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THE ECOLOGICAL DISTRIBUTION OF MICROSCOPIC ORGANISMS IN LAKE NIPIGON

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During the summers of 1921 and 1922 the author made extensive collections of planktonic and other microscopic organisms in Lake Nipigon and environs and presented the results in two papers (Bigelow 1923, 1924) in which the organisms were listed systematically with notes on occurrence and relative abundance. Collections were continued in 1923, when the following additional species were taken:

Algae

Nephrocytium agardhianum Nägeli
Ankistrodesmus spiralis Lemmermann
Pediastrum integrum Nägeli
Pediastrum araneosum Raciborski
Micrasterias radiosa Ralfs
Micrasterias laticeps Nordst

Diatomaceae

Cocconeis sp.
Diatoma sp.

Protozoa

Hyalosphenia elegans Leidy
Euglena spirogyra Ehr.
Rhipidodendron huxleyi S. K.
Codonella cratera Leidy
Vaginicola sp.

ROTATORIA

Euchlanis triquetria Ehr.
Trichotria tetractis Ehr.

ENTOMOSTRACA

Pleuroxus trigonellus (O. F. Müller)
Senecella calanoides Juday
Diaptomus leptopus Forbes var. *piscinae*

All of these organisms were found in Orient bay and vicinity. Specimens of *Senecella* were taken here and in other parts of the lake, usually in deep water. Identification of this species has been confirmed by Professor Chancey Juday. The only specimens of *Diaptomus leptopus* var. *piscinae* were large brilliant red individuals. These were taken about the middle of September from a pond near the railway station of Orient bay. In the spring the pond had been connected with the lake, but when the specimens of this copepod were taken the connection had disappeared.

In the present paper an attempt is made to show the ecological distribution of the planktonic and other microscopic organisms in Lake Nipigon based upon the data obtained during the summer months in three successive years, 1921, 1922, and 1923. It has not been possible to determine the habitat of every species. The main habitats, however, have been recognized and a fairly complete list of the organisms of each habitat is given. Special attention is given to the Entomostraca and the Rotatoria, since the author is most familiar with the species of these groups.

The system of ecological classification followed is that proposed by Klugh (1923) It appears that three main associations may be recognized in Lake Nipigon. These, with their subdivisions, are as follows:

1. LIMNETIC ASSOCIATION
   Epilimnile systasis
   Hypolimnile systasis

2. PROTECTED BAY ASSOCIATION
   Vegetation systasis
   Pelagic systasis
      Surface cenosis
      Subsurface cenosis

3. BOTTOM ASSOCIATION
   Inshore bottom systasis
      Ooze-film cenosis
      Associated ooze-film cenosis
   Offshore bottom systasis

In the lists of organisms forming these communities the following designations have been used:

1. A single asterisk denoting that the species is found in this community only.

2. A double asterisk indicating that the species occurs commonly in this community, but is occasionally found in another community, which, however, is not indicated.

3. The absence of an asterisk meaning that the species is an overlapping form, occurring in equal numbers in two or more communities.

Because of the continuity of the aquatic environment it is often difficult to determine the characteristic habitat of a species. The arrangement following is based upon frequency of occurrence and abundance of individuals during the period of the investigation.

LIMNETIC ASSOCIATION

The members of this association are those plankton organisms occurring in the open waters of lakes. Klugh (*loc. cit.*) recognizes three systases, namely epilimnile, thermoclinile, and hypolimnile, but in Lake Nipigon where the thermocline is very small and often wanting, a distinct thermoclinile systasis has not been recognized.

Epilimnile systasis

This is the group of phyto- and zoo-plankton of the open waters of the lake living in the upper waters from the surface to approximately 30 yards in depth. Very few species occur only in this habitat, since relatively few species are fitted to endure the vicissitudes of this open water existence.

