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SOME OBSERVATIONS ON MICRO-COENOSES IN A BOG REGION INFLUENCED BY MAN

(PRELIMINARY REPORT)

P. J. SCHROEVERS

(*RIVON, State Institute for Nature Conservation Research, Zeist*)

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1. Introduction

The observations were made in the reserve "Mariapeel", S.E. of the village of Deurne. The region may be regarded as a relic of the large bog "De Peel", formerly many square kilometers in extent, and situated between the towns of Nijmegen, Helmond, Roermond and Venlo.

For a long time a "living" bog has been completely out of the question. In the course of time man has put his stamp more and more upon this region, partly by peat-digging, in later times also by reclamation on a more or less extensive scale. The different kinds of peat-winning all have their own effect on the environment (Schroevers, 1966).

For centuries the region has mostly been impenetrable. Peat-digging did take place, but in a very primitive manner and only along the boundaries of the bog. This was done by the farmers in the surroundings. The work must be done within one day, otherwise the water rises too high in the dug pit to make the work possible. This manner of working has given rise to a large number of isolated peat-pools, concentrated in special, more or less approachable spots. Within these pits a regeneration of the bog-succession has begun. They are the only places in which living bog-vegetations are found (cf. Schroevers and Van der Voo, 1965).

At the beginning of the 19th century a start was made with a system of drainage by means of canals. These canals form a furcate system, and are, via the Noorderkanaal, connected with the river Maas. They have greatly contributed to a considerable change in the area. To-day they do not withdraw water, but their presence leads to a penetration of eutrophic water into an oligotrophic area.

This drainage has lead to a standstill of the process of peat-formation. The vegetation has changed; the originally very rich moss layer has been replaced by a carpet of *Sphagnum cuspidatum*. In the herb layer the grass *Molinea coerulea* dominates, while as a new element a tree layer has appeared, in which *Betula pubescens* forms the major part. We may call this type the "unrigged bog" (Van Leeuwen, 1962). Along the canals and in the parts which are influenced by the canal-water, we find a flora, characterized by plants of the eutrophic region such as *Brachythecium rutabulum*, *Acrocladium cuspidatum* and other species in the moss layer, *Phragmites communis*, *Glyceria maxima*, *Stratiotes aloides* e.g. in the herb layer and *Alnus glutinosa*, *Quercus robur* and other trees in the tree layer (see also WESTHOFF, 1964). Apart from this group of species we can also find species which must be called characteristic of the transition stages in zones of contact between eutrophic and oligotrophic water. *Juncus effusus* and *Typha latifolia* are examples of this category.

As a result of the reclamations taking place in the same period, when the above mentioned changes occurred, large areas of these vegetations disappeared, so that the parts still present set themselves up as enclaves in the middle of a disorderly and hardly attractive landscape.

During recent years we also find mechanical peat-winning, having a rigorous effect on the environment, and working very impoverishingly on flora and fauna. The concessions for this work will last for some years. The idea is that after this period the whole territory gets a function as a nature reserve and a recreation area.

2. PLANNING AND METHODS OF THE INVESTIGATION

In 1962 the RIVON (State Institute for Nature Conservation Research) was given the task of carrying out an inventarisation of the Maria- and Helenapeel area, such in relation to the new destination of these parts, mentioned above. Of course it is very difficult to get, from so large an area, and in relatively so short a time, a sufficiently accurate survey of the microorganisms and microcoenoses to be found. Within two weeks $\pm$ 50 samples were collected. Within certain limits this series of samples may be regarded as a "simultaneous series". In any case it is evident that differences due to periodicity do not balance by far those originating from differences in the environment. Of course this working method does not throw any light upon the structure and composition of the biocoenoses. This requires research over a longer time. But it is possible to get an insight into the differentiation within the area. With a sufficient number of samples we can even make a typology which enables to find out ecological backgrounds.

On the basis of these results we can indicate which sample-spots represent certain types in the best way, and so form the best places for further research. This research is now in full swing. The present report deals only with the results of the inventarisation, and the theoretical conclusions based upon these results.

Samples are taken with a plankton-net. 30 litres of water are saved, and so the living stock is concentrated down to 1 cm^3 for analysis. The samples are fixed with formalin. For practical reasons it seemed impossible, during the inventarisation, to use the method of sedimentation, considered the best method for representative sampling, at least for *Protococcales* and *Desmidiales*, the most important groups of organisms worked on. The continuation of the work takes place in this manner.

Identification of the species in the list is based upon the variations as they are found in nature. Many sketches are made with the aid of a drawing-prisma. They form the basis of a species-classification, which is afterwards incorporated into the existing system. Many divergencies proved to exist if we compare with the literature. The names used in the list must be accepted with the reserve needed for such a situation. In a separate publication an account will be given of the determinations and the nomenclature followed.

3. Typology of the area and choice of the sample-spots

For the choice of the sample-spots we proceeded from the external differentiation of the area, as expressed in geomorphological structure and in vegetation. As the structure of the area involves that differences in the environment are mainly due to differences in the origin of the water (bog-water or canal-water, and the many types of mixture), it is right to use this classification for a study of the distribution of micro-organisms.

Contact between the water in the reserve and that in the surroundings is maintained by the Deurnse kanaal and the Helenavaart. At ± 9 km south of the village of Helenaveen both canals are connected with the Noordervaart, which in its turn, forms a communication with the Zuidwillemsvaart and thus with the river Maas. To the north of the reserve the Deurnse kanaal goes through reclaimed land, and is connected there with the original rivulet-system of Brabant. The Helenavaart finds its end in the village of Griendsveen. The waste water of the village of Helenaveen is drained into this canal. The canal is able to get through this in a fairly satisfactory way, so that we may speak of a reasonably balanced eutrophic situation.

By way of a forked system of canals this water penetrates into the area.

These secondary canals are held at a permanent level, probably more or less equal to the original level of the bogwater before the draining of the bog began. As a result of peat digging and draining the water-level in the direct surroundings of these canals is much lower. Here are, however, large fluctuations in the course of the year. There is no mixture of canal water with bog water in the canals.

As a result of loss of minerals the canal water changes towards the end from eutrophic to more or less mesotrophic. The relatively more important contribution of rainwater is of course significant. The phanerogames, building up the vegetation of the bank, distinctly show the existence of such a gradient. *Acorus calamus*, *Sparganium erectum* and other species are replaced by *Typha latifolia*, *Sparganium minimum*, *Comarum palustre* and others.

The original peat part gets its water from the air. Much of this water is removed by draining. Peat digging and partly setting has led to the present situation, where the bottom of the canals lies higher than the direct surroundings. There are however places where the peat water reaches far higher than the level of the canals. This relates to the oldest remains of the bog with ancient peat-diggings. This water, however, has no direct contact with that of the canals.

The water of the pits is rich in dissolved humic substances. It may be regarded as dystrophic. The acid-dystrophic environment has, in its qualitative biological aspects, fully the character of oligotrophy. There are, however, also mesotrophic pits. Perhaps these pits get minerals from the surroundings by washing in. The minerals get there by burning of the vegetation, which regularly takes place. Further "metatrophic" pits must be mentioned, i.e. pits that are disturbed in their food-management, mostly due to human activities. These pits are only found along the edges of the reserve. (For the term "metatrophy", see the discussion).

