A SURVEY OF THE ENTOMOSTRACA OF MANITOBA

AND

A STUDY OF FEEDING OF LAKE WINNIPEG CISCOES

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INTRODUCTION

The scientific value of a survey of the Entomostraca of Manitoba was first suggested to the author as a worthy undertaking, and as a suitable subject for a Ph. D. thesis, by Dr. J. A. McLeod under whose direction this work was begun over five years ago. The years intervening have been spent in the examination of samples of plankton collected from nearly 80 lakes from various parts of Manitoba. Samples from over 100 ponds, ditches and sloughs, and from 20 rivers and creeks have also been studied. Collections from so many sources and from such an extensive area could never have been made by one worker and the assembling of all these collections for study by the author represents an example of scientific teamwork which should be heartening to all scientific workers and reflects great credit on the agencies involved. The chief agencies for collection of plankton samples were: The Game and Fisheries Branch, Department of Mines and Natural Resources, Province of Manitoba; and the Central Fisheries Research Station, Fisheries Research Board of Canada, Winnipeg, Manitoba. During the years 1941-1947, plankton samples were collected for the Game and Fisheries Branch, Province of Manitoba, by Dr. J. A. McLeod and/or D.R. Moir, and subsequently by other field parties under the direction of G. E. Butler. Collections made included dredge samples, vertical lifts, horizontal drags usually at the surface and at 12-15 feet, and littoral collections along the shore and among water plants. Collections made by these agencies were supplemented by extensive collections made by the present worker.

The importance of a survey of the Entomostraca of Manitoba (Parts I, II and III of this thesis) may be dealt with under three headings:

(1) Entomostraca as links in food chains and especially as food of fishes.

(2) Entomostraca as intermediate hosts of parasitic organisms.

(3) The value of a survey of the Entomostraca of Manitoba as a contribution to general scientific knowledge.

ENTOMOSTRACA AS LINKS IN FOOD CHAINS AND ESPECIALLY AS FOOD OF FISHES

It is quite impossible in the space that can be devoted to this topic to deal adequately with it. All that can be done is to briefly outline representative studies that have been made by a few of many competent scientific workers.

Mann (1917) so well expresses some of the fundamental relationships existing in food chains that I have taken the liberty of quoting in full the following paragraph: "The diatom is the smallest of all the green, chlorophyll-bearing plants; but despite its insignificant size, these lilliputian workers are so numerous that the sum total of their activity is almost beyond calculation. Professor Kofoid has estimated that the average number of diatoms in 1 cubic meter of water in the Illinois River is 35,558,462. Thriving abundantly in all the waters of the earth, fresh and salt, from the north pole to the south, the countless myriads of these plants are turning the substances held in solution in the waters of the streams, lakes and seas into living material and are doing this in that strange alembic where it always takes place, namely, the green, chlorophyll-grain. By harnessing in some way a sunbeam to its machinery it turns out from the crude material of mineral matter the vital material of plant tissue, and on this plant tissue there feeds directly or indirectly most of the animal life of the sea. Some of the minuter forms of economic value to mankind, like the smaller fishes (for example, the sardine) and the shellfish (clams and oysters) make these plants their principal if not their exclusive food. The teeming swarms of tiny animal creatures, of which the copepods may be cited as an example, are the links between the diatoms and those other organisms which in turn prey upon them".

The Importance of Entomostraca as Links in Feed Chains

Lowe (1936) made observations on some Pacific diatoms as the food of Copepoda and fishes. He listed the following food chains:

Chart of Food Chains

Fish	Feed, 1st degree	Feed, 2nd degree	Feed, nth degree
Spring salmon	Herring	Copepoda	Diatoms
Ling Cod	Herring	Copepoda	Diatoms
Rockfish	Herring	Copepoda	Diatoms
Dogfish	Herring	Copepoda	Diatoms

Chart of Food Chains

Fish	Feed, 1st degree	Feed, 2nd degree	Feed, nth degree
Adult Herring	Crustacea		
Flounder	Mollusca		
Lemon Sole	Mollusca		

Similar observations were made by Lebour (1918, 1925) at Plymouth, England, upon the herring Clupea harengus L. and the sprat Clupea sprattus L. Lebour found that the young herring and the young sprat, in the postlarval stage, fed upon diatoms, larval molluscs, and small copepods, and, further, that the young mollusca and copepods fed upon diatoms and the flagellated green alga, Halosphaera viridis. Mann (1921) examined the stomach contents of some hake and found them gorged with small herring; the herring in turn were filled with copepods and the copepods with diatoms. The concluding remark of his observations was: "No diatoms, no hake".

Forbes (1883) shows that many of the larger predaceous species of fishes feed on smaller fishes, which, in turn, feed very largely on entomostracans, the percentage of Entomostraca in the animal food taken by Eucalia inconstans being 50%, by Pungitius pungitius 40%, by Abramis chrysoleucas 15%, by Notropis heterodon 56%, and by Notropis atherinoides 19%. The same author (1883) states that from experimental evidence the first food of the common whitefish consists chiefly of two copepods Cyclops thomasi and Diaptomus sicilis. Ryder (1888) states that the sturgeon Acipenser sturio when one or two inches long feeds largely on microcrustaceans. Hankinson (1908) found that young of yellow perch feed entirely on Entomostraca while Needham (1909) states that young *Eupmotis gibbosus* two inches long had eaten chiefly copepods.

Hankison (1910) states that from the examination of the stomachs of fishes collected from shoals with much plant life, it appeared that midge larvae and entomostracans were the chief food of the smaller fishes--minnows, darters, and the young of perch, sunfish, black bass, rock bass, and catfish. The larger fishes were taking principally insect larvae and crayfish.

Reighard (1913) lists a specimen of *Notropis cornutus* as having 2/3 of the food-mass cladocerans, and a young *N. hudsonius* as "filled with *Cladocera*". Pearse (1918) found that Entomostraca made up the following percentages by volume of the food of some fishes of Wisconsin:

Fish	Ostracoda	Cladocera	Copepoda
Catostomus commersonii	16.8	3.6	14.8
Eucalia inconstans	3.2	16.0	19.3
Notropis heterodon	.5	33.4	11.0
Micropterus salmoides	.1	15.1	2.9
Cyrpinus carpio	7.0	3.6	10.4
Pimephales notatus	.3	25.1	2.6

Clemens and Bigelow (1922) after examining the alimentary canals of 211 ciscoes of several species state that "*Daphnia* formed the great bulk of the contents". Moore (1922) says that "the most important single item in the food of the small-mouth bass is waterfleas" and lists Cladocera as among the most important food of young Leucichthys osmeriformis, Amblo-plites rupestris, and Notropis cayuga. Bigelow (1923) found that young Catostomus commersonii from 1.7 to 2.1 cm. in length fed chiefly on Daphnia, Bosmina, Alona and Copepoda. Clemens, Dymond and Bigelow (1924) showed that young white-fish, Coregonus quadrilateralis and C. clupeaformis feed chiefly on entomostracans, as do the young of the pike perch Stizostedion vitreum, and the adults of the spot-tailed minnow, Notropis hudsonius.

Brooker Klugh (1929) states that from observations in the field in many habitats he is inclined to believe that the chief food of dragonfly nymphs consists of entomostracans.

Forbes (1880) notes the variation in food habits of the common perch with age. He states that the common perch has a food history of three periods--the periods of infancy, youth, and mature age. In the first it lives wholly on Entomostraca and the minutest larvae of Diptera; in the second, commencing when the fish is about an inch and a half long, it takes up first the smaller and then the larger kinds of aquatic insects in gradually increasing ratio, the entomostracan food at the same time diminishing in importance; and in the third it appro-priates, in addition, mollusks, crayfishes, and fishes--in the lake specimens depending almost wholly on the last two elements.

Pearse (1915) studied the food of small shore fishes in waters near Madison, Wisconsin. He found that some fish changed their food as they grew larger, while others stuck to one diet. Some ate the same food in all habitats while others varied their diet with varying environment. Different species of fish captured in the same habitats were found to have selected different kinds of food from the available supply.

Pearse noted three cases of change of food with increase in size. Of twenty Labidesthes sicculus collected at Station 1, the ten largest individuals (average length 41.2 mm.) had eaten 38.5% Cyclops and a trace of plants, whereas the ten smallest (average length 22.6 mm.) had eaten only 1.7% Cyclops and 44.4% algae and seeds. Lepomis pallidus as it grew larger consumed more Hyalella and less Cyclops. The smaller stickle-backs, Eucalia inconstans, ate more Chydorus sphaericus than larger individuals of the same species which had taken Cyclops instead.

In most species of fish which Pearse examined he found that there was considerable variation in feed with changes in environment. Perca flavescens, for example, ate 33% of dipterous larvae at Station 5; at Station 6, 57.7% Hyalella; and at Station 7, 96.2% Daphnia hyalina. Fundulus majalis menona was very variable in its food habits having eaten 55% Cladocera at Station 3; 35% Cladocera at Station 6; 63.8% Ostracoda at Station 8 (August); and 30.8% vegetation at Station 8 (September). Micropterus salmoides at different times fed largely on fish at one station (66%) and on dipterous larvae (57.7%) at another.

Turner and Kraatz (1920) studied the food of young large-mouth black bass in some Ohio waters. They found that up to 30 mm. in length the food consists almost entirely of Entomostraca and minute midge larvae. From 30 to 50 mm. in length Entomostraca become negligible in quantity and midge larvae diminish rapidly, while amphipods form the principle articale of diet, and larger insect larvae and fish are taken in small quantities. From 50 to 80 mm. in length the food consists principally of larger insect larvae and fish while Entomostraca, midge larvae and Amphipoda practically disappear from the diet.

Eddy and Surber (1947) report that the paddlefish (Polyodon spathula Walbaum) may attain a length of over 6 feet and a maximum weight of 185 pounds. They also state that these large fish feed chiefly on minute crustacea, which they secure by swimming with their mouths open. "The crustacea are strained from the water by means of long, fine gill-rakers, which form very efficient plankton nets. The stomachs examined by Eddy and Simer (1929) were usually filled with minute water fleas and copepods. Occasionally they may sweep up a few small aquatic insects." Eddy and Simer (1929) estimated the amount of water strained through the gills of a large paddlefish as between 62 cubic meters and 203 cubic meters to obtain enough Corethra larvae and Cyclops to fill a stomach with a capacity of 700 cc.

These and many other studies indicate the importance of Entomostraca as links in food chains. They also indicate that while *Entomostraca* are the basic food of nearly all fish in infancy or youth, they may continue to be the chief food utilized in some large fish, such as the paddlefish, which have developed a straining apparatus which enables even adult specimens to continue feeding on these tiny crustacea. The application of this knowledge has led to the growing of *Entomostraca* in culture to be used as food for fish in breeding ponds. Most commercial and game fish, however, are caught from lakes and/or rivers where they feed on the bounty provided by nature. A study of the *Entomostraca* in these bodies of water will provide us with some means of estimating the possibilities of stocking such lakes and/or rivers with commercial or game fish with some likelihood of their survival. Simply dumping fry or fingerlings into lakes which have not been thus examined may be wasteful indeed. A survey of the *Entomostraca* of Manitoba waters may therefore, be considered as basic to a knowledge of the fish populations these waters may be expected to support. It is the "watery equivalent" to a study of pasturage for grazing land animals.

The commercial fishing industry of Manitoba plays a very important part in the economy of this province. The average total productions for the twelve year period 1938-1950 was over 31,000,000 pounds of fish, and during the last three years the average annual value of fisheries production was over $5,000,000. It is interesting to note that in fiscal year 1938-1939 the total value of fisheries production was $1,769,000. while over

34,000,000 pounds of fish were produced in that year. In other words the annual value of fisheries production has multiplied about three times in the twelve year interval.

The number of fishermen employed in the winter fishery alone was nearly 7,000 in the fiscal year 1948-1949, and the value of boats, skiffs and other equipment used was nearly $2,500,000. About from one-third to one-half as many men were employed in the summer fishery.

So large is the province that the problem of supervision of commercial fishing is a difficult one and during the summer, on Lake Winnipeg, Lake Winnipegosis and Lake Manitoba, constant operation of patrol boats is required. These are diesel-powered and equipped with two-way radio. During the winter, Bombardier snowmobiles and a snowplane patrol the larger lakes of southern Manitoba. Difficulties of supervision are multiplied during the winter especially in the northern part of the province, where last year 62 lakes were involved in an area covering some 80,000 square miles. Bombardier patrols from The Pas covered many of the lakes in that immediate vicinity, and in addition a Bombardier was located at Gods Lake to patrol lakes of that area. It may be of interest to note that fish produced at South Indian Lake (No. 62, Fig. 24) during the winter was flown out in the fresh state.

Enough has been said to indicate the great importance of Manitoba's fishing industry. It is an industry whose continued expansion is assured as hundreds of smaller lakes are brought into production. This gigantic fisheries industry is entirely dependent upon *Entomostraca*. These tiny crustacea form the basis of the food supply of all fish, since all species feed upon *Entomostraca* in their infancy, and upon reaching maturity they either continue to feed upon *Entomostraca*, or they feed upon insects, fish, or other organisms which in turn feed upon *Entomostraca*. Thus, it will be seen how important the present study is to the welfare of this province.

ENTOMOSTRACA AS INTERMEDIATE HOSTS OF PARASITIC ORGANISMS

Various investigators have determined the life histories of tapeworms and of other parasites that infest fish, birds, and mammals. While it is true that complete life histories of many of these parasites are still to be determined by future investigation, yet partial or complete life histories of certain parasitic forms have been ascertained.

It is at first surprising to note how often *Entomostraca* are the first intermediate hosts for such parasites. Yet, on contemplation, how could it be otherwise! These parasites are absolutely dependent on reaching their second intermediate and final hosts via the alimentary canal, and to do so must be enclosed within the living food of the latter forms. Hence, *Entomostraca*, which form the food of almost all fish in their earliest stages and of many fish throughout life, provide the ideal means of accomplishing the desired result.

I am indebted to R. A. Wardle (1932, 1932a, 1933, 1933a, 1935), to R. A. Wardle and J. A. McLeod (1951), and to R. B. Miller (1944, 1945, 1946) for the following list compiled from their publications:

ORGANISM	FIRST Inter.Host	SECOND Inter.Hose	FINAL Host
1. *Hymenolepis* brachycephala	Cyclops sp.		Charadriiform Birds (Lapwings, plovers, turnstones)
2. *Hymenolepis collaris*	Diaptomus Cyclops Cypris		Anseriform Birds (Ducks, Geese, etc.)
3. *Hymenolepis coronula*	Cypridae		Anseriform Birds
4. *Hymenolepis gracilis*	Copepoda Ostracoda		Anseriform and Gruiform Birda (Cranes, etc.)
5. *Drepaindotaenia lanceolata*	Cyclops Diaptomus		Anseriform Birds
6. *Fimbriaria fasciolaris*	Cyclops Diaptomus		Anseriform Birds
7. *Cyathocephalus truncatus*	*Pontoporeia affinis*		*Coregonus clupeaformis* and *Salvelinus alpinus*
8. *Bothridium pithonis*	*Cyclops viridis*		
9. *Spirometra mausonoides*	Procercoid in Cyclops		
10. *Dibothriocephalus laruli*	Procercoid in *Diaptomus oregonensis*		
11. *Schistocephalus solidus*	Procercoid in Cyclops		
12. *Bothriocephalus rarus*	Procercoid in Cyclops		
13. *Triaenophorus crassus*	Procercoid in *Cyclops bicuspidatus thomasi*	Cisco and Whitefish	Pike (*Esox lucius*)

ORGANISM	FIRST Inter.Hose	SECOND Inter.Host	FINAL Host
14. Triaenophorus nodulosus (Pallas)	Procercoid in Cyclops b. thomasi	Ling or Burbot (Lota maculosa)	Pike (Esox lucius)
15. Triaenophorus stizostedionis	Procercoid in Cyclops b. thomasi	Trout Perch (Percopsis omiscomaycus	Pike-perch (Stizostedion vitreum Mitchill)
16. Proteocephalus pinguis	Cyclops bicuspidatus		Pike (Esox lucius)
17. Diphyllobothrium latum	Procercoid in Diaptomus oregonsis	Pickerel (Luciopera vitreum) Pike-perch(Stizostedion vitreum) Yellow Perch (Perca flavescens) Pike (Esox lucius) and (Esox estor)	Mammal

With constantly expanding knowledge due to the research of many workers in the field of helminthology, there are constantly being added new revelations of the importance of Entomostraca as intermediate hosts for parasitic worms. The need for teamwork between helminthologists and specialists working with microcrustacea is underlined, since it is obvious that such teamwork will be exceedingly fruitful.

In Manitoba the most immediate practical problem facing the fisheries industry is that of the infestation of ciscoes Leucichthys and whitefish, Coregonus clupeaformis with the second intermediate stage of the tapeworm, Triaenophorus crassus. The work of Miller (1944, 1945, 1946) has been outstanding both in tracing the life history of this parasite and in outlining various methods of attacking the problem presented by it. The author's studies of the percentage infestation of the crustacean host with procercoids of *Triaenophorus* are briefly summarized in the section dealing with *Cyclops bicuspidatus thomasi* in Part I of this thesis. Studies made by the author of the feeding of Lake Winnipeg ciscoes, which form Parts IV, V, and VI of this thesis are an additional contribution towards this phase of fisheries research.

THE VALUE OF A SURVEY OF THE ENTOMOSTRACA OF MANITOBA AS A CONTRIBUTION TO GENERAL KNOWLEDGE

One of the most stimulating features of this research has been the interest and encouragement offered by other workers in the field. Many of the *Entomostraca*, which the author found in Manitoba, are quite far out of their previously known range of distribution. Since unusual distribution records are open to some justifiable suspicion, the author has taken the precaution of having his identifications verified by outstanding authorities, for whose services fitting acknowledgment is made later in the text. These authorities have been kind enough to urge immediate publication of these new distribution records, and steps have been taken by the author to that end. The occurrence of *Senecella calanoides* in Manitoba was surprising indeed, as was the occurrence of *Diaptomus arcticus* and *Epischura nevadensis*. The author's publication of a description of a new species of *Diaptomus* (*Diaptomus manitobensis* Arnason, 1950) was of considerable interest to Mrs. M. S. Wilson to whom the author sent mounts of this species. Mrs. Wilson proposes to include the author's description of *D. manitobensis* in her revision of the *leptopus-piscinae* group of the genus *Diaptomus*.

The value of this survey as a contribution to general scientific knowledge is considerable since so much work has been done by specialists both east and west of Manitoba, in Canada, and of course through most regions of the U. S. A. Meanwhile this province, lying in the center of Canada, vast in area and studded with lakes and rivers of all sizes, has been relatively neglected in so far as the present very important field of study is concerned. The material presented in this thesis will do much to fill a very important gap in scientific knowledge, and, moreover, because of Manitoba's strategic position on the continent the discoveries herewith presented may help in the determination of centers of origin and paths of distribution for many species. The presence of *Diaptomus arcticus* in Manitoba barely north of 50° N. Lat. may perhaps be construed as an evidence of southward migration of this species. The presence of *Senecella calanoides* in West Hawk Lake at such a great distance from the ocean raises the question of whether it should still be included with the *fauna relicta*. Incidentally it has been possible for the author working in the field to confirm some of the experimental research of Brooks, Coker and Addlestone, et al., as to the effects of temperature on crest development in species of *Daphnia*. The investigations of Yeatman (1944) of the interrelationships of the forms of *Cyclops vernalis* found ample confirmation during the course of these studies. This portion of the thesis, as is often true of investigations involving so-called "pure science" has already proved most fruitful.

ORGANIZATION OF THE THESIS

The thesis has been divided into six sections or parts. Part I deals with the identification of species of Entomostraca found in Manitoba and with their distribution within the province. No one worker could hope in a lifetime to completely study the Entomostraca of every lake, river, pond and pool of this vast province, nor would it have been possible for the author to have done even a fraction of the very considerable work he has been able to accomplish without the assistance of the agencies already mentioned, namely: The Game and Fisheries Branch of the Province of Manitoba; and the Central Fisheries Research Station, Fisheries Research Board of Canada.

Part I also contains a description of a new species of Diaptomus named by the author Diaptomus manitobensis in honour of this great province. It also deals with an experimental determination of the percentage infestation of Cyclops bicuspidatus thomasi with procercoids of Triaenophorus tapeworms in waters of Heming Lake.

Part II contains a specific study of the Entomostraca of Heming Lake over a two year period, while Part III is a similar study of the Entomostraca of Lake Winnipeg. From these studies we learn of the fluctuation of numbers of Entomostraca in a given body of water from year to year, and throughout the year we see the rise and fall of plankton populations with the changing seasons. We find the waters teeming with *Entomostraca* in July and August, and almost barren of *Entomostraca* in January and February. Yet in early May even before the ice has melted the period of winter dormancy is over and *Entomostraca* are stirring beneath their icy covering. Soon after the ice melts there is a rapid increase in the tempo of activity, and as the waters warm the reproductive rate rises faster and faster, and as a result the numbers of *Entomostraca* approach again the midsummer peak, to be followed once more by a tapering off as the waters cool--a never ending cycle.

Part IV of this thesis deals with a study of the feeding of Lake Winnipeg ciscoes. In this study an examination is made of 345 ciscoes of which all but 14 were collected between July 7, 1949 and February 23, 1950. The remaining 14 specimens were taken on October 27, 1948. This study shows the changes in the nature of the food chosen by ciscoes of different sizes, and also the variation in feeding of ciscoes during the summer, autumn, and winter seasons. Part V is an investigation of the correlation existing between the feeding of ciscoes upon *Entomostraca* and the limnetic Entomostraca available in the area where these fish were feeding. Part VI is an experimental study of the filtration of plankton *Entomostraca* by the gill-rakers of Lake Winnipeg ciscoes. This experiment is an entirely new attack on the problem of whether mechanical filtration by gill-rakers of ciscoes is the sole or chief determinant of the species of *Entomostraca* fed upon by these fish. Parts IV, V, and VI taken together throw considerable new light upon the feeding of Lake Winnipeg ciscoes, and demonstrate that selection of certain species of *Entomostraca* as food by these fish is intentional and not simply a matter of chance.

CLASSIFICATION OF THE ENTOMOSTRACA

The author wishes to make reference to the recent classification prepared for Section F, American Association for the Advancement of Science (Pearse, 1948). Only that portion of this classification which relates to this thesis is herewith submitted:

- Phylum Arthropoda
  - Subphyllum Mandibulata
    - Superclass Crustacea
      - Class Eucrustacea
        - Subclass Branchiopoda
          - Order Anostraca
          - Order Notostraca
          - Order Conchostraca
          - Order Cladocera
        - Subclass Ostracoda
        - Subclass Copepoda
          - Order Eucopepoda

There is considerable justification for revision along these line and many leading scientists have adopted the new classification. Pending universal acceptance, however, the author has preferred to follow the still acceptable but older and more conservative classification for the main groups of *Entomostraca*.

The classification followed by the author is mainly that of Sars. The author agrees with Gurney (1933) and Yeatman (1944) in resisting a tendency to elevate the genus *Cyclops* to the rank of a Family or Subfamily, with the consequent elevation of subgenera to the rank of genera. As Gurney (1933) states: "There are two main requirements of any system--that it should be practical, not only for the specialist, but still more for the non-specialist; and that it shall, as far as may be, reflect current ideas of phylogeny. Both these objects tend to be defeated by excessive splitting of genera". The genus *Cyclops* has, therefore, been retained and has beem divided into subgenera only where necessary to indicate relationships within the genus. This system generally follows that of Kiefer (1929). There is considerable value in retaining the generic name *Cyclops* (rather than a multiplication of genera), since as already noted fresh-water Copepods are receiving attention from helminthologists and others as the intermediate hosts of parasitic "worms". For the specialist the advantage of grouping together closely related species is achieved by the use of subgenera.

Light (1938, 1939) with the assistance of Mrs. M. S. Wilson has proposed the grouping together of closely ralated species of *Diaptomus* into subgenera. While this system has advantages for the specialist, it has no real disadvantages for the non-specialist, since the present generic and specific names are retained.

The nomenclature for the genus *Daphnia* proposed by Wolter-eck (1932) has been followed, though a new revision in process of preparation by J. L. Brooks will undoubtedly throw further light on the interrelationships of the members of this genus. For the genus *Bosmina* the nomenclature followed is that of Rylov (1935).

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PART I

STUDIES OF ENTOMOSTRACA OF MANITOBA

Addenda:

Diaptomus pribilofensis Juday and Muttkowski, 1915

Diaptomus sanguineus Forbes, 1876

CLASS CRUSTACEA

Sub-Class ENTOMOSTRACA

COPEPODA OF MANITOBA

Order COPEPODA

Sub-Order CALANOIDA Sars

Family CENTROPAGIDAE

Genus LIMNOCALANUS Sars, 1863

Limnocalanus macrurus Sars, 1863

Family DIAPTOMIDAE

Genus DIAPTOMUS Westwood, 1836

Sub-Genus *Hesperodiaptomus* Light, 1938

Diaptomus arcticus Marsh, 1920

Sub-Genus *Leptodiaptomus* Light, 1938

Diaptomus minutus Lilljeborg, 1889

Diaptomus sicilis Forbes, 1882

Diaptomus siciloides Lilljeborg, 1889

Diaptomus tenuicaudatus Marsh, 1905

Sub-Genus *Aglaodiaptomus* Light, 1938

Diaptomus leptopus Forbes, 1882

Diaptomus manitobensis Arnason, 1950

Diaptomus piscinae Forbes, 1893

Diaptomus stagnalis Forbes, 1882

Sub-Genus *Skistodiaptomus* Light, 1939

Diaptomus oregonensis Lilljeborg, 1889

Sub-Genus *Eutrichodiaptomus* Light, 1939

Diaptomus ashlandi Marsh, 1893

Family SENECELLIDAE Marsh, 1933

Genus SENECELLA Juday, 1923

Senecella calanoides Juday, 1923

Family TEMORIDAE Baird, 1850

Genus HETEROCOPE Sars, 1863

Heterocope septentrionalis Juday and Muttkowski

Genus EPISCHURA Forbes, 1882

Epischura lacustris Forbes, 1882

Epischura nevadensis Lilljeborg, 1889

Sub-Order CYCLOPOIDA Sars

Family CYCLOPIDAE Sars

Genus CYCLOPS Muller, 1776

Sub-Genus *Macrocyclops* Claus, 1893

Cyclops albidus Jurine, 1820

Sub-Genus *Tropocyclops* Kiefer, 1927

Cyclops prasinus Fischer, 1860

Sub-Genus *Eucyclops* Claus, 1893

Cyclops agilis Koch, 1838

Sub-genus *Acanthocyclops* Kiefer, 1927

Cyclops bicuspidatus thomasi Forbes, 1882

Cyclops bicuspidatus lubbocki Brady, 1868

Cyclops bicuspidatus navus Herrick, 1882
= *Cyclops navus* Herrick, 1882

Cyclops magnus Marsh, 1920

Cyclops vernalis var. *americanus* Marsh, 1893
= *Cyclops viridis* var. *americanus* Marsh, 1893
= *Cyclops americanus* Marsh, 1893

Cyclops vernalis Fischer, 1853
= *Cyclops brevispinosus* Herrick, 1884
= *Cyclops vernalis* var. *robustus*
= *Cyclops lucidulus* and *C. robustus* Sars, 1863

Sub-Genus *Microcyclops* Claus, 1893

Cyclops varicans Sars, 1863

Sub-Genus *Mesocyclops* Sars, 1914

Mesocyclops edax Forbes, 1891
= *Mesocyclops leuckarti edax* Forbes, 1891

Sub-Order HARPACTICOIDA Sars

Family CANTHOCAMPTIDAE Sars

Genus CANTHOCAMPTUS Westwood, 1836

Sub-Genus *Attheyella* Brady, 1880

Canthocamptus illinoisensis Forbes
= *Attheyella illinoisensis*, Forbes

Sub-Genus *Bryocamptus* Chappuis, 1929

Canthocamptus minutus Claus, 1863

SUB-ORDER CANANOIDA

CENTROPAGIDAE OF MANITOBA

Genus LIMNOCALANUS Sar, 1863

Only one species of this genus was found in Manitoba, that species being *Limnocalanus macrurus* Sars, 1863.

Limnocalanus Macrurus Sars, 1863

Limnocalanus macrurus was not common in Manitoba Lakes. It was found in George Lake in the Whiteshell Forest Reserve in southeastern Manitoba in Fishing Lake (52° 05'N. 95° 25'W.) in Lake Winnipeg, and in the lakes of northwestern Manitoba including Eden Lake (56° 39'N. 100° 15'W.), Southern Indian Lake (56° 50' N. Lat. 98° 45' W.Long.) and Stag Lake (56° 30' N. Lat. 100° 25' W. Long). (Table 1)

Limnocalanus macrurus is generally considered to belong to the *fauna relicta*; that is, it is a salt-water form that has gradually become adapted to a fresh-water environment. Marsh (1933) states: "Generally speaking, it is found only in fairly deep lakes, and most abundantly at considerable depth." The present findings are in agreement with this statement.

In George Lake, which has an average depth of 80 to 90 feet and a maximum depth of 116 feet, it was fairly common in two bottom samples but did not occur in eleven other samples of plankton from this lake. The sample from Eden Lake in which this occurred was a vertical sample from 66 feet, in which it was abundant. L. macrurus did not occur in a sample taken at 12 feet below the surface of this lake. Though usually rare, or more often absent from surface collections, L. macrurus did occur in a single surface sample from Southern Indian Lake, a few specimens being present. In Stag Lake L. macrurus was rare in a surface sample collected at 11:30 a.m., absent from a drag sample taken at a depth of 12 feet at 11:40 a.m., and common in a vertical sample taken from 50 feet at 11:45 a.m. In Lake Winnipeg it was usually found at depth but was occasionally taken at the surface (Table I also Fig. 24).

Occurrence:- Limnocalanus macrurus is found in many localities in Scandinavia and in Finland (Sars et. al.). Its occurrence in America has been recorded in all the Great Lakes, in Green Lake, Wisconsin, and in Lake Nipigon, Ontario (Marsh). It was found in lakes in New York State (Birge and Juday, 1914). It was reported from Lake Winnipeg (Bajkov, 1930). It has also been recorded from Greenland (Stephenson, 1913, and Haberbosch, 1916).

Remarks: The lakes in which this species is found in Manitoba are alike in several respects. They lie in areas of Pre-Cambrian rocks consisting of granites, schists and gneisses, in regions lying east and north of Lake Winnipeg, and forming a part of the Laurentian Shield. These lakes are also as already indicated, fairly deep. The distribution of Limnocalanus macrurus may perhaps be correlated with temperature since these lakes lie within the isotherms for mean summer temperature of 60° and 62°F.

DIAPTOMIDAE OF MANITOBA

Genus DIAPTOMUS Westwood,1836

The species of the genus Diaptomus have few variable characteristics. Morphologically these species are very distinct, and even when widely separated geographically, this distinctness is maintained. The distinguishing characteristics are size, colour, (in fresh specimens), the armature of the antepenultimate segment of the first antenna of the adult male, the structure of the right fifth foot of the male and the structure of the fifth feet of the female.

The genus Diaptomus is worldwide in distribution, though few of its species are distributed widely. Marsh found Diaptomus bacillifer in a collection taken from a pond one foot deep and one hundred feet above sea level on a ridge at Bernard Harbour, Northwest Territories. He also found the same form in a collection taken on St. Paul Island, Alaska. Diaptomus bacillifer has been found in Siberia, and in islands north of Siberia, Central Asia, India, the Caucasus, Syria, Asia Minor, several places in the Alps, as well as in Scotland and Norway. It is a stenothermal coldwater form, which is found in bodies of water near the sea level in the far north, and farther south in lakes in the higher mountains. Apparently Diaptomus bacillifer encircles the glove in the neighborhood of the Arctic circle. Diaptomus castor which is widely distributed in Europe in temporary spring pools also occurs in Greenland. A variety of Diaptomus eiseni has been reported from Siberia as well as from California and Nebraska (Marsh) and from British Columbia (Carl) and was also found in Alaska (Kincaid--unpubl.). It has been reported from Yukon Territories by Hooper, 1947. This species had previously been recorded from Norway (Sars 1903), Scandinavia (Ekman 1905), Alps mountains (De Guerne, and Richard 1889), Russia (Rylov 1930) and central Asia (Sars 1903). With the exception of these four species which are widely distributed, the species of Diaptomus which occur in America are peculiar to this continent, and many of them have a very narrow and restricted range. Only one North American species of Diaptomus has been found in South America. (D. marshi Juday).

There appear to be two great factors controlling the distribution of Diaptomi in the opinion of Marsh (1907). One is ease of water communication, and the other is temperature. Temperature appears very often to be a controlling or limiting factor; while some species such as Diaptomus oregonensis, can live under a wide range of temperature, other species are distinctly stenothermal. Recently it has been shown by Hedgepeth (1943) that the presence of free carbonate, and the concentration of magnesium in proportion to calcium may influence the distribution of certain species of Diaptomus.

The genus Diaptomus forms an important part of the food of many fishes, especially in the early stages of development. Some species of Diaptomus also harbor intermediate stages in the life cycles of various parasites of fishes and mammals, including several species of tapeworms. As one example, Diaptomus oregonensis harbors the procercoid of the large tapeworm Diphyllobothrium latum, the plerocercoid of which develops in a fish, and the adult of which develops in a mammal.

