>Oscillatoria</i> sp. 1.										+				+	+				+	+									+						
13. <i>Oscillatoria</i> sp. 2.						+				+	+				+				+	+							+	+		+	+		+		
14. <i>Oscillatoria amphibia</i>																			+																
15. <i>Spirulina maior</i>																			+																
16. <i>Spirulina subsalsa</i>										+					+				+	+															
<b>EUGLENOPHYTA</b>																																			
17. <i>Astasia</i> sp.																													+						
18. <i>Colacium</i> sp.																			+																
19. <i>Euglena acus</i>					+									+	+					+														+	
20. <i>Euglena tripteris</i>					+														+																
21. <i>Euglena</i> sp. small	+			+	+														+	+								+							
22. <i>Euglena</i> sp. large									+		+				+				+	+	+							+	+	+					
23. <i>Phacus brevicaudatus</i>															+																				
24. <i>Phacus hamatus</i>																													+						
25. <i>Phacus inflexus</i>															+					+															
26. <i>Trachelomonas</i> sp.																													+					+	

Table 1.: Presence-absence data of species found during this study

Explanation: I: Herrenlacke; II: Lake Hidegségi; III: Lake Nagyhatár; IV: Small Herrenlacke; V.: Lake Átjáró; VI: Oberlacke; VII: Lake Pitner; 1: 19.04.1982; 2: 17.05.1982; 3: 21.06.1982; 4: 30.07.1982; 5: 27.10.1982

table 1. cont.

	I.					II.					III.					IV.					V.					VI.					VII.				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	4	5	1	2	4	5	1	2	3	4	5	5						

PYRROPHYTA

27. <i>Cryptomonas</i> sp.	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+										+	+	+	+	+					
28. <i>Peridinium</i> sp.				+					+																													
29. <i>Rhodomonas</i> sp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+										+	+	+	+	+					

CHRYSOPHYTA

30. <i>Achnanthes lanceolata</i>					+					+	+	+			+																							
31. <i>A. lanceolata</i> var. <i>elliptica</i>	+									+																												
32. <i>A. minutissima</i>				+						+					+																							
33. <i>Amphora ovalis</i>		+								+					+																							
34. <i>A. ovalis</i> var. <i>pediculus</i>										+																												
35. <i>Amphiprora costata</i>		+								+																												
36. <i>Bacillaria paradoxa</i>																																						
37. <i>Caloneis amphisbaena</i>																																						
38. <i>Caloneis permagna</i>																																						
39. <i>Caloneis silicula</i>																																						
40. <i>Campylodiscus clypeus</i>															+																							
41. <i>C. clypeus</i> var. <i>bicostata</i>		+	+		+																																	
42. <i>Chaetoceros muellerii</i>				+						+																												
43. <i>Cocconeis pediculus</i>										+																												
44. <i>Cyclotella meneghiniana</i>	+	+	+	+	+	+	+	+	+		+				+	+	+	+		+	+	+						+	+									
45. <i>Cyclotella ocellata</i>	+										+																											
46. <i>Cymbella cystula</i>	+																																					
47. <i>Cymbella lacustris</i>	+						+								+																							
48. <i>Cymbella ventricosa</i>							+	+																														
49. <i>Cymbella</i> sp.	+																																					
50. <i>Diatoma elongatum</i>															+																							
51. <i>Diatoma vulgare</i>	+																																					
52. <i>Dinobryon sertularia</i>										+																												+
53. <i>Epithemia</i> sp.	+														+																							+
54. <i>Eunotia gracilis</i>																																						
55. <i>Fragilaria</i> sp.	+	+			+	+				+																												





Table 2: Relative frequencies of species having a relative frequency of 5% in any cases  
Explanation: see in Table 1