Finally, a very interesting aspect is presented by those parts of the area in which mixing appears between the dystrophic peat water and the eutrophic water. It may be useful to distinguish between agricultural water – which is enriched on the spot – and canal-water, which is supplied as such. In general it may be said that influence by agricultural water is less intensive than that by canal-water. Therefore comparison is only partly possible. Places, where mixing takes place of bog-water with canal-water are especially characterized by the phanerogamic species *Typha latifolia* and *Carex rostrata*. Lesser influenced parts are recognized by *Carex curta* and species of the genus *Utricularia*.

One of the most interesting aspects of the situation described is the difference resulting from contact with, and contact without disturbance. Therefore these two forms of influence are considered separate types. It is difficult often, however, to draw a distinct boundary between both types.

Summarizing, we can distinguish the following types of environment:

A. The canal, as it enters the area. We may speak of a more or less balanced eutrophic environment.
B. The middle part of the canal is regarded as a separate type, to demonstrate the gradual change towards the ends of the canals.
C. The ends must be characterized as mesotrophic.
D. In the dystrophic area are little pools with mesotrophic water. Perhaps they may be regarded as relics of broads, which had been connected with the canals.
E. These pools are influenced in certain cases by agricultural water. Together with the ditches accompanying these pools they are regarded as a type apart.
F. In some places the water of the canals penetrates into the bog, thus giving rise to the origin of more or less extended broads. They are metatrophic.

G. In places, where this contact happens at the ends of the canals, we find another type, regarded as mesotrophic. Similar situations are found in the transition zone between type F and the uninfluenced peat-water behind this.

H. Peat-pits of the oligotrophic type, originated during fairly recent, but non-mechanical digging activities.

I. Meso-oligotrophic pits, rests of the much older farmer-peat-digging. In these pits regeneration of bog vegetations takes place. Probably this type best links with the situations that predominated in the living bog in past times.

K. Recent pits, originating from mechanical digging, metratrophic and partly ephemeric in character. This type includes also the elder pits, which have become metatrophic through human action (such as the digging of ditches, tramping abouts, burning, etc.).

Of course a classification like this can only be preliminary. But it enables us to indicate the distribution of the organisms over the area. Particularly within the group of peat pits, a classification into more types would have been possible if more analyses were available. Within the scope of this article, however, this is not of importance. They are taken together and handled as our type "H".

4. Species-combinations in the different types

A superficial look at the list shows at once that the various types show distinct differences. The pure, uninfluenced peat-pits represent one extreme, the beginning of the canals the other. Many types, on the other hand, show a distinct mixture. An examination of the distribution is possible by checking in which types every species is found. In this way we can build up species groups, characteristic of certain types or type-groups. Apart from the arbitrary value as a result of too few observations, there are, however, several complications. The most important of these is in the fact that we cannot speak of plankton *sensu stricto*. There is also, within the series of samples, also a differentiation caused by differences in depth, presence or absence of submerged vegetation, and so on. Also the presence of current might be of influence.

Organisms which are observed only once are not recorded in the scheme, because it cannot be stated with certainty whether their limited distribution is due to their rarity or to their stenoek nature. But they are mentioned at the end of this paragraph as being collected under a special type.

The most important division is that between the specific canal organisms and those which are never found in the canals. The first table gives a list of all species found only in the canal, with their distribution over the types A, B and C.

SPECIES	TYPE A	TYPE B	TYPE C
Merismopedia tenuissima	—		
Scenedesmus spec. 1	—		
S. curvatus	—		
S. tenuispina	—		
Pediastrum biradiatum	—		
P. longicorne	—		
Micractinium pusillum	—		
Oocystis lacustris	—		
Lagerheimia cf subsalsa	—		
Actinastrum hantzschii	—		
Tetrastrum staurogeneiforme	—		
Selenastrum gracile	—		
Ankistrodesmus longissimus	—		
Closterium aciculare	—		
Staurastrum avicula	—		
S. paradoxum	—		
Nitzschia actinastroides	—		
Lepocinclis texta	—		
Phacus pyrum	—		
Trachelomonas armatus var. Steinii	—		
T. oblonga	—		
Bosmina longirostris	—		
Pediastrum duplex	—	—	
P. tetras	—	—	
Scenedesmus carinatus	—	—	
S. dimorphus	—	—	
Coscinodiscus rothi	—	—	
Diatoma vulgare	—	—	
Fragilaria capucina	—	—	
Asterionella formosa	—	—	
Nitzschia acicularis	—	—	
N. sigmoidea	—	—	
Euglena acus	—	—	
Phacus tortus	—	—	
Mallomonas acaroides	—	—	
Codonella lacustris	—	—	
Peracantha truncata	—	—	
Pleuroxus trigonellus	—	—	
Tetracladium marchalianum		—	
Lyngbya limnetica		—	
Chroococcus turgidus		—	
Tetraedon trigonum		—	
Scenedesmus oahuensis		—	
Closterium pritchardianum		—	
Cosmarium turpinii		—	
Mougeotia robusta		—	
Tabellaria fenestrata		—	
Fragilaria virescens		—	
Navicula cuspidata		—	
Cymatopleura solea		—	
Surirella linearis		—	
Lepocinclis ovum		—	
Phacus gigas		—	
Mytilina ventralis var. brevispina		—	
M. ventralis var. macracantha		—	
Anureopsis fissa		—	
Asplanchna spec.		—	
Testudinella patina		—	

Species	Type A	Type B	Type C
Lepadella rhomboides		—	
Lecane hamata		—	
L. stokesi		—	
Graptoleberis testudinaria		—	
Eurycercus lamellatus		—	
Coelosphaerium naegelianum		—	—
Nostoc kihlmani		—	—
Stigonema spec.		—	—
Cosmarium depressum var. achondrum		—	—
Gomphonema acuminatum		—	—
Rhopalodia gibba		—	—
Phacus caudatus		—	—
Anabaena flos-aquae		—	—
Eudorina elegans		—	—
Merismopedia elegans			—
Cosmarium obtusatum			—
C. punctulatum			—
C. obsoletum			—
C. pachydermum			—
C. quadrum			—
C. reniforme			—
C. subcucumis			—
Pleurotaenium trabecula			—
P. truncata			—
Euastrum verrucosum			—
E. dubium			—
E. inermis			—
Micrasterias americana			—
Desmidium swartzii			—
Gonatozygon monotaenium			—
Staurastrum striolatum			—
Navicula cryptocephala			—
Vorticella spec.			—
Lecane ludwigii			—
Acroperus harpae			—
Alona costata			—
A. quadrangularis			—
Pediastrum boryanum	—	—	—
Tetraedron minimum	—	—	—
Scenedesmus armatus	—	—	—
S. spec. 2	—	—	—
Dictyospaerium pulchellum	—	—	—
D. ehrenbergianum	—	—	—
Ankistrodesmus falcatus	—	—	—
Synedra ulua	—	—	—
Gomphonema constrictum	—	—	—
Epithemia turgida	—	—	—
Dinobryon divergens	—	—	—
Keratella quadrata	—	—	—
Oscillatoria redekei	—	—	—
Gomphosphaeria aponina	—	—	—