Diaptomi are herbivorous, subsisting on algae including Anabaena, Aphanizemenon, Melosira and a goodly percentage of one-celled diatoms. They thus serve to convert the "grass of the waters--the algae" into "flesh" and are themselves eaten by young fish which in turn provide food for larger predaceous species.

The following species of Diaptomus have been found in Manitoba; Diaptomus arcticus, Diaptomus ashlandi, Diaptomus leptopus, Diaptomus manitobensis (n. sp.), Diaptomus minutes, Diaptomus oregonensis, Diaptomus sicilis, Diaptomus siciloides, Diaptomus stagnalis, and Diaptomus tenuicaudatus, Diaptomus pribilofensis, Diaptomus sanguineus.

Diaptomus arcticus Marsh, 1920

Two male specimens of this large species were found in a collection obtained from a marshy bay near the north westerly tip of Lake Francis (50° 20' N. Lat. 98° W. Long.)(Fig. 24). This fingerlike projection of Lake Francis is known locally as Lambert Creek. The sample of plankton which contained *D. arcticus* was collected by a field party under the direction of Dr. J. A. McLeod, on June 27, 1948. Of the two male specimens found one is in the collection of the author and the other was forwarded to the U. S. Nat. Museum. The identification was made by Mildred S. Wilson. This is the first record of *D. arcticus* from Manitoba.

Distribution: According to Marsh (1929) *D. arcticus* was named from material collected by Fritz Johansen on Herschel Island and up to that time had been found in no other locality. M. S. Wilson states (in correspondence with the author, 1951): " I am not yet prepared to make a definite decision as to whether *D. arcticus* is distinct enough to have specific status or be considered a sub-species of *D. eiseni*. At present the northern form should probably be called *arcticus*." M. S. Wilson (1941) further reports a record of *D. eiseni* from Hudson Strait but states concerning it (also in correspondence with the author): "You will note that record from Hudson Strait in the enclosed reprint is called *eiseni*--this is probably the *arcticus* form but Marsh himself identified it as *eiseni*!"

Diaptomus minutus Lilljeborg, 1889

Diaptomus minutus was found in fifteen lakes of over eighty lakes examined. East of Lake Winnipeg it occurred in Aikens Lake (about 51° 15' Lat. N. 95° 33' N. Long.), and in three lakes of the Whiteshell Forest Reserve. It was also found at two locations in Lake Winnipeg. The other lakes in which it was found were chiefly in the northwest corner of the province, north of The Pas (Table I, Fig. 24). All these lakes lie in areas of Pre-Cambrian rocks composed chiefly of granites, schists and gneisses, in regions east and north of Lake Winnipeg, and forming a part of the Laurentian Shield. Pre-Cambrian rocks also underlie the locations in Lake Winnipeg at which this copepod was found. This distribution of *Diaptomus minutus* may also be correlated with temperature since these lakes lie within the isotherms for mean summer temperatures of 60° and 62°F.

While *Diaptomus minutus* is typically a cold water form, yet, it is possible for this organism to survive fairly high temperatures. This is evident from the fact that it has been recorded by Dr. R. E. Coker (1938) from certain relatively warm, shallow, coastal plain lakes in North Carolina. (See Coker, R. E., 1938, in Journal Elisha Mitchell Sci. Soc. 54; 76-87 and Archiv. Hydrobiol. 34: 130-133). The author also found *D. minutus* still present on July 25, 1948, in the surface waters of Heming Lake, Manitoba, (54° 53' N. Lat. 101° 07' W. Long.) although the water temperature was 68° F. On the other hand *Diaptomus minutus* occurred in winter plankton samples taken through the ice at Heming Lake, on the following dates: December 4, 1949; January 16, 1950, February 15, 1950 and April 1, 1950. It was also found in winter plankton samples taken through the ice on Lake Winnipeg on December 31, 1950, and in similar collections made from West Hawk Lake in January, February and April, 1950 (Fig. 24).

Distribution: Greenland (Lilljeborg); Iceland (De Guerne and Richard); Newfoundland (Schacht); Great Lakes, Michigan, Wisconsin (March); New Brunswick (Willey); Nipigon Lake, Ontario (Bigelow); Yellowstone National Park (Schacht); Woods Hole, Mass. (Wilson).

Diaptomus sicilis Forbes, 1882

Diaptomus sicilis was found only in Lake Dauphin, Singush Lake, Lake Winnipeg, (Table I, Fig. 24) and in the Payuk River. In British Columbia Carl found *Diaptomus sicilis* in small temporary pools and stagnant lakes, on the coast and in the interior. In the United States it generally occurs in the spring or early summer in the smaller lakes, and throughout the year in the larger lakes.

Distribution: Michigan, Wisconsin, New York (Marsh); Lake Superior, Yellowstone Park (Forbes); Detroit River (Reighard); Colorado, Lake Huron, North Dakota (Marsh); Quill Lake, Saskatchewan (Willey); Cedar Lake and Fox Lake, Illinois (Schacht); British Columbia (Carl).

Diaptomus siciloides Lilljeborg, 1889

Diaptomus siciloides was found in the following lakes in Manitoba; Lake Dauphin, in a marshy bay of Lake Francis, Singush Lake, Shoal Lake and Lake Winnipegosis. In Lake Dauphin and Singush Lake it was associated with *Diaptomus sicilis*, but occurred less frequently than the latter form. Only in Lake Dauphin and in Shoal Lake was it common (Fig. 24).

Distribution: California, Oregon (Lilljeborg); Nebraska (Brewer); Iowa (Pearse); Wisconsin, Michigan (Marsh); Minnesota (Herrick); Iowa, Illinois, Indiana (Schacht); Northwest Territories (Marsh); eastern Massachusetts (Pearse); Great Lakes (Marsh); Ontario, New Brunswick (Klugh); Colorado (Dodds); Utah, North Dakota, Kansas, Indiana, Missouri, Texas, (Marsh); San Salvador (Juday); British Columbia (Carl); Saskatchewan (Moore). Carl found *Diaptomus siciloides* only in an alkaline pond near Cache Creek, B. C. Moore found this species in saline lakes where the solids in p.p.m. ran up to 120,000 in Saskatchewan.

Diaptomus tenuicaudatus Marsh, 1907

Diaptomus tenuicaudatus was found in the following lakes in Manitoba; Aikens Lake, Lake Athapapuskow, West Hawk Lake, Mantario Lake, Reed Lake, and Wilfred Lake (Table I, Fig. 24). Lake Athapapuskow and Reed Lake lie in the northwest corner of the province between 54° and 55° N. Lat., while the other four lakes lie east of Lake Winnipeg. West Hawk Lake and Mantario Lake are situated in the Whiteshell Forest Reserve and lie against the boundary between Manitoba and Ontario, or immediately west of the boundary in the case of Wilfred Lake, and Aikens Lake also lies a little west of the same boundary and about 1° further north. All of the lakes in which *D. tenuicaudatus* was found occur in areas of Pre-Cambrian rocks composed chiefly of granites, schists and gneisses, in regions east and north of Lake Winnipeg, and forming part of the Laurentian Shield.

These lakes lie within the isotherms for mean summer temperatures of 60° and 62° F. The distribution of this species resembles the distribution of *Diaptomus minutus* in Manitoba, though it occurs less frequently. Both *Diaptomus minutus* and *Diaptomus tenuicaudatus* are found associated in the following lakes: Aikens Lake, Lake Athapapuskow and Wilfred Lake (Fig.24).

Distribution: Marsh described *D. tenuicaudatus* from material collected by Dr. R. T. Congdon in Glen Lake, Saskatchewan. It was found in collections made in Lake Nipigon, Ontario by Prof. H. H. Mackay. Marsh also collected *Diaptomus tenuicaudatus* from Utah Lake, Utah. Moore recently (1944) found it common in the saline lakes of Saskatchewan.

Diaptomus leptopus Forbes, 1882

Diaptomus leptopus was found only once, one adult male specimen occurring in a collection from George Lake, Manitoba (Fig. 24).

Distribution: Its distribution in the United States is reported as follows: Wisconsin, Michigan, Indiana, Colorado, Southern Utah (Marsh); Minnesota (Herrick); Colorado, Illinois (Forbes); Iowa (Stromsten); Kentucky (Chambers); Woods Hole, Mass. (Forbes, M. and R. Rathbun); North Dakota (Juday in correspondence with Marsh); Mt. Lake, Virginia (Yeatman H. C. in correspondence with the author).

<u>Diaptomus manitobensis</u> Arnason, 1950

Large stout species. Female 2.4 mm. exclusive of furcal setae, male 2.6 mm. Metasome plump with first segment longer than three following, strongly convex in dorsal profile especially in mid region and at anterior end; posterolateral projections directed obliquely posteriorly and laterally each tapering to sharp hyaline points tipped by tiny spines; a second larger point and spine on dorsal margin.

First segment of female abdomen longer than rest of abdomen; much dilated in front and somewhat laterally with two small lateral spines. Second segment very short. Furca about the same length as the second segment. Furcal rami ciliate on inner margins of distal third.

Antennae 25-segmented; slender and relatively long, reaching to middle of abdomen. Small setae unmodified (Fig. 3); three setae on segment 2 and segment 16, two each on segments 6, 9-11, 13-15, 17, 18, 22-24, one each on all others save segment 25 which has five. Major spines on segments 10, 11 and 13 of right antenna of male (Fig. 3); major spines slightly to considerably incurved; spine of segment 10 about the same length as width of antenna, that of segment 11 slightly longer, and that on segment 13 at least twice as long as that on segment 10, incurved and bluntly hornlike in appearance. Segments 13-17 of male

Diaptomus manitobensis n.sp.

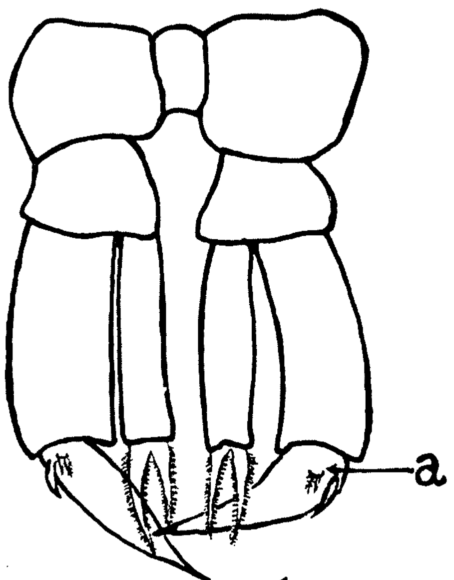
Fig. 1. Fifth legs of female. X 104.

(a, rudimentary third segment of exopodite).

Fig. 2. Fifth legs of male. X 100.

(a, process; b, hook; c, process).

Fig. 3. Right antenna of male. X 104.



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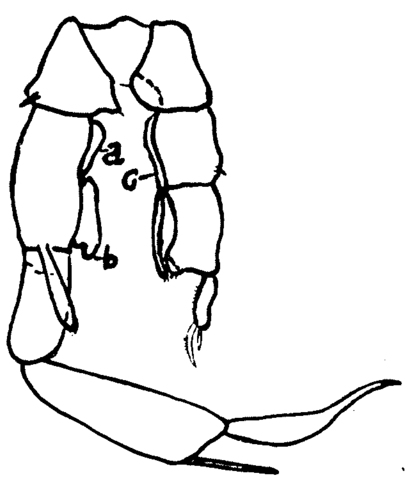

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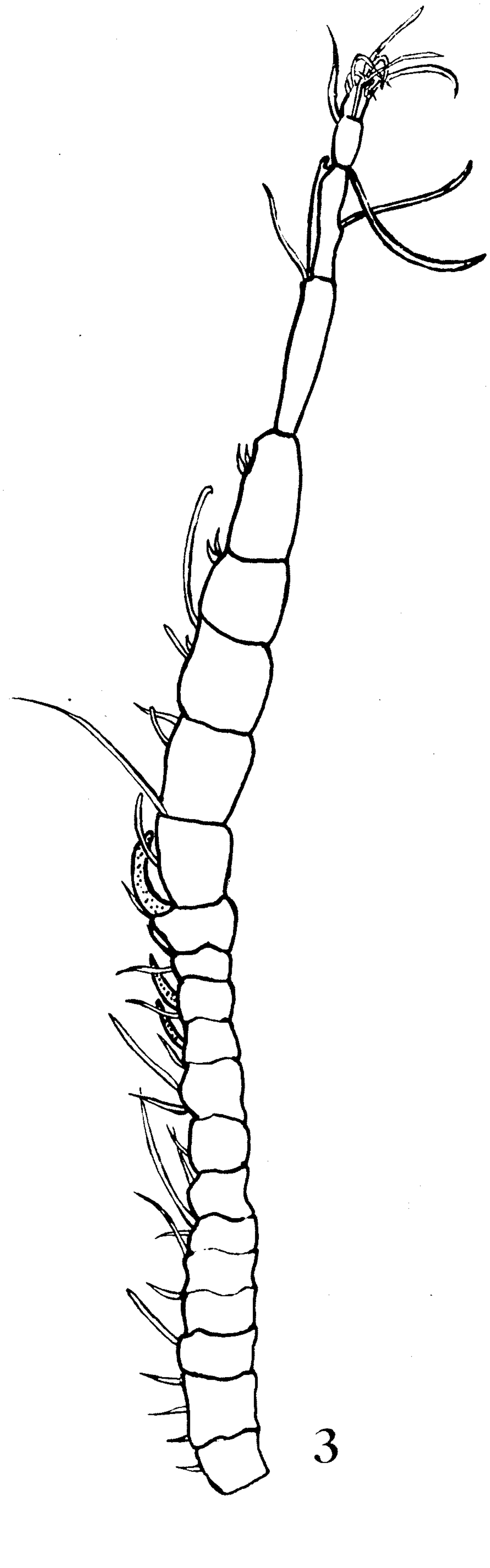

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right antenna markedly swollen, segment 18 somewhat less so; lateral hyaline membrane on antepenultimate segment slender and terminating in a short delicate incurved hook.

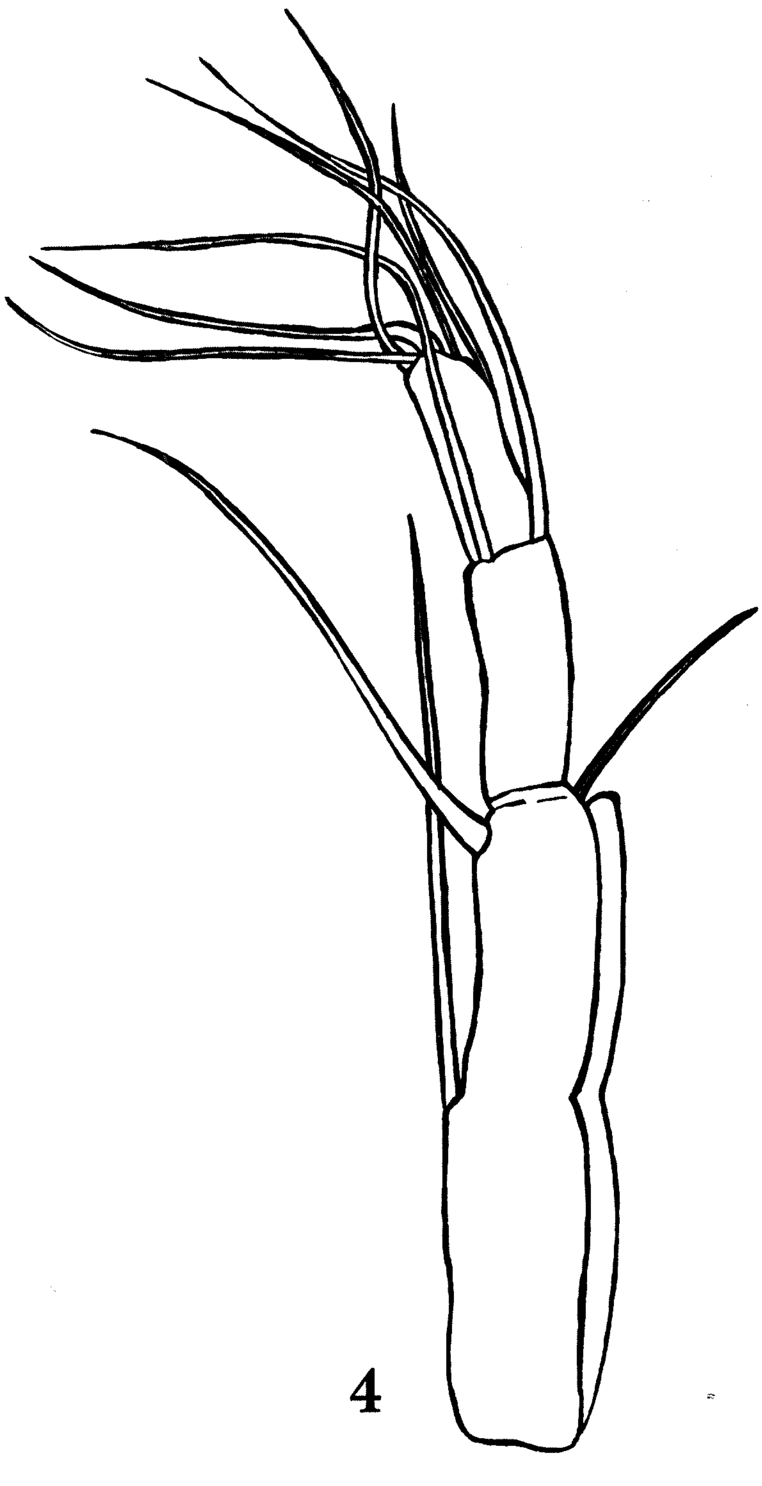
Fifth legs of male narrow, elongated; left leg reaching just past middle of first segment of exopodite of right leg. Spines of basal segments of male fifth feet short, stout and blunt. Second basal segment of right food quadrangular, about two and one-half times as long as wide; near the proximal end a dome-shaped hyaline projection confluent with a lateral hyaline lamella extending most of its length along the inner surface and terminating distally ih a broad hyaline hook-shaped process. The first segment of exopodite of right leg about four-fifths as wide and about two-thirds as long as the second basal segment. Second segment of exopodite slender, widening somewhat about seven-eighths from the proximal end, and then narrowing sharply in the distal eighth; about one and one-half times as long as the first exopodite or about the same length as the second basal segment (basipodite). Lateral spine, narrow and straight, about one-third longer than segment is wide, arising from distal lateral angle, continuing almost in line with lateral margin of segment of exopodite, slender, smooth, somewhat swollen in proximal portion, curved symmetrically inward in the middle region and outward at the pointed tip. The endopodite slender, one-segmented, extending about seven-eighths of the length of the first segment of the exopodite, coarsely setose at the distal end. Second basal segment of left leg quadrangular, one and one-half times as broad as first segment of exopodite, with a narrow hyaline ridge running the length of the inner lateral margin; lateral spine short and stout, inserted slightly anterior to distal angle. First segment of exopodite about twice as long as broad, widening distally, its outer margin almost straight, its inner margin curved; inner margin terminating in a rounded or dome-shaped projection which is finely setose. Second segment of exopodite slender, about four times as long as wide, terminating in two spines, the outer of which is short and smooth and the inner of which is long curved and setose. Endopodite one-segmented, slender, extending slightly beyond the distal end of the first exopodite, crenulated along the inner margin and setose at the tip.

Fifth legs of female (Fig. 1) relatively long and stout; third segment of exopodite rudimentary, indistinct, its spine nearly as long as its seta; spine on second segment stout, incurved, about twice as long as seta of third segment. Second segment with claw about the same length as inner margin of first segment; claw relatively slender, somewhat curved, finely denticulate on both inner and outer margins, but somewhat less so on outer margin. Endopodite one-segmented, slender, reaching nearly to end of first segment of exopodite; apical

Diaptomus piscinae from Mt. Lake, Virginia.

Fig. 4. Terminal segments of right antenna of male.

Fig. 5. Fifth foot of female.



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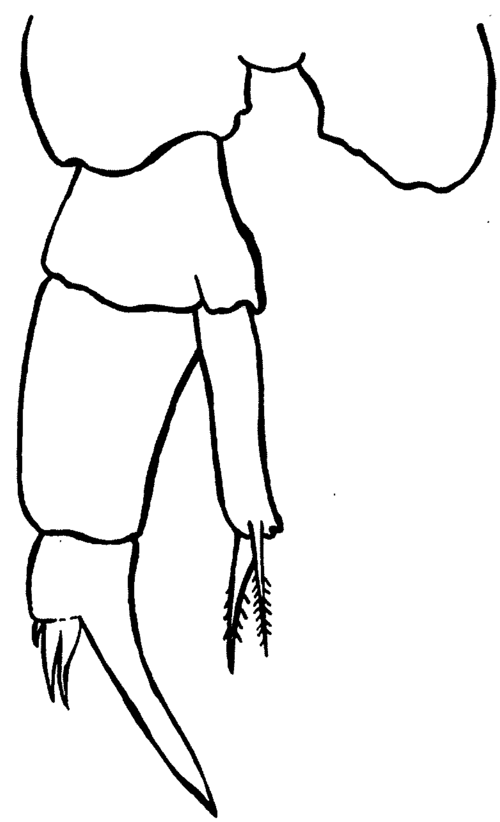

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portion of endopodites truncated, bearing two long apical setae, the median slightly over four-fifths as long as the lateral, and with proximal spinelets graduating into distal hairs.

TAXONOMIC POSITION

This species resembles Diaptomus caducus Light, 1938 in size and in large number of setae on the antennae, but differs from it slightly in the distribution of the setae. (D. manitobensis has three setae on segment 2 and segment 16, and one on segment 19, while D. caducus has four setae on segment 2, and two each on segments 16 and 19). The armature of the antepenultimate segment of the male right antenna, and the details of structure of the male and female fifth legs, distinguish this species both from D. caducus and from the closely related Diaptomus shoshone Forbes, 1893.

In D. caducus, the process on the antepenultimate segment of the male right antenna is longer than the penultimate segment, thicker at the base and usually tapering to a point, rarely with a swollen tip (Fig. 17). In D. shoshone, the process on the antepenultimate segment is only slightly longer than the penultimate segment (Fig. 21), thicker at the base, tapering to a point. Both these species lack the lateral hyaline membrane found on the antepenultimate segment of D. manitobensis. In both D. caducus and D. shoshone there is a dis-

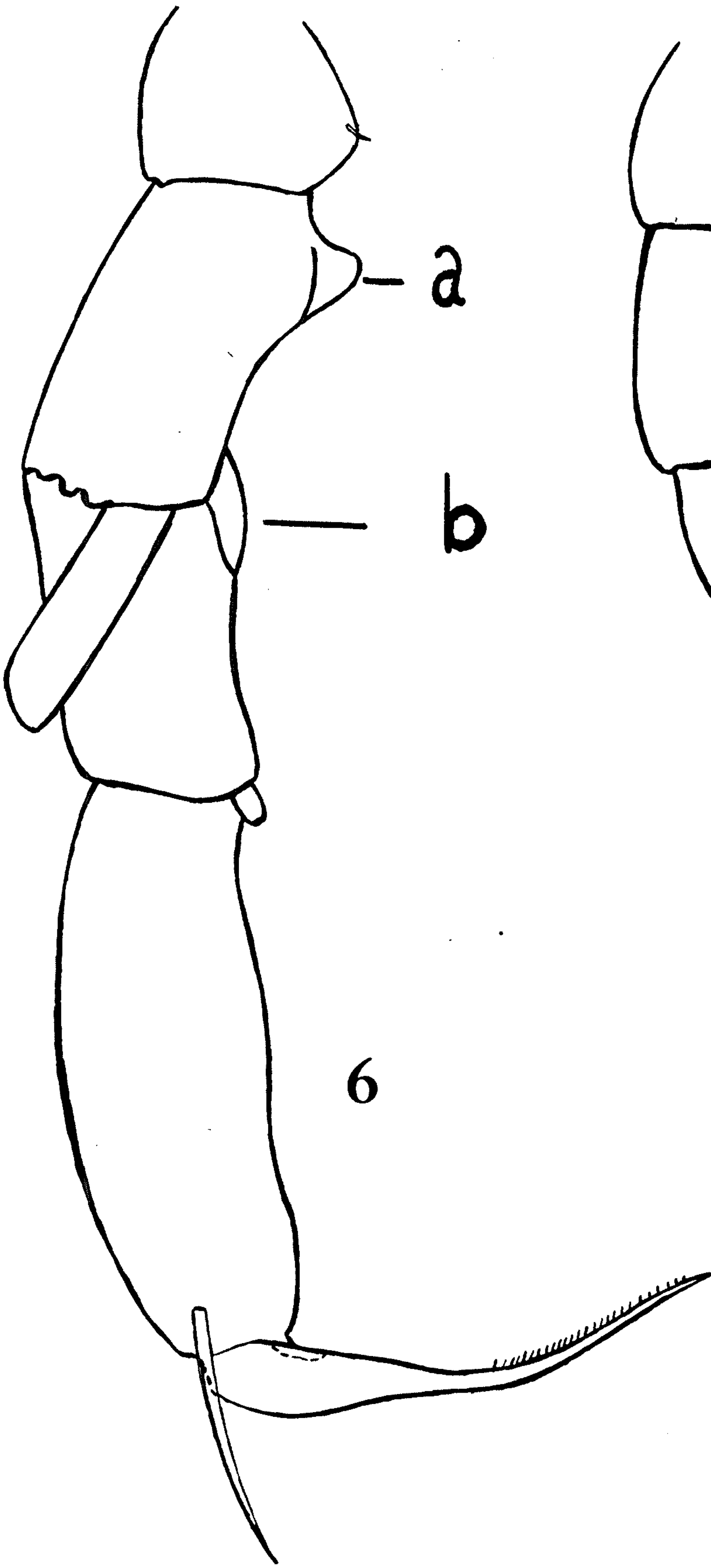
Diaptomus piscinae from Mt. Lake, Virginia.

Fig. 6. Right fifth foot of male.

(a, process on second basal segment of right exopodite; b, hook on second basal segment long and large).

Fig. 7. Left fifth foot of male, twisted around.

(c, endopodite very long).



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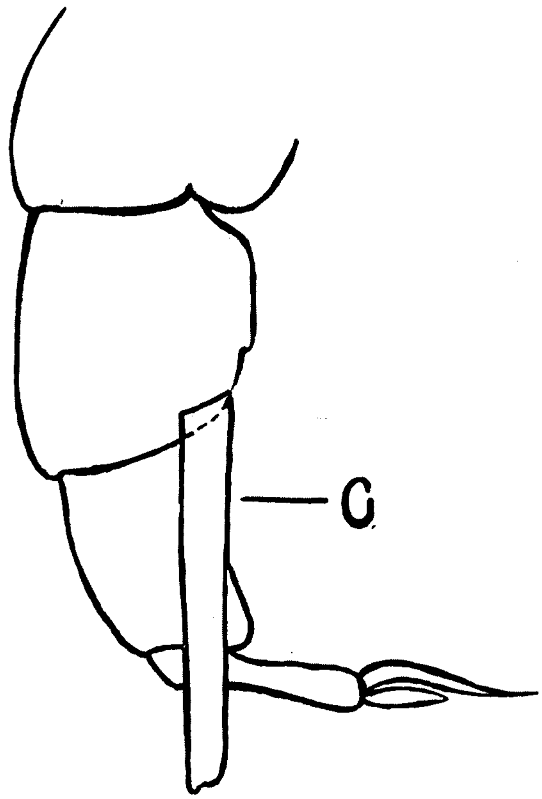

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tinct third segment of the exopodite of the female fifth leg, while the corresponding third segment of the exopodite in D. manitobensis is rudimentary and indistinctly separated from segment 2. In D. manitobensis the endopodite of the male fifth leg is one-segmented (in both right and left fifth legs), while in D. caducus it is two-segmented (Figs. 19,20). In D. shoshone the endopodite of male left fifth leg is two-segmented, while the endopodite of male right fifth leg is one-segmented.

In D. manitobensis the absence of the slender apical extensions of the endopods of the fifth legs of the female is noteworthy. This character is a point of resemblance between this species and Diaptomus leptopus Forbes, D. piscinae Forbes and D. caducus, and also a point of distinction from D. shoshone.

D. manitobensis resembles D. leptopus and D. piscinae as well as D. caducus and D. shoshone in that the male right antenna appears to have only 22 segments instead of 25. This is due, in each case, to the fact that segments 19,20, and 21 are ankylosed, as are also segments 22 and 23 (Fig.3).

In D. manitobensis the end of the lateral hyaline lamella on segments 22 and 23 is projected distally into an incurved hyaline hook-shaped process (Fig.3). This characteristic distinguishes D. manitobensis from D. piscinae. It, moreover, distinguishes it from D. leptopus according to "Marsh and several other copepod taxonomists" (1893), Herrick and Turner (1895), and Yeatman (correspondence with the author, 1949). Also the specimen of D. leptopus collected from Singush Lake, Manitoba, by the present author, lacks such a hook. Schacht (1897), however, in his description of D. leptopus, states that the segments 22 and 23 of the male right antenna have "...a narrow hyaline lamella produced into a hook which extends but a little beyond the end of the segment." Also S.A. Forbes (1882), in his original description of D. leptopus states: "The antennae reach to the tip of the furca, and the antepenultimate segment of the right antenna bears a small hook at the tip in the male." Forbes shows no antennal figure, and neither he nor Schacht says whether this hook is incurved or outcurved. Wilson (1932) states concerning the same character of D. leptopus: "Right antenna much swollen anterior to the geniculating segment; a narrow hyaline membrane on the antepenultimate segment, prolonged slightly at the distal end into a small knob."

It may be that Forbes and Schacht found specimens of D. leptopus with a small knob, such as Wilson finds on his specimens, at the distal end of the hyaline membrane of the male right antenna, and that this has been inaccurately described as a hook.

The following additional characters serve to distinguish D. manitobensis from D. leptopus Forbes and also from D. piscinae Forbes:

1. The relatively short endopodite of the left fifth foot of the male found in D. manitobensis. The endopodite of the left fifth foot of the male is only slightly longer than the first segment of the exopodite in D. manitobensis, while in

Diaptomus _leptopus_ from Marthas Vineyard, Massachusetts.

Fig. 8. Fifth legs of male.

Fig. 9. Fifth legs of female. (Both after Wilson, 1932).

Diaptomus _leptopus_ from Woods Hole, Massachusetts.

Fig. 10. Left fifth leg of male. X 91.

Fig. 11. Right fifth leg of male. X 91.

Fig. 12. Left fifth leg of female. X 91.

(All after Forbes, 1882).

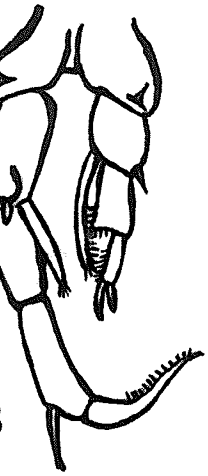
Diaptomus _piscinae_.

Fig. 13. Fifth feet of male.

Fig. 14. Fifth feet of female, Portage Slough specimen. X 280.

Fig. 15. Last thoracic segment and abdomen of female. X 140.

Fig. 16. Fifth foot of female, Yellowstone Park specimen. X 280. (All after Schacht, 1897).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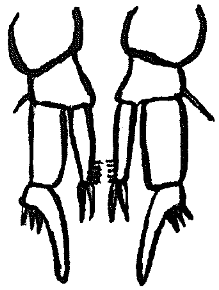
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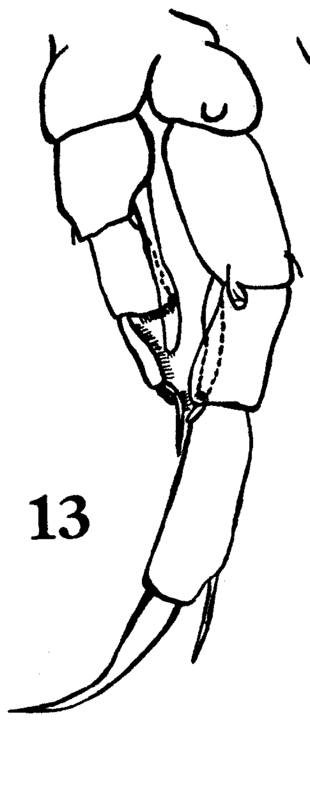
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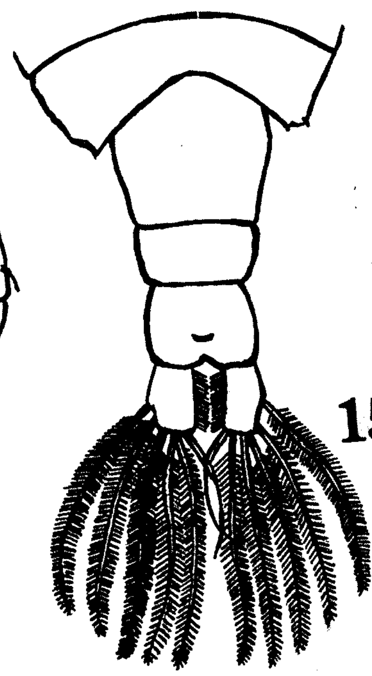
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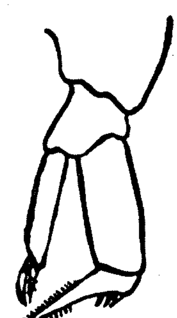
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D. leptopus the corresponding endopodite is considerably, and in D. piscinae greatly longer. In the latter species the length of the endopodite is equal to that of both first and second segments of the exopodite.