<i>Dactylococcopsis raphidioides</i>	I/4: 53%
<i>Oscillatoria</i> sp. I.	V/5: 6%
<i>Oscillatoria</i> sp. II.	IV/4: 6%
<i>Colacium</i> sp.	IV/2: 7%
<i>Euglena acus</i>	I/5: 5%
<i>Cryptomonas</i> sp.	I/3: 16%, I/5: 60%, II/1: 17%, II/3: 11%, II/4: 29%, II/5: 52%, III/1: 52%, III/4: 7%, III/5: 71%, IV/1: 38%, IV/2: 17%, IV/4: 66%, IV/5: 72%, V/2: 6%, V/4: 10%, V/5: 60%, VI/2: 9%, VI/3: 40%, VI/4: 46%, VI/5: 72%, VII/5: 23%
<i>Peridinium</i> sp.	V/4: 43%
<i>Rhodomonas</i> sp.	I/1: 67%, I/2: 23%, I/3: 12%, I/4: 6%, II/1: 47%, II/2: 69%, II/3: 49%, II/4: 8%, II/5: 40%, III/1: 30%, III/2: 54%, III/3: 93%, III/4: 70%, IV/1: 14%, IV/2: 64%, IV/5: 5%, V/2: 56%, V/4: 19%, VI/2: 81%, VI/3: 46%, VI/4: 9%, VI/5: 18%
<i>Campylodiscus clypeus</i> var. <i>bicostata</i>	I/2: 34%
<i>Chaetoceros muellerii</i>	II/3: 18%
<i>Cyclotella meneghiniana</i>	I/2: 9%, I/3: 17%, II/3: 6%, II/4: 8%, V/2: 15%

table 2. cont.

<i>Fragilaria</i> sp.	II/1: 6%
<i>Nitzschia</i> sp.	I/1: 7%, I/2: 10%, II/1: 17%, II/2: 18%, II/3: 5%, III/2: 16%, III/5: 7%, IV/1: 11%, IV/4: 6%, V/2: 7%, VI/2: 5%, VI/3: 5%, VI/4: 31%
<i>Ankistrodesmus angustus</i>	VII/5: 46%
<i>Chlamydomonas</i> sp.	VII/5: 29%
<i>Crucigenia quadrata</i>	II/4: 19%
<i>Scenedesmus ecornis</i>	I/5: 5%, II/4: 14%
<i>Scenedesmus quadricauda</i>	II/4: 9%, III/2: 8%, III/4: 9%
<i>Schroederia setigera</i> f. minor	I/3: 41%, I/4: 28%
<i>Sphaerocystis schroeterii</i>	I/3: 6%