What catches the eye at once is the fact that no category AC is found. This clearly demonstrates the existence of a gradient situation. A group of organisms comes forward (category ABC), which makes relatively few demands on the environment. This category as a whole is closely related to the group of organisms which we find in all eutrophic waters of the Netherlands. Apart from this group we find certain groups that are more or less connected with the trophic state of the water. We give a summary in species-numbers of the groups of *Chlorophyceae, Conjugatae, Bacillariae* and *Cyanophyceae,* as far as belonging to the categories A, B, C, AB and BC:

	A	B	C
Chlorophyceae	9	6	1
Cyanophyceae	0	4	5
Bacillariae	6	8	2
Conjugatae	0	2	5

The number of species of *Chlorophyceae* declines from A to C; a little further on also that of the Diatoms. The species-number of *Conjugatae* – especially *Desmidiaceae* – on the other hand, increases, together with that of *Cyanophyceae.* The latter result must partly be brought about by the changing of the depth and width of the canal towards the end. This favours the development of *Cyanophyceae* and of *Desmidiales.* The parallelism between the development of these two groups gives rise to a search in this direction for a solution of the problem. We must say, however, that disturbance – favouring certain blue green algae – is sooner to be expected in oligotrophic than in eutropic water. In any case it is shown that the Nygaard quotient, in which *Cyanophyceae* together with *Eugleninae, Centricae* and *Protococcales* forms the eutrophic component – is not correct. The reader is referred to my publication on sedimental plankton of the "Kippenest", 1965.

I am convinced, however, that to a great extent the differences between A, B and C are the result of changes in the interior food-relations in the biocoenosis, or in its trophic level.

The following table gives the species found only in the peat region itself:

	Type				
Species	H	E	D	F	G
Lecane lunaris	—	—			
L. stichaea		—	—		
Lecane scutata		—			
Staurastrum muricatum		—			
Rotaria spec.	—	—	—	—	
Oedogonium undulatum				—	—
Closterium calosporum				—	—
Acanthocystis turfacea				—	—
Scenedesmus asymmetricus				—	—
Kellicottia bostoniensis				—	

Species	Type H	Type E	Type D	Type F	Type G
Actinocyclus normanni				———	
Nitzschia scalaris				———	
N. filiformis				———	
Polyarthra vulgaris				———	
Closterium decorum					———
C. juncidum					———
Euastrum didelta					———
E. oblongum					———
Micrasterias crux-melitensis					———
Arthrodesmus incus					———
Scapholeberis mucronata	———	———	———	———	———

This table is much smaller than the first one. This was to be expected. The less productive water has a smaller number of species, and it is also more difficult to find good indicators in this environment.

The total number of phytoplankton species is small; the number of species in zooplankton is relatively of greater importance, especially in the bogwatertypes, not influenced by canal water. A distinct difference exists between these types (H, E and D) and the types F and G. Thus influence by canal water leads to a new situation, diverging from all the other types. F and G have four species in common. *Kellicottia bostoniensis*, found in F, is regarded as characteristic for instability in the trophic situation (Schroevers, 1962). This situation is called metatrophic, following Leentvaar, 1959. Of *Polyarthra vulgaris* this fact is still unknown. An interesting species is *Actinocyclus normanni*, which used to be rare, but is certainly characteristic of sample point 7, i.e. in type F. *Actinocyclus normanni* is known in large numbers from the Biesbosch area (reports of the excursions of the Hydrobiological Society in 1959–1960). It is also found in the guanotrophic Wasmeer at Hilversum and in the Leersumse plassen, prov. of Utrecht, (Leentvaar, unpublished) and thus seems to be metatrophic as well. Also the other diatoms, *Nitzschia scalaris* and *N. filiformis* may be connected with instability of the environment, as they are also characteristic of more or less brackish waters (Van der Werff, 1963).

On the other hand a group exists which is characteristic of type G. In this category we find many Desmids. It seems to be correct to call F metatrophic and G mesotrophic.

More difficult it is to find a way in the species found inside the canals, as well as outside. Type D will be considered first. The species of the combination canal-type D are:

Englena spirogyra
Lepadella patella/ovalis
Phacus granum.
Coelastrum microporum
Crucigenia quadrata.

These species are eutraphentic. Their difference from the category ABC is that they were able to stay for a long time, if the situation changes. It is to be expected, however, that this might be the case with many other species of the category ABC. Thus the difference is to a great extent due to chance.

A large group is that of organisms found in the canals either in F and G, or in one of these two. The list is given here:

Species	Type F	A	B	C	G
Scenedesmus acutiformis		—	—	—	—
Aphanocapsa delicatissima		—	—	—	—
Scenedesmus vitiosus		—	—	—	—
Kirchneriella obesa		—	—	—	—
Closterium moniliferum		—	—	—	—
Staurastrum gracile		—	—	—	—
Cosmarium bioculatum			—	—	—
Euglena oxyurus			—	—	—
Cosmarium granatum var. subgranatum			—	—	—
C. tetraophthalmum			—	—	—
Botryococcus braunii			—	—	—
Monommata aequalis			—	—	—
Tetraedron regulare				—	—
Scenedesmus lefevrii				—	—
Cosmarium botrytis				—	—
C. humile				—	—
Staurastrum alternans				—	—
S. inflexum				—	—
Euastrum elegans				—	—
Ophiocytium capitatum				—	—
Chroococcus limneticus	—	—	—	—	
Synedra pulchella	—	—	—	—	
Lyngbya hieronymusii	—	—	—	—	
Oscillatoria spec.	—	—	—	—	
Scenedesmus pseudoarmatus nov. sp.	—	—	—	—	
S. quadrispina	—	—	—	—	
Selenastrum westii	—	—	—	—	
Synura uvella	—	—	—	—	
Lionotus spec.	—	—	—	—	
Dactylosphaerium radiosum	—	—	—	—	
Daphnia pulex	—	—	—	—	
Trichocerca similis	—	—	—	—	
Closterium costatum	—	—	—	—	—
Microcystis aeruginosa	—	—	—	—	—
Gloeocystis gigas	—	—	—	—	—
Asterococcus superbus	—	—	—	—	—
Lecane closterocerca	—	—	—	—	—

The species *Closterium costatum* is usually held to belong to the group FABC. This is not exactly correct: In the canals the species is only found in type C. It should probably be considered as penetrating from the mesotrophic part of the broad, which is regarded as belonging to type F. In that case the species belongs to category CG, together with *Closterium calosporum* and others.

The gradient situation described on the ground of the first table is clearly demonstrated also here, as is the difference between F and G. The number of Protococcales decreases from A to C, the number of Desmids increases. It is worthwhile to mind the exceptions. *Closterium moniliferum* and *Staurastrum gracile* penetrate into A, but are still well represented in the mesotrophic circumstances of G. On the contrary, the species *Tetraedon regulare* and *Scenedesmus lefevrii*, genuine green algae, are not found outside the mesotrophic environment. Earlier *Scenedesmus lefevrii* has been regarded as metatraphentic (SCHROEVERS, 1962); in the Peel-region it appears to be mesotraphentic.

The difference between F and G is clearly demonstrated by the following table, in which the numbers are mentioned of the species that occur in that type, but not in the other:

GROUPS	TYPE	
	F	G
Green algae	5	7
Blue-green algae	4	1
Diatoms	3	1
Desmids	1	10

The most striking features may be seen in blue-green algae and desmids. The relation between these groups is here reverse, contrary to what is seen in the types A, B and C. The metatrophic state of type F is thus clearly evident.