DIATOMACEAE

Rhizosolenia sp.*
Asterionella formosa**
Melosira sp.
Stephanodiscus sp.
Synedra sp.
Fragillaria sp.
Tabellaria fenestrata

PROTOZOA

Difflugia lobostoma
Codonella cratera

ROTATORIA

Keratella cochlearis
Notholca longispina
Synchaeta stylata
Polyarthra trigla
Asplanchna priodonta
Conochilus unicornis
Collocheca mutabilis

ENTOMOSTRACA

Diaphanosoma leuchtenbergianum**
Diaptomus silicis**
Diaptomus ashlandi**
Daphnia retrocurva
Daphnia longispina hyalina
Bosmina longirostris
Leptodora kindtii
Cyclops bicuspidatus

Many of the members of this systasis have developed devices for floating, or they are of such a shape as to expose a surface to the water which is large in proportion to their weight. The Copepoda, besides having powerful swimming antennae, possess oil globules which are often brightly coloured. Cladocera also show various interesting characteristics. The species of *Daphnia* have long slender spines at the posterior ends of the shells, while the heads are prolonged into great crests. *Leptodora* is a light, slender creature,

with relatively immense antennae bearing fringes of long, closely placed hairs. *Diaphanosoma*, as its name indicates, is another delicate transparent organism, which possesses greatly expanded swimming antennae.

Among the Rotatoria, *Asplanchna* is a large floating sac in which the internal organs are relatively very small. *Collotheca mutabilis* is surrounded by a light gelatinous envelope. *Synchaeta stylata* is a delicate transparent species. The shell of *Notholca longispina* is drawn out into several long, thin, seta-like spines. *Polyarthra* has clusters of long, feathery paddles.

The diatoms are usually long slender cells as, for example, *Synedra* and *Rhizosolenia*, which have the ends of the valves prolonged into slender spines or have the ribbon arrangement as in *Melosira* and *Fragillaria*.

The Protozoa do not show evident structures of flotation, but doubtless the presence of vacuoles has some significance in this connection. Some species are known to float by means of gases in the loricae or shells.

Hypolimnile systasis

The members of this community occur in depths ranging from approximately the 30 yard level to the bottom, which in Lake Nipigon is a maximum of 134 yards. The peculiarities of this habitat are low temperature (seldom above 5° C.), little light, and considerable pressure. Few indeed are the plankton organisms which are able to maintain themselves in this region.

PROTOZOA

Podophrya sp.*
Vorticella sp.

ROTATORIA

Keratella cochlearis
Notholca longispina

CRUSTACEA

Mysis relicta*
Senecella calanoides**
Limnocalanus macrurus**

The three crustaceans listed are the largest of the plankton Crustacea and all are powerful swimmers. *Limnocalanus* has long slender antennae, while *Senecella* has large antennae worked by powerful muscles. *Mysis* and *Limnocalanus* occur in enormous numbers and are extremely important economically, in that they form the food of the ciscoes (*Leucichthys*, several species), which in turn are the chief food of the lake trout (*Cristivomer namaycush*). They have been taken in surface tows at night and it is quite probable that they exhibit a daily vertical movement, coming into the epilimnion at night and retreating into the depths of the hypolimnion during the day. Little is yet known of the natural history of *Senecella*, and it may be that much the same might be said of this species.

The two rotifers mentioned appear to range throughout most of the hypolimnion as well as in the epilimnion.

The two protozoans are epizooitic on the appendages of *Mysis* and *Limnocalanus*.

PROTECTED BAY ASSOCIATION

This resembles the pond association of Klugh (*loc. cit.*) and would probably correspond to the lake-pond community of Shelford (1913). Two definite systases may be recognized (1) that among the vegetation and (2) that beyond the plant growth in more open water (pelagic).

Vegetation systasis

This community is composed of myriads of organisms of infinite variety.

ALGAE

Chroococcus turgidus*
Merismopedia elegans*
Pandorina morum*
Eudorina elegans*
Volvox aureus*
Tetraspora sp.*
Ankistrodesmus spiralis*
Crucigenia sp.*
Scenedesmus spp.*
Sorastrum americanum*
" spinulosum*
Actinastrum sp.*

ALGAE—*Continued*

Pediastrum tetras*
" biradiatum*
Penium sp.*
Closterium rostratum*
" lineatum*
" lunula*
" moniliferum*
Docidium baculum*
Spirotaenia sp.*
Netrium lamellosum*
Staurastrum megacanthum*
" coronulatum*
" orbiculare*
Micrasterias rotata*
" radiosa*
" furcata*
" truncata*
" laticeps*
Euastrum oblongatum*
" verrucosum*
Cosmarium broomei*
" ornatum*
" tetropthalmum*
Sphaerozosma pulcrum*
" filiforme*
Hyalotheca sp.*
Desmidium swartzii*
Aptogonum baileyi*
Gymnozgyga sp.*
Chaetophora pisiformis**
Coleochaete sp.**
Oedogonium sp.**
Spirogyra sp.**
Zygnema stellinum**
Mougeotia viridis**
Cosmarium spp.