Austria

Figure 1

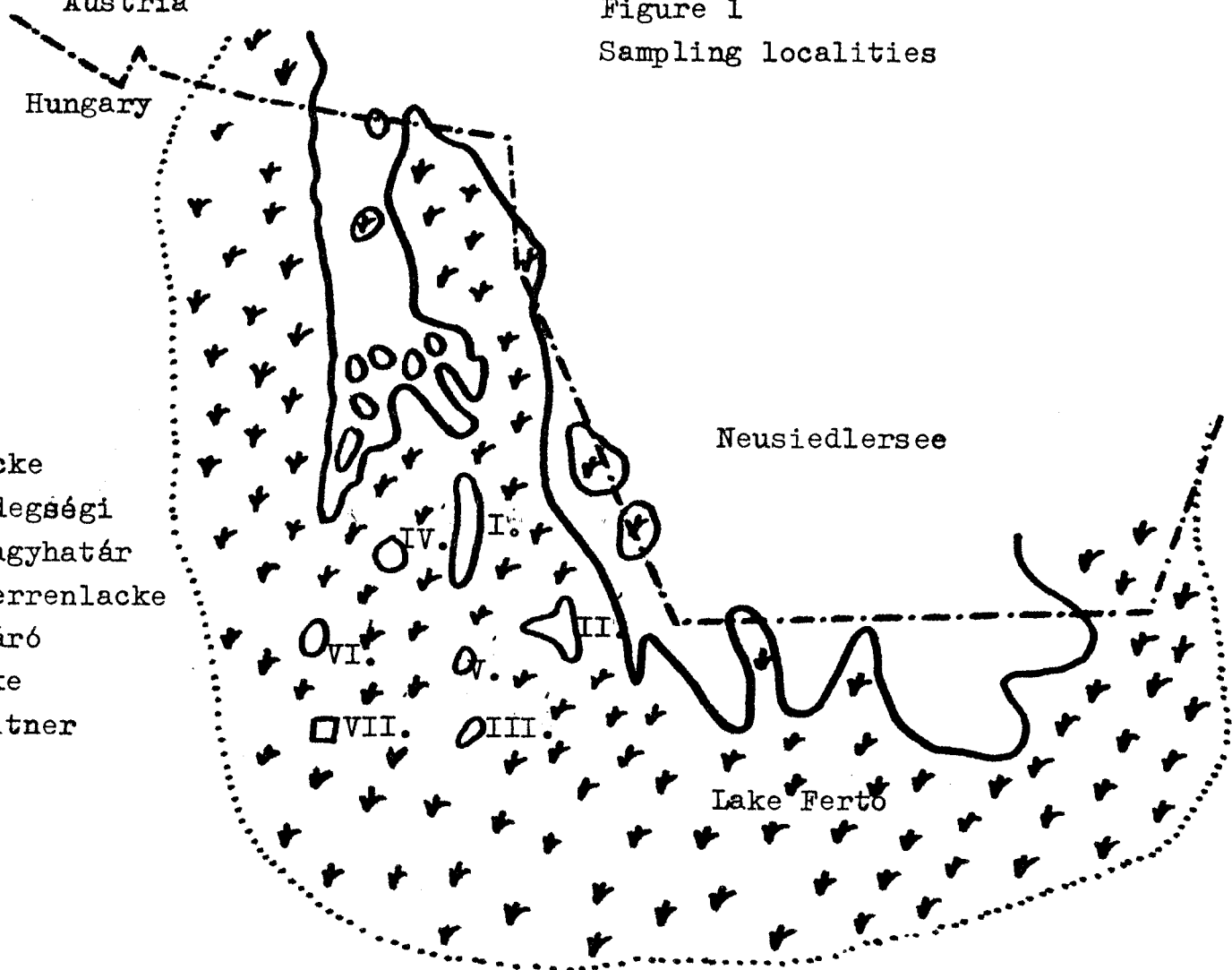
Sampling localities

Hungary

Neusiedlersee

Lake Fertő

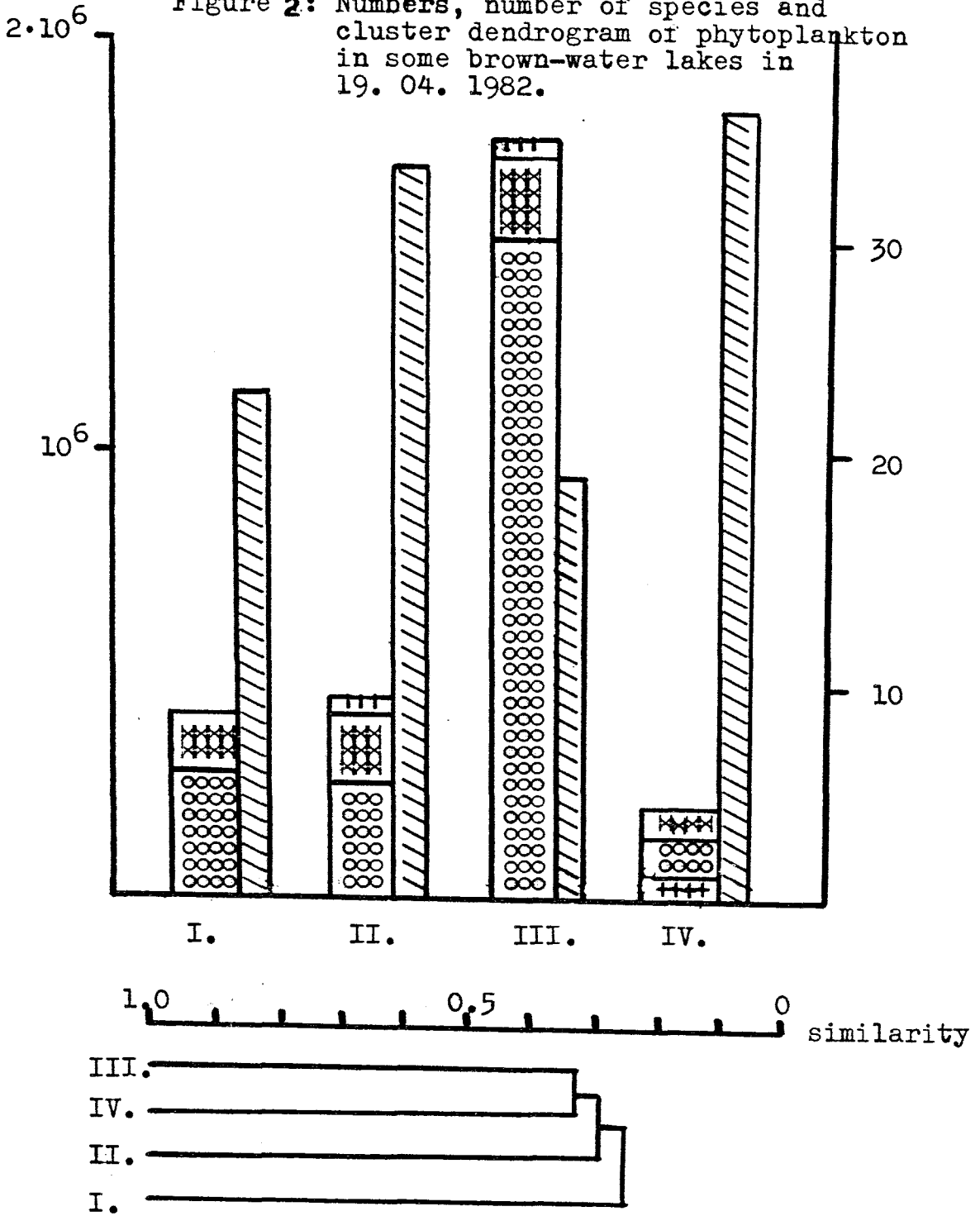
- I. Herrenlacke
- II. Lake Hidegségi
- III. Lake Nagyhatár
- IV. Small Herrenlacke
- V. Lake Átjáró
- VI. Oberlacke
- VII. Lake Pitner