To compare with these findings we here give a table dealing with the categories found in the canals, in the affected parts, and in the enriched types D and E (these are all the types except the "pure" peat-pit).

	A	B	C	D	F	G	E
Trachelomonas volvocina	—	—	—		—	—	—
Ceriodaphnia pulchella	—	—	—	—	—		—
Simocephalus vetulus	—	—	—	—			—
Microthamnion kützingianum		—	—	—	—	—	—
M. strictissimum		—	—	—	—	—	—
Pinnularia viridis			—	—			—
cf. Chlorothecium pirottae			—	—			—
Trichotria tetractis	—	—	—				—
Euglena spec.		—	—				—
Staurastrum polymorphum		—	—				—
Keratella cochlearis	—	—	—	—	—		
Phacus suecicus	—	—	—	—	—		
Fusarium spec.	—	—	—	—		—	
Phacus pleuronectes	—	—	—	—	—	—	

It is difficult to draw conclusions from this list, because of the many types and the relatively few samples. Certain species may surely occur regularly in types where they have so far never been found. Some facts, though, may be stated:

A large number of species may be regarded as "ubiquitous" within the originally rich and enrichened environment. These species are: *Simocephalus vetulus*, *Trichotria tetractis*, *Keratella cochlearis*, *Phacus suecius*, *Fusarium* spec. and *Phacus pleuronectes*. Striking is the absence of merely photoautotrophic organisms within this category. All these species seem to be able to tolerate a certain instability in the conditions under which they live. Species with the same trend, but only occurring in less productive water, are *Microthamnion strictissimum* as well as *M. kützingianum*, *Euglena* spec., *Staurastrum polymorphum*, *Pinnularia viridis* and *cf. Chlorothecium pirottae*. The two species of *Microthamnion* are called β mesosaprobic in the system of Liebmann. My own experience is that they are found in places with conditions between meta- and mesotrophic (cf. SCHROEVERS, 1963), though they are also known from polluted waters of a more eutrophic nature.

Finally the species will be considered from the unaffected peat-pits, regarded here as one type, though there are many differences within this group. The species found in H and other types are (for species of categories D to H, see the second table):

Species	Type H	A	B	C	D	E	F	G
Proales spec.	—		—	—				
Gloeothece rupestris	—			—				
Alonella nana	—			—			—	
Chydorus sphaericus	—	—	—	—	—	—		—
Eunotia lunaris	—	—	—	—	—	—	—	—

Of *Proales* spec. and *Alonella nana* it is clear that we do not have enough observations. *Gloeothece rupestris* probably is washed in from the banks. Five species are found in both H and E. *Chydorus sphaericus* and *Eunotia lunaris* can be regarded as "ubiquitous" between the boundaries of the area.

Scapholeberus mucronata and *Rotaria* spec. are found in all the waters of smaller area. Only *Lecane lunaris* appears to be a good indicator of the oligotrophic type, within the area. But more research is needed.

Summarizing the results of the given analysis, we can draw the following conclusion:

As a result of the typical structure of the area, in which eutrophic water makes contact in several ways with oligo- and dystrophic water, a system has arisen with an enormous differentiation, leading to a great wealth of species. The division into types, as was done in § 3 appears to be useful. As a matter of fact we can see that the canals show a gradient from eutrophic to mesotrophic. There is a principal difference between areas with, and those without, contact with the canal water. The latter factor gives rise to a proper environment with its own species. Within this type we can distinguish a metatrophic (F) and a mesotrophic (G) phase. Enrichment by agricultural influence appears to have less influence on the structure of the biocommunity than by canal water (type E). Uninfluenced rests, finally, show different types (D, H) with few species peculiar to them. Without doubt a further division is possible.

This paragraph closes with a list of the organisms that were observed in only one sample. They are arranged according to the type in which they are found:

A. Scenedesmus naegelii
S. subspicatus
Closterium leibleinii
Cosmarium depressum
Staurastrum cuspidatum
S. laeve
Characium subulatum
Fragilaria crotonensis
Phacus pyrum
Strombomonas chodati
Pyramidomonas spec.
Lecane saginata
Filinia longiseta

B. cf. Thiodictyon elegans
Characium saccatum
Synchaeta spec.
Sphaerodinium cinctum
Peridinium borgei
Strombidium spec.
Trichocerca brachyura
T. elongata
Polyarthra dolichoptera

C. Yeast-like organism
Gongrosira debaryana
Closterium cynthia
C. linea
C. tenuissimum
Mesotaenium spec.
Navicula dicephala
Colacium cyclopicola
Peridinium bipes
Euastrum monocyclum
Chrysococcus minutus
Cryptomonas spec.
Stylonychia spec.
Euchlanis dilatata
Lepadella acuminata
Trichocerca rosea
Microcodides chlaena
Campthocercus macrurus

F. Colchliopodium vestitum
Polyarthra remata
Alona rectangula

G. Euastrum pulchellum var. retusum
Hyalotheca dissiliens

H. Polyphemus pediculus

5. Chemical data

In seven places, on 23–11–1962, a sample was taken for chemical analysis. The result of this analysis appeared to be in accordance with the classification developed above. There exists a principal difference between the water of the canals and that of the peat-pits; only the pH measurements do not show this. Within the category of peat-pits, however, we can see a great differentiation in pH. It is good to sum up the values given for inorganically and organically linked ammonium, because we found a great variation of these two factors in samples 49 and 50. Apparently the one is transformed into the other by an unknown cause. The difference in the pH of the same samples may be due to the same origin. Bad buffering of the water leads to strong pH fluctuations at every change in the chemical composition of the water in these spots. Incidental pH measurements, therefore, have little value.

The samples 7 (type F) and 12 (type G) show an intermediary position between the extremes mentioned. Noteworthy is the fact that this is not the case with the values of PO_4. We observed a lowering from A to D and further on to F and G, but high values in the peat-pits. Perhaps this is connected with the variation in ammonium, already mentioned. Nevertheless it is strange why this is not the case in the samples 7 and 12. Perhaps this is due to differences in depth and water surface area (cf. also the situation in the "Kippenest", N.W. Overijssel, SCHROEVERS, 1965).

Sample 7 (F) shows closer relation to the eutrophic type than sample 12 (G). Only the Chloride value shows a slightly controversal tendency. Thus the bog-character is better maintained in G than in F. This is quite in accordance with the results of the biological analyses. Therefore it seems to be useful to attribute the biological differences to the chemical nature of the water.

Why does this difference exist? Three explanations can be given:

(a) The quantity of water-masses of different origin is so, that, percentually more peat-water comes into 12 than into 7.
(b) The contact between canal- and peat-water is direct in 7, but indirect (subterranean water movement) in 12.
(c) The canal-water of C is not of the same composition as that in type A. Difference between peatwater and canal-water is much smaller in 12 than in 7.

(a) is hardly credible. The total quantity of water is much bigger in 7 than in 12; this is only due to the fact that the bottom of the canal is relatively higher here. Percentually the differences between A and F are greater than between C and G; only the bicarbonate hardness does not show this. Therefore the reason for the difference between F and G is, in the first place, to be sought in a difference of the water of A and C, and not in a buffering working of the peat in G. It is, however, very dangerous to draw this conclusion from one analysis on each spot. It is important to continue the chemical research and to attend to the following points:

1. How many waters of different origins are mixing together?
2. What is the influence of water-depth on the situation?
3. What is the frequency in which mixture takes place?
4. Can moving of water through the peat bottom be proved to occur?