2. Differences in the armature of the segments of the male right antenna. The armature of the segments of the male right antenna of D. manitobensis has been noted in the description of this species. For purposes of comparison the armature of the segments of the male right antenna of D. leptopus is quoted from Schacht (1897): "...The first segment without armature, the other segments armed as follows: 2, with a short seta and a sense-club; 3, short seta and sense-club; 4 and 6, long spine; 5 and 7, long seta and sense-club; 8, long spine and very short spine; 9, long seta, long spine and sense-club; 10 and 11, process and long spine; 12, long spine, very short spine, and sense-club; 13, process, long spine and sense-club; 14, long seta, long spine, and sense-club; 15, process, short seta, long spine, and sense-club; 16, process, long spine, long seta, and sense-club; 17, process, and short thick spine; 18, process; 19,20 and 21 (completely ankylosed), a narrow hyaline lamella produced into a hook which extends but little beyond the end of the segment, and two long setae; 24, two long setae; and 25, four long setae and a sense hair. Some of the setae on the last segment are sparsely hairy." It will be seen that D. manitobensis differs in some or all details of the armature of every segment of the male right antenna, excepting

only the ankylosed segments 22 and 23, and segment 24. In these segments, only, is the armature identical.

I have not found a detailed description of the armature of all the segments of the male right antenna of D. piscinae. The following is quoted from Forbes (1893): "The right antenna of the male is without notable distinctive characters. The antepenultimate segment is as long as the two following taken together; the fourth from the tip bears two long sword-like spines at its margin, both attached to its basal fourth; the expanded segments are well armed with conical spines, straight and curved, but without hooks." Forbes also states:"...This species (D. piscinae) differs from D. leptopus by its more slender form and by the absence of the antennal hook." The fourth segment from the tip of the male right antenna of D. manitobensis bears only a single seta, at its distal end, whereas Forbes' specimens of D. piscinae bore two long sword-like spines at the margin, both attached to the basal fourth, on the corresponding segment of the male right antenna. In addition, Marsh, for D. leptopus (1907,Pl.XX,Fig.5) and Carolyn Coker (Fig.4) for D. piscinae, both show a slender hair-like seta at the distal end of the antepenultimate segment, and on the same side as the hyaline lamella. This is not found in D. manitobensis. Furthermore, Wilson (1932) shows an illustration (Pl.I,Fig.f.) of a female D. leptopus bearing extremely hairy setae. In the female of D. manitobensis only a few setae are sparsely hairy, the remainder being naked.

Diaptomus caducus.

Fig. 17. Right antennule of male. X 58.

Fig. 18. Fifth legs of female. X 72.

Fig. 19. Fifth legs of male in posterior view. X 58.

Fig. 20. Fifth legs of male in anterior view. X 83.

(All after light, 1938).

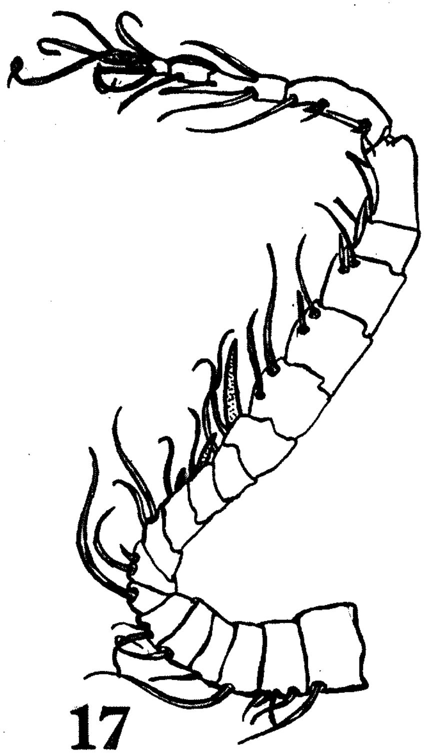
Diaptomus shoshone.

Fig. 21. Terminal segments of right antenna of male. X 248.

Fig. 22. Fifth feet of male. X 149.

Fig. 23. Fifth feet of female. X 149.

(All after Marsh, 1907).



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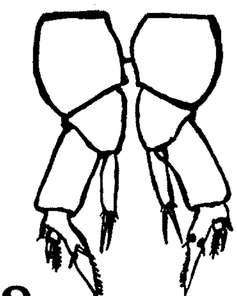

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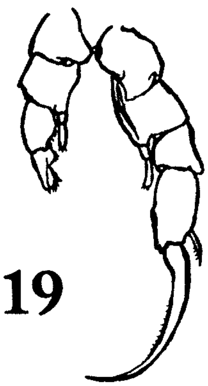

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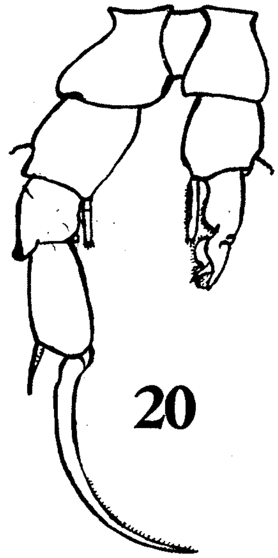

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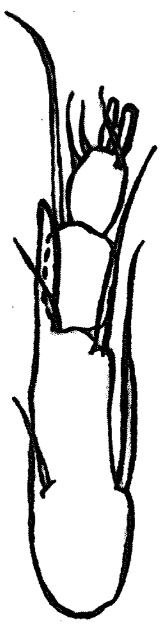

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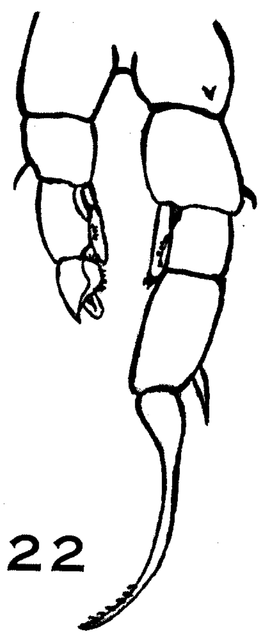

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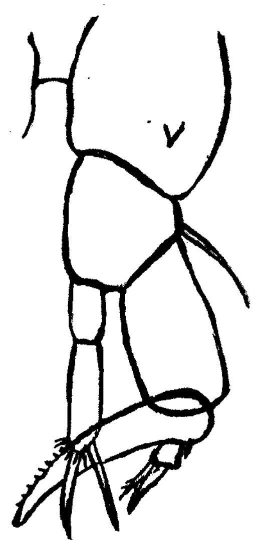

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3. Terminal hook of the male right fifth foot not denticulate in D. manitobensis; denticulate in D. leptopus and in D. piscinae.

4. Second basal segment of left fifth foot of male with a narrow hyaline ridge or process running the length of the inner lateral margin in D. manitobensis; not present in D. leptopus nor in D. piscinae.

5. D. manitobensis is somewhat larger than is usual for D. leptopus or D. piscinae. No great significance is attached to this difference in itself, since factors such as water temperature might influence size.

In conclusion, the author is of the opinion that sufficient evidence has been presented to justify the establishment of the new species Diaptomus manitobensis. It appears to be closely related to D. leptopus Forbes.

This species was obtained from alimentary canals of young goldeyes, Amphiodon alosoides (Rafinesque), collected by Dr. W.M. Sprules from Head River Lake, Manitoba (53° 45' N.Lat. 100° 35' W. Long.).

The author wishes to express his thanks to Mr. H.C. Yeatman for kindly reading first and second drafts of this paper, and for helpful suggestions and criticisms. Thanks are also due to Carolyn Coker (former student in hydrobiology at the University of North Carolina) for tracings of drawings of D. piscinae from Mt. Lake, Virginia. These are reproduced by permission as Figures 4-7.

Diaptomus piscinae Forbes, 1893

Schacht, 1897, found Diaptomus piscinae in collections from Portage Slough, Manitoba. It has not been reported since, nor have I found it in the collections I have examined.

Distribution: Carl (1940) found this form very common throughout the interior of British Columbia, and also in a few lakes of the coastal belt. Diaptomus piscinae was reported by Bigelow (1928) from a pond near the Railway Station of Orient Bay, Ontario. In the spring of 1923 the pond had been connected with Lake Nipigon, but when the specimens of this copepod were taken the connection had disappeared. Forbes described the species from material gathered at Gardner, Mont. It has also been found in Colorado, by Dodds (1908, 1915a, 1915b, 1924), et al. It has been collected in Saskatchewan, Montana, North Dakota, at Ithaca, N. Y. and at Woods Hole, Mass.

Diaptomus stagnalis Forbes, 1882

Diaptomus stagnalis was extremely abundant in a collection made by Mr. R. Stewart-Hay from a railway ditch, at Fort Garry, Manitoba. It was not found in any of the other collections. This is a very large bright red species. The males were 2.9 mm. long and the females from 2.8 mm. to 2.9 mm. in length.

Distribution: Illinois (Forbes); Minnesota, Ohio, Kentucky and Alabama, (Herrick and Turner, 1895); Georgia, (Turner,1910); Chicago and Great Falls, Va., (Marsh).

Diaptomus pribilofensis Juday and Muttkowski, 1915

A male and female of Diaptomus pribilofensis were found in a collection from Stag Lake, Manitoba, taken on August 17, 1948. This collection was made by a field party under the direction of G. E. Butler. Diaptomus pribilofensis has been considered synonymous with D. Tyrellis Poppe, 1888, for many years, but Mrs. Wilson has separated the two species in a paper shortly to be published. Mrs. Wilson also confirmed the identification of this species and states (in correspondence with the author): "The record of the D. pribilofensis is very valuable and interesting to me. It is the common Alaskan and western Canadian species, and finding it as far east as Manitoba is a little surprising." The presence of D. pribilofensis in Manitoba is a new distribution record for this species.

Distribution: Pribilof Islands (Juday and Muttkowski); Alaska and western Canada (Mrs. M. S. Wilson); Stag Lake, Manitoba (Arnason).

Diaptomus sanguineus Forbes, 1876

A few immature specimens of Diaptomus sanguineus Forbes were present with immature specimens of Diaptomus stagnalis Forbes collected from a railway ditch at Fort Garry, Manitoba, by R. Stewart-Hay. The identification of these immature specimens was confirmed by Mrs. M. S. Wilson. This is a new record for Manitoba.

Distribution: Near Normal, Ill. (Forbes); near Minneapolis, Minn. (Herrick); Nebraska (Brewer); Nebraska and Spokane, Wash. also at Wellesley and Medord, Mass.; at Glendale, Long Island (Gissler) Albama (Herrick; Augusta, Ga. (Turner); near New Orleans, La. (Foster); in the Okoboji Lakes (Stromsten); also near Ripon, Wis. and at Saranac Inn, N. Y. (Marsh); Fort Garry, Man. (Arnason).

Diaptomus oregonensis Lilljeborg, 1889

Diaptomus oregonensis was easily the most common of the Diaptomi in the Manitoba lakes examined, occurring in sixty-three lakes of the eighty-one examined, (Table I, Fig. 24). It was also found in three river samples and in a sample from No. 1 Pickerel Pond, Rennie, Manitoba. Its range extended over the Province, from the southern border to beyond 57° N. Lat.

Distribution: Oregon (Lilljeborg); Wisconsin, Michigan (Marsh); Minnesota (Herrick); Iowa, Illinois, Indiana (Schacht); Northwest Territories (Marsh); Massachusetts (Pearse); Great Lakes (Marsh); Ontario, New Brunswick (Klugh); British Columbia (Carl); Saskatchewan (Moore): In British Columbia, Carl found Diaptomus oregonensis only on Vancouver Island, and on the mainland only in the southwest corner.

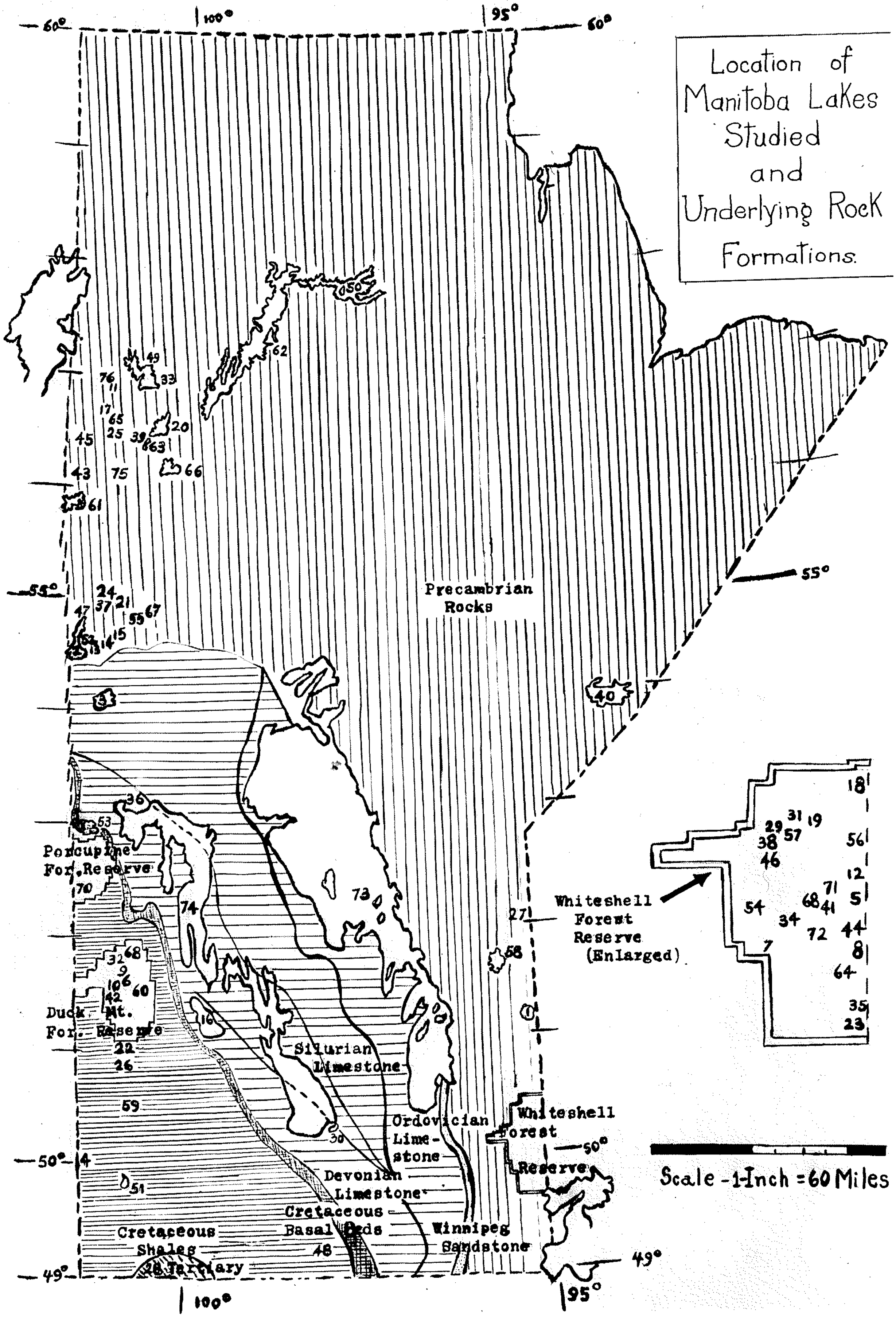
Diaptomus ashlandi Marsh, 1893

Diaptomus ashlandi was found in the following lakes in Manitoba: Lake Athapapuskow, South Indian Lake and Lake Winnipeg (Table I, Fig. 24). In plankton samples from Lake Winnipeg it was very common or abundant, but in the other two lakes it was only fairly common. None of the other Manitoba lakes studied revealed the presence of this form.

Distribution: Marsh (1929) reported Diaptomus ashlandi as occurring in the Great Lakes; in Round Lake and Pine Lake in Michigan; in Yellowstone Lake and in Flathead Lake, Montana;

Fig. 24. Map of Manitoba showing location of lakes studied.

1. Aikens
2. Athapapuskow
3. Atikameg
4. Beautiful
5. Bedford
6. West Blue
7. Brereton
8. Caddy
9. Cash
10. Child's
11. Cockeram
12. Crowduck
13. 1st Cranberry
14. 2nd Cranberry
15. 3rd Cranberry
16. Dauphin
17. Dunphy
18. Eagle Nest
19. Echo
20. Eden
21. Elbow
22. East Angling
23. Falcon
24. Fay
25. Finch
26. Fish
27. Fishing
28. Flossy
29. Forbes
30. Francis
31. George
32. Glad
33. Goldsand
34. Granite
35. West Hawk
36. Head River
37. Heming
38. Horseshoe
39. Hunter
40. Island
41. Jessica
42. Laurie
43. McCallum
44. Mantario
45. Matheson
46. Meditation
47. Mikanogan
48. Minnewashta
49. Motriuk
50. North Indian
51. Oak
52. Payuk
53. Red Deer
54. Redrock
55. Reed
56. Ryerson
57. Saddle
58. Sassaginnigak
59. Shoal
60. Singush
61. Sissipuk
62. South Indian
63. Stag
64. Star
65. Story
66. Suwannee
67. Tramping
68. Wellman
69. White
70. Whitefish
71. Whiteshell
72. Wilfred
73. Winnipeg
74. Winnipegosis
75. Wolfpack
76. Zed


Location of Manitoba Lakes Studied and Underlying Rock Formations.
Precambrian Rocks
Silurian Limestone
Ordovician Lime-stone
Devonian Limestone
Cretaceous Basal Beds
Winnipeg Sandstone
Cretaceous Shales
Tertiary
Porcupine For. Reserve
Duck Mt. For. Reserve
Whiteshell Forest Reserve
Whiteshell Forest Reserve (Enlarged)
Scale - 1 Inch = 60 Miles
60°
100°
95°
55°
50°
49°

in Lake Pond d'Oreille, Idaho; in Washington Lake, Seattle; it had been reported by Schacht (1897) in Indiana and in Oregon. Bigelow (1928) lists Diaptomus ashlandi as being present in Lake Nipigon, Ontario. Carl (1940) reported Diaptomus ashlandi from British Columbia.

SENECELLIDAE OF MANITOBA

Genus SENECELLA Juday, 1923

Senecella calanoides Juday, 1923

Senecella calanoides was found only in two collections both from West Hawk Lake taken February 14, 1950, at the same station. The vertical samples taken at 84 feet and at 60 feet each contained a single adult male of this rare species. Both specimens were sent to Dr. Samuel Eddy, who confirmed the identification (Fig. 24).

Senecella calanoides has not previously been reported from Manitoba. It is characteristic of deep water.

Distribution: This species was described by Juday (1923) from collections from Senecay, Cayuga and Owasco Lakes, N. Y. Marsh (1933) found Senecella calanoides in Pine Lake, Michigan, and in Lake Superior. He also reports it from Lake Timagimi and Lake Nipigon, Ontario. Smirnov has found this species in Siberia, Smirnov, 1938).

TEMORIDAE OF MANITOBA

Two genera of this family are known from Manitoba. They are as follows: Genus Heterocope Sars, 1863; and Genus

Epischura Forbes, 1882

Genus HETEROCOPE Sars, 1863

Heterocope septentrionalis Juday and Muttkowski

No species of *Heterocope* were found in the material examined by the present author, but Dr. Samuel Eddy identified *Heterocope septentrionalis* from material collected near Churchill Manitoba. (See Hooper, F. F. Trans. Am. Mic. Soc., Jan., 1947).

Genus EPISCHURA Forbes, 1882

Only two species of this genus were found in Manitoba. They were *Epischura lacustris* Forbes, 1882, and *Epischura nevadensis* Lilljeborg, 1889. With the exception of two species of Epischura, *E. baikalensis* and *E. chankensis*, which are found in Asia, this genus occurs only in North America, and only exceptionally south of 40° N. Latitude. Its range extends north to Alaska. The distribution of the three American species appear to be fairly restricted according to Marsh (1933); *Epischura nevadensis* to the mountains of the Pacific region from central California to Alaska, except for the present record in Lake Winnipeg and in far northern Manitoba; *Epischura lacustris* to the general region of the Great Lakes extending northward into Manitoba; *Epischura nordenskieldii* to the Atlantic coast region from North Calina to Newfoundland.

Epischura lacustris Forbes, 1882

Epischura lacustris is extremely well distributed over the province of Manitoba and was found in 32 lakes from all regions. The most northerly record is from Northern Indian Lake (57° 22' N. 97° 20' W.) (Table I, Fig. 24). This species was *very common* only in Big Whiteshell Lake and in one surface sample from Southern Indian Lake. It was *common* in Granite Lake, Wellman Lake, in one sample from Northern Indian Lake at 12 feet, in a vertical sample from 17 feet in the same lake, in Heming Lake, and in Lake Winnipeg, also in a sample taken at 12 feet from Stag Lake. *Epischura lacustris* was *fairly common* in a surface sample from Sassaginnigak Lake and in a vertical sample from Second Cranberry Lake (maximum depth 117 feet). In all other Manitoba lakes examined it was infrequent or rare in numbers.

Epischura nevadensis Lilljeborg, 1889

Epischura nevadensis was comparatively rare in Manitoba, being found in only four lakes of which two are in the northwestern corner of the Province. It was found in one sample from Eden Lake (56° 39' N. 100° 15' W.), and in two samples from Southern Indian Lake (56° 50' N. 98°45' W.). In one sample from Southern Indian Lake it was associated with *Epischura lacustris*. *E. nevadensis* was also found in Heming Lake (1949), and in Lake Winnipeg (1949). In both these lakes it was associated with *E. lacustris* (Table I, Fig. 24).

This is the first record of _Epischura_ _nevadensis_ from Manitoba and indeed, from the central section of North America.

CYCLOPIDAE OF MANITOBA

Genus CYCLOPS Muller, 1776

The genus _Cyclops_ is one of the most common of the _Entomostraca_ being found in almost every type of freshwater locality from puddles, ponds and pools to rivers and lakes, in all quarters of the glove. A large number of species are known, and many of them are divided into subspecies and varieties. Breeding experiments have demonstrated that some of the forms often classed as varieties are true species since they do not interbreed with forms to which they are apparently closely related, and conversely breeding experiments have shown that previously established species are really varieties or forms of a single species.

The distinguishing characteristics of the species of Cyclops are size, colour (in fresh specimens); the number of segments in the antennae of the adults; the hyaline membrane present on the last antennal segment of some species; the structure of the fifth feet; the number of segments in the first, second, third and fourth feet, and the number and arrangement of the spines and setae theron; the relative lengths of the segments of the abdomen; the appearance of the furcal setae, and the arrangement and relative lengths of the furcal setae and of the lateral spine, also the presence or absence of lateral denticles or hairs on the furcae; the

TABLE I COPEPODA OF MANITOBA LAKES

LAKES	Senecella Calanoides	Limnocalanus macrurus	Epischura nevadensis	Epischura lacustris	Canthocamptus illinoisensis	Canthocamptus minutus	Diaptomus ashlandi	Diaptomus siciloides	Diaptomus sicilis	Diaptomus leptopus	Diaptomus tenuicaudatus	Diaptomus minutus	Diaptomus oregonensis	Cyclops vernalis var. americanus	Cyclops vernalis var. robustus	Cyclops vernalis Fischer-brevispinosus	Cyclops prasinus	Mesocyclops edax	Cyclops bicuspidatus lubbocki	Cyclops bicuspidatus var. navus	Cyclops bicuspidatus thomasi	Cyclops agilis	Cyclops albidis
Aikens											A	VC	R				FC	I			FC		
Athapapuskow				I			FC				C	A	I	FC		I	I	I			C		
Atikameg												VC					R				R		
Beautiful													R	R				R					
Bedford													C										
West Blue													C								R		
Brereton				C									VC					I			I		
Caddy				R									C				R	R			C		
Cash													VC				C	I			C		
Child's				I									C			R		R			VC		
Cockeram												VC	R	C		FC		FC			I		
Crowduck																							
1st Cranberry				R								C	I	I		I	C	I			I		
2nd Cranberry				FC									C	C		FC		R			I		
3rd Cranberry				R									VC	C		C	FC	FC			C		
Dauphin								C	VC				C	C		C		A			FC		
Dunphy													FC	VC		A					EA		
Eagle Nest				R		R							I	I		R	R				R		

EA- Extremely Abundant
C- Common
R- Rare
A- Abundant
FC- Fairly Common
VC- Very Common
I- Infrequent

TABLE I COPEPODA OF MANITOBA LAKES

LAKES	Senecella Calanoides	Limnocalanus macrurus	Epischura nevadensis	Epischura lacustris	Canthocamptus illinoisensis	Canthocamptus minutus	Diaptomus ashlandi	Diaptomus siciloides	Diaptomus sicilis	Diaptomus leptopus	Diaptomus tenuicaudatus	Diaptomus minutus	Diaptomus oregonensis	Cyclops vernalis var. americanus	Cyclops vernalis var. robustus	Cyclops vernalis Fischer-brevispinosus	Cyclops prasinus	Mesocyclops edax	Cyclops bicuspidatus lubbocki	Cyclops bicuspidatus var. navus	Cyclops bicuspidatus thomasi	Cyclops agilis	Cyclops albidis
Echo													C			C	R	VC					
Eden		A	R									C	VC	FC							VC		
Elbow				R									VC	I		I		I			C		
East Angling													C								FC		
Falcon						R							A	I		R	R	VC			C		
Fay													VC				VC						
Finch				FC										R				FC			FC		
Fish													I				R				R		
Fishing												FC		FC		FC		FC			FC		
Flossy													C								C		
Forbes												C											
Francis													FC								R		
George		I				R				R		C	R	I		R	I	R			C		
Glad													R				C				I		
Goldsand												FC	FC	VC		I							
Granite				C									I								C		
West Hawk	R			R							FC	C		VC			C				R		
Head River																							

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Heming			C	C			R					C	C	I		I		VC			A	R	R
Horseshoe						FC							C					C	I		C		
Hunter													C	FC							VC		
Island				R									C	I		R			C		C		
Jessica													I						I		I		
Laurie				R	R	R							C								R		
McCallum				R								A	VC	C				C	FC		C		
Mantario				R							R		C					I	I		I		
Matheson														FC									
Meditation													C					R	I		C		
Mikanogan		R		R									VC								C	R	
Minnewashta													R										
Motriuk													C	C									
North Indian				C									R			R		R			VC		
Oak													VC					R			VC		
Payuk																							
Red Deer				R									I	FC	A	I					R		
Redrock													I				I						

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Reed											I	I	FC					I			C		
Ryerson				R									VC				I	R			C		
Saddle				R									VC	C		R		I			C		
Sassaginnigak				FC									A					I			I		
Shoal														VC				FC			FC	C	C
Singush								R	I				I	R		C	C	C			VC	R	R
Sissipuk												VC	C								C	VC	
South Indian		R	I	C			C					C	C	FC		C					C		
Stag		FC		FC								C	VC	VC		C		VC			VC		
Star													C				VC	R			I		
Story														C							FC		
Suwannee													C			C					VC		
Tramping													C	C		I		VC			VC		
Wellman				C									A	C		VC	R	VC	I	R		I	
White													VC				I					R	
Whitefish													FC										
Whiteshell				VC													I	C			C	I	
Wilfred					R						FC	C	R				R				C		

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Winnipeg		FC	FC	FC		R	A		FC			R	C	FC		I	R	I			A		
Winnipegosis								I					C		R	I					I		
Wolfpack													C					C			C		
Zed													VC	FC							I		

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appearance of the receptaculum seminis of the female, etc., Most species can be quickly identified by examination of the first antennae and of the fifth feet of adult specimens.

The chief factor determining the distribution of *Cyclops* appears to be ease of water communication. Cyclops appear to be tolerant of a wide range of conditions, though some species choose characteristic habitats and are rarely found in other situations. *Cyclops vernalis* is, however, more commonly found in ponds and pools in Europe, whereas it is also a common limnetic species in America.

Together with other copepods the species of the genus Cyclops are eaten in great numbers by the young of most species of fish. Several species of tapeworms are harboured by species of *Cyclops*. At Heming Lake in the summer of 1948 an attempt was made to estimate the percentage infestation of *Cyclops bicuspidatus* with procercoids of *Triaenophorus*. The findings indicated that this first intermediate host is rather highly infested during the spring and early summer.

Species of *Cyclops* are omnivorous, feeding on *Diaptomus*, *Daphnia* and even on young of their own species, as well as taking a variety of algae in their food. The present author has several times observed *Mesocyclops edax*, and *Cyclops bicuspidatus thomasi* seize and devour young of their own species, and tear away at dead and weakened specimens of *Daphnia longispina*. The intestines of some specimens, however, contain chiefly diatoms, so their reputation for being omnivorous is evidently well founded.

The following species of Cyclops have been found in Manitoba: *Eucyclops agilis*, *Cyclops albidus*, *Cyclops bicuspidatus thomasi*, *Cyclops bicuspidatus lubbocki*, *Cyclops bicuspidatus navus*, *Mesocyclops edax*, *Cyclops magnus*, *Cyclops prasinus*, *Cyclops vernalis americanus*, *Cyclops vernalis brevispinosus*, *Cyclops vernalis robustus*, and *Cyclops varicans*.

Cyclops albidus Jurine, 1820

Cyclops albidus was found only in four locations in Manitoba. It occurs in Shoal Lake, in Singush Lake in association with *Eucyclops agilis* in Heming Lake, and was also found in Bird's Hill West Pond. It appears to be a relatively rare species in Manitoba. This is a very large grayish species, the females often reaching 2.5 mm. in length. Gurney (1933) states that the male of the European species reach a length of about .96 mm. Wilson (1932) found the males as large or larger than the females at Woods Hole, Mass. In Manitoba the females and males are about the same length though the male is somewhat more slender than the female. In each case adults were about 2.25 mm. long.

Distribution: Germany (Koch; Europe, Northern Asia, Central Africa, Australia, Hawaii, Norway (Sars); Turkestan (Uljanin); Poland (Lande); British Isles (Baird, Gurney); Switzerland (Heller); Russia (Poggenpol); Netherlands (Hoeck); North America (Herrick, Marsh, E. B. Forbes); Massachusetts (Cragin); British Columbia (Carl); South America (Brian, Daday, Thiebaud).

As will be seen from the above list this copepod is very cosmopolitan. Carl found this species very common and widely distributed in British Columbia in the smaller lakes and ponds near weed beds.

Cyclops prasinus Fischer, 1860

Cyclops prasinus is a common species in Manitoba occurring in twenty-six lakes and four rivers. It was not found in pond samples. In England, Gurney (1933) reports it as more common in small ponds, and as not occurring in the plankton. Though it has been found breeding throughout the year it is definitely a summer form. Wolf found two breeding periods--in June and September. Marsh found it in Green Lake, Wisconsin, at all seasons but in maximum numbers in October and November. In Manitoba its range extends as far north as 56° 05' North latitude. This appears to be a new record for North America. The only other portion of the globe where its range extends as far north is in Scotland. *C. prasinus* is a small slender species.

Distribution: Gurney reports this species as absent from Scandinavia and the far north of Europe, and states that apart from Scotland its most northern locality appears at Oisterwyk, Holland (About 51° 51' North Latitude). Though an almost cosmopolitan species its distribution is mainly in the south. It is generally distributed over middle and southern Europe and eastward through Russia. It has been widely reported from the southern portion of Asia, Sumatra, Ceylon, Java (Daday); India, Ceylon, (Gurney); China (Brehm); Japan (Harada). From various regions of Africa it has been reported by Roy and Gauthier, Gurney, Daday, and Richard, Brehm, Kiefer, and Sars. Marsh for the United States, reports Cyclops prasinus from the Rocky Mountains to the Atlantic and as far south as Mexico. Carl (1940) reports that he found this species quite common in British Columbia. It occurred in samples from all areas except the Kootenay, and was widely distributed. Its occurrence in regions of South America is reported by Brian, Daday, Marsh, Van Douwe and Scott. In the Autralian region it is recorded by Henry, Lowndes, Kiefer and Oye. Apart from regions of the far north it may be said to be cosmopolitan.

Eucyclops agilis Koch, 1838

Eucyclops agilis was found in the following lakes in Manitoba: Big Whiteshell Lake, Eagle Nest Lake, Heming Lake, Mikanogan Lake, Shoal Lake, Singush Lake, Sissipuk Lake, Wellman Lake, White Lake and Lake Winnipeg, as well as in the Souris River and Watson River. Only in Sissipuk Lake was it very common, though it was common in both the Watson River and Souris River and fairly common in Shoal Lake. In other bodies of water where it occurred it was infrequent or rare. Its distribution throughout the province is rather scattered. Three of the lakes Big Whiteshell, Eagle Nest and White, lie in the Whiteshell Forest Reserve in the southeastern corner of the province, while three Heming, Sissipuk and Mikanogan, are near the western border of the province north of The Pas.