numbers ind·l<sup>-1</sup>

number of species

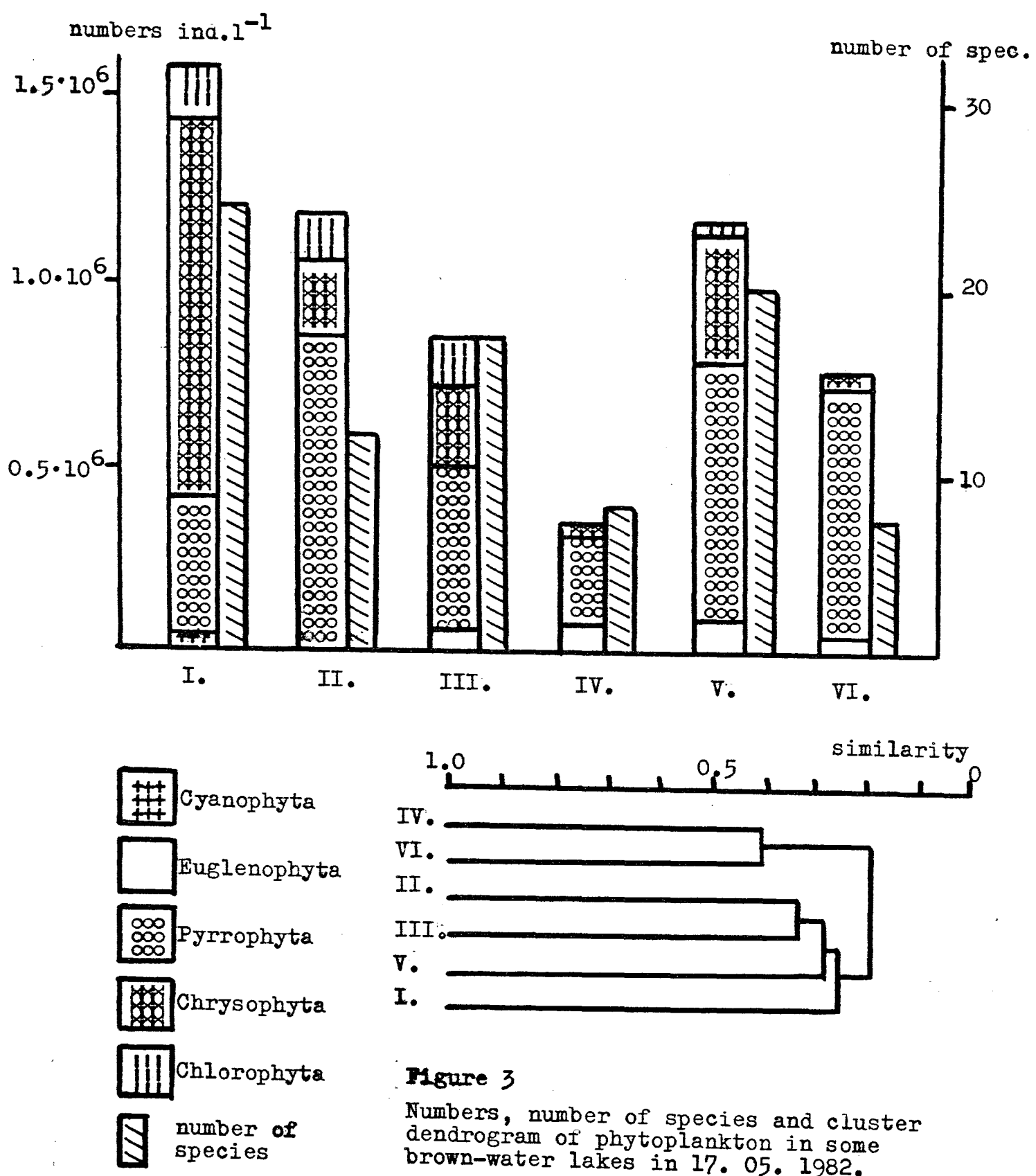
Figure 2: Numbers, number of species and cluster dendrogram of phytoplankton in some brown-water lakes in 19. 04. 1982.