DIATOMACEAE

Gomphonema sp.*
Cocconeis sp.*
Achnanthes sp.*
Diatom sp.**
Pinnularia sp.
Navicula sp.
Cymbella sp.
Cocconema sp.
Cymatopleura sp.
Surirella sp.
Tabellaria fenestrata
" flocculosa
Epithemia sp.

PROTOZOA

Amoeba sp.*
Arcella dentata*
Actinophrys sol*
Euglena acus*
" viridis*
" spirogyra*
Trachelomonas hispida*
" crebea*
Phacus pleuronectes*
" longicauda*
Spongomonas sp.*
Rhipidodendron splendidum*
" huxleyi*
Stentor coerulens*
Ophrydium eichhornii*
Vaginicola sp.*

PROTOZOA—*Continued*

Pyxicola sp.*
Arcella vulgaris**
Centropyxis aculeata
Difflugia acuminata
" pyriformis
" corona
Nebela dentistoma
Sphenoderia lenta
Cyphoderia ampulla
Assulina seminulum
Euglypha alveolata
Vorticella sp.

ROTATORIA

Notommata aurita*
Diaschiza sp.*
Cephalodella forficula*
Monommata orbis*
Platyias quadricornis*
Keratella serrulata*
Mytilina mucronata*
Euchlanis triquetria*
Diplois propatula*
Lecane leontina*
Monostyla quadridentata*
Squatinella longispinatum*
Trichotria poccilum*
" tetractis*
Scaridium longicaudum*
" eudactylotum*
Diurella stylata*
Trichocerca cristata*
Trichocerca cylindrica*
" lata*
" longiseta*
Ascomorpha eucadis*
Testudinella patina*
Floscularia ringens*
Limnias melicerta*
Collotheca algicola*
" ambigua*
" cornuta*
Adineta sp.*
Euchlanis deflexa
" dilatata
Lecane ohioensis
" luna
Monostyla lunaris
" bulla

ENTOMOSTRACA

Simocephalus serrulatus*
Ceriodaphnia reticulata*
Streblocerus serricaudatus*
Lathonura rectirostris*
Kurzia latissima*
Alonella exigua*
Pleuroxus trigonellus*
Diaptomus leptopus var. piscinae*
Cyclops ater*
Daphnia pulex**
Simocephalus vetulus**
Scapholeberis mucronata**
Chydorus globosus**

ENTOMOSTRACA—*Continued*

Alona rectangula**
Graptoleberis testudinaria**
Cypria sp.**
Spirocypris sp.**
Chydorus sphaericus
Eurycercus lamellatus
Acroperus harpae
Alona costata
" guttata
Pleuroxus denticulatus
Cyclops viridis

This vast and varied assemblage of organisms lives amidst the beds of aquatic plants (*Potamogeton*, *Utricularia*, *Myriophyllum*, *Sagittaria*, *Elodea*, *Nymphozanthus*, *Eleocharis*, *Ranunculus*, etc.), some forms floating or swimming about among the vegetation, some sessile for the most part, others creeping over stems and leaves. Here in a quiet, sheltered situation, with optimum physico-chemical conditions, a succession of forms develops during the summer months and the water teems with countless numbers of tiny plants and animals. This is one of the most important communities in the lake, economically, in that young fish of very many species live in this habitat and are almost wholly dependent upon these small organisms as a food supply following the absorption of the yolk sac.

Pelagic systasis

As stated previously a community exists in the protected bays outward beyond the area of vegetation. Two distinct groups of organisms occur here, namely a surface cenosis and a subsurface cenosis.

Surface cenosis. This group is found in the upper three or four feet of water, and very often includes an admixture of typical open water forms.

ALGAE

Chroococcus limneticus**
Microcystis aeruginosa**
" flos-aquae**
Anabaena lemmermanni**
Aphanizomenon flos-aquae**
Botryococcus braunii**
Gloeocystopsis limneticus**
Oocystis sp.**

ALGAE—*Continued*

Tetradron trigonum**
Quadrigula lacustris**
Selenastrum gracile**
" bibraianum**
Coelastrum microsporum**
" cambricum**
Coelastrum proboscidium**
Pediastrum boryanum
" duplex
Staurastrum spp.
Cosmarium spp.