These lakes are alike in that they lie in areas of Precambrian rocks, between the mean summer isotherms of 60° and 62° F. and in northern coniferous vegetation regions. Wellman and Singush Lakes lie in the Duck Mountain Forest Reserve close to the Saskatchewan border and between the fifty-first and fifty-second parallels of latitude. Shoal Lake lies further south by about one degree of latitude, and the Souris River flows in a direction approximately north-east by east from the southwestern corner of the Province to join the Assiniboine River. Wellman, Singush and Shoal Lakes, and the Souris River all overlie an area of Cretaceous Shales and vegetation regions varying from the Mixed Woods Section to the Prairie and Aspen Grove section. The mean summer isotherms for this latter group vary from 60° to 65°F.

Lake Winnipeg overlies limestone in the southern third and Precambrian granites in the northern two-thirds. All of the west shore is Ordovician limestone, while all but the most southerly portion of the east shore is bordered by granite (Fig. 24).

Distribution: *Eucyclops agilis* Koch is a cosmopolitan species, which occurs in the largest lakes as well as in ditches, ponds and pools. It is a fresh-water species and shuns even the slightest trace of salinity. It occurs more commonly on the bottom and much more rarely in surface tows, or in company with limnetic species, and it is to be regarded as a true bottom form according to Wilson (1932). In Manitoba it does occur both in surface tows and in company with species that

that are designated as limnetic, as well as in bottom samples (Table I, also Fig. 24).

Distribution: It has been reported from the following locations; Europe; Algeria; central and northern Asia; Azores; polar islands north of Grinnell Land; North America; Australia; New Zealand; (Brady); Nantucket Island (Pearse); Rhode Island (Williams); Woods Hole (Wilson); British Columbia (Carl).

Cyclops bicuspidatus thomasi Forbes, 1882

Cyclops bicuspidatus thomasi is by far the commonest species of the genus *Cyclops* in Manitoba. It occurs in almost every lake from which plankton was examined and in almost every type of habitat. It occurs also at the surface, at the bottom, and in the intermediate zone. It was not nearly as common in pond samples and much less common in river samples, being found only in Vermilion River (Table I, Fig. 24).

Sars (1918) states that specimens of *thomasi*, sent by Forbes, are distinct from *C. bicuspidatus*, and that, consequently *C. thomasi* should be considered a separate species. Gurney (1933) considers *C. thomasi* is a form sufficiently distinct to be regarded as a subspecies. Yeatman (1944) agrees with this view and states in part "....the difference between *C. bicuspidatus* and *C. b. thomasi* appear very slight. *C. b. thomasi* generally has longer first antennae; has the outwardly-produced, posterolateral angles of the dorsa of the last 2 thoracic segments more promounced; has the terminal segment of the endopod of P4 more slender; and has the outer terminal spine of this segment nearer twice as long as the inner spine." The author has followed Gurney and Yeatman in treating C. b. thomasi as a subspecies rather than as a separate species.

Cyclops bicuspidatus thomasi was found by Birge and Juday (1908) to pass the summer in cysts on the bottom of Wisconsin Lakes. Recently examination of the stomach and intestinal contents of five-spined Sticklebacks (Eucalia inconstans) disclosed the fact that Cyclops bicuspidatus thomasi does enter such a resting stage in Manitoba waters. The Sticklebacks were from Insectary Creek, Churchill, Manitoba, collected June 29th, 1948 by W. M. Sprules. This is the first report of the occurrence of the encystment of this copepod in Manitoba. The encysted copepods apparently form an appreciable part of the food of this Stickleback.

Cyclops bicuspidatus thomasi is widely distributed over North America. It probably does not occur in Europe. On the other hand Cyclops bicuspidatus Claus rarely occurs in North America, though it is extremely common in Europe. Forbes (1897) states that the only American specimen of C. bicuspidatus Claus as described by Schmeil that he had found was from Woods Hole, Massachusetts. Wilson (1932) also records Cyclops bicuspidatus Claus from Woods Hole, Mass. No specimens of C. bicuspidatus Claus were found in Manitoba. Unlike C. bicuspidatus Claus in Europe, Cyclops bicuspidatus thomasi is a common plankton form in North American lakes and it differs from the former in the greater slenderness of body and limbs associated with limnetic life. It is worth noting that summer encystment has been observed only in Cyclops bicuspidatus thomasi and not in Cyclops bicuspidatus. Nevertheless the true status of this sub-species can only be determined by breeding experiments.

Distribution of Cyclops bicuspidatus Claus: Germany (Claus); Europe, Asia, Norway (Sars); England (Pratt); British Isles (Gurney); Massachusetts (Forbes, Wilson).

Distribution of Cyclops bicuspidatus thomasi, Forbes: Wisconsin Lakes, Indiana (Marsh); Great Lakes (E. B. Forbes); Bigelow (1928) reports Cyclops bicuspidatus from Lake Nipigon, and Carl (1940) reports Cyclops bicuspidatus Claus from 73 of 229 lakes examined from British Columbia. Carl expresses the opinion that the slight differences between Cyclops bicuspidatus thomasi Forbes and Cyclops bicuspidatus Claus do not warrant their separation as species, and hence uses the name Cyclops bicuspidatus for the North American species also.

Miller (1943, 1945, 1948) has shown that the North American form of Cyclops bicuspidatus (i.e. thomasi) is the first intermediate host for three species of Triaenophorus (crassus, nodulosus and stizostedionis). Triaenophorus crassus is a serious parasite of whitefish and ciscoes, as these fish serve as a second intermediate host, and the whitish or yellowish cysts of the plerocercoid adversely affect the appearance of the flesh, and seriously interfere with its marketability. The present author has attempted to assess the degree of infestation of the Cyclops host with _Triaenophorus_ procercoids in an investigation carried on at Heming Lake, Manitoba, during the summer of 1948.

INFESTATION OF CYCLOPS BICUSPIDATUS WITH TRIAENOPHORUS AT HEMING LAKE, MANITOBA DURING THE SUMMER OF 1948

Other studies by the author have shown that where _Cyclops bicuspidatus_ occurs in surface waters it is usually more abundant at depths of 12 to 15 feet, the maximum depth of Heming Lake. A Clarke and Bumpus plankton sampler was used to collect semi-weekly surface samples of plankton from June to August. All samples contained _C. bicuspidatus_, the first intermediate host of _Triaenophorus crassus_, T. _nodulosus_ and _T. stizostedionis_. Dissection of _Cyclops_ revealed the _Triaenophorus_.

	June							July		
	4	7	15	18	22	25	28	4	6	8
No. of _C. bicuspidatus_ examined	47	18	7	6	5	8	20	8	30	4
No. with _Triaenophorus_	20	3	0	3	0	0	1	0	0	0
Per cent infestation	43	17	0	50	0	0	5	0	0	0
No. of procercoids per infested _Cyclops_	1.2	1	0	1	0	0	1	0	0	0
Estim. No. _C. bicuspidatus per cu. m._	6398	1764	432	102	787	906	741	1553	1800	244

Negative infestation continued throughout July and August. If the first two samples taken in June be considered together and the subsequent samples be grouped by threes, there appears to be an almost linear decline in infestation, reaching the vanishing point in early July. Based on individual samples, the infestation was insignificant by the end of the third week in June. This is probably the first quantitative measurement of the infestation of *C. bicuspidatus* with procercoids of *Triaenophorus* and strongly confirms the findings of Dr. R. B. Miller that (1) *C. bicuspidatus* is the first intermediate host of *Triaenophorus*, since examination of other plankters in Heming Lake did not reveal its presence in any of them and (2) that the duration of *Triaenophorus* procercoids within *C. bicuspidatus* is generally one month or less.

Cyclops bicuspidatus lubbocki, Brady 1868

This sub-species is distinguished from the preceding one by the fact that the antennules have only fourteen segments instead of seventeen; segment 8 of the copepodid remaining undivided. The furcal rami are generally shorter and stouter than in the typical form, though they may be equally long and slender.

Cyclops bicuspidatus lubbocki was found only in one lake, Wellman Lake in the Duck Mountain Forest Reserve. It was also found in one pond sample. Most authorities agree that this should be regarded as merely a form rather than a sub-species of C. bicuspidatus. They believe that the suppression of segmentation of the antennules is a response to some environmental condition. Since it sometimes occurs in brackish water it has been suggested that the stimulus bringing about the suppression of segmentation of the antennules might be salinity. This would not, however, explain the presence of C. bicuspidatus lubbocki in fresh water. This form occurred in only one sample of ten collected at Wellman Lake. The sample in which it was found had a pH of 6.8 slightly lower than that of any of the other samples which ranged from pH 7.0 to pH 7.6. Cyclops bicuspidatus lubbocki seems a suitable object for experimental solution of the problem involved in suppression of segmentation of the antennules in this species.

Distribution:- British Isles (Brady, Scott, Gurney); Europe (Sars); North Africa (Roy, Gauthier, Kiefer); Asia (Rylov and Gurney). Herrick (1895) reports that specimens sent to him from Long Island seemed identical with Cyclops lubbocki Brady, but he discusses this matter under the heading Cyclops insignis Claus. There seems, therefore, considerable doubt as to his identification. If we do not accept Herrick's report of the occurrence of this species, then it has not been previously reported for North America.

Cyclops bicuspidatus var. navus Herrick, 1882.

Forbes (1897) said that he found specimens in the Illinois River which completely bridge the gap between C. bicuspidatus and Herrick's *Cyclops navus*. Marsh (1909) verified the statement of Forbes that all intermediate stages occur and states there is no doubt that *navus* is simply a variety of *Cyclops bicuspidatus*.

In the present investigation *C. bicuspidatus* var. *navus* was found only twice; once in a single surface sample of plankton from Wellman Lake, where it occurred with *C. bicuspidatus thomasi* and *C. bicuspidatus lubbocki*; the only other occurrence was from a pond on the Fort Garry site of the University of Manitoba.

Distribution: No definite distribution for *Cyclops bicuspidatus* var. *navus* has been given by any author, though Forbes and Marsh both mention it as a variety of *Cyclops bicuspidatus*.

Cyclops magnus Marsh, 1920

No specimens of *Cyclops magnus* were found in Manitoba by the present worker. Yeatman (1944) reports, however, that *Cyclops magnus* was found in collections made from Churchill, Manitoba, (sent to Dr. R. E. Coker by H. Elliott McClure of Ames, Iowa).

Distribution: Yeatman (1944) states "*C. magnus* seems to be an exclusively northern species, as it has been collected only in arctic Alaska, Northwest Territories, Canada, and Churchill, Manitoba".

Cyclops vernalis Fischer, 1853

Cyclops vernalis was found in samples of plankton from thirty-one lakes in Manitoba. It is widely distributed throughout the Province (Table I, Fig. 24). It also occurred in two pond samples, and in the Watson River. In Europe it is a very common species in ditches and small pools, but is never found in lakes or open bodies of water. In America on the other hand it is like *Cyclops bicuspidatus* a common limnetic form. It has been found in brackish as well as in fresh water and tolerates a wide range of pH (4.6 - 8.2 Lowndes, 1928).

While most common in spring and summer it is to be found breeding throughout the year in Europe.

Distribution: Common throughout Europe; Central Asia (Sars); Turkestan (Daday); Manchuria (Rylov); China (Daday); Greenland, Iceland (Haberbosch); U. S. A. (Marsh, Herrick); Canada (Marsh); British Columbia (Marsh, 1918; Thacker, 1923; and Foerster, 1925). Carl (1940) reports it as common in all areas of British Columbia and found in lakes and pools of all sizes. He records both varieties *americanus* and *brevispinosus* from lakes of all sizes. Canaries (Richard); Ceylon (Poppe and Mrazek); South America (Daday); Peru (Kiefer); Algeria (Roy and Gauthier).

Cyclops robustus Sars, 1863 (*Cyclops vernalis* var. *robustus*)

In the present dissertation *Cyclops robustus* is treated as a variety of *Cyclops vernalis* Fischer. Lowndes (1928) found that the two species are fertile when crossed, and that typical *C. robustus* forms may appear in the offspring of typical *C. vernalis* at different temperatures. He found that most of the specimens developing at intermediate temperatures could be classified as *C. vernalis*, as described by Sars; occasional specimens, reared at high intermediate temperatures, as *robustus* of Sars; many specimens, reared at low temperatures (10° C.) as *americanus*, Marsh; and many specimens, reared at temperatures above (25°C) as *parcus*, Herrick. Yeatman (1944) reared off-spring indistinguishable from *parcus*, *americanus*, and *brevispinosus*, from a single female of *Cyclops vernalis*.

Cyclops robustus was found only in Red Deer Lake, Lake Winnipegosis and in a sample from a Tuxedo ditch. In Red Deer Lake it was extremely abundant; in Lake Winnipegosis it was infrequent; while in the Tuxedo ditch it was common. The temperature of the water in Red Deer Lake when this sample was collected was between 21° C. and 24° C. The pH varied between 7.4 and 7.8 and the oxygen content between 8.0 and 8.2 mg. per litre. This is a shallow lake whose depth is between six and seven feet. *Cyclops robustus* in Manitoba was relatively scarce as compared with *Cyclops vernalis* (*brevispinosus*) and *Cyclops americanus* which were relatively common.

Cyclops vernalis americanus Marsh, 1893
(*Cyclops viridis americanus* Herrick & Turner, 1895)

Cyclops americanus Marsh is regarded for the purpose of this dissertation as a variety of *Cyclops vernalis* Fischer.

The reasons for this view are already presented under the discussion of Cyclops robustus given above and the relationships of the viridis-vernalis groups are thoroughly examined by Yeatman (1944).

Cyclops americanus were found in thirty-six lakes, three rivers and three pond samples in Manitoba. It was very widely distributed throughout the Province, and was usually associated with Cyclops vernalis (brevispinosus), (Table I, Fig. 24).

Distribution: Gurney reports Cyclops americanus from the midlands and southern England; Claus records it from Germany; Scourfield found it in Holland; Marsh found it widely distributed in North America.

Discussion of the Cyclops vernalis group

Specimens have been found which bridge all the gaps between the varieties of this group, in the collections made in Manitoba. A specimen has even been found which had on one side of its body feet and a furcal ramus characteristic of Cyclops vernalis (brevispinosus) while on the other side the feet and furcal ramus possessed the characteristics of Cyclops americanus. The findings of the present author are in agreement with those of Yeatman (1944).

Cyclops varicans Sars, 1863

Cyclops varicans was found in collections made from a railway ditch in Winnipeg, Manitoba, on May 2, 1951. One of the samples which contained this species was collected for the author by Miss O. Armstrong. Dr. H. C. Yeatman kindly confirmed the identification of this species, as he had previously done for other species of *Cyclops*.

This is the first record of this small species of *Cyclops* from Manitoba.

Distribution: Gurney (1933) states: "*C. varicans* is one of the rarest species in the British Isles, but has been reported from England, Scotland, Ireland and Wales". Gurney also reports this species from Europe, Asia, Africa, North America (Marsh), Canada (Willey), South America, New Zealand and Australia.

Yeatman (1944) points out that Marsh's (1893 and 1910) and Herrick's (1895) descriptions and figures of "*C. bicolor*" show these copepods to be specimens of *C. varicans* instead of *C. bicolor*. Yeatman also states: "*C. varicans* or its subspecies *rubellus* is rather widely distributed in eastern North America and is usually abundant wherever found, although it may be overlooked because of its small size.

Mesocyclops edax Forbes, 1891

Mesocyclops edax is, next to *Cyclops bicuspidatus thomasi*, the most common member of the genus *Cyclops* found in Manitoba waters. It was found in thirty-six lakes and in five pond samples as well as in two river samples. *Mesocyclops edax* is characterized by having the furcal rami hairy. This together with other distinctions outlined by Coker (1943) serves to distinguish Mesocyclops edax from Mesocyclops obsoletus Koch, 1838 (Cyclops leuckarti Claus, 1857). (Coker R. E., Journal of the Elisha Mitchell Scientific Society 59, No. 2., December, 1943)

Distribution: Mesocyclops edax is well distributed in North America, as far south as Mexico, (Coker, 1943). In Manitoba its range extended throughout all regions examined (Table I, Fig. 24).

SUBORDER HARPACTICOIDA

CANTHOCAMPTIDAE OF MANITOBA

Genus CANTHOCAMPTUS Westwood, 1836

Little is known of the occurrence and distribution of Copepoda of the family CANTHOCAMPTIDAE in Manitoba, chiefly on account of the fact that most members of this family are bottom forms often attached to mosses or other plants, and, therefore, relatively rarely found in ordinary collections.

Those which were found were species of the genus Canthocamptus. They occurred either in bottom samples or were obtained by dissection from the alimentary canals of fishes. Further investigation, especially of the latter source of information will, no doubt, reveal that members of this family are much more common and much more widely distributed in Manitoba than can at present be stated with certainty.

Only two species of this family were found in Manitoba: Canthocamptus illinoisensis Forbes, 1876; and Canthocamptus minutus Claus, 1863. Canthocamptus illinoisensis occurred only once being found in company with *Canthocamptus minutus* in a sample from Laurie Lake. *Canthocamptus minutus* was also found in the following lakes: Eagle Nest Lake, Falcon Lake, George Lake, Horseshoe Lake, Wilfred Lake and Lake Winnipeg. It was not found in any pond or river samples. It was found quite commonly in the stomachs and intestines of *Eucalia inconstans* from Insectary Creek, Churchill, Manitoba.

Laurie Lake is in the Duck Mountain Forest Reserve west of Lake Winnipeg. The other lakes mentioned are all in the Whiteshell Forest Reserve in the southeastern corner of the Province (Table I).

Distribution: *Canthocamptus illinoisensis* was recorded by Forbes in Illinois, and by Herrick and Turner (1895) for Wisconsin.

Canthocamptus minutus has been reported as follows: Sweden (Lilljeborg); British Isles (T. Scott); Germany (Claus); Holland (Van Breemen); United States (Herrick and Turner); everywhere in the northern parts of the globe (Marsh).

Remarks: *Canthocamptus minutus* is distinguished by its small size (.4-.6 mm.) and short first antennae. It is peculiar in that the tips of the spinules on the anal operculum are bifid. It is usually found firmly attached to wet moss, though occasionally free swimming.

It is rather interesting to note that Borutzky (1929) is mentioned by Gurney (Vol. II, 1933) as having described resting eggs as the method of wintering over in *Canthocamptus arcticus*.

CLASS CRUSTACEA

Sub-Class ENTOMOSTRACA

Order BRANCHIOPODA Sars
(PHYLLOPODA)

Sub-Order PHYLLOPODA Sars
(EUPHYLLOPODA)

Section I -- ANOSTRACA Sars

Family CHIROCEPHALIDAE Daday

Genus EUBRANCHIPUS Verrill

Pristicephalus bundyi Forbes, 1876
(*Eubranchipus gelidus* Hay, 1889)

Eubranchipus ornatus Holmes, 1910

SECTION II -- NOTOSTRACA Sars

Family APODIDAE Burneister

Genus LEPIDURUS Leach, 1816

Lepidurus couesi Packard, 1875

SECTION III -- CONCHOSTRACA Sars

Family CAENESTHERIIDAE Daday

Sub-Family ESTHERIANAE Packard

Genus CAENESTHERIELLA Daday
(Genus CYZICUS Audouin, 1837)
(Genus ESTHERIA Ruppel, 1857)

Caenestheriella mexicana Claus, 1860
(*Estheria mexicana* Claus, 1860)

Family LYNCEIDAE Sayce

(Sub-Family LIMNETINAE Packard)
(Family LIMNETIDAE Sars)

Genus LYNCEUS Muller, 1785
(LIMNETIS Loven, 1846)
(HEDESSA Lievin, 1848)

Lynceus brachyurus brachyurus Muller, 1785
(*Limnetis gouldii* Baird, 1862)

Family CHIROCEPHALIDAE Daday

Genus EUBRANCHIPUS Verrill

Pristicephalus bundyi Forbes, 1876
(Eubranchipus gelidus Hay, 1889)

Specimens of fairy shrimps were collected by Mr. R. Stewart-Hay of the Department of Zoology, University of Manitoba, in May 1942, from a railway ditch in Fort Garry, Manitoba. Several hundred specimens were collected at that time. These were identified in May 1946, by the present worker as Pristicephalus bundyi (Eubranchipus gelidus). This is the first record of this anostracan in Manitoba.

Distribution: Pristicephalus bundyi has a wide range and has been previously reported from New York, Massachusetts, Indiana, Michigan, Illinois, Wisconsin, Alaska, Quebec, Ontario (Ferguson, 1935), Alberta, and Yukon Territory, Canada. Dexter (1946) reports having collected Pristicephalus bundyi from a pool in northeastern Ohio in 1942.

The Hays (1889) hatched the eggs of this anostracan from dried mud without preliminary freezing and thawing, and described the developmental stages.

Eubranchipus ornatus Holmes, 1910

Eubranchipus ornatus Holmes was not found in Manitoba until May 2, 1951, when it was obtained from a railway ditch in Winnipeg by the present worker. It was, however, previously obtained by Professor Ferris Neave of the University of Manitoba, Department of Zoology and was identified by Ferguson (1935). This is a species measuring on the average about 12 mm. and the living specimens are of a beautiful bluish green coloration. Holmes (1910) states that these fairy shrimps live for only a few weeks in the spring, in which respect they resemble Pristicephalus bundyi (Eubranchipus gelidus).

Distribution: Eubranchipus ornatus Holmes has been previously recorded from Minnesota and Wisconsin.

Family APODIDAE Burmeister

Genus LEPIDURUS Leach, 1816

Lepidurus couesi Packard, 1875

Several hundred specimens of Notostraca were collected from a pond on the campus of the University of Manitoba, at the Fort Garry site, by Mr. R. Stewart-Hay, of the Zoology Department, University of Manitoba. These were identified by the present worker as Lepidurus couesi Packard. In this collection males and females were present in nearly equal numbers. This is the first record of Lepidurus couesi from Manitoba.

Distribution: Packard (1883) states that this species was first collected by Dr. Elliott Coues, naturalist of the United States Northern Boundary Commission, from several prairie pools on the boundary line, 49° N. Lat. just on the west bank of Frenchman's River, Montana. Several females with eggs were also obtained by C. carrington, of Hayden's U. S. Geological Survey, at Smithfield Cache Valley, Utah.

Family LYNCEIDAE Sayce

Genus LYNCEUS Muller

(LIMNETIS Loven, 1846, HEDESSA Lievin, 1848)

Lynceus brachyurus brachyurus Muller, 1785
(Limnetis gouldii Baird, 1862)

Lynceus brachyurus was found in two surface samples of plankton from Jessica Lake, in the Whiteshell Forest Reserve of southeastern Manitoba. Several hundred specimens were also obtained from a pond on the campus of the University of Manitoba, in a collection made by Mr. R. Stewart-Hay, Department of Zoology, University of Manitoba. The latter specimens were examined and identified by the present worker on October 25, 1947.

Distribution: Lynceus brachyurus (Limnetis gouldii) is the most abundant North American species and has been recorded from many localities in eastern and central America westward to the Mississippi River at Rock Island, Illinoies. It was first collected in America by Charles Gould, Esq., June, 1857, from fresh water at St. Annes, twenty miles from Montreal, Quebec. It is usually found in ponds. The present record extends the range of this species northward somewhat and westward considerably. Wagler (1937) reports this species from North America, Siberia, Russia, Poland, Scandinavia, Denmark, Finland, Czechoslovakia, Hungary, and Germany.

Family CAENESTHERIIDAE Daday

Genus CAENESTHERIELLA Daday
(Genus ESTHERIA Ruppel, 1857)

Caenestheriella mexicana Claus, 1860
(Estheria mexicana Claus, 1860)
(Caenestheriella monesi Claus, 1860)

About one hundred specimens of this conchostracan were collected by Dr. J. A. McLeod, University of Manitoba, from the Red River near Lockport, Manitoba. This is about twenty miles from Winnipeg, Manitoba. These were examined and identified by the present worker, October 27, 1947, as Caenestheriella mexicana (Estheria mexicana). This species was also obtained in the northern portion of Lake Winnipeg in collections made in July, 1949, by the author.

Distribution: Caenestheriella mexicana (Estheria mexicana) is according to Packard, (1883) the most abundant and widely diffused species on the continent. He records the following distribution:

"Lake Winnipeg, North America (W. Caldwell, Esq.); (Mus. Brit.) (Baird).

Puddle in Lexington, Kentucky, (H. James Clark).

Cart rut in Cincinnati, Hamilton County, Ohio (V. T. Chambers).

Ellis, Kansas, "in an upland pool supplied by a spring" (Dr. L. Watson); Fort Wallace, Kansas, (Prof. J. Lindahl). Common at the pueblo of Santa Ilsanfonsa, New Mexico, August (A. S. Packard). Zimapan Mexico, (Prof. W. Dunker) Claus."

Mattox (1939) also reports this species from Illinois.

Sub-Order CLADOCERA Sars

SECTION I -- CALYPTOMERA

Tribe CTENOPODA

Family SIDIDAE Baird

Genus SIDA Straus, 1820

Sida Crystallina Muller, 1785

Genus DIAPHANOSOMA Fischer, 1850

Diaphanosoma brachyurum Lievin, 1848

Family HOLOPEDIDAE Sars

Genus HOLOPEDIUM Zaddach, 1855

Holopedium gibberium Zaddach, 1855

Tribe ANOMOPODA

Family DAPHNIDAE Straus

Genus DAPHNIA Muller, 1785

Daphnia pulex de Geer, 1778
(D. pulex pulex Woltereck, 1932)

Daphnia pulex obtusa Kurz, 1874
(D. Pulex obtusa Woltereck, 1932)

Daphnia pulex pulicaria Forbes
(D. pulex pulicoides Woltereck, 1932)

Daphnia pulex form retrocurva Forbes, 1882
(D. pulex parapulex form retrocurva, Woltereck, 1932)

Daphnia longispina proper Muller, 1785

Daphnia longispina hyalina Leydig, 1860

Daphnia longiremis Sars, 1861

Genus SIMOCEPHALUS Schoedler

Simocephalus serrulatus Koch, 1841

Genus SCAPHOLEBRIS Schoedler

Scapholebris mucronata Muller, 1785

Genus CERIODAPHNIA Dana

Ceriodaphnia reticulata Jurine, 1820

Family BOSMINIDAE Sars

Genus BOSMINA Baird, 1845

Bosmina longirostris Muller, 1785

Forms *typica*

brevicornis Hellich

cornuta Jurine

Bosmina coregoni Baird, Rylov

Bosmina coregoni longispina Leydig, 1860
(*Bosmina longispina* auct; Birge)

Bosmina coregoni longispina obtusirostris Sars, 1861
(*Bosmina obtusirostris* auct; Birge)

Family CHYDORIDAE Stebbing

Sub-Family EURYCERCINAE Kurz

Genus EURYCERCUS Baird, 1843

Eurycercus lamellatus Muller, 1785

Sub-Family CHYDORINAE Kurz

Genus CAMPTOCERCUS Baird, 1843

Camptocercus rectirostris Schoedler, 1862

Genus ACROPERUS Baird, 1843

Acroperus harpae Baird, 1835

Genus ALONA Baird

Alona affinis Leydig, 1860

Genus CHYDORUS Leach

Chydorus latus Sars, 1862

Chydorus sphaericus Muller, 1785

SECTION II -- GYMNOMERA

Tribe I ONYCHOPODA

Family POLYPHEMIDAE Baird

Genus POLYPHEMUS Muller, 1785

Polyphemus pediculus Linne, 1761

Tribe II HAPLOPODA Sars

Family LEPTODORIDAE Lilljeborg

Genus LEPTODORA Lilljeborg

Leptodora kindtii Focke, 1844

Family SIDIDAE Baird

The members of this family may be recognized as elongated forms with well developed, heavy antennae, the two rami of which are each composed of two or three flattened podomeres, bearing numerous lateral or marginal setae. Two genera of this family were found in Manitoba; *Sida* and *Diaphanosoma*.

Genus SIDA Straus, 1820

The genus may be distinguished from closely related genera by the presence of three rather than two podomeres in the dorsal ramus of the antenna. Only one species of this genus is recorded; *Sida Crystallina*.

Sida crystallina Muller, 1785

Sida crystallina was relatively rare in Manitoba. It was found only in the following ten lakes, as far as present samplings indicate: Lake Athapapuskow, Big Whiteshell, Brereton, Echo, Forbes, Red Rock, Star, Red Deer Lake, Northern Indian Lake, and Lake Winnipeg. It was not found in pond or river samples. It was common in only two lakes: Lake Brereton and Echo Lake. In all other lakes in which it was found Sida crystallina was infrequent or rare (Table II, Fig. 24). This is a form which appears in the spring and vanishes in the fall.

Both Echo Lake and Lake Brereton lie in the Whiteshell Forest Reserve in the southeastern corner of the Province, as do also Big Whiteshell, Forbes, Red Rock and Star Lakes. Lake Athapapuskow, Red Deer and Northern Indian Lakes lie in the north-western corner of the Province. Thus eight of the ten lakes in which this form occurred lie in areas of Precambrian rocks which form a part of the Laurentian Shield. Lake Winnipeg, however, is underlain with Ordovician limestone, although along its eastern border it has the same rock formation as the other eight lakes mentioned. Red Deer Lake, however, is in a region of Devonian limestone.

Distribution: *Sida crystallina* is a cosmopolitan species. In Reelfoot Lake, Tennessee, Hoff (1943) finds this species often associated with certain plants including pondweeds, lilies and *Heteranthera*. He has collected as many as one hundred individuals in a single sample from such habitats.

Genus DIAPHANOSOMA Fischer, 1850

In this genus the antennae have the dorsal ramus of two podomeres. The antennules of the female are small and truncate while in the male there is a long sensory seta or flagellum. There are no spines on the post-abdomen. The terminal claw has three well-developed basal spines. In Manitoba only a single species was found: Diaphanosoma brachyurum Lievin, 1848

Diaphanosoma brachyurum Lievin, 1848

Diaphanosoma brachyurum was very common and widely distributed in Manitoba, occurring in thirty-seven lakes. It was not found in pond or river samples. It was abundant or very common in the following lakes: Lake Brereton, Cockeram Lake, Eden Lake, Goldsand Lake and Sassaginnigak Lake. In most other lakes it was infrequent or rare. Its abundance was usually greater at a depth of 12 feet or more, but occasionally it was extremely abundant in surface samples, (Table II, Fig. 24).

Distribution: This is a cosmopolitan species but is only found during the warmer months. In Reelfoot Lake, Tennessee, Hoff (1943) found Diaphanosoma brachyurum in large numbers associated with lilies.

Family HOLOPEDIDAE Sars

Specimens of the family HOLOPEDAE may be readily recognized by the large, globular, gelatinous, transparent bivalve case, and by the antennae which are biramous in the male and uniramous in the female. The sole genus is Holopedium Zaddach, 1855, Only one species was found in Manitoba; Holopedium gibberium Zaddach, 1855.

Holopedium gibberium Zaddach, 1855

Holopedium gibberium was widely distributed in Manitoba (Table II). It occurred in twenty-eight lakes, but was not found in any pond or river samples. This species is generally reported to be more abundant in waters which are neutral or slightly acid and to shun waters on the alkaline side of neutrality. The present findings support this view. For example, Holopedium gibberium was abundant in Fay Lake, pH 6.8--7.0, and common in Granite Lake, pH 6.8--7.0.

Distribution: Holopedium gibberium is found both in Europe and in North America. Birge records it for many parts of the United States. Carl (1940) found this species widely distributed in British Columbia. Adamstone (1928) found it in Lake Muskoka in Ontario. Rawson and Moore (1944) did not report this form as occurring in the saline lakes of Saskatchewan.

Family DAPHNIDAE Straus

The family DAPHNIDAE includes species which have a rather rounded head and an oval body. The eyes are large; the antennules are usually small and hidden; occasionally large and attached to the ventral side of the head, the antennae are long and slender, with four podomeres in the dorsal ramus and three in the ventral; there are anal spines on the post abdomen; there are no basal spines on the post abdominal claws; the intestine is not convoluted. Four genera; DAPHNIA, SIMOCEPHALUS, SCAPHOLEBRIS and CERIODAPHNIA were found in Manitoba.

Genus DAPHNIA Muller, 1785

Specimens of the genus Daphnia are characterized by having a transparent carapace, often reticulated, and rounded so that the animal has an oval shape except in those species in which a crest or helmet is developed on the head. The antennules are hidden by the well-developed rostrum. The cervical sinus is lacking. The posterior margin of the carapace is extended to form an elongated caudal spine. A number of species were found in Manitoba, some of which were represented by several varieties or forms. Each variety or form will be dealt with separately.

Daphnia pulex de Geer, 1778
(D. pulex pulex Woltereck, 1932)

This species is characterized by having a stout and heavy body, rarely transparent. Antennules very small, the apices appearing as papillae on posterior surface of rostrum. Anus at end of post-abdomen; anal spines 12 to 17. Summer eggs numerous; ephippium with two eggs placed nearly vertically. Colour variable but usually yellow-brown.

Daphnia pulex de Geer was very widely distributed and quite common in Manitoba. It was found in twenty-five lakes from all regions, but was more abundant in the regions east and south of Lake Winnipeg. It was only found in a few lakes of those examined from the northwestern corner of the Province. It was also found in pond samples but was lacking in the river samples examined.
Distribution: This species has been recorded from various parts of the United States (Birge, Hoff, et al.) from Ontario (Adamstone) from Saskatchewan (Rawson and Moore), from British Columbia (Carl).