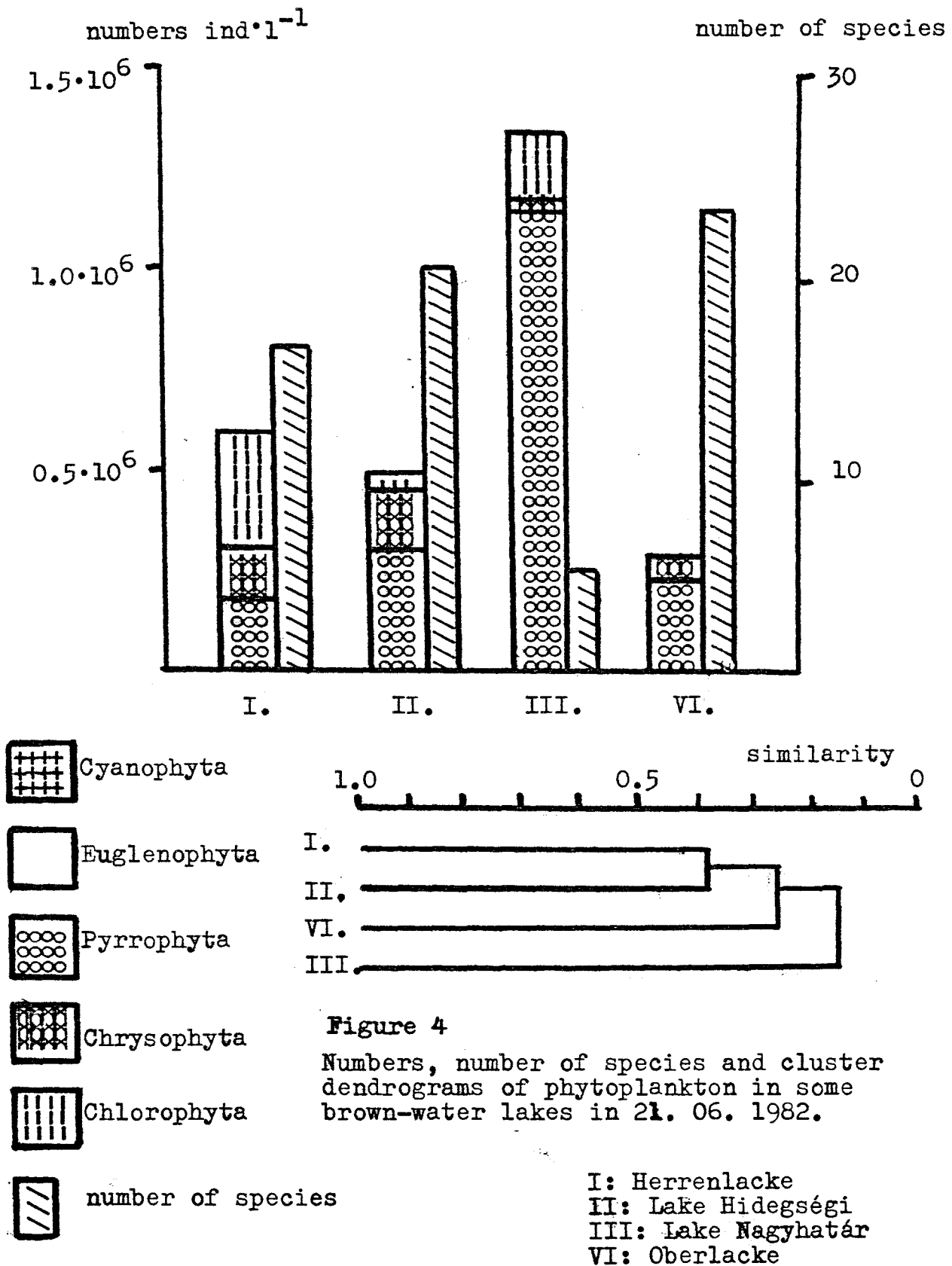
 Cyanophyta  
 Euglenophyta  
 Pyrrophyta  
 Chrysophyta