DIATOMACEAE

Melosira sp.
Stephanodiscus sp.
Navicula sp.
Synedra sp.
Fragillaria sp.
Tabellaria fenestrata
" flocculosa

PROTOZOA

Mallomonas sp.**
Dinobryon sertularia**
" bavaricum**
Peridinum sp.**
Ceratium hirundinella**
Centropyxis aculeata
Difflugia lobostoma
Nebela dentistoma
Sphenoderia lenta

ROTATORIA

Macrochaetus collinsii*
Ploesoma lenticulare*
" hudsoni*
Keratella quadrata**
Trichocerca multicrinis**
Chromogaster ovalis**
Gastropus stylifer**
Keratella cochlearis
Notholca longispina
" striata
Notholca foliacea
Euchlanis deflexa
Lecane ohioensis
Monostyla bulla
Synchaeta stylata
Polyarthra trigla
Asplanchna priodonta
Conochilus unicornis
Collotheca mutabilis

ENTOMOSTRACA

Holopedium gibberum*
Diaphanosoma brachyurum**
Ceriodaphnia lacustris**
" quadrangula**
Diaptomus minutis**

ENTOMOSTRACA—*Continued*

Sida crystallina
Daphnia longispina hyalina
" retrocurva
Bosmina longirostris
Polyphemus pediculus
Leptodora kindtii
Epischura lacustris
Diaptomus oregonensis
Cyclops bicuspidatus
" viridis

Subsurface cenosis. This group is found in the protected bays from 3 or 4 feet beneath the surface to the bottom. Although there is some intermingling of surface species, the cenosis is nevertheless quite distinct.

ALGAE

Pediastrum boryanum
" duplex
Staurastrum spp.
Cosmarium spp.

DIATOMACEAE

Pennularia sp.
Navicula sp.
Cymbella sp.
Amphora sp.
Cocconema sp.
Cymatopleura sp.
Surirella sp.
Tabellaria fenestrata
" flocculosa
Epithemia sp.

PROTOZOA

Difflugia lobostoma
" pyriformis
Cyphoderia ampulla

ROTATORIA

Notholca striata
Notholca foliacea

ENTOMOSTRACA

Ophryoxus gracilis*
Drepanothrix dentata*
Acantholeberis curvirostris*
Macrothrix laticornis*
Chydorus faviformis*
Sida crystallina
Chydorus sphaericus
Alonella excisa
Pleuroxus denticulatus
Polyphemus pediculus
Epischura lacustris
Diaptomus oregonensis
Cyclops viridis

BOTTOM ASSOCIATION

On the lake bottom live many small organisms which are seldom free-swimming. Two systases may be recognized, namely, inshore or shallow water and offshore or deep water. The line of division between these two communities has not been determined; in fact, it is probable that there is no clear line of demarcation, but rather a gradation from one into the other.

Inshore bottom systasis

This community exists on or close to the bottom in relatively shallow water and two cenoses may be distinguished.

Ooze-film cenosis. The ooze-film is a very thin layer of material, mostly organic, covering the entire bottom of the lake. It is a heterogeneous substance, the nature and thickness of which varies considerably in various parts of the lake. It consists largely of the decomposing plants and animals which have died and settled on the bottom. The plankton contributes a large part of this material as enormous numbers of diatoms and other algae, rotifers, copepods, and cladocerans die and settle to the bottom. The bodies of higher plants and animals also are added. On its upper surface the ooze-film is being continually renewed by the settling of more material, while below it is ever decomposing and breaking up into simpler organic and inorganic materials. In bays and bayous the ooze-film is probably less than one-sixteenth of an inch in thickness. It covers the stems of aquatic plants, as well as all sticks and stones which have remained in the water for any length of time.

Living in and on this ooze-film is a distinct ecological group of organisms. Bacteria, protozoans, and diatoms abound here. Several species of *Rotatoria*, *Copepoda* and *Cladocera* occur, the latter showing interesting modifications.

ALGAE

Ulothrix sp.**
Cladophora sp.**
Mougeotia sp.**

DIATOMACCAE

Encyonema sp.*
Campylodiscus sp.*
Ceratoneis arcus*
Pleurosigma sp.**
Pinnularia sp.
Navicula sp.
Cymbella sp.
Amphora sp.
Cocconema sp.
Surirella sp.
Tabellaria fenestrata
" flocculosa
Epithemia sp.