TABLE II

CLADOCERA OF MANITOBA LAKES

LAKES	Sida Crystallina	Polyphemus pediculus	Leptodora kindtii	Holopedium gibberium	Eurycercus lamellatus	Diaphanosoma brachyurum	Daphnia retrocurva s.c.	Daphnia retrocurva l.c.	Daphnia l.h. mendotae	Daphnia l.h. galeata	Daphnia l.h. typica	Daphnia longiremis	Daphnia longispina	Daphnia pulex pulicaria	Daphnia pulex obtusa	Daphnia pulex	Chydorus latus	Chydorus sphaericus minor	Chydorus sphaericus	Ceriodaphnia reticulata	Camptocercus rectirostris	Bosmina c.l. obtusirostris	Bosmina c. longispina	Bosmina longirostris var. brevicornis	Bosmina longirostris var. cornuta	Bosmina longirostris
Aikens																			I			VC	VC			
Athapapuskow	R	FC	R			R	FC			VC	I		R						R			C	R			R
Atikameg																						R				
Beautiful						R	C	FC	C		R											R				
Bedford				VC		R				R	I		A			C										
West Blue																R										
Brereton	C			I		VC	FC	C	R		C		FC			R										
Caddy										C	I		VC			VC			R			I				
Cash										I												I				
Child's			R							R		R	R	C	R	A		R								
Cockeram			VC	FC		VC	C			I	I							VC				VC	I			I
Crowduck						R		FC								R										
1st Cranberry			R			R	C			VC	C								R							
2nd Cranberry						I				VC	R											I		R		R
3rd Cranberry				R		R		I		VC									C			R		R		R
Dauphin										A												C	C	C		
Dunphy																										
Eagle Nest		C		R					R	R						R						R		R		R
Echo	C				I					VC			I						C			R				R
Eden			FC			VC	C			A	I								I			R				

EA - Extremely Abundant
A - Abundant
VC - Very Common
C - Common
R - Rare
FC - Fairly Common
I - Infrequent

TABLE II (Cont'd)

CLADOCERA OF MANITOBA LAKES

LAKES	Sida Crystallina	Polyphemus pediculus	Leptodora kindtii	Holopedium gibberium	Eurycercus lamellatus	Diaphanosoma brachyurum	Daphnia retrocurva s.c.	Daphnia retrocurva l.c.	Daphnia l.h. mendotae	Daphnia l.h. galeata	Daphnia l.h. typica	Daphnia longiremis	Daphnia longispina	Daphnia pulex pulicaria	Daphnia pulex obtusa	Daphnia pulex	Chydorus latus	Chydorus sphaericus minor	Chydorus sphaericus	Ceriodaphnia reticulata	Camptocercus rectirostris	Bosmina c.l. obtusirostris	Bosmina c. longispina	Bosmina longirostris var. brevicornis	Bosmina longirostris var. cornuta	Bosmina longirostris
Elbow			R			R	R			C	R							VC	VC							
East Angling										R	R															
Falcon			R						R	R	R		R			R			R			R				
Fay				A															A			VC				
Finch					R	R																				
Fish																R						FC				
Fishing				R		I			FC		R											R				
Flossy																										
Forbes	I																		VC			VC				
Francis														C	A	VC						R	R			R
George				VC			FC	I		I									I			C	R			R
Glad		R								R									R			R				
Goldsand			R	FC		VC				I									VC			FC				C
Granite				C					R	I						I										
West Hawk													R									C				
Head River															R											
Heming	R		I	FC		I	C	FC	I	A	A		A					FC	C	R		C	I			R
Horseshoe																R			R			VC		R		
Hunter						I													EA			A	C			C
Island			R			I	I	I		I								R	A							

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TABLE II (Cont'd) CLADOCERA OF MANITOBA LAKES

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Jessica				VC						R			R		I	FC						I				
Laurie													R			I						I				
McCallum				R		VC			R	C	FC								A			C				
Mantario				R					R	I			I						R			C	I	R		
Matheson											C											C				
Meditation										R									R			R	R			
Mikanogan		I				R			R													I				
Minnewashta																R										
Motriuk				R						R						R						A	FC			FC
North Indian	R		C	R		I	I												C			FC	R			R
Oak											I		R			R			R							
Payuk		EA																								
Red Deer	R					R	FC	A	FC	R	R					I										
Redrock	I	I		EA															C	I		I				
Reed			I			FC	R			R									C							
Ryerson				A		R	R				R											VC				
Saddle				A				R		C						I			R							
Sassaginnigak			R	FC		VC	FC	C	FC	C												R				
Shoal					R					C	C				A	VC			C			FC	C		C	C

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TABLE II (Cont'd) CLADOCERA OF MANITOBA LAKES

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Singush										C	R		R			C						I				
Sissipuk			R	FC		I		VC	I	R									A			R				
South Indian			FC	VC		FC	C	I		C	C					R			C			FC	I			FC
Stag			FC	FC		VC	FC		R	VC	I				R	FC			A							
Star	R			I		I										R			R	I		A				
Story						R																R	FC			FC
Suwannee						C			C	VC	C								VC							
Tramping			I			I	I	R		I									C			R				
Wellman			R	R		R		R	VC	VC	VC		R						I		I	R		I		R
White				VC		R	R			R	I					FC										
Whitefish						I																				
Whiteshell	R				I										R							R				
Wilfred				I						R			R						I			I				
Winnipeg	R		FC			C	VC	FC	C	FC	FC	R	FC	R	R							C	FC	R		R
Winnipegosis										R									C			VC			VC	FC
Wolpack				FC						FC									EA			R	I			I
Zed				R		R				R									R			C	R			R

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Rawson and Moore (1944) showed that Daphnia pulex de Geer will tolerate salinities up to 20,000 parts per million.

Daphnia pulex obtusa Kurz 1874
(D. pulex obtusa Woltereck,1932)

Daphnia pulex obtusa was much less common in Manitoba than Daphnia pulex de Geer. It was found only in the following lakes; Bedford Lake, Child's Lake, Jessica Lake, Shoal Lake, Stag Lake and Lake Winnipeg. It was also found in the contents of the alimentary canals of goldeyes from Head River Lake, northern Manitoba. The other lakes range northward west of Lake Winnipeg: Shoal Lake (50°25'N.Lat. 100°37' W. Long) in the southwestern corner of the province south of Riding Mountain National Park; Child's Lake (51°40' N. Lat. 100°57' W. Long.) in the Duck Mountain Forest Reserve; Head River Lake (53°35' N. Lat. 100°35' W. Long) southeast of The Pas; and Stag Lake (56°30' N. Lat. 100° 27' W. Long.) in the northwestern corner of Manitoba.

Distribution: Daphnia pulex var. obtusa Kurz has been reported by Birge from Maine, Wisconsin and southern states of the United States. It has not previously been reported from Canada. Wagler (1937) states that in Europe this form is found in calcium-poor, slightly acidic waters. This statement appears to be fairly true of Bedford Lake (pH 6.8--7.1) and Jessica Lake (pH 6.8), but not of Child's Lake (pH 7.6--7.8). This species has been reported from Europe chiefly from the southern part.

Daphnia pulex pulicaria Forbes
(D. pulex pulicoides Woltereck, 1932)

Daphnia pulex pulicaria was comparatively rare in Manitoba. It occurred in only one lake, Child's Lake in which it was common. It was extremely abundant in one pond sample from Bird's Hill, Manitoba. Child's Lake in Duck Mountain Forest Reserve had a surface temperature of 11° to 13°C. at the time samples were taken and a pH at the surface of 7.6--7.8. The number of collections was too limited to permit of general conclusions.

Distribution: Birge records Daphnia pulex publicaria as common in lakes in the United States. It has not previously been reported for Canada.

Daphnia pulex form retrocurva Forbes, 1882
(D. pulex parapulex form retrocurva Woltereck, 1932)

This species may be recognized by the following characteristics: Body pellucid, much compressed. Eye small with numerous projecting lenses; no ocellus. Spine ordinarily above middle of valves. Crest sometimes very large, variable. Claws with two pectens, the distal of 7-9 teeth. Anal spines 7-12.

Daphnia pulex form retrocurva was found in thirty-four lakes in Manitoba; twelve east of Lake Winnipeg: eighteen west of Lake Winnipeg; three directly north of Lake Winnipeg; and also in Lake Winnipeg itself. Of the thirty-four lakes: thirty are in areas of Precambrian rocks forming a part of the Laurentian Shield; two are underlain with Cretaceous shales; one is in region of Devonian limestone; while Lake Winnipeg is underlain with limestone in the shallower southern one-third and by both limestone and granite in the northern deeper two-thirds of this large lake.

In thirteen of these lakes D. retrocurva had large crests at the time of collection, while in twenty-one lakes specimens with moderate or small crests were taken. The influence of temperature on crest formation is discussed in the sections dealing with the Copepoda and Cladocera of Heming Lake and of Lake Winnipeg.

Distribution: Daphnia retrocurva is widely distributed in limnetic regions of lakes in many regions of the United States. It has been recorded from the Harrison Lake district of British Columbia (Foerster, 1925) from Lake Nipigon, Ontario (Bigelow, 1928) and from Lake Muskoka, Ontario (Adamstone, 1928). This species is not found in Europe.

Daphnia longispina Muller, 1785

This species is characterized by having a long spine, and claws without pecten. This is a very variable species. It is less robust than Daphnia pulex, ordinarily rather transparent, frequently hyaline. Daphnia longispina proper has the head not helmeted and the eye close to the margin. There are many varieties of Daphnia longispina proper but all of them are considered together in this study, since the distinctions between them are very minor ones.

Daphnia longispina proper occurred in sixteen lake samples and in five pond samples of those examined. It was not found in river samples in Manitoba, nor was it found north of 52° N. latitude. It occurred in ten lakes east of Lake Winnipeg, nine of which (Bedford Lake, Brereton Lake, Caddy Lake, Echo Lake, Falcon

Lake, West Hawk Lake, Jessica Lake, Mantario Lake, and Wilfred Lake) are in the Whiteshell Forest Reserve in the southeastern corner of the Province, and one of which (Aikens Lake 50°15' N. Lat. 95°33' W. Long) lies slightly north of it. It was found in six lakes west of Lake Winnipeg, four of which (Child's Lake, Laurie Lake, Singush Lake and Wellman Lake) are in the Duck Mountain Forest Reserve between the fifty-first and fifty-second parallels of latitude, and two of which (Oak Lake and Shoal Lake) lie further south.

Distribution: Daphnia longispina proper has been recorded by Birge from all regions of the United States. The pond samples from which it was obtained in Manitoba were all from within a radius of forty miles from Winnipeg.

Daphnia longispina hyalina Leydig, 1860

This form is usually more delicate and transparent than Daphnia longispina proper. The head is helmeted and the eye, therefore, further from the margin. The crest may be rounded and small (typica); more or less conical with an acute point in front (galeata), which may even be extended to form a short spine; or expanded into a broad elliptical projection (mendotae). Although these three forms frequently occur together they will be discussed separately in this dissertation.

Some interesting studies have been made by Coker and Addlestone (1938) and Brooks (1946,1947) on effects of environmental factors such as temperature, turbulence, etc., on the relative rate of growth of the helmets of Daphnia longispina and

Daphnia retrocurva, and they have demonstrated that such environmental factors have a definite bearing on the rate of helmet development in these species. It has often been reported that helmeted forms are restricted to the upper turbulent waters of lakes, at least of stratified lakes.

Daphnia longispina hyalina form *typica*

Daphnia longispina hyalina form *typica* was found in twenty-six lakes, eighteen of which lie west of Lake Winnipeg and eight of which lie east of the same body of water. The lakes west of Lake Winnipeg range through over 7° of latitude from Oak Lake 49° 44' N. to Southern Indian Lake 57° 00' N. The lakes east of Lake Winnipeg range through less than 3° of latitude. Six of the latter group (Bedford Lake, Brereton Lake, Caddy Lake, Falcon Lake, White Lake, and Ryerson Lake) lie between 49°N. and 50°N., one of them (Aikens Lake) at 51° 10' N. and one of them (Fishing Lake) at 52° 05' N. At the time these samples were taken temperature readings were recorded for sixteen of these lakes. In general temperatures at the surface were high at the time collections were made, being close to or above 20°C. (e.g. Lake Athapapuskow, 18°--20°C.; Beautiful Lake, 24.5°C.; Singush Lake, 15.7°--18.7°C.). In two lakes, however, the water was rather cold; Caddy Lake, 14.8°C and Falcon Lake, 9.4°C. In most lakes where samples containing *typica* were obtained, *galeata* was also present, and much less frequently *mendotae*.

Daphnia longispina hyalina form *galeata*

Daphnia longispina hyalina form *galeata* was found in forty-six lakes in Manitoba. In many lakes it was abundant or very common, as well as being extremely widely distributed. This form occurred in some of the larger lakes such as Lake Dauphin and Lake Winnipegosis as well as in smaller lakes, and also in deep as well as in shallow lakes. It was not found in pond or river samples. In some lakes *galeata* occurred, at the time of sampling, as fairly uniformly distributed through various depths. In other lakes it was abundant at the surface, but rare or lacking at depth; while sometimes the reverse was true, due, possibly, to diurnal or seasonal changes in distribution (c.f. Langford, 1938). Certainly this helmeted form is not restricted to the upper waters of Manitoba lakes, or even of stratified lakes.

Woltereck (1932) states that elongated heads are developed only in lakes where these daphnids have to live and migrate in a distinctly stratified medium and within rather narrow layers of water.

There is very little evidence of thermal stratification in most lakes of Manitoba, no doubt because of their shallow nature, and because of the effects of wind action. In the few deep lakes (e. g. West Hawk Lake) thermal stratification does, however, occur. The shallow water of most of the lakes of Manitoba will, undoubtedly, restrict the vertical movements of these daphnids and this restriction of movement may be a factor in crest development. My own findings at Heming Lake and on Lake Winnipeg indicate a close correlation between crest development and rise in water temperature, although possibly turbulence may also be a contributory factor. These results thus lend further support to the findings of Coker and Addlestone (1938) and of Brooks (1947). Further discussion of form galeata as well as of mendotae will be found under the headings; "Copepoda and Cladocera of Heming Lake" and "Copepoda and Cladocera of Lake Winnipeg".

A noteworthy feature of the Manitoba specimens of galeata is the extreme development of the crest during the warm months. That this crest development is extreme indeed, resembling that found in European forms, has been confirmed by J. L. Brooks to whom the author has sent material. Brooks states that from no other location in North America has he been able to secure specimens of D. longispina hyalina galeata with such well developed crests.

Daphnia longispina hyalina form mendotae

Daphnia longispina hyalina form mendotae was less common than typica or galeata. While it occurred in fifteen lakes, in most of them it was infrequent or rare. It did not occur in any pond or river samples examined. Of the lakes which contained it seven are east of Lake Winnipeg, while eight are west of Lake Winnipeg. Of the eastern group of lakes five are in the White-shell Forest Reserve (Lake Brereton, Eagle Nest Lake, Falcon Lake, Granite Lake, and Mantario Lake), while two (Sassaginnigak, 51° 40' N. Lat. 95° 36' W. Long.) and (Fishing Lake, 52° 05' N. Lat. 95° 25' W. Long.) are slightly farther north. Of the eight lakes west of Lake Winnipeg which contain mendotae, only two are south of The Pas (Beautiful Lake, 51° 00' N. Lat. 101° 30' W. Long.) and (Red Deer Lake, 52° 55' N. Lat. 101° 25' W. Long.). The other six lakes (Mikanogan Lake, Eden Lake, McCallum Lake, Sissipuk Lake, Stag Lake and Suwannee Lake) are north of 53° N. Lat. The most northerly of these is Eden Lake, 56° 35' N. Lat. 100° 10' W. Long. Thirteen of the fifteen lakes lie in areas of Precambrian rocks forming a part of the Laurentian Shield. Of the other two, one (Beautiful Lake) is underlain with cretaceous shales, while the other (Red Deer Lake) is in a region of Devonian limestones, (Table II, Fig. 24).

Temperature and pH readings were taken for ten of the fifteen lakes which contained mendotae, at the time the samples were collected. The range of temperature varied from 9.4° C. (Falcon Lake to 24.5° C. (Beautiful Lake). The pH range was from 6.8--6.9 (Eagle Nest Lake) to 8.2 (Beautiful Lake).

Daphnia longiremis Sars, 1861

This variety has the valves broadly oval; spine long and slender. Head helmeted, small and round; ocellus absent. Antennae very long, reaching well toward the posterior margin of valves when reflexed.

This variety was extremely rare in Manitoba, occurring only once in a sample from Child's Lake in the Duck Mountain Forest Reserve, west of Lake Winnipeg, which lies between the fifty-first and fifty-second parallels of latitude. It has not previously been reported for Manitoba, (Table II, Fig. 24).

Distribution: Birge records longiremis from Indiana and from deep water of lakes in the southern part of Wisconsin. Herrick (1895) reports it from Minnesota.

Simocephalus serrulatus Koch, 1841

Simocephalus serrulatus was found only in a few pond samples, from the neighborhood of Tuxedo, Manitoba.

Distribution: Birge reports it as common everywhere in the United States among weeds. Carl (1940) records Simocephalus serrulatus as widely distributed as far as the northern boundary of British Columbia, but did not find it in any of the large lakes. Bigelow (1928) and Adamstone (1928) report it in Ontario.

Genus SCAPHOLEBRIS Schoedler, 1858

Only one species of this genus was found in Manitoba.

Scapholebris mucronata, Muller, 1785

This dark coloured species was found only in pond samples, from near Winnipeg. It swims on its back at or near the surface.

Distribution: Birge reports it as common everywhere in pools and lakes in weedy water. Carl reports it as very common and widely spread in British Columbia, ranking next to Daphnia longispina in number of times collected. Bigelow (1928) records it as occurring amidst beds of aquatic plants in Lake Nipigon, Ontario. Adamstone (1928) reports S. mucronata from Lake Muskoka, Ontario.

Genus CERIODAPHNIA Dana, 1853

Only one species of this genus was found in Manitoba.

Ceriodaphnia reticulata Jurine, 1820

Ceriodaphnia reticulata appeared to be rare in Manitoba from the present sampling. It was found in three lakes two of which, Red Rock Lake and Star Lake, lie in the Whiteshell Forest Reserve in the southeastern corner of the Province. The other lake in which this species was found was Heming Lake (54° 53' N. 101° 07' W.) where it occurred both in the plankton and in the alimentary canals of fishes. These three lakes all lie in areas of Precambrian rocks forming a part of the Laurentian Shield (Table II, Fig. 24).

Distribution: *Ceriodaphnia reticulata* is common in Europe in small bodies of water. It is also common and widely distributed in the United States. Carl (1940) reports it as commonly found in lakes of all areas of British Columbia. Bigelow (1928) records it as common among aquatic plants in Lake Nipigon, Ontario. Rawson and Moore (1944) record this species from littoral regions of saline lakes in Saskatchewan.

Family BOSMINIDAE Sars

Genus BOSMINA Baird, 1845

Bosmina longirostris Muller, 1785

Three vareities of this species occurred in Manitoba, namely: *Bosmina longirostris* var. *typica*, *Bosmina longirostris* var. *brevicornis*, and *Bosmina longirostris* var. *cornuta*. Each variety will be dealt with separately.

Bosmina longirostris var. *typica*

Bosmina longirostris var. *typica* was found in seventeen lakes and in one pond sample in Manitoba. The only lakes east of Lake Winnipeg which contained this variety were three lakes of the Whiteshell Forest Reserve, namely: Eagle Nest Lake, Echo Lake, and George Lake (Table II, Fig. 24). All the other lakes which harboured *typica* were west of Lake Winnipeg, and all except Lake Winnipegosis, Wellman Lake, and Shoal Lake, were north of 53° N. Lat. This variety occurred at the surface in almost all the lakes, but was obtained from a seventeen foot vertical sample from Northern Indian Lake and from a drag sample at a depth of 20 feet from Southern Indian Lake. In the latter lake it also occurred at the surface. If we except Lake Winnipegosis, which lies across areas of Devonian and Silurian limestones, also Shoal Lake and Wellman Lake which lie in an area of cretaceous shales, then all the remaining lakes, in which *typica* was found, lie in areas of Precambrian rocks which form a part of the Laurentian Shield. The pond sample in which this form was found was No. 1 Large Pickerel Pond, Rennie, Manitoba.

Bosmina longirostris var. *brevicornis* Hellich

Bosmina longirostris var. *brevicornis* was found in only seven lakes and in one pond in Manitoba. Of these, three lakes were in the Whiteshell Forest Reserve (Eagle Nest Lake, Horsesho Lake and Mantario Lake), east of Lake Winnipeg in areas of Precambrian rocks, and two were in similar areas west of Lake Winnipeg (2nd Cranberry Lake and 3rd Cranberry Lake). The remaining two lakes are also west of Lake Winnipeg, Wellman Lake in the Duck Mountain Forest Reserve in an area of Cretaceous shales, and Lake Dauphin in an area of Devonian limestones. The pond samples which contained this variety were obtained from No. 2 Small Pickerel Pond, Rennie, Manitoba, (Fig. 24).

Bosmina longirostris var. cornuta Jurine

Bosmina longirostris var. cornuta appears to be rare in Manitoba. It was found in only three lakes and in one pond sample in the Province, namely: Lake Winnipegosis and Shoal Lake, Eagle Nest Lake, and No. 1 Large Pickerel Pond, Rennie, Manitoba. Lake Winnipegosis and Shoal Lake lie well over in the western half of the Province, while Eagle Nest Lake lies in the southeastern corner of Manitoba, in an area of Precambrian rocks. Lake Winnipegosis lies mostly in an area of Devonian limestones, while Shoal Lake is in an area of Cretaceous shales, (Table II, Fig. 24).

Distribution: Bosmina longirostris, including its three varieties, is very common and widely distributed in open water of lakes, in their weedy margins, and in pools and marshes, throughout the United States. It is also widely distributed in Europe, and, in fact, may be considered cosmopolitan. In British Columbia, Carl (1940) found this species in lakes of the Southern Dry Belt and of the Coastal Belt. Bigelow (1928) found it in Lake Nipigon, Ontario, and Adamstone (1928) records it from Lake Muskoka, Ontario. It has not previously been recorded for Manitoba.

Bosmina coregoni Baird, Rylov

Bosmina coregoni longispina Leydig, 1860
(Bosmina longispina auct; Birge)

Bosmina coregoni longispina was obtained from sixteen lakes and from two ponds in Manitoba, including Lake Winnipeg. Only four of the lakes from which this species was recorded lie east of Lake Winnipeg, and all of these, except Aikens Lake (George Lake, Mantario Lake, and Meditation Lake) lie in the Whiteshell Forest Reserve. Nine of the remaining lakes lie west and north of Lake Winnipeg between 54° 30' N. (Lake Athapapuskow) and 57° 20' N. (Northern Indian Lake). The other two lakes which harboured this species were Lake Dauphin and Shoal Lake. Thirteen of the sixteen lakes lie in areas of Precambrian rocks forming a part of the Laurentian Shield. The southern portion of Lake Winnipeg is underlain with Ordovician limestone, and Lake Dauphin with Devonian limestones, while Shoal Lake is in an area of Cretaceous shales. The ponds in which Bosmina coregoni longispina was found were located near Bird's Hill, Manitoba, (Table II, Fig. 24).

<u>Distribution</u>: Birge records <u>Bosmina</u> <u>longispina</u> (<u>Bosmina</u> <u>coregoni</u> <u>longispina</u>) as rare in lakes in the United States. Wagler reports it as widely distributed in Europe. Adamstone (1928) records this species from Lake Muskoka, Ontario. Carl (1940) found it common in lakes of all districts of British Columbia. Bajkov reports this species as being found only in Lakes Winnipeg, and Atikameg, during the latter part of the summer and as being rare.

<u>Bosmina</u> <u>coregoni</u> <u>longispina</u> race <u>obtusirostris</u> Sars, 1861
(<u>B</u>. <u>obtusirostris</u> auct; Birge)

This was by far the commonest race of the subspecies <u>Bosmina</u> <u>coregoni</u> <u>longispina</u> found in Manitoba. It occurred in fifty-five lakes (Table II, Fig. 24) and in most pond samples examined. It was not found in river samples. It was also extremely common in the alimentary canals of young fish, from various parts of the Province. It is not only extremely common but is also extremely widely distributed. This is the first report of the occurrence of the race in Manitoba.

<u>Distribution</u>: Birge records <u>Bosmina</u> <u>obtusirostris</u> (<u>Bosmina</u> <u>coregoni</u> <u>longispina</u> race <u>obtusirostris</u> Sars) as not rare in pools and lakes in various regions of the United States. Adamstone (1928) reports it from Lake Muskoka, Ontario. Carl (1940) found this less common than the preceding one but widely distributed in all districts of British Columbia. Rawson and Moore found it widely distributed in Saskatchewan, and in the saline lakes it occurred in salinities up to 20,000 parts per million.

Family CHYDORIDAE Stebbing

Sub-family EURYCERCINAE Kurz

Sole Genus EURYCERCUS Baird, 1843

Only one American species.......Eurycercus lamellatus.

Eurycercus lamellatus Muller, 1785

Eurycercus lamellatus was found in plankton from only two lakes in Manitoba, Shoal Lake (52° 25' N. Lat. 100° 40' W. Long.) and Finch Lake (56° 33' N. Lat. 100° 55' W. Long.), (Table II, Fig. 24). It was also recovered from alimentary canals of fish from Big Whiteshell Lake in the Whiteshell Forest Reserve, and from the alimentary canal of a large Sucker from Heming Lake (54° 53' N. Lat. 101° 07' W. Long.). This species was found in only one pond sample from Bird's Hill, Manitoba. This is a large bottom-loving species.

Distribution: Birge reports Eurycercus lamellatus as found everywhere in the United States in permanent pools or weedy margins of lakes. It is common in Europe. Bigelow (1928) records it from amidst beds of aquatic plants in Lake Nipigon, Ontario. Adamstone (1928) found it in Lake Muskoka, Ontario. Carl (1940) found it widely distributed in all districts of British Columbia. Rawson and Moore (1944) record E. lamellatus from lakes in Saskatchewan and in salinities up to 1,000 parts per million. Bajkov found this species common in many places of Lake Winnipeg drainage system, in pools and in shallow portions of lakes among weeds.

Sub-family CHYDORINAE Kurz

Genus CAMPTOCERCUS Baird, 1843

Only one species of this Genus was found in Manitoba.

Camptocercus recitrostris Schoedler, 1862

Camptocercus rectirostris was found only in one lake in Manitoba, Wellman Lake in Duck Mountain area of the western portion of the Province (Fig. 24). Even in this lake it was infrequent in the samples of plankton collected. It was not found in pond or river samples.

Distribution: *Camptocercus rectirostris* is widely distributed in Europe. In the United States Birge reports it as common everywhere among weeds in margins of lakes. Bigelow (1928) records it as a bottom organism from Lake Nipigon, Ontario. Carl (1940) found this species in collections from the Dry Belt of British Columbia and from two locations on the coast. Two of the locations from the Dry Belt (Okanagan and Long Lake) were from stomachs of carp (*Cyprinus carpio*). This is the first record of *Camptocercus rectirostris* from Manitoba.

Genus ACROPERUS Baird, 1843

Only one species of this genus was found in Manitoba.

Acroperus harpae Baird, 1835

Acroperus harpae was found in a few plankton samples from near shore and amongst water plants at Heming Lake (54° 53' N. Lat. 101° 07' W. Long.). It was also obtained from the alimentary canals of yellow perch (*Perca flavescens*), and common sucker (*Catostomus commersonii*) from the same lake. It occurred in the alimentary canals of yellow perch from Cockeram Lake (56° 49' N. Lat. 100° 50' W. Long.). It was present in the alimentary canals of goldeyes from Head River Lake (53° 35' N. Lat. 100° 35' W. Long.) (Table II, Fig. 24). At Heming Lake it was found through June and July.

Distribution: Birge reports this species common everywhere in the United States among weeds in relatively open water; not in muddy pools. It swims awkwardly or creeps along the sustratum. It is fairly common in Europe. Adamstone (1928) records this species from Lake Muskoka, Ontario. Carl (1940) found it widely distributed in British Columbia, having been collected from all districts except the Kootenay.

Genus ALONA Baird, 1850

Alona affinis Leydig, 1860

Alona affinis was obtained from the alimentary canals of yellow perch from Cockeram Lake (56° 49' N. Lat. 100° 50' W. Long.). The fish which contained this species were collected August 19th, 1948, by representatives of the Game and Fisheries Branch, Department of Natural Resources, Province of Manitoba, (Fig. 24).

Distribution: Birge reports this largest species of the genus as very abundant in the United States, in all regions, in margin of ponds and lakes among weeds. Wagler records *Alona affinis* as very common in Europe, but most common in weakly and strongly alkaline waters. Bigelow (1928) found it close to the bottom in Lake Nipigon, Ontario. Adamstone (1928) records it from Lake

Muskoka, Ontario. Carl (1940) found this a common species in all localities of British Columbia.

Genus CHYDORUS Leach, 1843

Two species of this genus were found in Manitoba.

Chydorus latus Sars, 1862

Chydorus latus was found only once in Manitoba. A single specimen occurred in a plankton sample from Child's Lake in the Duck Mountain Forest Reserve, (Table II, Fig. 24).

Distribution: Birge reports this species as rare, occurring in Canada from near Lake Erie. Wagler records it as rare in Europe.

Chydorus sphaericus Muller, 1785

Chydorus sphaericus was extremely common and widely distributed in Manitoba, occurring in over forty lakes, and in numerous pond samples. This was to be expected since this is the commonest species of all the *Cladocera* occurring all over the world. It was also commonly recovered from the alimentary canals of fishes of various species and from various regions of the Province. This species also occurs from top to bottom throughout lakes. *Chydorus sphaericus* var. *minor* was found in two lakes namely: Elbow Lake (54° 45' N. Lat. 100° 52' W. Long.) and Island Lake (53° 45' N. Lat. 94° 00' W. Long.) in the Grass River system, (Table II, Fig. 24).

Distribution: Carl (1940) recorded this species from all areas of British Columbia, Rawson and Moore (1944) found it in the saline lakes of Saskatchewan and in salinities up to 20,000 parts per million. Adamstone (1928) found it in Lake Muskoka, Ontario, and Bigelow (1928) in Lake Nipigon in the same Province.

SECTION II -- GYMNOMERA

Tribe I. ONYCHOPODA

Family POLYPHEMIDAE Baird

Sole American Genus POLYPHEMUS Muller, 1785

Sole Species....Polyphemus pediculus Linne, 1761

Polyphemus pediculus Linne, 1761

Polyphemus pediculus was found in seven lakes in Manitoba but was not found in any pond or river samples examined. Two of the lakes (Eagle Nest, and Red Rock Lake) in which this species occurred lie in the Whiteshell Forest Reserve in the southeastern corner of the Province, while the other five (Lake Athapapuskow, Glad Lake, Heming Lake, Mikanogan Lake and Payuk Lake) lie west of Lake Winnipeg. Glad Lake is in the Duck Mountain Forest Reserve between 51° and 52° N. Lat., while the remaining three lakes lie north of 54° N. Lat. All except Glad Lake are in areas of Precambrian rocks forming a part of the Laurentian Shield. It was extremely abundant only in a littoral sample from Payuk Lake. This lake had a pH of 7.2 and a surface temperature of 21.5° C. at the time of sampling, (Table II, Fig. 24).

Polyphemus pediculus was common in a littoral sample collected on June 18, 1948, from the north end of Heming Lake. It was found in a bottom sample (at Station 2) from Mikanogan Lake;

in a horizontal sample at 15 feet (at Station 1) from Glad Lake; and in surface samples (at Stations 15 and 16) from Lake Athapapuskow, (at Station 5) from Eagle Nest Lake and (at Station 2) from Red Rock Lake. Thus, although a littoral species, it does occur in limnetic collections but usually not in any considerable numbers, (Table II, Fig. 24).

Polyphemus pediculus is a predaceous species which seizes its prey with its thoracic feet and tears it apart with its sharply pointed madibles. It is found only in summer.

Distribution: *Polyphemus pediculus* is common in Europe. Birge found it common in northern United States in lakes, pools, and marshes. Bigelow (1928) found it in open water below the surface of Lake Nipigon, Ontario. Adamstone (1928) records it from the plankton of Lake Muskoka, Ontario. Rawson and Moore (1944) reported it from the saline lakes of Saskatchewan and in salinities up to 1,000 parts per million. Carl (1940) found this species in lakes of all sizes, common and widely distributed in British Columbia.

Tribe II HAPLOPODA Sars

Family LEPTODORIDAE Lilljeborg

Genus LEPTODORA Lilljeborg

Sole species...*Leptodora kindtii* Focke, 1844

Leptodora kindtii Focke, 1844

Leptodora kindtii was found in eighteen lakes in Manitoba, including Lake Winnipeg. East of Lake Winnipeg it occurred in three lakes, Falcon Lake in the Whiteshell Forest Reserve, Sassaginnigak Lake (51° 40' N. Lat. 95° 36' W. Long.) and Island Lake (53° 45' N. Lat. 94° 00' to 95° 00' W. Long.) somewhat further north. West of Lake Winnipeg this species was found in fifteen lakes, thirteen of which lie north of 54° N. (Athapapuskow, Cockeram, 1st Cranberry, Eden, Elbow, Goldsand, Heming, Northern Indian, Reed, Sisipuk, Southern Indian, Stag, Tramping). The remaining two lakes (Child's Lake and Wellman Lake) are located in the Duck Mountain Forest Reserve between 51° and 52° North Latitude, (Table II, Fig. 24).