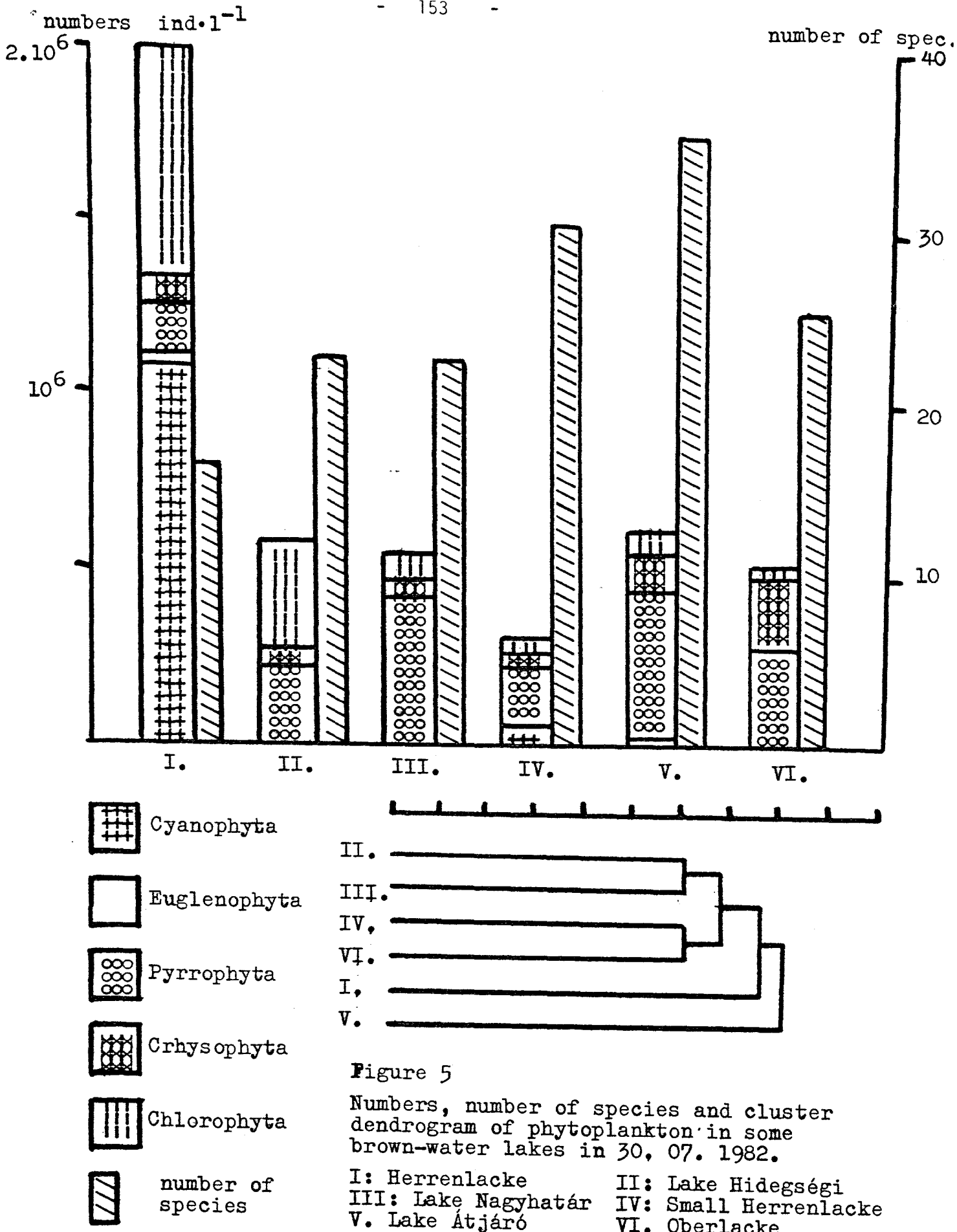
 Chlorophyta  
 number of species

I: Herrenlacke  
 II: Lake Hidegségi  
 III: Lake Nagyhatár  
 IV: Small Herrenlacke



**Figure 3**  
 Numbers, number of species and cluster dendrogram of phytoplankton in some brown-water lakes in 17. 05. 1982.  
 I: Herrenlacke      II: Lake Hidegségi  
 III: Lake Nagyhatar      IV: Small Herrenlacke  
 V: Lake Atjaró      VI: Oberlacke

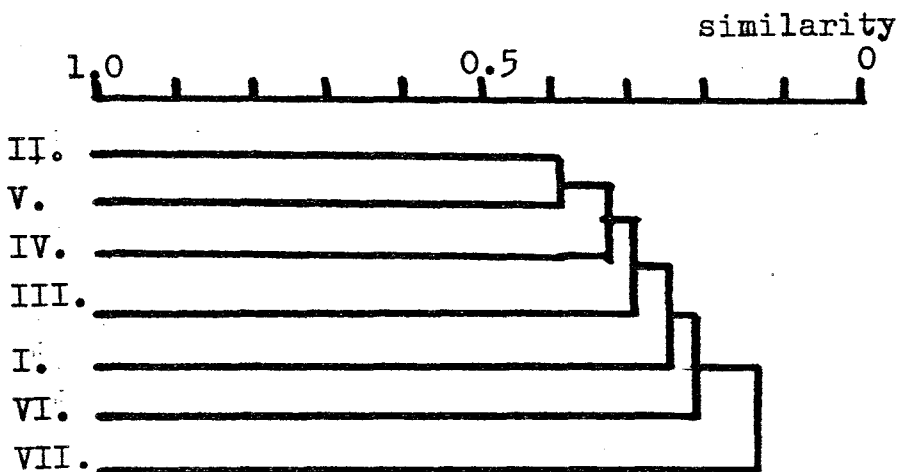




**Figure 5**  
 Numbers, number of species and cluster dendrogram of phytoplankton in some brown-water lakes in 30. 07. 1982.

Figure 6

Numbers, number of species and cluster dendrogram of phytoplankton of some brown-water lakes in 27. 10. 1982.



Cyanophyta

I: Herrenlacke



Euglenophyta

II: Lake Hidegségi



Pyrrophyta

III: Lake Nagyhatár



Chrysophyta

IV: Small Herrenlacke



Chlorophyta

V: Lake Átjáró



number of species

VI: Oberlacke

VII: Lake Pitner

numbers ind. l<sup>-1</sup>

10<sup>6</sup>

0.5 · 10<sup>6</sup>

Figure 6. cont.

3,060,810

number of species