6. DISCUSSION

The structure of the area is, in the first place, typified by the fact that we have to do with a, on the whole, oligotrophic environment of relatively large proportions. The incoming eutrophic water is not able to destroy the existing structure.

Therefore the "eutrophication" does not lead to an impoverishment of flora and fauna, but, on the contrary to an enrichment. The great differentiation in the nature and structure of the biocoenose is in the first case due to this phenomenon. In principle two reasons are responsible for this:

1. As a result of the fact that the eutrophic water is not influenced by the surrounding, while the canal system ends blind at one side, a fine gradient has arisen from eutrophic till oligotrophic.
2. Because contact exists in several places between this water and the original Peelwater, the consequences of this contact, destroying the biological equilibrium, are well worth studying.

Surveying the results, as communicated in § 4, we may say that we have to do with more distinctly demonstrable units which owe their origin to the two above mentioned conditions. Therefore it is important to search for a theoretical basis which may be either consolidated or contradicted by further research.

In modern limnology the problem of productivity seems to take a more and more central place. Beside this, qualitative research, too, takes place all the time; which, however, has never led to the same stormy development, which is the case in experimental ecological research. This is understandable. The basis for this work is much more vague and difficult than for the experimental work, in which the basis is laid by the worker himself.

It appears that, between the typology obtained from qualitative biological research and the results of productivity-research, and also of chemical water-analysis, a more or less demonstrable connection exists. In past times this connection has led to a kind of mutual identification. In fact this was already caused by Thienemann, by taking over Naumann's terms "oligotrophic", "mesotrophic" and "eutrophic" for his own typology, which, in fact, was explained by way of chemical and geomorphological features, but which was based upon merely qualitative biological differences of his lakes, in this case the Chironomid fauna of the profundal. Naumann, however, based his terminology on the nature of the water and the production was the result of this. The confusion which was due to this course of affairs has never disappeared and today still gives cause for concern.

It seems consistent to interconnect these phenomena. Of course, the question, how the community develops, is dependent on the physical and chemical properties of the water, although the history of the waterbody concerned is also of importance. Examination of the water on the basis of chemical properties is possible within certain limits, but it is very difficult because we cannot decide beforehand which factor is to be regarded as a minimum factor; neither do we know the maxima and minima, nor the strength of the fluctuation on their frequence, unless through intensive and expensive chemical research.

In fact, we tend to solve a biological problem in which biological ways are possible, by chemical methods. The properties mentioned of a biological nature are of the greatest importance, because it is the development in the course of time, which is one of the master factors in establishing biotic communities (cf. MARGALEF, 1961; VAN LEEUWEN, 1964). This brings us to a new approach to the problem.

If a biocoenosis is in a state of balance, we can speak of a high degree of structure. Therefore time has been needed. Thus the analysis of a plankton-community can yield information not only of the present state, but also of the conditions in the environment in the past, over at least one year, but mostly over a much longer time. The occurrence or absence of any species is due to these internal relations within the biocoenosis. It is to be expected that, within a given situation to be studied, the presence of relatively few species is decided in a direct way by the chemical properties of the water. Of course the indirect way is of much importance. The relations between the species are to a great extent established by the factor of "supply and demand", where the word "food" comes to mind. With food we mean all that has to do with energy-transfer. But also not-energy-transferring substances have their influence. The amount in which these are present, and their sphere of action are dependent on the production of the species concerned, and thus belong in the same food-relations; so it is quite imaginable that waters of low productivity, in a characteristic way qualitative-biological, are to be distinguished from those with high productivity. This relation is not, however, a simple linear one.

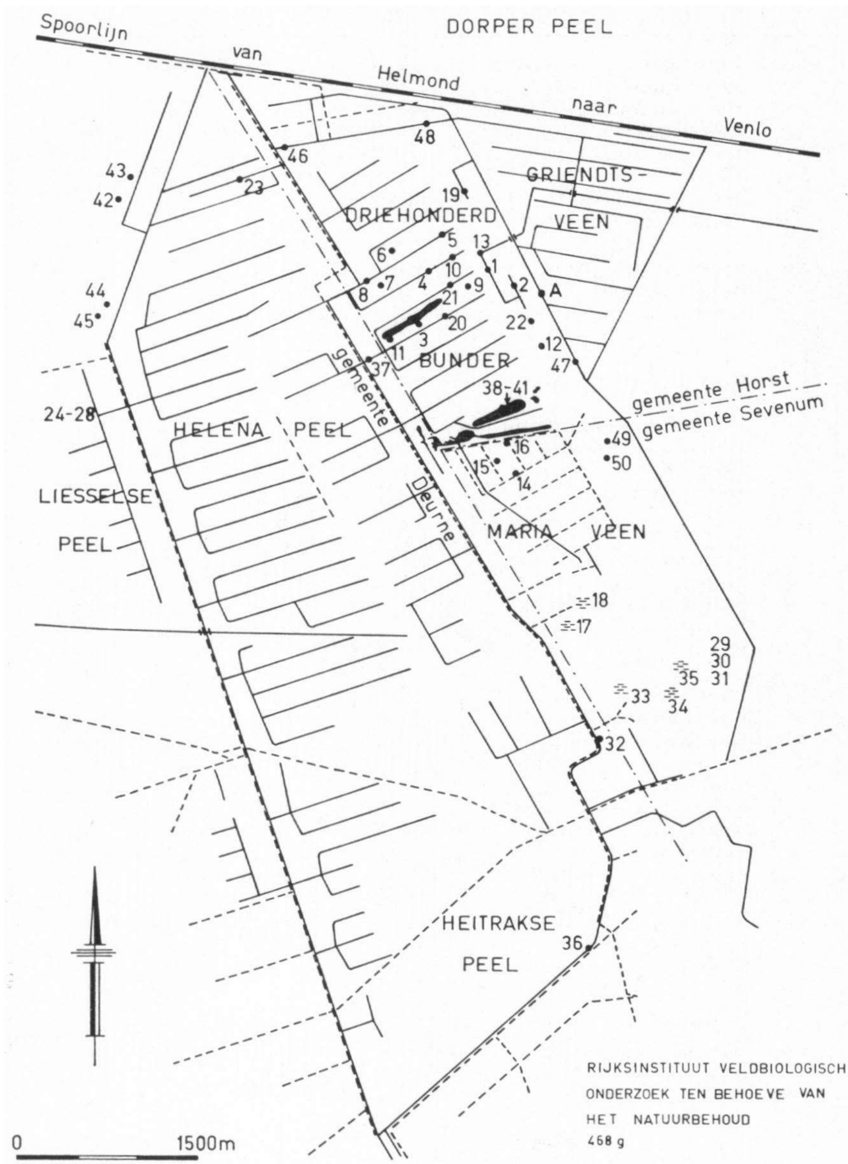
The phenomenon which constitutes the crucial point is a theoretical-biological one. This might be called "trophy" and cannot be measured. It finds its direct repercussion, however, in the qualitative nature of the biocoenosis, so that a division into classes, based upon this, can be handled as a criterion. The physico-chemical environment is the occasion for the arising of a certain "trophic level", as the productivity forms the measurable reflexion of it, running parallel to the trophic level in undisturbed situations, but more or less diverging from it in disturbed ones. Of course the approach to this most essential heart of biocoenology along all three ways is very necessary. In accordance with the viewpoints stated above, however, it is preferable to reserve the terms oligotrophic, mesotrophic and eutrophic for the classification of types based upon the qualitative properties of biocoenoses. For research in this direction, four ways exist:

1. To make a statistical analysis of association between species; thence to derive a series which illustrates the transition from oligotrophic till eutrophic.
2. To select units of combinations of species, based upon fidelity ("Synusien"). Relationships-analyses may also lead to the formation of a series from oligotrophic to eutrophic.
3. Within a restricted area the behaviour of species can be followed up, particularly in gradient-situations. In this case to a certain extent the water chemistry is to be used as a guide.
4. Different taxonomical groups have different ecological preferences. On the ground of the species-numbers of these groups an approximation can be given of the trophic level within the biocommunity.