Leptodora kindtii is the largest of the Cladocera reaching a length of 18mm. although most of the Manitoba specimens are less than 12mm. It is a beautiful transparent species. It is carnivorous and feeds on such forms as *Cyclops* and *Daphnia* by sqeezing and sucking out the soft parts of the body, rejecting the hard outer covering. It in turn is fed upon by various species of fish.

Distribution: Birge records *Leptodora kindtii* as not rare from the Great Lakes and small lakes in the northern United States. It has been recorded from various parts of Europe chiefly from deeper lakes. Bigelow (1928) reports the species from surface to thirty yards in depth in Lake Nipigon, Ontario. Adamstone (1928) found it in Lake Muskoka, Ontario. Carl (1940) collected it in all areas of British Columbia, usually in large lakes but occasionally also in small lakes. Rawson and Moore (1944) reported *Leptodora* from the saline lakes of Saskatchewan, and in salinities up to 5,000 parts per million.

OSTRACODA OF MANITOBA

Order OSTRACODA

Sub-Order PODOCOPA

Family CYPRIDIDAE (CYPRIDAE Sars)

Sub-Family CYPRODOPSINAE (CYPRIDOPSIDES Sars)

Genus CYPRIDOPSIS Brady, 1868

Cypridopsis vidua Muller, 1785

Genus POTAMOCYPRIS Brady, 1870

Potamocypris smaragdina Vavra, 1891

Sub-Family CYPRINAE (EUCYPRIDES Sars)

Genus EUCYPRIS Vavra, 1891

Eucypris virens Jurine, 1820

Genus CYPRINOTUS Brady, 1885

Cyprinotus incongruens Ramdohr, 1808

Sub-Family CYCLOCYPRINAE (CYCLOCYPRIDES Sars)

Genus CYCLOCYPRIS Brady and Norman, 1889

Cyclocypris ovum (Jurine) Muller, 1820

Sub-Family CANDONINAE (CANDONIDES Sars)

Genus PARACANDONA Hartwig, 1899

Paracandona euplectella Brady and Norman, 1889

Genus CANDONA Baird, 1850

Candona candida Muller, 1785

Discussion of Ostracoda of Manitoba

Seven genera of the family CYPRIDIDAE (CYPRIDAE) each represented by one species, are here reported for the first time from Manitoba.

While of less importance as food of fishes than Cladocera and Copepoda, the Ostracoda did form an appreciable part of the food of Manitoba sticklebacks collected from Insectary Creek, near Churchill, Manitoba. Ostracods formed only a trifling part of the food of whitefish from Lake Winnipeg, although other bottom organisms were abundantly present. Rawson (1928) points out that in Lake Simcoe, Ontario, slightly less than 5 per cent of the food of whitefish (Coregonus clupeaformis) consisted of ostracods. Bigelow (1923) states that ostracods were of very great importance as food for bottom feeding fish in Lake Nipigon, Ontario, as nearly all examined had eaten at least some of these crustaceans.

Genus CYPRIDOPSIS Brady, 1868

Only one species of this genus is recorded from North America.

Cypridopsis vidua Muller, 1785
(C. helvetica Kaufmann, C. obesa Brady and Robertson, C. tumida Kaufmann)

A few specimens of Cypridopsis vidua were found in a collection from a pool in Fort Garry, Manitoba, in June, 1946, together with large numbers of green algae. In 100 collections made from ponds between June, 1946 and June, 1950, it was found only thrice. The samples which contained this species were collected near Headingley, Manitoba.

Distribution: This is said to be the most common North American species. It is also common in Europe and Asia. Hoff (1943) reports *Cypridopsis vidua* as the most common species of ostracod in Reelfoot Lake, Tennessee. He found individuals abundantly in areas where there was a dense blanket of duckweed, (*Lemna minor*, *Spirodela polyhiza*, *Wolffia columbiana*), and throughout the summer. It appeared to shun open water.

Genus POTAMOCYPRIS Brady, 1870

Only one species of this genus is recorded from North America.

Potamocypris smaragdina Vavra, 1891 (Daday, 1900)

Potamocypris smaragdina was found in a ditch near Headingley, in June 1943. It occurred amongst vegetation and was rare. In 120 pond collections made between June, 1943, and August, 1950 it was collected only five times.

Distribution: Wagler reports this species from Switzerland, Bohemia, and North America. Sharpe (1918) records it from South Chicago and Mexico. Hoff (1943) states: "*P. smaragdina* is very common in stagnant waters not only in North America but also in Europe. In Reelfoot Lake, Tennessee, this species is confined entirely to the west part of the lower lake. This form is found chiefly in the vegetation and was not taken from open water. It never abundant in any collections, since most samples have only two or three, never more than ten individuals".

Genus EUCYPRIS Vavra, 1891

Only one species of this genus was found in Manitoba.

Eucypris virens Jurine, 1820

Eucypris virens was found in the following locations in Manitoba; Tuxedo ditch in a collection made May 15, 1938; Stroman Lake, an artificial lake four to five feet deep in the Peace Garden on the Canada-United States boundary of Manitoba, collected July 20, 1946; from alimentary canals of five-spined sticklebacks (*Eucalia inconstans* Kirtland) collected August 20, 1947, from No. 2 Pond, Rennie, Manitoba. Rennie lies on the western border of the Whiteshell Forest Reserve. *Eucypris virens* was abundant in Stroman Lake, common in the Tuxedo ditch, and was present in numbers of two to eight specimens in the stomachs and intestines of the sticklebacks examined. It was found in forty pond collections of 100 examined between June, 1946 and August, 1950.

Distribution: Wagler records *E. virens* from Europe, North America, Greenland, North Africa, Azores. Herrick and Turner (1895) report it from Granville, Ohio. Sharpe (1918) records this species from weedy ponds; April to July. Massachusetts, Mexico, Ohio, Wisconsin.

Genus CYPRINOTUS Brady, 1885

One species only of this genus was found in Manitoba.

Cyprinotus incongruens Ramdohr, 1808
(*Herpetocypris incongruens* Sars)

Cyprinotus incongruens was found in collections made from a ditch near Headingley, Manitoba, in May and June, 1943. This species occurred in large numbers in this location. In 100 pond collections made between June, 1946 and August, 1950 it was found only twice.

Distribution: Wagler records this species as common everywhere in small ditches and pools, Europe, Asia, Africa and North America. Pearse (1918) reports *Cyprinotus incongruens* from Florida, Ohio and Pennsylvania.

Genus CYCLOCYPRIS Brady and Norman, 1889

Only one species of this genus was found in Manitoba.

Cyclocypris ovum (Jurine) Muller

Cyclocypris ovum was found in the contents of the alimentary canals of sticklebacks from Insectary Creek (58° 37' N. Lat. 94° 07' W. Long.), near Churchill, Manitoba. Both five-spined sticklebacks (*Eucalia inconstans* Kirtland) and nine-spined sticklebacks (*Pungitius pungitius* Linnaeus) were dissected, and examination of stomach and intestinal contents revealed the presence of from one to eight specimens of this ostracod in most of these fish. It was also found in bottom and vertical samples

from 20 lakes mostly from the northwestern region of this Province. It was found in the northern portion of Lake Winnipeg and was a very minor constituent of the food of whitefish from that lake.
Distribution: Wagler records this species from Germany, Switzerland, Czechoslovakia, Great Britain, Central Asia and North America.

Genus PARACANDONA Hartwig, 1899

Only one species of this genus was found in Manitoba.

Paracandona euplectella Brady and Norman, 1889

Paracandona euplectella was found only four times in Manitoba. A single specimen was obtained on examination of the intestinal contents of a nine-spined stickleback (*Pungitius pungitius* Linnaeus) from Insectary Creek (58° 37' N. Lat. 94° 07' W. Long.) near Churchill, Manitoba. The date of collection was June 23, 1948, and the collector P. M. Jackin. It was also found in three swamp collections made by Dr. J. A. McLeod in 1948 from northwestern Manitoba.
Distribution: Sharpe (1918) records *Paracandona euplectella* from New Jersey from shallow, swampy regions, in mud and debris of the bottom; spring months. It has also been reported from bogs and swamps from Germany, Sweden, England and North America (Wagler).

Genus CANDONA Baird, 1850

Only one species of this genus was found in Manitoba.

Candona candida Muller, 1785

Candona candida was obtained from a pond sample collected at Bird's Hill, Manitoba, July 4th, 1946. It was also found in three bottom samples from Oak Lake (49° 44' N. Lat. 100° 48' W. Long) in the southwestern corner of the Province. Oak Lake has a maximum depth of 10 feet and is heavily overgrown with rank vegetation near shore. Parts of this lake are quite marshy. All Manitoba specimens examined were females. This species was *infrequent* in one of the samples from Oak Lake. In the other samples from Oak Lake and in the pond samples, *Candona candida* was rare. It was also obtained from ten swamp samples collected by Dr. J. A. McLeod in 1948 from northwestern Manitoba. It was once obtained in a vertical lift from the northern part of Lake Winnipeg and also occurred occasionally in stomachs of whitefish (*Coregonus clupeaformis*) from Station 2, Lake Winnipeg.

Distribution: *Candona candida* has previously been reported from Europe, the eastern Baltic region, Asia (Wagler); and from Massachusetts, U. S. A. (Sharpe, 1918). Wagler states that it is common everywhere in Europe in ponds, pools, and lakes. Sharpe states that it is found in Massachusetts in shallow temporary ponds and ditches; April and September.

PART II

STUDIES OF COPEPODA AND CLADOCERA OF HEMING LAKE

FLUCTUATIONS OF LIMNETIC COPEPODA AND CLADOCERA AT THE SURFACE OF A FAR NORTHERN MANITOBAN LAKE

Heming Lake (54° 54' N. Lat. 101° 07' W. Long.) is a small narrow lake of great scenic beauty, situated 18 miles south of the town of Sherridon in northern Manitoba. The lake is three miles long, from one-eighth to one-half mile wide and has an area of 588 acres (Fig. 25).

The underlying rock formation is Precambrian granite forming a part of the Laurentian Shield. The lake lies in a relatively long, narrow cleft in the bedrock, and at the northern end and throughout the middle portion of the lake the shore and surrounding terrain are high and rugged with frequent rounded or jagged out-croppings of the bedrock (Fig. 26). The southern end of the lake has a much lower shoreline with regions of sand and traces of mud occurring. Marshy conditions prevail at the extreme southern tip of Heming Lake.

Heming Lake is fed by two streams, one at the northwest corner and the other at the southern tip. Both these streams contribute an appreciable flow of water throughout the summer from the small lakes which they drain. The outlet is a single stream situated in the northeast corner of the lake, which drains into Home Lake, 2 miles distant, and thence into the Grass River which is a tributary of the Nelson River.

Heming Lake lies in the northern coniferous section of the Boreal Forest Region. The rugged middle region and the northern portion of the shoreline are fairly heavily timbered with the boreal forest type of growth consisting of spruce, jackpine, birch and poplar (Fig. 26, Fig. 27). In the more southerly portion of the lake the low shoreline is dotted with patches of poplars and willows.

The emergent vegetation consists of rushes and lily pads in the bays and shallower southerly portions of the lake (Fig.28).

PHYSICAL AND CHEMICAL CHARACTERS

Heming Lake is a shallow lake, the deepest, north central portion not exceeding eighteen feet in depth, while at the northern end the average depth is about eight feet and at the southern end not over five feet. In the bays most of which are shallow there are gently sloping, often sandy, bottoms. In the main channel the bottom consists of fine inorganic silt. At the south end of Heming Lake the bottom consists of spongy matted vegetation, forerunner of future peat bogs. Transparency was measured by using a Secchi disk. Transparency in this lake was low being in general about three feet.

Surface samples of lake water were slightly basic (pH 7.3) at the north end of Heming Lake, very slightly acidic (pH 6.9) in the middle region of the lake, and very slightly basic (pH 7.1) at the southern end. There was indeed very little variation in hydrogen ion concentration throughout this lake. Temperature of the surface water was recorded throughout July and varied from a high of 22.22° C. at 4:45 p. m. on July 20, 1948 to a low of 16.66° C. at 11:30 a. m. on August 1, 1948. The temperature of the surface water had dropped to 5^{o} C. on October 4, 1948.

MATERIALS AND METHODS

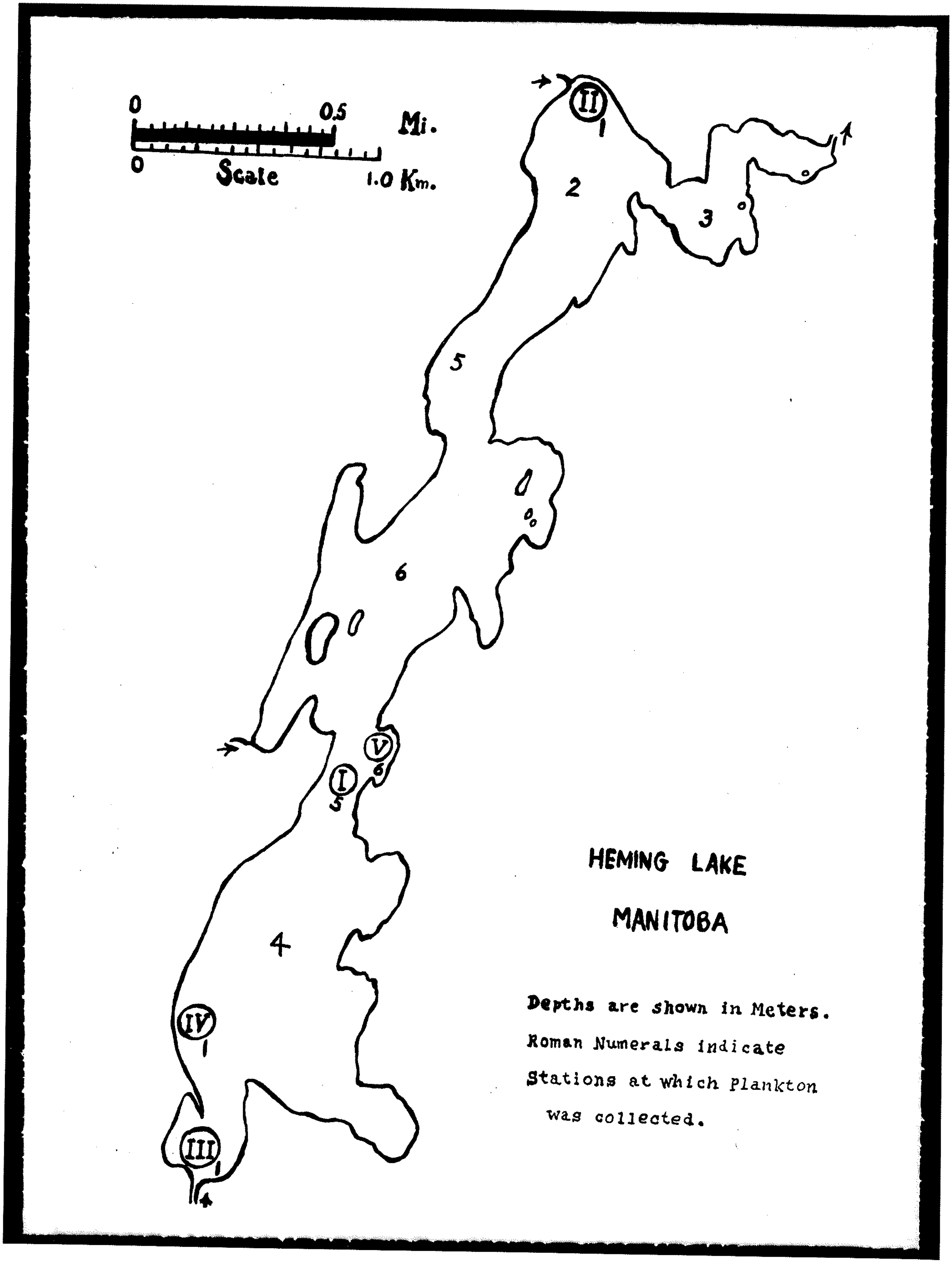
Surface samples of plankton from Heming Lake were collected twice weekly throughout June and July, 1948 by means of a Clarke and Bumpus plankton sampler. One sample was collected on October 4, 1948 by Dr. K. H. Doan.

Before this instrument can be used for quantitative work, the propellor-counter mechanism must be calibrated in terms of liters of water filtered per revolution of the propellor. Such calibration was done by passing known volumes of water through the tube at various speeds. The coefficient for the instrument used in this investigation was 4.00, i.e. a unit on the dial corresponded to 4.00 liters.

In the present investigation the Clarke and Bumpus plankton sampler was lowered just below the water surface, and samples were taken from one side of an 18-foot canoe driven by an outboard motor attached to the stern, and operated at a speed of about $1\frac{1}{2}$ to 2 miles per hour.

Readings of the instrument were taken immediatly before and at the conclusion of sampling. Using the coefficient previously determined the volume of water which passed through the instrument at each sampling was calculated in liters. The killing and preserving agent used was 15 per cent formalin which was added to produce quick killing and preservation of all plankters. For the July samples the temperature of the surface water was also

Fig. 25. Map of Heming Lake showing stations at which plankton samples were taken, and depth in meters.


HEMING LAKE
MANITOBA
Depths are shown in Meters.
Roman Numerals indicate Stations at which Plankton was collected.
0 0.5 Mi.
0 Scale 1.0 Km.
II
1
2
3
5
6
V
6
I
5
4
IV
1
III
1
4

recorded at the time each sample was collected. The pH of water samples was also determined.

The method used in estimating the number of each entomostracan per cubic meter was as follows:

(1) The total volume of the whole sample was determined by pouring all of it, after preliminary stirring with a glass rod, into a graduate or graduates and this volume (a) was recorded.

(2) All of the sample was then returned to the orôginal container and a portion of the sample, after preliminary stirring to distribute the organisms, was poured into a graduate and this volume (b) was recorded.

(3) The volume (b) was poured into a graduated Petri dish and the Entomostraca in each division were counted and the total number of each found.

(4) The number of each organism in the sample was then estimated and then the number of each Entomostracan per cubic meter was calculated.

For example let up suppose that readings of Clarke and Bumpus Plankton sampler were:

Reading .... 1.................... 340.0

Reading .... 2.................... 380.0

Difference .... 40.0 units

Conversion factor 4.00

Therefore volume of water passing through sampler.......

40.0 X 4.00 = 160.0 liters

Total volume of sample ......(a) .... 100.0 cc.

Volume of sample examined ...(b) .... 10.0 cc.

If X is the number of any species of Entomostracan present in 10.0 cc.

Then 10 X is the number of the same Entomostracan present in 100 cc., i.e. derived from 160 liters of lake water.

Then number of this organism in 1 cu. m. = $10\ X . \frac{1000}{160}$

It may be of interest to note that the Petri dish was marked off into 8 equal segments (by etching with hydrofluoric acid), cut again by circular lines (similarly etched) dividing the dish into 40 parts.

The counting of the plankters was done by placing the Petri dish containing the measured sample on the stage of a dissecting microscope. It was found that the various species of Entomostraca could be identified and counted under magnifications of from 20 X to 30 X. As a routine check, however, and to eliminate the possibility of error in identifying the species, permanent mounts were made of organisms from each sample, and these were examined carefully under higher powers.

The tables herewith included indicate the results obtained.

Stations at which plankton was collected are shown on a map of Heming Lake (Fig. 25).

COPEPODA OF HEMING LAKE

Epischura lacustris Forbes, 1882

This species shows two peaks in abundance, one late in June (June 28th, 28,304) and the other late in July (July 26th, 34,478). Langford (1938) notes that Epischura lacustris shuns surface waters in daylight when the temperature of these waters rises above 20° C. On July 20th, with a surface temperature of 22.22° C. at 4:45 p.m. only thirty-three individuals were found per cubic meter. On the other hand, on July 26th, at 9:40 p.m. with a surface temperature 20.00° C. there were 34,478 specimens of *Epischura lacustris* per cubic meter. These findings are in agreement with Langford's observations. Various investigators have shown the movements of this species is due to a complex of factors. It is interesting to compare the variation in numbers present in surface waters at the same location at approximately the same time of the evenings of July 26th, and July 29th. The variation in numbers on these two occasions is apparently due to a change in the temperature of the surface water, a drop in temperature of 2.33° C. decreasing the numbers of *Epischura*, as a result of downward migration, on July 29th, to less than one-third the number present on July 26th.

Diaptomus ashlandi Marsh, 1893

The presence of this Copepod, though occurring in only one sample is of great interest since it occurs typically in larger, deeper lakes and is not characteristic of small lakes such as Heming Lake. It was found in one bay northeast of the dock.

Diaptomus minutus Lilljeborg, 1889

It is interesting to note that this "stenothermal cold water" form is present throughout the season in Heming Lake. It occurs in maximum abundance, however, during June.

Table I. NUMBERS PER CUBIC METER IN SURFACE COLLECTIONS OF COPEPODA FROM HEMING LAKE, 1948

Station	Time of Collection	Date of Collection	Temp. Deg. C.	Nauplii	Epischura lacustris	Diaptomus minutus	Diaptomus oregonensis	Diaptomus	Eucyclops Koch	Cyclops vernalis Fischer	Cyclops vernalis americanus	Mesocyclops edax	Cyclops bicuspidatus thomasi
1	3:00 p.m.	4/VI		3,031	4,378	2,357	7,072				337	3,031	6,398
1	2:00 p.m.	7/VI		2,520	9,576	2,302	14,868			252		2,772	2,016
2	11:00 a.m.	15/VI		1,007	5,468	2,302	24,320		144			288	432
2	11:00 a.m.	18/VI		393	1,836	918	6,556			17	17		102
1	3:00 p.m.	22/VI		3,150	3,544	3,150	13,387			787	1,181	3,150	787
2	11:30 a.m.	25/VI		725	906	1,812	18,843						906
3	11:30 a.m.	28/VI		341	28,304	341	2,387				341	341	1,705
1	2:30 p.m.	4/VII		776	2,076	518	3,106					1,812	1,553
1	9:00 p.m.	6/VII	20.44		50		550					1,750	1,800
4	5:30 p.m.	8/VII	20.44		549		61						244
1	6:20 p.m.	14/VII	19.77	1,151	1,278	1,023	4,092				128	639	2,046
5	9:20 p.m.	16/VII	17.77	38	38	82	419	13		19		169	119
1	22:22 p.m.	20/VII	22.22	1,416	33	395	98			65	98	199	297
5	12:00 a.m.	25/VII	17.77	261	218	523	174				46	436	479
1	9:40 p.m.	26/VII	20.00		34,478	1,343	5,373		168	1,791	896	4,030	448
1	9:15 p.m.	29/VII	17.77		10,133	1,680	1,568			784	710	224	336
1	11:30 a.m.	1/VIII	16.66		354	245	282			27		109	
1	2:00 p.m.	4/X		35	1,064	1,008	8,736				56		840

N.B. Stations: 1 - 200 yds off Dock Centre of Lake. 2 - North end of lake. 3 - South end of lake. 4 - South end of lake near shore among weeds. 5 - Bay Northeast of Dock.

Table II NUMBERS PER CUBIC METER IN SURFACE COLLECTIONS OF CLADOCERA OF HEMING LAKE, 1948.

Station	Time of Collection	Date of Collection	Temp. Deg. C.	Leptodora kindtii	Polyphemus pediculus	Chydorus sphaericus var. minor	Chydorus sphaericus	Acroperus harpae	Bosmina c.l. obtusirostris	Bosmina longirostris	Bosmina c. longispina	Ceriodaphnia reticulata	Daphnia pulex form retrocurva	Daphnia longispina hyalina mendotae	Daphnia longispina hyalina typica	Daphnia longispina hyalina galeata	Holopedium gibberium	Diaphanosoma brachyurum	Sida crystallina
1	3:00 p.m.	4/VI					1010		1011	337	337	252	21889	504	7071	1347	6398	337	
1	2:00 p.m.	7/VI					1008		3276	504			28890	12376	9072	7560	3276		
2	11:00 a.m.	15/VI					1007		1151	144			25759	2491	1871	5900	3742		
2	11:00 a.m.	18/VI		131	131		262		637				24914		131	918	1836	131	
1	3:00 p.m.	22/VI		394		2362			787	394			5003		394	18505	23230		
2	11:30 a.m.	25/VI					362		1087				34787		725	1268		725	
3	11:30 a.m.	28/VI		75									6138			1023	341		
1	2:30 p.m.	4/VII					2070						16822	776		5176	2487		
1	9:00 p.m.	6/VII	20.44				1750		50		150		5000			600	1000		
4	5:30 p.m.	8/VII	20.44	366			305	122	61				366			366	366	793	122
1	6:20 p.m.	14/VII	19.77				6138		1790	128		1151	7289			895	256	511	
5	9:20 p.m.	16/VII	17.77	94			75		56	12	6	6	468		31	87	131	12	
1	4:45 p.m.	20/VII	22.22				264		326	65	99	33	196				891		
5	12:00 a.m.	25/VII	17.77			523	523		174	305	131	44	1002	44	131	305	392	44	87
1	9:40 p.m.	26/VII	20.00	1791			168						5721			448	1959	616	168
1	9:15 p.m.	29/VII	17.77	2211									840			112	168		
1	11:30 a.m.	1/VIII	16.66	18		726			36				1605	9	91	508	145	18	
1	2:00 p.m.	4/X		112		392			1512	224			2128	168	224	784	563	696	

N.B. Stations: 1. 200 yds. off Dock Centre of lake. 2. North end of lake. 3. South end of lake. 4. South end of lake near shore among weeds. 5. Bay Northeast of Dock.

Diaptomus oregonensis Lilljeborg, 1889

This species reaches its peak of abundance in Heming Lake about the middle of June. The relatively large numbers present on October 4th, would seem to indicate that a late peak in abundance also occurs.

Eucyclops agilis Koch, 1838

Although found only on two occasions the presence of this Copepod in Heming Lake is noted with interest. The specimens found on July 26th, were adult females bearing eggs. It may also be of interest to note that var. *speratus* was the form of this species found on June 15th, while typical *Eucyclops agilis* was found on July 26th.

Cyclops bicuspidatus var. *thomasi* Forbes, 1882

The peak of abundance for this Copepod occurred June 4th, at the beginning of the sampling. It did, however, persist throughout the summer, and was recorded as late as October 4th. It may be of interest that the peak in abundance of this species corresponds with or overlaps the period when the eggs of *Triaenophorus* tapeworms are being released from the bodies of pike. Thus the coracidia which hatch from these eggs find an abundance of their first intermediate host readily available.

Mesocyclops edax Forbes, 1891

This species is generally more abundant during June showing a peak in the latter part of the month. Another peak occurred on July 26, 1948 but study of this latter peak would appear to indicate that this organism is probably abundant below the surface throughout the season. On July 26th, favourable circumstances for its presence at the surface included dim light (9:40 p.m.) and fairly high water temperature (20.00° C.).

Cyclops vernalis form brevispinosus and Cyclops vernalis form americanus

These two organisms often occur together as might be expected since they are considered to be forms of the same species. Peaks in abundance occurred on June 22nd, and July 26th, respectively. A clarification of the taxonomic position of these forms is given by Yeatman (1944).

Nauplii

Nauplii appear from these samplings to be somewhat more abundant at the surface in June than later in the season. It is probable that the cooler surface waters occurring later in the season explained the apparent scarcity of these organisms.

It has been reported by Birge and Juday (1908) that Cyclops bicuspidatus thomasi spends a period, extending even up to several months during the summer, encysted on the bottom. Deevey (1941) reports a resting period in the Harpacticoid copepod Canthocamptus staphylinoides Pearse, and no doubt a similar resting period occurs in other copepods as well. A drop in numbers of copepods, such as often occurs suddenly during the summer, may well be the result of such a period of encystment, and there would naturally be a similar drop in the number of Nauplii present following upon this phenomenon, due to the cessation of reproductive as well as other activity.

CLADOCERA OF HEMING LAKE

Sida crystallina Muller, 1785

Sida crystallina was found only in three samplings of which only one was from open waters of the lake. The other two locations in which it occurred were from the south end of Heming Lake and from a bay northeast of the dock. The dates on which it was found were July 8, 25, and 26.

Diaphanosoma brachyurum Lievin, 1848

Diaphanosoma brachyurum was found in just over half the samples collected. Its numbers in surface waters varied considerably probably as a result of vertical migration. Its peak amazingly enough occurred on October 4th, at a time when the surface waters of this northern lake were at 5° C. This observation is not in agreement with the observations of Wagler (1937) who states that this species is found in European lakes only in the warmer months.

Holopedium gibberium Zaddach, 1855

Holopedium gibberium is much more abundant in June and shows a rapid decrease in numbers in surface as the season advances. Its peak is reached on June 22nd. Nevertheless it continues throughout the period of investigation.

Daphnia longispina hyalina Leydig, 1860

Three forms of Daphnia longispina hyalina (i.e. typica, galeata, and mendotae) were found in Heming Lake. They were present in greatest abundance in June and showed a decrease in numbers throughout the season. It is extremely interesting to note that the ephippial females of form galeata which, were present in the collection made on October 4th, showed only the slightest trace of the pointed crest which characterized this form during the earlier part of the summer. As a result the October specimens of form galeata approached very closely to form typica. A similar decrease in size of crest occurred in var. mendotae. Yet throughout the summer even the very young daphnids of these forms had typical crests. The peak in numbers for these forms were June 7th, for form typica, June 15th, for form mendotae and June 22nd, for form galeata.

Coker and Addlestone (1938) used Daphnia longispina hyalina galeata to demonstrate the influence of temperature on cyclomorphosis. They found that the neonatae reared below 11°C. are roundheaded while those reared above 15°C. always have pointed, so-called "spike" heads. Under natural conditions at Heming Lake (and in other Manitoban lakes) the author found that, at the period when the water temperature was highest there were developed long pointed crests. Crest development was so great as to mark Manitoban races as distinct from all races of *galeata* so far collected by J. L. Brooks from American sources.

The author's observations confirm the results obtained experimentally by Coker and Addlestone, but the change in the size of the crest resulting from lowering temperature is more remarkable since crest size is greater in Manitoba specimens at the time of maximum development.

Daphnia retrocurva Forbes, 1882
(*Daphnia pulex parapulex* form *retrocurva* Woltereck, 1932)

Daphnia retrocurva was present throughout June and July, 1948, being found in all the surface samples taken. It was also present in the collection of October 4, 1948. Throughout June the crests, of those specimens collected, were small, but during July large-crested specimens were present together with the smaller crested forms.

In a surface collection taken July 4, 1948 over one-third (6,500 of about 17,000 per cu. m.) were large-crested, while the remainder had moderate or small crests. It seems probable, therefore, that large-crested specimens of *D. retrocurva* were present below the surface late in June. In one collection, that of July 26, 1948, over two-thirds of the specimens taken in a surface sample were large-crested. As a rule, however, nearly all *D. retrocurva* taken were small-crested. On October 4, 1948 there were about 2,128 specimens of *D. retrocurva* per cu. m. and slightly over two per cent of these had large crests while the remainder had small crests.

Fig. 26. Granite outcrop and pine forest growth on the east shore of Heming Lake, north of the Narrows.

Fig. 27. View across Heming Lake at the Narrows from the west shore. Station I. in the foreground.

Fig. 28. View of water grasses and shore vegetation about halfway between Station IV. and Station I. along the west shore of Heming Lake.

26

27

28

No specimens of the uncrested forms *Daphnia retrocurva* var. *breviceps* Birge were found amongst any of the specimens examined from these collections.

Daphnia retrocurva was most abundant throughout June with a peak on June 25th. The numbers decreased during the season. The irregularities in numbers present in surface waters were probably due to vertical migration as a result of changing conditions of light or temperature.

Ceriodaphnia reticulata Jurine, 1820

Ceriodaphnia reticulata was found in only five surface samples. It was fairly common on July 14th, 1948.

Bosmina longirostris Muller, 1785

Bosmina longirostris occurred in only five surface samples. It appeared to be relatively rare. Its greatest abundance was on June 4th.

Bosmina coregoni longispina Leydig, 1860
(*Bosmina longispina* auct; Birge)

Bosmina c. longispina occurred in nine out of seventeen samples. It was never abundant but was rather more common during June.

Bosmina coregoni longispina obtusirostris Sars, 1861
(*Bosmina obtusirostris* auct; Birge)

Bosmina c. l. obtusirostris was the most common species of this genus in Heming Lake. Its peak in abundance was on June 7th. It showed a second smaller peak on July 14th and appeared to be abundant again on October 4th.

Acroperus harpae Baird, 1835

Acroperus harpae was found in only one surface plankton sample. The location from which this sample was collected was from among weeds near the shore at the south end of Heming Lake (Fig. 28).

Chydorus sphaericus Muller, 1785

Chydorus sphaericus occurred throughout the season in surface samples from Heming Lake. Its peak in abundance was in mid-July.