PROTOZOA

Difflugia constricta*
" cratera**
Pontigulasia spectabilis**
Campascus sp.**
Centropyxis aculeata
Difflugia acuminata
" pyriformis
Difflugia corona
Nebela dentistoma
Sphenoderia lenta
Cyphoderia ampulla
Assulina seminulum
Euglypha alveolata

ROTATORIA

Rotaria neptunia
" citrina
Philodina spp.**

ENTOMOSTRACA

Illyocryptus acutifrons*
" sordidus*
" spinifer*
Leydigea quadrangularis*
Rhynchotalona falcata*
Monospilus dispar*
Candona sp.*
Canthocampus spp.**

OTHER ANIMALS

Tardigrada*
Hydracarina (Oribatidae)*

The Cladocera present many striking adaptations to this environment. They seldom swim but creep about by means of their antennae or push themselves through the ooze by means of their post-abdomens, which are usually broad and powerful. The eye has a tendency to become small and may even disappear.

Particularly well fitted for this environment are the species of *Illyocryptus*. Their shells are never completely shed in moulting, but form layers one above the other. The shells are spiny and ooze clings to them so as to hide the animal entirely. In fact, the animals may be encased in a mass of ooze several times their size. They progress by dragging their way through the ooze-film with their antennae, while continually shoving and kicking with their broad, spiny post-abdomens. The eye is quite small. *Leydigea quadrangularis* has a similar post-abdomen and a small eye, and is quite like *Illyocryptus* in its habits. In *Monospilus dispar* the eye has completely disappeared, and only the large pigment spot beside it remains. As in *Illyocryptus* the shell is retained after moulting and forms layers. The post-abdomen is less broad and powerful, but is armed with a powerful claw at its tip and with a large tooth at the base of the claw. Doubtless this is a very efficient organ for pushing the animal through the ooze. *Rhynchotalona falcata* possesses a short thick post-abdomen with a strong claw and four strong denticles. The rotifiers creep about with leech-like movements, but are also able to swim freely in the water.

The water bears (*Tardigrada*) with stumpy legs and long curved claws are well fitted for crawling through the ooze-film, as are also the horny water mites (*Oribatidae*), which cannot swim, but creep about on the ooze.

In addition to these smaller animals, many larger forms live in the ooze. Among these are: Amphipoda (*Hyalella, Gammarus*, and occasionally *Pontoporeia*); Ephemeridae (*Hexagenia, Ephemera, Caenis, Tricorythus*); Odonata (*Gomphus, Aeshna*); and Chironomidae. All of these animals, except the Odonata, feed upon the ooze-film and the smaller organisms in it. The small inhabitants of the ooze-film are of economic importance in the lake in that they are fed upon by young sturgeon, suckers, darters, and other fish. They are also fed upon by the larger invertebrates mentioned above, which in turn are extremely important as fish food.

Associated ooze-film cenosis. Organisms in this group are directly dependent upon the ooze-film for sustenance and are seldom found far from it. They do not live in the ooze-film or creep through it, although they may occasionally rest upon it, but swim about immediately adjacent to it. Most of the organisms in this group are Cladocera.

ROTATORIA

Lecane sulcata*	Lecane luna
Lepadella ovalis*	Monostyla lunaris
Colurella uncinatus*	

ENTOMOSTRACA

Latona setifera*	Eurycercus lamellatus
Camptocercus rectirostris*	Acroperus harpae
Alonella nana*	Alonella excisa
" rostrata*	Alona costata
Alona quadrangularis*	" guttata
" affinis**	Pleuroxus denticulatus
Chydorus sphaericus	

Structural modifications are not outstanding in the members of this group. They do not swim far for food and do not creep through the ooze, the swimming antennae and post-abdomens of the Cladocera are found to be relatively simple. Some members are yellowish or brownish in colour, but the majority are colourless or transparent.

Offshore bottom systasis

This community has not been studied carefully. Its members are small and its species few, and special apparatus is necessary for carrying out an adequate investigation. Observations have shown, however, that a rich organic ooze covers the bottom of the lake even in its greatest depths, and Adamstone (1924) has shown that this material constitutes the food supply of a vast population of oligochaete worms, *Pontoporeia hoyi*, chironomid larvae and various species of molluscs.

As stated previously, this paper is an attempt to indicate the ecological distribution of the smaller organisms in a large lake. The distribution of these organisms is of interest not only from an ecological point of view, but also from an economic standpoint since they form the fundamental food supply of the lake. Such information will find an application in a variety of fishery problems.

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PRELIMINARY STUDIES OF THE BOTTOM FAUNA OF LAKE SIMCOE, ONTARIO

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