List of the sampling-stations (Map 1)

		Type	
1	Little pool in the neighbourhood of an agricultural enclave	D	Driehonderd Bunder
2	Ditch around agricultural enclave	D	,,
3	Lower part in Molinia-vegetation	E	,,
4	End of a canal	C	,,
5	Idem	C	,,
6	Broad, formed by overflowing with canal-water	F	,,
7	Idem	F	,,
8	Canal on the place of contact with the broads of 6 and 7	B	,,
9	Lower part in Molinia-vegetation	E	,,
10	End of a canal	C	,,
11	Lower part in Molinia-vegetation	E	,,
12	Broad, formed by overflowing with canal-water	G	,,
13	Ditch around agricultural enclave	D	,,
14	Rest of a canal, with recent peat-digging	K	Mariapeel North
15	Idem	K	,,
16	Recent peat-pit (small)	K	,,
17	Idem (large)	K	,,
18	Idem (,,)	K	,,
19	Little ditch in Molinia-Calluna-vegetation	E	Driehonderd Bunder
20	End of a canal	C	,,
21	Idem	C	,,
22	Broad, formed by overflowing with canal-water	G	,,
23	Idem	G	,,
24–28	Pits of ancient farmer-diggings	I	Liesselse Peel South
29–31	Canals with influence of reclamation	K	Mariapeel South
32	Canal supplying water from the surroundings	A	Between Maria- and Helenapeel
33–35	Recent peat-pits (large)	K	Mariapeel South
36	Canal supplying water from the surroundings	A	Outside the studied area
37	Idem	A	Between Maria- and Helenapeel
38–41	Rather recent peat-pits	H	Mariapeel North
42–45	Ephemeric pools in recent diggings	K	Liesselse Peel North
46	Middle of canal	B	Between Maria- and Helenapeel
47	End of canal	C	Between Griendtspeel and Mariapeel
48	Middle of canal	B	Driehonderd Bunder
A	Idem	B/C	Between Maria- and Griendtspeel

We may conclude that the concept "trophy" is linked with a situation of balance within the relations of supply and demand. Hence only in stable situations can we speak of a trophic level. It cannot be the case in, for instance, brackish or pulluted water. Research according to the four points mentioned must therefore be restricted to waters of stable types.


Spoorlijn van Helmond naar Venlo
DORPER PEEL
GRIENDTS-VEEN
DRIEHONDERD BUNDER
HELENA PEEL
LIESSELSE PEEL
gemeente Deurne
gemeente Horst
gemeente Sevenum
MARIA VEEN
HEITRAKSE PEEL
0 1500m
RIJKSINSTITUUT VELDBIOLOGISCH ONDERZOEK TEN BEHOEVE VAN HET NATUURBEHOUD
468 g

Map 1.

If the existing balance between the different phases is disturbed, the management of the food-chain, the relation between production and consumption at certain points in the food-chain, is invariably affected. In cases where waste is added this is clear. Manuring with inorganic compounds enables certain species to multiply in large quantities. This leads to stagnation and accumulation within the cycle, and as a result to pollution. Temporary drying up, extreme changes in physical circumstances etc. also have this result.

To conclude: there are two basic criteria for the classification of stagnant fresh water: trophy and disturbance. Both properties are to be studied in the described microcoenoses of the Peel. It is clearly obvious how changes in the environment lead to changes in the biological composition of the community. The distribution of all the species must be followed within the system, and used for an ecological approach. If we have enough observations at our disposal, much can be achieved in the form described. This work is in full swing.

What can be distinctly seen is how contact of eutrophic with oligotrophic water leads to a disturbance of the balance. This is evident from the speciesnumber, and from the ratio between species groups and the presence of typical disturbance indicators. As examples of this category may be mentioned the rotifer *Kellicottia bostoniensis*, till now only found in disturbed places, and the diatom *Actinocyclus normanni*, already mentioned above. Striking are the resemblances and the differences between the types of F and G. They show that disturbance of the balance is less when the zone of contact is found more towards the end of the canals.

An explanation of this phenomenon may be that, here, the difference between the two water-types is smaller. It shows that the degree of the disturbance is not only dependent on the amount of pollution, but also on the nature of the receiving water. An interesting fact is that, in the transition zone between the broads of type F to the oligotrophic type, a zone is found, belonging to type G, just as was to be expected on ground of the arguments developed above.

In this transition the species *Microthamnion strictissimum* and *M. kützingianum* play an important role (SCHROEVERS, 1963). These species are also found in the types D and E. It may be expected that further research will show a greater resemblance between these types, just as we can see in the vegetation.

The possibility of reducing a disturbance within the "wheels" of the biological system is greatest in the eutrophic environment. First the differentiation here in the relations between organisms is great, and secondly this is also the case with the "turn over", so that extra charge of a certain amount is percentually smaller. This may schematically be expressed in the following way: see Fig. 1.

Disturbed environments may be classified on the basis of the amount of disturbance (vertical in the figure) and according to the nature of the disturbed environment (horizontal in the figure). The terms of the saprobic system are generally used for pollution of eutrophic water. It might be useful to restrict these terms exclusively to this category. In

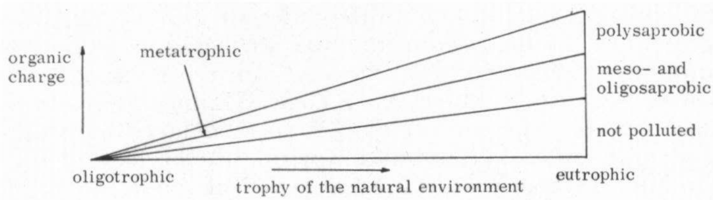


Fig. 1.

that case we would have to search for new terms for disturbed or polluted waters of the oligotrophic type. Leentvaar has proposed for environments of that type the term "metatrophic". Leentvaar here means environments originating from contact between eu- and oligotrophic water, in which a mixture-coenose is found of changing composition, varying in the course of time from more oligotrophic to more eutrophic and vice versa. Although I do not agree with this point of view, it is clear that Leentvaar has his eye on the same situations as described here. Therefore a situation as found in type F, which is characteristic of many waters on sand in the East-Netherlands, called "vennen" is called metatrophic. For further information about this terminology the reader is referred to SEGAL (1965).