Chydorus sphaericus var. *minor*

Chydorus sphaericus var. *minor* was found in only one surface sample from Heming Lake, a sample taken on June 22nd, at 3:00 p.m.

Polyphemus pediculus Linne, 1761

Polyphemus pediculus occurred in a surface sample taken on June 18th, 1948. In spite of its innocent appearance *Polyphemus pediculus* is a predaceous species which seizes its prey and tears it apart with its hooked mandibles.

Leptodora kindtii Focke, 1844

Leptodora kindtii is a large carnivorous species. It was not common in morning samples except on dull days, but often present in late afternoon and evening surface collections. Its greatest abundance was on July 29th in a sample taken at 9:15 p.m.

SEX AND AGE RATIOS OF ENTOMOSTRACA OF HEMING LAKE FROM COLLECTIONS MADE DURING THE SUMMER OF 1948

For each of the species of *Entomostraca* found in Heming Lake a tabulation was made of the percentage of specimens of females bearing eggs, females not bearing eggs, males, and of young. For the *Cladocera* ephippial females occurring late in the summer were also included in the tabulation. For the *Copepoda* the term young is used to include only copepodid stages, and not nauplii or netanauplii. The tabulation is done for each species omitting only those of very infrequent occurrence. Results of the tabulation were as follows:

COPEPODA

Epischura lacustris

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade		Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.						100
1.	" 7	2.00 p.m.			3		2	95
2.	:" 15	11.00 a.m.			11		36	53
2.	" 18	11.00 a.m.				14	14	72
1.	" 22	3.00 p.m.				11	11	78
2.	" 25	11.30 a.m.				20	20	60
3.	" 28	11.30 a.m.				81	13	6
1.	July 4	2.30 p.m.				25	12	63
1.	" 6	9.00 p.m.	20.44					100
4.	:" 8	5.30 p.m.	20.00					100
1.	" 14	6.20 p.m.	19.77			20		80
5.	" 16	9.20 p.m.	17.77					100
1.	" 20	4.45 p.m.	22.22					100
5.	" 25	12.00 a.m.	17.77			20	20	60
1.	" 26	9.40 p.m.	20.00			27	49	24
1.	" 29	9.15 p.m.	17.77			30	48	22
1.	Aug. 1	11.30 a.m.	16.66			26	22	52
1.	Oct. 4	2.00 p.m.				78	11	11

COPEPODA

Diaptomus minutus

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade		Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.			43	43		14
1.	" 7	2.00 p.m.			57	14	14	15
2.	" 15	11.00 a.m.			12	39	41	8
2.	" 18	11.00 a.m.				57	43	
1.	" 22	3.00 p.m.			25		13	62
2.	" 25	11.30 a.m.				100		
3.	" 28	11.30 a.m.				100		
1.	July 4	2.30 p.m.				50	50	
1.	" 6	9.00 p.m.	20.44					
4.	" 8	5.30 p.m.	20.00					
1.	" 14	6.20 p.m.	19.77			25	50	25
5.	" 16	9.20 p.m.	17.77		25	7	61	7
1.	" 20	4.45 p.m.	22.22			42	50	8
5.	" 25	12.00 a.m.	17.77			33	67	
1.	" 26	9.40 p.m.	20.00			56	22	22
1.	" 29	9.15 p.m.	17.77			27	43	30
1.	Aug. 1	11.30 a.m.	16.66			22	59	19
1.	Oct. 4	2.00 p.m.				55	40	5

COPEPODA

Diaptomus oregonensis

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade		Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.			33	33	5	29
1.	" 7	2.00 p.m.			10	12	2	76
2.	:" 15	11.00 a.m.			3	58	8	31
2.	" 18	11.00 a.m.			6	60	8	26
1.	" 22	3.00 p.m.				18	20	62
2.	" 25	11.30 a.m.			2	37	10	51
3.	" 28	11.30 a.m.				29	42	58
1.	July 4	2.30 p.m.				67	8	25
1.	" 6	9.00 p.m.	20.44			9		91
4.	:" 8	5.30 p.m.	20.00			100		
1.	" 14	6.20 p.m.	19.77			32	13	55
5.	" 16	9.20 p.m.	17.77			36	19	45
1.	" 20	4.45 p.m.	22.22					100
5.	" 25	12.00 a.m.	17.77			50		50
1.	" 26	9.40 p.m.	20.00			92	8	
1.	" 29	9.15 p.m.	17.77			46	8	46
1.	Aug. 1	11.30 a.m.	16.66			32	26	42
1.	Oct. 4	2.00 p.m.				80	15	5

COPEPODA

Cyclops bicuspidatus var. thomasi

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade		Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.						100
1.	" 7	2.00 p.m.			12			88
2.	:" 15	11.00 a.m.				33		67
2.	" 18	11.00 a.m.						100
1.	" 22	3.00 p.m.						100
2.	" 25	11.30 a.m.						100
3.	" 28	11.30 a.m.				80		20
1.	July 4	2.30 p.m.				66	17	17
1.	" 6	9.00 p.m.	20.44			3	3	94
4.	:" 8	5.30 p.m.	20.00		50	50		
1.	" 14	6.20 p.m.	19.77			50	19	31
5.	" 16	9.20 p.m.	17.77			63	11	26
1.	" 20	4.45 p.m.	22.22			11		89
5.	" 25	12.00 a.m.	17.77			36	9	55
1.	" 26	9.40 p.m.	20.00					100
1.	" 29	9.15 p.m.	17.77			83		17
1.	Aug. 1	11.30 a.m.	16.66					
1.	Oct. 4	2.00 p.m.				7	7	86

COPEPODA

Mesocyclops edax

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade		Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.				67		33
1.	" 7	2.00 p.m.			18	27	55	
2.	:" 15	11.00 a.m.			50	50		
2.	" 18	11.00 a.m.						
1.	" 22	3.00 p.m.			50	50		
2.	" 25	11.30 a.m.						
3.	" 28	11.30 a.m.			100			
1.	July 4	2.30 p.m.			29	71		
1.	" 6	9.00 p.m.	20.44		17	68	15	
4.	:" 8	5.30 p.m.	20.00					
1.	" 14	6.20 p.m.	19.77		20	80		
5.	" 16	9.20 p.m.	17.77			15	7	78
1.	" 20	4.45 p.m.	22.22					100
5.	" 25	12.00 a.m.	17.77			20		80
1.	" 26	9.40 p.m.	20.00			24		76
1.	" 29	9.15 p.m.	17.77			50		50
1.	Aug. 1	11.30 a.m.	16.66			84	8	8
1.	Oct. 4	2.00 p.m.						

COPEPODA

Cyclops vernalis form brevispinosus

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade		Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.						
1.	" 7	2.00 p.m.						100
2.	:" 15	11.00 a.m.						
2.	" 18	11.00 a.m.						100
1.	" 22	3.00 p.m.						100
2.	" 25	11.30 a.m.						
3.	" 28	11.30 a.m.						
1.	July 4	2.30 p.m.						
1.	" 6	9.00 p.m.	20.44					
4.	:" 8	5.30 p.m.	20.00					
1.	" 14	6.20 p.m.	19.77					
5.	" 16	9.20 p.m.	17.77			67		33
1.	" 20	4.45 p.m.	22.22					100
5.	" 25	12.00 a.m.	17.77					
1.	" 26	9.40 p.m.	20.00			58		42
1.	" 29	9.15 p.m.	17.77			29		71
1.	Aug. 1	11.30 a.m.	16.66					
1.	Oct. 4	2.00 p.m.						

COPEPODA

Cyclops vernalis form americanus

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade		Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.						100
1.	" 7	2.00 p.m.						
2.	" 15	11.00 a.m.						
2.	" 18	11.00 a.m.						100
1.	" 22	3.00 p.m.						100
2.	" 25	11.30 a.m.						
3.	" 28	11.30 a.m.						100
1.	July 4	2.30 p.m.						
1.	" 6	9.00 p.m.	20.44					
4.	" 8	5.30 p.m.	20.00					
1.	" 14	6.20 p.m.	19.77					100
5.	" 16	9.20 p.m.	17.77					
1.	" 20	4.45 p.m.	22.22					100
5.	" 25	12.00 a.m.	17.77					100
1.	" 26	9.40 p.m.	20.00					100
1.	" 29	9.15 p.m.	17.77			18		82
1.	Aug. 1	11.30 a.m.	16.66					
1.	Oct. 4	2.00 p.m.				100		

DISCUSSION

A study of the sex and age ratios of the Copepoda of Heming Lake shows that reproduction in most species is going on actively throughout the spring, summer and autumn seasons. This is evidenced by the constantly large percentage of young forms occurring throughout the period under investigation. The drop both in absolute numbers and in percentage of young forms in the latter part of the period is a general indication of a drop in reproductive activity. Nevertheless, there appears to be both an early spring and a late fall peak in the reproductive activity of certain species, such as Diaptomus oregonensis.

In assessing conditions in Heming Lake which influence reproductive activity consideration must be given to its far-northerly position (54° 53' N. Lat.) which means that the lake is not normally free of ice before May 20, and that the waters remain quite cool well into June. After the middle of June this shallow lake warms rapidly through June and into July. There is no evidence of a thermocline and warming proceeds repidly to the bottom. After the middle of July gradual cooling takes place, and by the end of September or early October the fall overturn has taken place, and the waters have cooled to 4° C. At the end of October ice cover is likely to form and winter conditions prevail.

CLADOCERA

Sida Crystallina

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.						
1.	" 7	2.00 p.m.						
2.	" 15	11.00 a.m.						
2.	" 18	11.00 a.m.						
1.	" 22	3.00 p.m.						
2.	" 25	11.30 a.m.						
3.	" 28	11.30 a.m.						
1.	July 4	2.30 p.m.						
1.	" 6	9.00 p.m.	20.44					
4.	" 8	5.30 p.m.	20.00		50	50		
1.	" 14	6.20 p.m.	19.77					
5.	" 16	9.20 p.m.	17.77					
1.	" 20	4.45 p.m.	22.22					
5.	" 25	12.00 a.m.	17.77		100			
1.	" 26	9.40 p.m.	20.00		100			
1.	" 29	9.15 p.m.	17.77					
1.	Aug. 1	11.30 a.m.	16.66					
1.	Oct. 4	2.00 p.m.						

CLADOCERA

Holopedium gibberium

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.						100
1.	" 7	2.00 p.m.			16			84
2.	:" 15	11.00 a.m.			7	58		35
2.	" 18	11.00 a.m.			14	57		29
1.	" 22	3.00 p.m.			29	66		5
2.	" 25	11.30 a.m.						
3.	" 28	11.30 a.m.						100
1.	July 4	2.30 p.m.						100
1.	" 6	9.00 p.m.	20.44					100
4.	:" 8	5.30 p.m.	20.00		33	67		
1.	" 14	6.20 p.m.	19.77		50			50
5.	" 16	9.20 p.m.	17.77		33	43		24
1.	" 20	4.45 p.m.	22.22			4	4	92
5.	" 25	12.00 a.m.	17.77		22	11	11	56
1.	" 26	9.40 p.m.	20.00		52	16	16	16
1.	" 29	9.15 p.m.	17.77		67	33		
1.	Aug. 1	11.30 a.m.	16.66	19	44			37
1.	Oct. 4	2.00 p.m.		100				

CLADOCERA

Daphnia longispina hyalina form typica

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.			57	29		14
1.	" 7	2.00 p.m.			53	42		5
2.	:" 15	11.00 a.m.			54	46		
2.	" 18	11.00 a.m.				100		
1.	" 22	3.00 p.m.				100		
2.	" 25	11.30 a.m.				100		
3.	" 28	11.30 a.m.						
1.	July 4	2.30 p.m.						
1.	" 6	9.00 p.m.	20.44					
4.	:" 8	5.30 p.m.	20.00					
1.	" 14	6.20 p.m.	19.77					
5.	" 16	9.20 p.m.	17.77		20	20		60
1.	" 20	4.45 p.m.	22.22					
5.	" 25	12.00 a.m.	17.77			33		67
1.	" 26	9.40 p.m.	20.00					
1.	" 29	9.15 p.m.	17.77					
1.	Aug. 1	11.30 a.m.	16.66					
1.	Oct. 4	2.00 p.m.		50		50		

CLADOCERA

Daphnia longispina var. hyalina form galeata

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.				25		75
1.	" 7	2.00 p.m.			10	23		67
2.	:" 15	11.00 a.m.			27	37		35
2.	" 18	11.00 a.m.			29	14		57
1.	" 22	3.00 p.m.			30	66		4
2.	" 25	11.30 a.m.				57		43
3.	" 28	11.30 a.m.				100		
1.	July 4	2.30 p.m.			10	45		45
1.	" 6	9.00 p.m.	20.44			50		50
4.	:" 8	5.30 p.m.	20.00			100		
1.	" 14	6.20 p.m.	19.77					100
5.	" 16	9.20 p.m.	17.77		22	7		71
1.	" 20	4.45 p.m.	22.22					
5.	" 25	12.00 a.m.	17.77		14			86
1.	" 26	9.40 p.m.	20.00		33	33		33
1.	" 29	9.15 p.m.	17.77		100			
1.	Aug. 1	11.30 a.m.	16.66	2	46	7		45
1.	Oct. 4	2.00 p.m.		14	29	50		7

CLADOCERA

Daphnia longispina hyalina form mendotae

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.						
1.	" 7	2.00 p.m.			100			
2.	:" 15	11.00 a.m.			53	38		9
2.	" 18	11.00 a.m.			31	53		16
1.	" 22	3.00 p.m.						
2.	" 25	11.30 a.m.						
3.	" 28	11.30 a.m.						
1.	July 4	2.30 p.m.				67		33
1.	" 6	9.00 p.m.	20.44					
4.	:" 8	5.30 p.m.	20.00					
1.	" 14	6.20 p.m.	19.77					
5.	" 16	9.20 p.m.	17.77					
1.	" 20	4.45 p.m.	22.22					
5.	" 25	12.00 a.m.	17.77			100		
1.	" 26	9.40 p.m.	20.00					
1.	" 29	9.15 p.m.	17.77					
1.	Aug. 1	11.30 a.m.	16.66		100			
1.	Oct. 4	2.00 p.m.		33	33	33		

CLADOCERA

Daphnia retrocurva

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.			12	30		58
1.	" 7	2.00 p.m.			33	15		52
2.	:" 15	11.00 a.m.			32	22		46
2.	" 18	11.00 a.m.			14	28		57
1.	" 22	3.00 p.m.			13	72		15
2.	" 25	11.30 a.m.			27	30		43
3.	" 28	11.30 a.m.			22	61		17
1.	July 4	2.30 p.m.			25	25		50
1.	" 6	9.00 p.m.	20.44		50			50
4.	:" 8	5.30 p.m.	20.00		33			67
1.	" 14	6.20 p.m.	19.77		10	37		53
5.	" 16	9.20 p.m.	17.77		34	24		42
1.	" 20	4.45 p.m.	22.22			83		17
5.	" 25	12.00 a.m.	17.77		13	43		44
1.	" 26	9.40 p.m.	20.00		31	54		15
1.	" 29	9.15 p.m.	17.77		67	33		
1.	Aug. 1	11.30 a.m.	16.66	2	25	20		53
1.	Oct. 4	2.00 p.m.		42	3	49		6

CLADOCERA

Ceriodaphnia reticulata

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.						
1.	" 7	2.00 p.m.				100		
2.	:" 15	11.00 a.m.						
2.	" 18	11.00 a.m.						
1.	" 22	3.00 p.m.						
2.	" 25	11.30 a.m.						
3.	" 28	11.30 a.m.						
1.	July 4	2.30 p.m.						
1.	" 6	9.00 p.m.	20.44					
4.	:" 8	5.30 p.m.	20.00					
1.	" 14	6.20 p.m.	19.77		50	50		
5.	" 16	9.20 p.m.	17.77		100			
1.	" 20	4.45 p.m.	22.22		10	90		
5.	" 25	12.00 a.m.	17.77		100			
1.	" 26	9.40 p.m.	20.00					
1.	" 29	9.15 p.m.	17.77					
1.	Aug. 1	11.30 a.m.	16.66					
1.	Oct. 4	2.00 p.m.						

CLADOCERA

Bosmina longirostris

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.				100		
1.	" 7	2.00 p.m.						
2.	:" 15	11.00 a.m.						
2.	" 18	11.00 a.m.						
1.	" 22	3.00 p.m.						
2.	" 25	11.30 a.m.						
3.	" 28	11.30 a.m.						
1.	July 4	2.30 p.m.						
1.	" 6	9.00 p.m.	20.44		100			
4.	:" 8	5.30 p.m.	20.00					
1.	" 14	6.20 p.m.	19.77					
5.	" 16	9.20 p.m.	17.77			100		
1.	" 20	4.45 p.m.	22.22			100		
5.	" 25	12.00 a.m.	17.77			100		
1.	" 26	9.40 p.m.	20.00					
1.	" 29	9.15 p.m.	17.77					
1.	Aug. 1	11.30 a.m.	16.66					
1.	Oct. 4	2.00 p.m.						

CLADOCERA

Bosmina c. Longispina

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.				100		
1.	" 7	2.00 p.m.			50	50		
2.	" 15	11.00 a.m.						100
2.	" 18	11.00 a.m.						
1.	" 22	3.00 p.m.						100
2.	" 25	11.30 a.m.						
3.	" 28	11.30 a.m.						
1.	July 4	2.30 p.m.						
1.	" 6	9.00 p.m.	20.44					
4.	" 8	5.30 p.m.	20.00					
1.	" 14	6.20 p.m.	19.77			100		
5.	" 16	9.20 p.m.	17.77			100		
1.	" 20	4.45 p.m.	22.22			47		53
5.	" 25	12.00 a.m.	17.77			100		
1.	" 26	9.40 p.m.	20.00					
1.	" 29	9.15 p.m.	17.77					
1.	Aug. 1	11.30 a.m.	16.66					
1.	Oct. 4	2.00 p.m.			100			

CLADOCERA

Bosmina c. l. obtusirostris

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.			67	33		
1.	" 7	2.00 p.m.			77	15		8
2.	:" 15	11.00 a.m.			88	12		
2.	" 18	11.00 a.m.			60	40		
1.	" 22	3.00 p.m.			50	50		
2.	" 25	11.30 a.m.			100			
3.	" 28	11.30 a.m.						
1.	July 4	2.30 p.m.						
1.	" 6	9.00 p.m.	20.44		100			
4.	:" 8	5.30 p.m.	20.00		100			
1.	" 14	6.20 p.m.	19.77		64	14		22
5.	" 16	9.20 p.m.	17.77		67	33		
1.	" 20	4.45 p.m.	22.22		20	70		10
5.	" 25	12.00 a.m.	17.77		25	50		25
1.	" 26	9.40 p.m.	20.00					
1.	" 29	9.15 p.m.	17.77					
1.	Aug. 1	11.30 a.m.	16.66		75	25		
1.	Oct. 4	2.00 p.m.			63	33		4

CLADOCERA

Acroperus harpae

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.						
1.	" 7	2.00 p.m.						
2.	:" 15	11.00 a.m.						
2.	" 18	11.00 a.m.						
1.	" 22	3.00 p.m.						
2.	" 25	11.30 a.m.						
3.	" 28	11.30 a.m.						
1.	July 4	2.30 p.m.						
1.	" 6	9.00 p.m.	20.44					
4.	:" 8	5.30 p.m.	20.00		50	50		
1.	" 14	6.20 p.m.	19.77					
5.	" 16	9.20 p.m.	17.77					
1.	" 20	4.45 p.m.	22.22					
5.	" 25	12.00 a.m.	17.77					
1.	" 26	9.40 p.m.	20.00					
1.	" 29	9.15 p.m.	17.77					
1.	Aug. 1	11.30 a.m.	16.66					
1.	Oct. 4	2.00 p.m.						

CLADOCERA

Chydorus sphaericus

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.			67	33		
1.	" 7	2.00 p.m.			100			
2.	:" 15	11.00 a.m.			71	29		
2.	" 18	11.00 a.m.				100		
1.	" 22	3.00 p.m.						
2.	" 25	11.30 a.m.			100			
3.	" 28	11.30 a.m.						
1.	July 4	2.30 p.m.			25	75		
1.	" 6	9.00 p.m.	20.44		57	14		29
4.	:" 8	5.30 p.m.	20.00			100		
1.	" 14	6.20 p.m.	19.77		17	33		50
5.	" 16	9.20 p.m.	17.77		42	25		33
1.	" 20	4.45 p.m.	22.22		37	57		26
5.	" 25	12.00 a.m.	17.77		17	50		33
1.	" 26	9.40 p.m.	20.00		100			
1.	" 29	9.15 p.m.	17.77					
1.	Aug. 1	11.30 a.m.	16.66		80	20		
1.	Oct. 4	2.00 p.m.		57	14	29		

CLADOCERA

Chydorus sphaericus var. minor

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.						
1.	" 7	2.00 p.m.						
2.	:" 15	11.00 a.m.						
2.	" 18	11.00 a.m.						
1.	" 22	3.00 p.m.			50	50		
2.	" 25	11.30 a.m.						
3.	" 28	11.30 a.m.						
1.	July 4	2.30 p.m.						
1.	" 6	9.00 p.m.	20.44					
4.	:" 8	5.30 p.m.	20.00					
1.	" 14	6.20 p.m.	19.77					
5.	" 16	9.20 p.m.	17.77					
1.	" 20	4.45 p.m.	22.22					
5.	" 25	12.00 a.m.	17.77		50	33		17
1.	" 26	9.40 p.m.	20.00					
1.	" 29	9.15 p.m.	17.77					
1.	Aug. 1	11.30 a.m.	16.66					
1.	Oct. 4	2.00 p.m.						

CLADOCERA

Polyphemus pediculus

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.						
1.	" 7	2.00 p.m.						
2.	:" 15	11.00 a.m.						
2.	" 18	11.00 a.m.				100		
1.	" 22	3.00 p.m.						
2.	" 25	11.30 a.m.						
3.	" 28	11.30 a.m.						
1.	July 4	2.30 p.m.						
1.	" 6	9.00 p.m.	20.44					
4.	:" 8	5.30 p.m.	20.00					
1.	" 14	6.20 p.m.	19.77					
5.	" 16	9.20 p.m.	17.77					
1.	" 20	4.45 p.m.	22.22					
5.	" 25	12.00 a.m.	17.77					
1.	" 26	9.40 p.m.	20.00					
1.	" 29	9.15 p.m.	17.77					
1.	Aug. 1	11.30 a.m.	16.66					
1.	Oct. 4	2.00 p.m.						

CLADOCERA

Leptodora kindtii

LOCATION	DATE	TIME	TEMPERATURE Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
1.	June 4	3.00 p.m.						
1.	" 7	2.00 p.m.						
2.	" 15	11.00 a.m.						
2.	" 18	11.00 a.m.				100		
1.	" 22	3.00 p.m.				100		
2.	" 25	11.30 a.m.						
3.	" 28	11.30 a.m.				100		
1.	July 4	2.30 p.m.						
1.	" 6	9.00 p.m.	20.44					
4.	" 8	5.30 p.m.	20.00			100		
1.	" 14	6.20 p.m.	19.77					
5.	" 16	9.20 p.m.	17.77			100		
1.	" 20	4.45 p.m.	22.22					
5.	" 25	12.00 a.m.	17.77					
1.	" 26	9.40 p.m.	20.00			67		33
1.	" 29	9.15 p.m.	17.77		19	33		48
1.	Aug. 1	11.30 a.m.	16.66			50		50
1.	Oct. 4	2.00 p.m.				100		

DISCUSSION

From a study of the sex and age ratios of these *Cladocera* several conclusions are strongly suggested:

(1) Low temperature seems to be a decided factor in producing the ephippial condition which is first noted in several species of the *Cladocera* in specimens from the collection made on August 1, 1948, but which is much more markedly present in specimens from the collection made on October 4, 1948. This statement applies particularly to the several species, varieties and forms of *Daphnia*.

(2) In a few species the presence of males is observed late in the season, which suggests their oft-repeated importance in fertilizing the winter eggs of the females. In other species male are either absent or present in negligible numbers at the surface.

(3) In *Leptodora kindtii* young and egg-bearing females were found late in the season, while in several species, notably *Bosmina obtusirostris* and *Chydorus sphaericus*, egg-bearing females and young were constantly present indicating that reproductive cycles followed one another at short intervals throughout the spring, summer and autumn.

Low temperature is suggested as the probable cause of the reduction in the size of the crests observed in specimens of *Daphnia retrocurva*, and in specimens of *Daphnia longispina* var. *hyalina* forms *mendotae* and *galeata*, collected on October 4, 1948. It appears significant that large-crested specimens of *D. retrocurva* were present at the surface during July, and even, on occasion, exceeded in numbers the small-crested specimens. A rise in water temperature appeared to be the chief factor influencing the production of the larger crest, and a drop in water temperature appeared to cause a reversion to the small-crested more typical (i. e. for Manitoba) form. The small percentage of large-crested Daphnia retrocurva found in the collection of October 4, 1948, are held to constitute the survivors of this group from among the July specimens. The possibility that turbulence is an accessory, or even a major factor in the production of the large-crested condition cannot be ruled out, since Brooks (1947) has demonstrated the importance of this factor experimentally.

FURTHER STUDIES OF LIMNETIC COPEPODA AND CLADOCERA OF HEMING LAKE

During May and June, 1949, collections of surface plankton were again made at Heming Lake. All samples were taken at station 1 (Fig. 27), about 200 yards off the dock in the camp narrows area, and between 6: p.m. and 9:30 p.m. on the dates indicated. Both vertical and horizontal samples were taken at the same location June 17, 19, 21, and 25, 1949. In order to follow the seasonal changes in abundance of these planktonts it was felt desirable to secure winter samples. This was made possible by Dr. K. H. Doan, who himself took a vertical sample through the ice on December 4, 1949, and secured the services of a trapper, sole inhabitant of this northern outpost during the winter, to take vertical samples in January, February, April and May, 1950.

Results of the surface samplings are tabulated in Tables III and IV, while results of vertical samplings are shown in Tables V and VI. The numbers shown in the tables indicate numbers of each organism per cubic meter. Station 1 at which this series of plankton collections were made is shown on the map of Heming Lake (Fig. 25).

MATERIALS AND METHODS

These collections were made, as in 1948, by the use of a Clarke and Bumpus plankton sampler.

The same procedures were followed as for the 1948 samples in killing, preserving and counting of plankters. The total settled volume of the plankton present in each sample was determined in cubic centimeters, and from this determination the volume of plankton present per cubic meter was estimated.

Table III. NUMBERS PER FUBIC METER IN SURFACE COLLECTIONS OF COPEPODA OF HEMING LAKE,1949.

Time of Collection p.m.	Date of collection	Temperature Deg. C.	Epischura lacustris	Epischura nevadensis	Diaptomus minutus	Diaptomus oregonensis	Cyclops albidus	Eucyclops agilis	Cyclops vernalis Fischer	Cyclops varnalis var. americanus	Mesocyclops edax	Cyclops bicuspidatus var. thomasi
7:15	8/V				3,414	6,460					388	13,837
9:00	10/V		574		820	2,295					5,000	16,720
7:15	13/V		160		3,924	7,067			1,121	80	5,365	24,024
7:15	15/V				3,298	7,129			213	106	7,767	42,666
7:15	17/V				10,182	19,299			237	118	4,618	14,918
7:15	19/V				5,504	4,736					1,664	14,016
6:50	21/V				5,616	8,748				324	4,860	21,168
6:35	23/V				1,911	9,318				228	1,119	13,140
6:45	25/V				2,867	8,602				358	3,942	35,123
6:15	28/V				3,520	2,080				640	2,400	40,640
6:15	30/V				845	8,026			211	845	14,573	29,779
6:25	1/VI				3,840	11,200	10			20	21,120	73,280
6:50	3/VI				3,658	5,690					8,534	55,677
6:30	5/VI		15	145	20,880	13,920					59,160	361,920
8:15	7/VI		582	696	8,700	4,872					4,872	109,794
6:00	9/VI		3,840	6,144	15,360	8,448					4,608	125,952
7:45	11/VI		7,168	11,648	25,984	36,736					108,416	85,120
7:00	13/VI		730	1,460	15,768	12,264					12,264	25,112
7:00	15/VI		1,569	1,176	21,177	18,432		16			10,980	15,686
6:45	17/VI	14.44	1,203	363	4,835	7,014			1,271	1,271	6,538	3,632
9:30	19/VI	15.55	2,660	760	7,600	6,840					11,780	6,080
9:30	21/VI	17.22	1,869	1,308	38,684	26,911					2,243	1,682
9:30	23/VI	16.66	2,280	200	960	2,880					3,360	4,320
9:30	25/VI	17.77	685		822	4,932			342		3,973	1,096

Table IV. NUMBERS PER CUBIC METER IN SURFACE COLLECTIONS OF CLADOCERA OF HEMING LAKE, 1949.

Time p.m.	Date of Collection	Temp. Deg. C.	Leptodora kindtii	Holopedium gibberium	Diaphanosoma brachyurum	Daphnia pulex form retrocurva	Daphnia longispina hyalina galeata	Daphnia longispina hyalina typica	Daphnia longispina	Daphnia longispina hyalina longiora	Daphnia longispina hyalina breviora	Chydorus sphaericus	Ceriodaphnia reticulata	Bosmina c.l. obtusirostris	Bosmina c. longispina	Bosmina longirostris var. brevicornis	Bosmina longirostris
7:15	8/V						427	5,005				39		466			
9:00	10/V						82	5,245					82	984			82
7:15	13/V				20		120	1,121	400	240	20			5,606	80		80
7:15	15/V			106			160	1,600	213	160	266			2,607		160	
7:15	17/V			30			118	20,246	11,248	3,315	237			3,540	118		
7:15	19/V		1,024	512			384	7,680	7,424	128				4,864			
6:50	21/V		14				1,188	3,672	1,512	216		648		1,944	108		
6:35	23/V						564	21,340	4,486			564		1,347			
6:45	25/V			2,150			4,659	29,747	64,512			3,942		10,394			
6:15	28/V		240				160	13,600	25,600			3,520	80	5,760	320		
6:15	30/V		158	158			1,267	39,072	10,138			1,690		5,702	1,056		
6:25	I/VI			400			3,200	116,480	29,760		100	2,560		24,640	6,400		
6:50	3/VI						4,064	142,240	11,379			1,219		9,347	1,219		
6:30	5/VI			145	15	44	74,820	116,580	48,720			15,660		85,260			
8:15	7/VI						2,436	99,876	4,350			1,218		3,480			
6:00	9/VI			1,536	24		9,984	545,088	105,984			6,144		960			
7:45	I/VI			42			10,752	605,696	199,808			6,272		3,584			
7:00	13/VI			4,672			24,528	290,248	52,560			2,336		4,672			
7:00	15/VI		229	1,961			25,098	78,824	39,216			1,961		2,353			
6:45	17/VI	14.4		3,995			48,419	255,693	75,705			8,240		2,429			
9:30	19/VI	15.6	1,425	3,325	760		65,740	110,200	58,820			6,080		1,900			
9:30	21/VI	17.2	1,822	187	187	374	25,042	29,714	374			1,682					
9:30	23/VI	16.7	180	300		1,200	24,000	31,200	1,920			3,240					
9:30	25/VI	17.8		205		411	15,069	4,109	10,959			274					

Table V. NUMBERS PER CUBIC METER IN VERTICAL COLLECTIONS OF COPEPODA OF HEMING LAKE, 1949-1950

Time of Collection p.m.	Date of Collection	Temperature Deg. C.	Nauplii and Metanauplii	Epischura nevadensis	Epischura lacustris	Diaptomus minutus	Diaptomus oregonensis	Cyclops vernalis brevispinosus	Cyclops vernalis americanus	Mesocyclops edax	Cyclops bicuspidatus var. thomasi
6:45	17/VI/49	14.44			(7) 11,820	(3) 14,547	(3) 20,002	(.75) 909	(.75) 909	(2) 11,820	(4) 13,638
9:30	19/VI/49	15.6		(4) 3,336	(2) 5,560	(10) 76,172	(3) 21,128	278	278	(2) 22,796	(5) 30,024
9:30	21/VI/49	17.2		(1.5) 2,224	(3) 6,672	(2) 65,608	(2) 52,264			(3) 6,672	(20) 35,584
9:30	25/VI/49	17.8		278	(0.5) 278	(7) 5,560	(1.3) 6,672			(2) 7,784	(2) 2,224
1:00	4/XII/49		92			12	9	18	21		1,043
1:00	16/I/50		1,996			9	15			649	823
1:00	15/II/50		3,941			49	49		3	636	1,126
1:00	1/IV/50		447			9					33
1:00	1/IV/50		492			3				85	66
1:00	5/V/50		406							64	67

N.B. The number in brackets indicates the ratio of the number per cu.m. in the vertical sample, to the number per cu.m. in the surface sample collected at the same time.

Table VI. NUMBERS PER CUBIC METER IN VERTICAL SAMPLES OF CLADOCERA OF HEMING LAKE, 1949-1950.