Of course the scheme developed here is incomplete, and open to further development. It seems to me, however, that nature gives us indications which make this line of thinking meaningful. Research can yield information on questions about the purifying capacity of surface waters, and on the conditions to be created when water is influenced from outside. Research of this type is only possible in areas where disturbance can be led into the way we want. It is clear that nature conservation thus assumes a practical significance; a meaning, which, in a technified world is still not deservedly appreciated.

SUMMARY

An inventarisation is made of a bog-region, influenced by eutrophic water, which enters into the area by way of a system of canals. 50 samples are analysed. A division into 8 groups is made, based upon the structure of the landscape and the vegetation. The distribution of planktonic species is analysed and the results are discussed. The canals have a fine gradient from eutrophic to mesotrophic conditions; the uninfluenced peat-pits are oligo-dystrophic. Of particular interest are the places of contact between the canal water and the peat-water. Two stages are distinguished: enrichment of the originally oligotrophic water, with disturbance and without disturbance. The greater the difference between the two waters that form contact with each other, the greater the disturbance. The disturbed type is called "metatrophic" after LEENTVAAR (1961). Theoretical backgrounds of these features are discussed and a comparison is made with the existing saprobic system. All these forms are to be seen in one system. The two main factors, controlling the difference within the category of stagnant fresh water, are trophy and stability. Together they will make a typology possible, a typology which may be of interest for those who are entrusted with the management of surface waters.

List of Species Recorded and Their Distribution over the Types A–K

	A	B	C	D	E	F	G	H	I	K
Bacteria and Fungi										
Sorochloris spec.			+	+		+	+			
Microchloris spec.		+	+							
Thiodictyon elegans		+								
Tetracladium marchalianum		+								
Dendrospora nov. spec.?						+				
Fusarium spec.	+	+	+	+			+			
Yeast-like organism			+							
Cyanophyceae										
Microcystis aeruginosa	+	+	+			+	+			
Aphanocapsa delicatissima	+	+	+				+			
Aphanothece nostocopsis		+								
Gloeothece rupestris			+					+		
Chroococcus limneticus	+	+	+			+				
C. turgidus		+								
Gomphosphaeria aponina	+	+	+							
Coelosphaerium naegelianum		+	+							
Merismopedia tenuissima	+									
M. elegans		+	+							
Dactylococcopsis raphidioides			+							
Nostoc kilmani		+	+							
Anabaena flos-aquae			+							
Oscillatoria spec.	+	+	+			+				
O. redekei	+	+	+							
Lyngbya spec.						+				
L. hieronymusii	+	+	+			+				
L. birgei		+	+							
L. limnetica		+								
Stigonema spec.			+							
Tolypothrix spec.						+				
Chlorophyceae										
Chlamydomonas spec.		+	+	+	+					
Pyramidomonas spec.	+									
Pandorina morum	+	+								
Eudorina elegans			+							
Tetraspora lacustris			+							
Gloeocystis major	+	+	+			+	+			
Asterococcus superbus	+	+	+			+	+			
Pediastrum biradiatum	+									
P. boryanum	+	+	+							
P. boryanum longicorne	+									
P. duplex	+	+								
P. tetras (+forma biradiata)	+	+								
Micractinium pusillum	+									
Oocystis lacustris	+									
Lagerheimia subsalsa (forma)	+									
Tetraedron minimum	+	+	+							
T. regulare (div. vormen)			+				+			
T. trigonum		+								

List of Species (*continued*)

	A	B	C	D	E	F	G	H	I	K
Scenedesmus abundans	+									
S. capitatus	+	+								
S. acutiformis	+	+	+				+			
S. armatus	+	+	+							
S. asymmetricus							+			
S. arvernensis	+	+	+							
S. bicaudatus		+								
S. carinatus	+	+								
S. curvatus	+									
S. spec. 1.	+									
S. dimorphus	+	+								
S. lefevrii			+				+			
S. oahuensis		+	+							
S. platydiscus	+	+								
S. pseudoarmatus nov. spec.	+	+				+				
S. quadricauda	+	+				+				
S. quadrispina	+	+				+				
S. subspicatus var. brevicauda	+									
S. tenuispina	+									
S. vitiosus (hystrix)	+	+	+				+			
S. spec. 2.	+									
Actinastrum hantzschii	+									
Crucigenia quadrata	+	+	+	+						
Tetrastrum staurogeneiforme	+									
Kirchneriella obesa	+	+	+				+			
Gongrosira debaryana			+							
Selenastrum gracile	+									
S. westii	+	+	+			+				
Dictyosphaerium ehrenbergianum	+	+	+							
D. pulchellum	+	+	+							
Ankistrodesmus falcatus	+	+	+							
A. longissimus	+									
Coelastrum microporum	+	+	+	+						
Protococcus spec.	+	+								
Oedogonium spec. div.	+	+	+	+	+	+	+	+	+	+
O. itzigsohnii		+								
O. undulatum							+	+		
Bulbochaete spec.							+			
Microthamnion kutzingianum			+	+	+				+	
M. strictissimum				+	+				+	
Microspora pachydermum									+	
Trochiscia spec.		+								
Conjugatae										
Closterium acerosum		+								
C. aciculare	+									
C. calosporum-pseudodianae						+	+			
C. costatum		+	+			+	+			
C. cynthia			+							
C. decorum							+			
C. ehrenbergii		+	+				+			
C. gracile							+			

List of Species (*continued*)

	A	B	C	D	E	F	G	H	I	K
Closterium jenneri			+				+			
C. juncidum							+			
C. kutzingii			+							
C. leibleinii	+									
C. linea			+							
C. moniliferum	+	+	+				+			
C. pritchardianum		+								
C. striolatum			+							
C. sublaterale							+			
C. tenuissimum			+							
C. venus			+							
Cosmarium bioculatum		+	+				+			
C. botrytis			+				+			
C. depressum	+									
C. depressum var. achondrum		+	+							
C. granatum var. subgranatum		+	+				+			
C. regnellii			+				+			
C. humile			+				+			
C. impressulum			+				+			
C. meneghinii var. latiuscula			+				+			
C. obsoletum			+							
C. obtusatum			+							
C. ochthodes			+							
C. pachydermum			+							
C. protumidum							+			
C. punctulatum			+							
C. quadrum			+							
C. reniforme			+							
C. subcucumis			+							
C. tetraophthalmum		+	+				+			
C. turpinii			+							
Staurastrum alternans			+				+			
S. avicula	+									
S. cuspidatum	+									
S. gracile	+	+	+				+			
S. furcatum		+						+		
S. cyrtocerum?			+				+			
S. laeve	+									
S. lunatum		+								
S. muticum?					+					
S. orbiculare		+								
S. paradoxum	+									
S. polymorphum		+								
S. punctulatum var. kjelmanni	+	+	+		+					
S. sebaldi			+							
S. striolatum			+							
S. tetracerum		+								
Euastrum elegans			+				+			
E. didelta							+			
E. dubium			+							
E. inerme			+							
E. monocyclum		+								

LIST OF SPECIES (*continued*)

	A	B	C	D	E	F	G	H	I	K
Euastrum oblongum							+			
E. pulchellum										
var. retusum							+			
E. verrucosum			+							
Micrasterias americana			+							
M. crux-melitensis							+			
M. denticulata			+				+			
M. truncata			+				+			
Arthrodesmus incus							+			
Pleurotaenium coronatum										
var. nodulosum			+				+			
P. trabecula			+							
P. truncatum			+							
Mesotaenium spec.			+							
Desmidium swartzii			+							
Hyalotheca dissiliens							+			
Gonatozygon monotaenium			+							
Spirogyra spec.		+		+			+			
Mougeotia spec.	+	+	+	+	+	+	+	+	+	
M. cf. robusta		+								
Heterocontae										
Tribonema spec. div.	+	+	+	+	+	+	+	+	+	+
Chlorothecium pirottae (?)			+	+	+					
Gloeochloris spec.		+								
Ophiocytium arbusculum			+							
O. capitatum			+				+			
O. cochleare		+	+							
O. parvulum			+							
Botryococcus braunii		+	+				+		+	
Characiopsis spec.	+					+				
C. longipes	+	+								
C. minutus							+			
C. pyriformis							+			
C. saccata		+								
C. subulata	+					+				
C. acuta		+								
Bacillariae										
Cyclotella meneghiniana		+								
Coscinodiscus rothi	+	+								
Actinocyclus normanni						+				
Tabellaria fenestrata		+								
T. flocculosa		+	+	+		+	+			
Diatoma vulgare	+	+								
Fragilaria capucina	+	+								
F. crotonensis	+									
F. virescens		+								
Synedra pulchella	+	+	+			+				
S. ulna	+	+	+							
Asterionella formosa	+	+								
Eunotia lunaris	+	+	+	+	+	+	+	+	+	+
Coconeis placentula	+	+	+							
Cymbella aspera		+								
Achnanthes spec.	+									
Frustulia rhomboides		+								

LIST OF SPECIES (*continued*)

	A	B	C	D	E	F	G	H	I	K
Stauroneis phoenicenteron		+	+							
Navicula spec.	+	+	+							
N. cryptocephala			+							
N. cuspidata		+								
N. dicephala			+							
Pinnularia viridis			+	+	+					
Gyrosigma acuminata		+								
Caloneis spec.	+	+				+				
Gomphonema acuminata var. coronata		+	+							
G. constrictum	+	+	+							
Epithemia turgida	+	+	+							
Rhopalodia gibba		+	+							
Nitzschia spec.			+			+	+			
N. actinastroides	+									
N. acicularis	+	+								
N. linearis		+	+							
N. sigmoidea	+	+								
N. scalaris		+								
Cymatopleura solea		+								
Surirella linearis		+								
S. linearis var. constricta		+								
Euglenophyceae										
Euglena acus	+	+								
E. oxyurus		+	+				+			
E. spirogyra	+	+	+	+						
E. spec. (cf. "viridis")	+	+	+		+					
Colacium cyclopicola			+							
Lepocinclis ovum		+								
L. texta	+									
Phacus acuminatus		+								
P. caudatus		+	+							
P. gigas		+								
P. granum	+	+	+	+						
P. pleuronectes	+	+	+	+		+	+			
P. pyrum	+									
P. suecicus	+	+	+	+		+				
P. tortus	+	+								
P. margaritatus		+								
Trachelomonas armata var. steinii	+									
T. hispida	+	+	+	+			+			
T. oblonga	+									
T. volvocina	+	+	+		+	+	+			
Strombomonas chodati	+									
Dinophyceae										
Gymnodinium palustre		+								
Sphaerodinium cinctum		+								
Peridinium aciculiferum		+								
P. bipes			+							
P. borgei		+								

LIST OF SPECIES (*continued*)

	A	B	C	D	E	F	G	H	I	K
Chrysophyceae										
Synura uvella	+	+	+			+				
Rhipidodendron huxleyi			+	+		+				
Chrysococcus minutus			+							
C. rufescens		+								
Dinobryon divergens	+	+	+							
D. sertularia		+								
D. utriculus		+								
Mallomonas acaroides	+	+								
Cryptomonas spec.			+							
Protozoa										
Strombidium spec.		+								
Euplotes spec.		+								
Codonella lacustris	+	+								
Lionotus spec.	+	+	+			+				
Stylonychia spec.			+							
Vorticella spec.			+							
V. convallaria		+								
Carchesium polypinum		+								
Amoeba gorgonia		+								
Dactylosphaerium radiosum	+	+	+			+				
Cochliopodium vestitum			+							
Arcella arenaria				+						
A. hemisphaerica		+	+	+	+	+	+			
A. vulgaris		+	+					+	+	+
Difflugia acuminata				+						
D. acuminata var. inflata			+							
D. globulosa					+				+	
D. oblonga	+	+			+					
D. oblonga f. compressa					+					
D. oviformis			+						+	
Centropyxis aculeata	+	+	+				+			
Nebela spec.		+								
Hyalosphaenia papilio		+							+	
Euglypha acanthophora			+							
Assulina muscorum					+					
Trinema lineare			+		+	+				
Acanthocystis turfacea						+	+			
Rotatoria (and other Vermes)										
Rotaria spec.				+	+	+		+		
Trichotria tetractis	+	+	+		+			+		
Mytilina ventralis var. brevispina		+								
M. ventralis var. macracantha		+								
Euchlanis dilatata			+							
Anureopsis fissa		+								
Keratella cochlearis	+	+	+	+		+				
K. cochlearis f. tecta										
K. quadrata	+	+	+							
K. serrulata			+				+			
Kellicottia bostoniensis						+				
Lepadella acuminata			+							
L. ovalis	+	+	+	+						
L. patella	+	+	+	+						
L. rhomboides		+								

LIST OF SPECIES (*continued*)

	A	B	C	D	E	F	G	H	I	K
Colurella uncinata		+	+							
Lecane closterocerca	+	+	+			+	+			
L. hamata		+								
L. ludwigii			+							
L. luna			+							
L. lunaris					+			+		
L. saginata	+									
L. scutata					+					
L. stichaea				+	+					
L. stokesii		+								
Proales spec.		+	+					+		
Monommata aequalis		+	+				+			
Monommata longiseta							+			
Cephalodella spec.			+							
Trichocerca brachyura		+								
T. elongata		+								
T. rosea			+							
T. similis	+	+	+			+				
Asplanchna spec.		+								
Polyarthra dolichoptera		+								
P. remata			+							
P. vulgaris						+				
Synchaeta spec.		+								
Testudinella patina		+								
Filinia longiseta	+									
Microcodides chlaena			+							
Nematode	+	+	+	+	+	+	+			
Oligochaeet		+								
Crustacea (and other Arthropods)										
Daphnia pulex	+	+	+			+				
D. longispina			+			+	+			
Scapholeberis mucronata				+	+	+	+	+		+
Simocephalus vetulus	+	+	+	+	+					
Ceriodaphnia pulchella	+	+	+	+	+	+				
Bosmina longirostris	+									
Eurycercus lamellatus		+								
Campthocercus macrurus			+							
Acroperus harpae			+							
Alona costata			+							
A. quadrangularis			+							
A. rectangula			+							
Graptoleberis testudinaria		+								
Alonella nana			+			+		+		
A. excisa									+	
Peracantha truncata	+	+				+				
Pleuroxus trigonellus	+	+								
Chydorus sphaericus	+	+	+	+	+		+	+		
Polyphemus pediculus								+		+
Ostracoda		+	+							
Cyclops serrulatus		+								
C. strenuus						+				
C. viridis		+								
C. spec.	+	+	+	+	+	+	+		+	
Nauplii	+	+	+	+	+	+	+		+	
Watermijten		+			+				+	

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