Time of Collection p.m.	Date of Collection	Temp. Deg. C.	Leptodora kindtii	Holopedium gibberium	Daphnia pulex form retrocurva	Daphnia longispina hyalina galeata	Daphnia longispina hyalina typica	Daphnia longispina hyalina breviora	Daphnia longispina	Chydorus sphaericus	Bosmina c.l. obtusirostris	Bosmina c. longispina	Bosmina longirostris
6:45	17/VI/49	14.4	682	(.5) 2,046		(2.3) 114,559	(0.71) 181,840		(1.3) 105,695	(0.88) 7,274			
9:30	19/VI/49	15.6	(0.2) 278	(1.2) 3,892		(1.5) 98,968	(1.5) 171,248		(0.25) 12,237	(1.3) 7,784	(0.4) 556		
9:30	21/VI/49	17.2	(0.6) 1,112	(12) 2,224	24,464	(11) 278,000	(4.2) 124,544		(24) 8,896	(14) 23,352	5,560		
9:30	25/VI/49	17.8	278	(10) 1,948	18,904	(2) 31,136	(1.5) 6,116			(4) 1,112			
1:00	4/XII/49					3	6			18	386	15	
1:00	16/I/50						6	6			122	24	12
1:00	15/II/50						9				1,310	465	73
1:00	1/IV/50						3				18	18	6
1:00	1/IV/50										12	24	15
1:00	5/V/50						6				6	3	

N.B. The number in brackets indicates the ratio of the number per cu.m. in the vertical sample, to the number per cu.m. in the surface sample collected at the same time.

COPEPODA OF HEMING LAKE

Epischura lacustris Forbes, 1882

This species occurred in only two out of eleven surface samples collected at Station 1 in May, 1949, but was found in eleven out of twelve surface samples taken at the same station in June collections. Since *E. lacustris* occurred in the second and third samples taken in May, it is evident that migration from the surface waters was the explanation for its apparent disappearance, as indicated by its absence from the remainder of the May surface samples. The peak in abundance at the surface for this organism (7,168 per cu. m.) occurred on June 11, 1949. It was evident, however, from vertical samples taken together with horizontal surface samples late in June, that this species is often more abundant below than at the surface. On June 17, it was over seven times as abundant (11,820 specimens per cu. m.) below the surface as at the surface.

Langford (1938) found *Epischura lacustris* more sensitive to light when in warm water (close to 20° C.) than in cold. He found that while in daylight this species would vacate surface waters at temperatures of 20°C. or greater, yet at night it would return to these warm upper strata. The author's observations are in agreement with those of Langford.

Epischura lacustris was not found in any of the vertical winter samples taken at Heming Lake between December 4, 1949, and May 5, 1950. It was, however, found in a sample taken October 4, 1948, at a water temperature of 5°C. It is probable that it disappears from the lake waters late in October or early in November soon after ice covers the surface.

Epischura nevadensis Lilljeborg, 1889

This species was not found in any of the collections made in the months of June, July or October, 1948. Yet in 1949, it was constantly associated with *E. lacustris* in ten surface collections made between June 5 and June 23. While it was absent from a surface collection made on June 25, it was present below the surface in a vertical sample taken at the same time and location. Moreover, from the time of its appearance in surface samples on June 5, 1949, until June 13, 1949 *E. nevadensis* occurred in larger numbers in these samples than did *E. lacustris*. It reached a peak in abundance at the surface, for the samples studied, at the same time as *E. lacustris*, namely on June 11, 1949. The numbers at that time were 11,648 per cu. m. From June 15, 1949 to June 25, 1949 this situation was reversed and *E. lacustris* was abundant in the surface samples studied than its fellow *Epischura*. Also in vertical samples taken late in June, 1949, *Epischura lacustris* was more abundant than *E. nevadensis* in three samples out of four, though in the fourth sample exactly equal numbers were found. In the first vertical sample, however, there were no Epischura nevadensis, while there were 11,820 Epischura lacustris per cu. m.

E. nevadensis, like E. lacustris, was absent from the winter samples collected at Heming Lake.

The absence of Epischura nevadensis from the collections taken in 1948, together with its presence in such abundance in 1949, is taken to denote that this species was present somewhere in Heming Lake even in 1948, but it must have been scarce indeed, when not even a single specimen was found in all the collections examined.

Diaptomus minutus Lilljeborg, 1889

Diaptomus minutus was constantly present in both surface and vertical plankton collections taken at Heming Lake. Its peak in abundance in the surface collections was reached on June 21, 1949, with 38,684 specimens per cu. m. On the same day a vertical sample taken at the same time had nearly twice (65,608) as many specimens per cu. m.

Although D. minutus was present and even continued to reproduce through the winter, its numbers were drastically reduced falling to a low of 3 specimens per cu. m. in one of the collections made on April 1, 1950, and with only 9 specimens per cu. m. in the other collection made on the same date. In the collection made on May 5, 1950 not a single specimen was obtained. Yet in a surface collection made on May 8, 1949 shortly after the ice melted, there were 3,414 specimens per cu. m.

Since during 1949, collections were made in May and June, while in 1948 surface collections were made during June and July, it might be thought advisable to compare only the June collections at this station. The average for surface collections in June, 1949 is 12,944 specimens of D. minutus per cu. m., while the average for surface collections in June, 1948 is 2,603 specimens of this copepod per cu. m. The average abundance of D. minutus in surface collections of June, 1949, is, therefore, about five times that found in surface collections of June, 1948. There seems to be evidence of a plankton pulse for this copepod in 1949.

It is to be noted that the average number of specimens of D. minutus per cu. m. in June, 1949 differs very little from the average number per cu. m. for both May and June of the same year. On the other hand the average number of this copepod for June, 1948 is about twice the average number per cu. m. for both June and July of the same year.

Diaptomus oregonensis Lilljeborg, 1889

This species was found in all surface collections of plankton from Heming Lake taken during May and June, 1949. It was also present in the vertical samples taken late in June, and was from 1.3 to three times as numerous in them as in surface samples taken at the same time. The peak in abundance for D. oregonensis in surface collections was reached on June 11, 1949, with 36,736 specimens per cu. m. On June 21, however, there were 52,264 specimens of *Diaptomus oregonensis* per cu. m. in a vertical sample and 25,911 per cu. m. in a surface sample taken at the same time.

Insofar as surface samplings alone are concerned during June and July, 1948, there was an average of 5,376 specimens of *D. oregonensis* per cu. m. while the average for surface samplings during May and June, 1949 was 10,162 per cu. m. Comparing June surface collections only there were on the average 11,776 specimens of *D. oregonensis* per cu. m. in 1948, and 12,318 per cu. m. in 1949. There appears to be no significant difference between the numbers of this copepod per cu. m. for June samplings. There was, however, a considerable drop in the average numbers of *D. oregonensis* in July, 1948, as compared with the average for June for the same year. As between May and June, 1949, there was roughly an increase of twenty per cent in June over the average number of this copepod present per cu. m. in May.

D. oregonensis was found in three out of six winter samples, being present in vertical samples taken in December, 1949 and January and February, 1950. Some of the specimens were females bearing eggs. There were only 9 specimens of this copepod per cu. m. in the collection of December 4, 1949; 15 specimens per cu. m. in the collection of January 16, 1950; and 49 specimens per cu. m. in the vertical sample taken on February 15, 1950. *Diaptomus oregonensis* was not found in the two collections taken in April, 1950, nor was it present in the sample taken through the ice early in May, 1950.

Cyclops albidus Jurine, 1820

A single specimen, a large female of this species was found in the surface collection taken at Station 1 on June 1, 1949 at 6:25 p.m. It was not found in any of the other collections made in 1948, or 1949, nor was it present in the winter samples taken during 1950. Gurney (1933) reports it as "found in the same conditions as *C. fuscus*, throughout the year", that is in clear weedy water.

Eucyclops agilis Koch, 1838

A single specimen of *Eucyclops agilis* was found in a surface collection taken at Station 1 on June 15, 1949 at 7:00 p.m. This species had been previously found in two plankton samples collected at Heming Lake in 1948, and was found at the same location in a sampling taken on July 26, 1948.

Cyclops bicuspidatus thomasi Forbes, 1882

This copepod was constantly present in both surface and vertical samples taken during May and June, 1949, as well as in the vertical samples taken during the period December, 1949 to May, 1950. It reached an amazing peak of 361,920 specimens per cu. m. in a surface collection taken on June 5, 1949. Oddly enough the peak for 1948 was recorded on June 4, but there were only 6,398 specimens per cu. m. in that collection. Thus at peaks for the two years there were nearly fifty-seven times as many of this copepod in 1949 as there were in 1948. Surely a plankton pulse of considerable magnitude!

The average for all surface collections made in June and July, 1948 was 1,652 specimens of Cyclops bicuspidatus per cu. m. The average for all surface collections made in May and June, 1949 was 47,285 specimens of Cyclops bicuspidatus per cu. m., or nearly twenty-nine times as many as for June and July of the previous year. The average for June, 1948 was 3, 067 specimens per cu. m. (nearly twice as many as for both June and July). The average was 66,828 specimens of C. bicuspidatus per cu. m. in the surface collections of June, 1949 nearly twenty-two times as many as for June, 1948, and about 1.4 times as many as for both May and June, 1949.

Cyclops bicuspidatus was from two to twenty times as numerous in four vertical samples taken late in June, 1949 as it was in the horizontal samples taken at the same time.

Although constantly present in winter samples it was much reduced in numbers, with as few as 33 specimens per cu. m. in a collection made through the ice in April, 1950. Another collection made at the same time had, however, twice as many specimens of the copepod. Reproduction continued, even at this unfavorable period, as evidenced by the presence of females bearing eggs, as well as of nauplii and of copepodids.

Mesocyclops edax Forbes, 1891

This species was present in all the surface collections made during May and June, 1949 and also in the vertical samples taken in June of that year. In the four vertical samples taken late in June it was from two to three times as abundant per cu. m. as in the horizontal samples taken at the same time. *Mesocyclops edax* was not found in two of the vertical samples taken during the winter, being absent from the collection made on December 12, 1949 and from one of the collections made on April 1, 1950 but present in the other collection made on the same date. It was also present in the collections made through the ice in January, February and May, 1950. Although females were present in the winter samples none were found bearing eggs, and males were completely absent from these collections. The numbers dropped off to a low of 64 specimens per cu. m. in the sample taken on May 5, 1950.

This species reached its peak in numbers present in surface collections on June 11, 1949 with 108,416 specimens per cu. m. This was over thirty times as many specimens per cu. m. as was obtained at the peak in June, 1948 and about twenty-five times as many as were found at the peak for surface collections in July, 1948. On the average there were over eight times as many specimens of this *Cyclops* in the surface collections of May and June, 1949 as there were in the surface collections of June and July, 1948. *Mesocyclops edax* was on the average 6.6 times as abundant in surface collections made in June, 1949 as it was in similar collections made in June, 1948. There seems sufficient evidence of a plankton pulse for this copepod also!

<u>Cyclops vernalis americanus</u> (<u>Cyclops americanus</u>) Marsh, 1893

This species was not constantly present in surface collections made at Station 1, being found in only 8 out of 11 collections made in May, 1949 and in only 2 of the 13 collections made in June of the same year. This copepod reversed the general trend for 1949 being relatively less abundant in surface samples in that year than it was in 1948. There was a drop in average numbers per cu. m. of about forty per cent in 1949. At the peak, however, there were 1,271 specimens of <u>Cyclops vernalis americanus</u> per cu. m. at the surface on June 17, 1949, while the corresponding peak for 1948 was on June 22 with 1,181 specimens per cu. m.

This copepod was present in two of the four vertical samples taken in June, 1949, and in one of the four surface samples taken at the same time. One June 17, 1949 it was about three-fourths as abundant in a vertical sample as it was in a surface sample taken at the same time. <u>Cyclops vernalis americanus</u> was found in only two of the winter samples, those of December 4, 1949 and of February 15, 1950. One female was found bearing eggs in the collection of December 4, 1949 but none were found in the sample of February 15, 1950. The numbers present in the winter samples dropped to 21 specimens per cu. m. in December, 1949 and to 3 per cu. m. in February, 1950.

<u>Cyclops vernalis</u>, Fischer, 1853

This species like <u>americanus</u> was not constantly present either in surface or vertical collections, being found in only

4 of 11 surface samples taken in May, 1949, and in only 2 of 13 collections taken in June, 1949. It, too, was less abundant, on the average, in surface collections taken in 1949 than it had been in June, 1948.

One June 17, 1949 C. vernalis was present in both a surface sample and in a vertical sample taken at the same time, being about three-fourths as abundant below the surface. It was present in a vertical collection but notat the surface on June 19, 1949, while on June 25, 1949 it was found in a surface sample but not in a vertical sample taken as the same time.

CLADOCERA OF HEMING LAKE

Sida crystallina Muller, 1785

This species was not found in the collections made in May or June, 1949, nor was it present in the winter samples collected. As it is commonly found among weeds near the shore and in the warmer months its absence from these collections is not surprising. In 1948 it was found in only three samples all of which were collected during July, and of which two were taken in shallow water among weeds.

Diaphanosoma brachyurum Lieven, 1848

This species was present in one out eleven surface collections made during May, 1949, and in four out of thirteen of the surface samples taken in June of that year. It was not found in the vertical samples taken late in June, but was present in two of the four surface samples taken at the same time. It was absent from the samples taken during the winter months, as was to be expected since previous records of its occurrence are from the warmer months. Diaphanosoma brachyurum was present to the extent of 337 specimens per cu. m. on June 4, 1948, while on June 5, 1949 only 15 specimens per cu. m. were found at the same location. The average number present for the four June collections at the surface were 246 per cu. m. It was, therefore, from somewhat less abundant to many times less frequent in 1949.

Holopedium gibberium Zaddach, 1855

This species was present in five of eleven surface samples collected in May, 1949, and in eleven of thirteen surface samples taken in June of the same year. It was present in the four vertical samples collected late in June, and was from one-half to twelve times as numerous in them as in the surface samples taken at the same time. On the average it was about 1.3 times as numerous below the surface as at the surface. In the surface samples taken in June, 1948, it was much more abundant than it was in surface samples collected in June, 1949. This was true both at the peak for these samplings and on the average. At the peak for surface samples taken in June, 1948 it was five times as numerous per cu. m. as at the peak for June, 1949. The average number per cu. m. for surface samples taken in June, 1948 was almost eight times the average number per cu. m. for the samples collected in June, 1949.

Daphnia longispina Muller, 1785

Daphnia longispina Muller was not found in the collections made at Heming Lake in 1948. It was, however, present in twenty-two out of twenty-four surface samples taken in May and June, 1949, and in three out of four vertical samples collected late in June of that year. In the three vertical samples which contained this form it was from one-fourth to twenty-four times as numerous per cu. m. as it was in the surface samples collected at the same time (Table IV). *Daphnia longispina* was not present in a vertical sample taken June 25, 1949, nor was it found in any of the winter samples. The peak in numbers in these collections was obtained on June 11, 1949 with almost 200,000 specimens per cu. m.(Table IV).

Daphnia longispina hyalina Leydig, 1860

Daphnia longispina hyalina Leydig was again represented by all of the forms found in the 1948 collections. Form *mendotae* was found only once, being present in the surface collection made on June 25, 1949. In the sample taken on that date there were 4,795 specimens per cu. m. It was not found in the vertical samples taken late in June, nor during the winter. This form had occurred with over 12,000 specimens per cu. m. in a surface sampling taken at the same location on June 7, 1948. Forms *typica* and *galeata* were, however, many times as numerous in 1949 as in 1948. At the peak on June 11, 1949 there were nearly 606,000 specimens of *typica* per cu. m. or nearly sixty-seven times as many as there were at the peak of this form on June 7, 1948. Typica was from seven-tenths to over four times (on the average 1.2 times) as numerous in vertical samples collected late in June as it was in surface samples taken at the same time. It was present in all but one of the winter samples taken through the ice, but was found in only one of the two collections made on April 1, 1950. It reached a low of 3 specimens per cu. m. on that date or less than 2 specimens per cu. m. if the two collections are averaged. This was the only daphnid form which was constantly found even in the winter samples. Two variants of typica must be reported. These were a form with an unusually long spine (designated longiora by the author) and a form with a very short spine (designated breviora by the author) resembling the "primitiva forms Burckhardt" figured by Woltereck (1932). The long-spined form occurred in five surface samples taken between May 13 and May 21, 1949, while the short-spined form also occurred in the first three of these samples, and in a surface collection made on June 1, 1949. It was next found in a vertical collection made through the ice on January 16, 1950. It must be mentioned, however, that the "primitiva forms" figured by Woltereck (1932) were much stunted animals, while the "breviora forms" of the present author though with stunted spines had normal bodies.

In surface collections made during May and June 1949 form galeata was constantly present, and was about four times as numerous at the peak on June 5, 1949 as it was on June 22, 1948, the peak for surface samples that year. It was also found in the four vertical samples taken late in June, and in one winter sample, a vertical sample through the ice, collected on December 4, 1949. In the four vertical samples taken between June 17 and June 25, 1949 it was between 1.5 and eleven times (on the average over three times) as numerous per cu. m. as in the surface collections made at the same time. It reached a peak of 278,000 specimens per cu. m. in the vertical collection made on June 21, 1949. Form galeata occurred only once in the winter collections, a single specimen being found in 327 liters of lake water strained through a plankton net, or about 3 specimens per cu. m. This specimen had the crest reduced to a tiny point and differed only in that respect from typica. It is probable that the crest disappeared altogether in the samples taken later in the winter, so that this form became indistinguishable from typica. This view is in agreement with the observations of Yeatman (correspondence with the author, 1949), who found a similar variation of the crest of galeata throughout the seasons in North Carolina waters. It must be mentioned, however, that galeata forms were present in the first collections made at Heming Lake in May, 1949 shortly after the ice had melted. These had very tiny crests but not so infinitesmal as those found in the collections of October, 1948 or of December, 1949.

A variant of galeata was one which combined the very short spine of the "primitiva" form with a very short pointed crest. This was found only in the collection taken at the surface on May 15, 1949. This may have resulted from the accidental breaking off of the spine, since such specimens were of rare occurrence.

Daphnia retrocurva Forbes, 1882
(Daphnia pulex parapulex form retrocurva Woltereck, 1932)

Daphnia retrocurva Forbes was found in only four of thirteen surface samples taken in June, 1949 and in none of the samples collected in May of that year. These were all forms with moderate or small crests. In samples taken at the surface it was 110 times as numerous per cu. m. on the average in June, 1948 as it was in June, 1949. At the peak for June, 1948 D. retrocurva was 24 times as numerous per cu. m. as it was for the peak in June, 1949. It was found in two of the vertical samples collected late in June, and was 55 times as numerous, on the average, in the vertical samples as it was in the two surface samples taken at the same time. The peak for this species in 1949 was found in a vertical sample taken on June 21, 1949 at which time there were 24,464 specimens per cu. m. Of these 4,448 per cu. m. or about 20 per cent were the large-crested form, this being the only occasion in 1949, when it was found. In 1948 the large-crested form of D. retrocurva was common in surface samplings taken in July (during the period of warmest weather), and was even found in the collection made on October 4, 1948.

Ceriodaphnia reticulata Jurine, 1820

Ceriodaphnia reticulata Jurine was found in only two surface collections, those of May 10 and May 28, 1949. It was not found in twenty-two other surface samples taken during May and June of the same year. Neither was it found in the vertical collections made late in June, 1949, nor in the winter samples taken between December 4, 1949 and May 5, 1950. On the basis of June surface samplings it appeared to be only about one-third as numerous in 1949, as in 1948.

Bosmina longirostris Muller, 1785

Bosmina longirostris Muller was found in only two of twenty-four surface samples taken in May and June, 1949, being present in the collections taken on May 10 and May 13, 1949. It was not found in the vertical samples taken between June 17 and June 25, 1949, but was present in four of the six winter samples being found in the sample taken on January 16, 1950, also in that of February 15, 1950, and in the two samples taken on April 1, 1950. In the winter collections no females were found bearing eggs. This species had a winter peak of 73 specimens per cu. m. on February 15, 1950, and a low of 6 specimens per cu. m. in one of the collections taken on April 1, while in the other sample taken at the same time there were 15 specimens per cu. m.

Bosmina longirostris var. brevicornis Hellich

Bosmina longirostris var. brevicornis Hellich was found in only one sample, a surface collection taken on May 15, 1949. It was not found in the collections made at Heming Lake in 1948. In the single collection in which it was found there were about 160 specimens per cu. m.

Bosmina coregoni longispina Leydig, 1860
(*Bosmina longispina* auct; Birge)

Bosmina longispina Leydig was found in seven out of twenty-four surface collections made in May and June, 1949 and in only two out of thirteen of the June collections. It was not found in the vertical samples taken late in June, but was present in all the winter collections (Table VI) with a high of 465 specimens per cu. m. on February 15, 1950, and a low of 3 specimens per cu. m. on May 5, 1950. On the average for the surface collections made in June, 1949 it would appear to be about nine times as numerous per cu. m. as in June, 1948. Females bearing eggs were found in the collections of December, 1949 and of January and February, 1950, but no in the collections made in April or May, 1950.

Bosmina coregoni longispina obtusirostris Sars, 1861
(*Bosmina obtusirostris* auct; Birge)

Bosmina obtusirostris Sars was again the most common species of this genus at Heming Lake, being present in twenty-one of twenty-four surface samples collected during May and June, 1949. While it was only found in two of the four vertical samples taken late in June, 1949, it was constantly present in the winter collections. In the sample taken on December 4, 1949 over three-fourths of the specimens were females bearing eggs. In the collection of January 16, 1950 only one female in ten was found bearing eggs, and in February no specimens with eggs were present in the sample examined. In the collections of April 1, 1950 the first sample contained no females bearing eggs while the second had an equal number with and without eggs. The few specimens present in the collection of May 5, 1950 were females without eggs.

At the peak for surface samples on June 5, 1949 there were 85,260 specimens per cu. m., while at the peak on June 7, 1948 there were only 3,276 specimens per cu. m. that is twenty-six times as many in 1949. On the average for surface samples taken at this station *B. obtusirostris* was over eight times as numerous per cu. m. in collections of June, 1949 as in the samples taken in June, 1948. On June 19, 1949 this species was four-tenths as numerous per cu. m. (Table VI) in a vertical sample taken at 9:30 p.m. as it was in a surface sample taken at the same time. Two days later in a collection made at 9:30 p.m. there were ten times as many specimens per cu. m. in a vertical collection (Table VI) but none were found in the surface collection made at the same time.

Acroperus harpae Baird, 1835

Acroperus harpae Baird was not found at this station in the collections made. As it is a littoral species its absence from these collections was not surprising. In the 1948 collections it was taken only once at the south end of the lake near shore and among weeds.

Chydorus sphaericus Muller, 1785

Chydorus sphaericus Muller was found in nineteen of twenty-four surface collections made in May and June, 1949. It was over four times as numerous per cu. m. on the average for the surface collections of June, 1949, as it was in similar collections made at the same station in June, 1948. This species was also found in the vertical samples taken late in June, 1949 and was from nine-tenths to fourteen (average 2.4 times) times as numerous in the vertical samples as it was in those taken at the surface at the same time. Chydorus sphaericus was only found in one winter collection, that of December 4, 1949 with only 18 specimens per cu. m. all of which were, however, females bearing eggs.

This species reached a peak of 15,660 specimens per cu. m. in a surface collection made on June 5, 1949, and was then over fifteen times as abundant as in the collection made on June 4, 1948. It was still more numerous in a vertical collection made on June 21, 1949, when there were 23,352 specimens per cu. m.

Chydorus sphaericus var. minor

This variety was not found in any of the collections made in this study and was recorded in only one June collection during 1948.

Polyphemus pediculus Linne, 1761

Polyphemus pediculus Linne is typically a littoral form and was not found at this station either in 1948 or in 1949. It was, however, recorded from two littoral stations in 1948.

Leptodora kindtii Focke, 1844

Leptodora kindtii Focke was taken in eight of twenty-four surface samples (Table II) collected in May and June, 1949, while it was found in only one of three surface collections made in June, 1948. This is easily explained since samples were taken in the evening in 1949. While it occurred in the four vertical samples taken late in June, 1949, it was only found in two of the surface samples taken at the same time. At 9:30 p.m. on June 19, 1949 there were five times as many specimens per cu. m. at the surface as were found below the surface in a vertical collection. At 9:30 p.m. on June 21, 1949 there were 1.7 times as many specimens per cu. m. at the surface as were taken below the surface in a vertical collection. On June 17, 1949 at 6:45 p.m. no specimens L. kindtii were found in a surface collection though it was present below the surface. Again at 9:30 p.m. on June 25, 1949 this species was present in a vertical collection but none were found in the surface sample taken at the same time.

Both vertical migration as a result of negative response to bright light and local swarming are suggested as factors influencing the varying distribution of this cladoceran.

L. kindtii was not found in any of the winter samples collected at Heming Lake, though it was found in the surface collection made on October 4, 1948 at 2:00 p.m.

SUMMARY AND CONCLUSIONS

There appeared to be a definite plankton pulse for certain *Copepoda* and *Cladocera* of Heming Lake in June, 1949. This is illustrated by Table VII. Table VII shows also that certain organisms, notably *Daphnia retrocurva*, reversed the general trend and were much reduced in numers. There was in June, 1949, no definite plankton pulse for *Epischura lacustris* and only a slight increase in the numbers of *Diaptomus oregonensis*. There appeared, however, to be a great pulse for *Epischura nevadensis*, since in 1948 plankton tows *no* specimens were taken, while in 1949 it was found to be very *numerous* indeed.

The following explanation is suggested for the occurrence of a plankton pulse in 1949. Near the outlet draining Heming Lake a large beaver dam had been constructed restraining the outflow and raising the water level. When this dam was destroyed at the end of June the level of Heming Lake soon dropped by over a foot. The rise of the waters is believed to have enriched the waters of Heming Lake by an influx of the organically rich bog and swamp waters from the regions bordering this lake. Initially this probably resulted in an increase in the blue-green algae and diatoms, and subsequently in the increase of the *Copepoda* and *Cladocera* noted above. This explanation is in agreement

Table VII. Ratios of Copepoda and Cladocera as to numbers per cu. m. for June, 1949 and June, 1948

Organism	Average No. June/49 : Average No. June/48	Peak June/49 : Peak June/48
Cyclops bicuspidatus thomasi	22:1	57:1
Mesocyclops edax	7:1	30:1
Diaptomus minutus	5:1	12:1
Diaptomus oregonensis	12:1	2.5:1
Bosmina coregoni longispina	9:1	19:1
Bosmina c. l. obtusirostris	8:1	26:1
Ceriodaphnia reticulata	1:3	1:3
Chydorus sphaericus	4:1	15:1
Daphnia longispina hyalina galeata	2.5:1	4:1
Daphnia longispina hyalina typica	33:1	67:1
Daphnia retrocurva	1:110	1:24

with the observations of Dr. Samuel Eddy of similar plankton pulses in the waters of Minnesota lakes. No satisfactory explanation for the observed reduction in numbers of *Daphnia retrocurva* is presently available.

DISCUSSION

Favourable temperature and sufficient sunlight are the factors which produce the greatest development of the basic food plants (diatoms, blue-green algae, etc.) on which animal life in the water ultimately depends. It is, therefore, logical that during June and July, when conditions of sunlight and temperature are most favourable, there should be the greatest flowering first of the basic food plants and subsequently of plankton *Entomostraca*. Reductions of numbers during the winter results from the drop in temperature and decrease of sunlight, which affect first the basic food plants, and ultimately the tiny crustacea dependent thereon.

In some cases the temperature as it drops possibly reaches a *lethal* temperature for such organisms as *Holopedium*, *Leptodora* and *Daphnia retrocurva*, and possibly *Epischura*, though the possibility of the hibernation of this form as an adult must not be overlooked. Studies of Lake Winnipeg and of West Hawk Lake confirm this view by the absence of these organisms from all winter collections.

SEX AND AGE RATIOS OF ENTOMOSTRACA OF HEMING LAKE FROM COLLECTIONS MADE DURING THE SUMMER OF 1949 AND DURING THE WINTER OF 1949-1950

For each of the species of Entomostraca found in Heming Lake a tabulation was again made of the percentage of specimens of females bearing eggs, females not bearing eggs, of males, and of young. For the Cladocera ephippial females were also included in the tabulation. For the Copepoda the term young is used to include only copepodid stages, and not nauplii or natanauplii. The tabulation is done for each species omitting only those of very infrequent occurrence. Results obtained were as follows:

COPEPODA

Epischura lacustris

LOCATION 1	DATE	TIME P.M.	Temperature Degrees Centigrade		Percentage of Egg-Bearing Females.	Percentage of other Females	Percentage of Males	Pecentage of Young
Surf.	8/V/49	7.15						
Surf.	10/V/49	9.00						100
Surf.	13/V/49	7.15				50	50	
Surf.	15/V/49	7.15						
Surf.	17/V/49	7.15						
Surf.	19/V/49	7.15						
Surf.	21/V/49							
Surf.	23/V/49	6.35						
Surf.	25/V/49	6.45						
Surf.	28/V/49	6.15						
Surf.	30/V49	6.15						
Surf.	1/VI/49	6.25						
Surf.	3/VI/49	6.50						
Surf.	5/VI/49	6.30					100	
Surf.	7/VI/49	8.15					33	67
Surf.	9/VI/49	6.00				14	14	72
Surf.	11/VI/49	7.45				38	12	50
Surf.	13/VI/49	7.00				20	40	40
Surf.	15/VI/49	7.00				25	50	25
Surf.	17/VI/49	6.45	14.44			80	20	
Surf.	19/VI/49	9.30	15.55			72	14	14
Surf.	21/VI/49	9.30	17.22			20	80	
Surf,	23/VI/49	9.30	16.66			24	50	26
Surf.	25/VI/49	9.30	17.77			50	50	
Vert.	17/VI/49	6.45	14.44			16	23	61
Vert.	19/VI/49	9.30	15.55			60	10	30
Vert.	21/VI/49	9.30	17.22			17	17	66
Vert.	25/VI/49	9.30	17.77				100	
Vert.	4/XII/49	1.00						
Vert.	16/I/50	1.00						
Vert.	15/II/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	5/V/50	1.00						

COPEPODA

Epischura nevadensis

Location 1	Date	Time P.M.	Temperature Degrees Centigrade		Percentage of Egg-bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
Surf.	8/V/49	7.15						
Surf.	10/V/49	9.00						
Surf.	13/V/49	7.15						
Surf.	15/V/49	7.15						
Surf.	17/V/49	7.15						
Surf.	19/V/49	7.15						
Surf.	21/V/49							
Surf.	23/V/49	6.35						
Surf.	25/V/49	6.45						
Surf.	28/V/49	6.15						
Surf.	30/V/49	6.15						
Surf.	1/VI/49	6.25						
Surf.	3/VI/49	6.50						
Surf.	5/VI/49	6.30						
Surf.	7/VI/49	8.15						100
Surf.	9/VI/49	6.00						100
Surf.	11/VI/49	7.45				12	12	76
Surf.	13/VI/49	7.00				40	30	30
Surf.	15/VI/49	7.00				10	40	50
Surf.	17/VI/49	6.45	14.44			33	33	34
Surf.	19/VI/49	9.30	15.55			67	33	
Surf.	21/VI/49	9.30	17.22			50	50	
Surf.	23/VI/49	9.30	16.66			14	72	14
Surf.	25/VI/49	9.30	17.77			30	20	50
Vert.	17/VI/49	6.45	14.44					
Vert.	19/VI/49	9.30	15.55					
Vert.	21/VI/49	9.30	17.22			40	60	
Vert.	25/VI/49	9.30	17.77				67	33
Vert.	4/XII/49	1.00					100	
Vert.	16/I/50	1.00						
Vert.	15/II/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	5/V/50	1.00						

COPEPODA

Diaptomus minutus

Location 1	Date	Time P.M.	Temperature Degrees Centigrade		Percentage of Egg-bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
Surf.	8/V/49	7.15						
Surf.	10/V/49	9.00			35	58	7	
Surf.	13/V/49	7.15			20	30	50	
Surf.	15/V/49	7.15			7	43	50	
Surf.	17/V/49	7.15			36	34	34	
Surf.	19/V/49	7.15			29	42	29	
Surf.	21/V/49				28	46	26	
Surf.	23/V/49	6.35			58	29	13	
Surf.	25/V/49	6.45			47	30	23	
Surf.	28/V/49	6.15			37	63		
Surf.	30/V/49	6.15			9	23	68	
Surf.	1/VI/49	6.25			25	50	25	
Surf.	3/VI/49	6.50				67	33	
Surf.	5/VI/49	6.30			45	33	22	
Surf.	7/VI/49	8.15			25	17	17	41
Surf.	9/VI/49	6.00			8	60	8	24
Surf.	11/VI/49	7.45			15	10	15	60
Surf.	13/VI/49	7.00			14	16	10	60
Surf.	15/VI/49	7.00			15	37	4	44
Surf.	17/VI/49	6.45	14.44		16	33	7	44
Surf.	19/VI/49	9.30	15.55		10	80	10	
Surf.	21/VI/49	9.30	17.22		10	50	10	30
Surf.	23/VI/49	9.30	16.66		6	27	38	29
Surf.	25/VI/49	9.30	17.77		50	50		
Vert.	17/VI/49	6.45	14.44			60	30	10
Vert.	19/VI/49	9.30	15.55			37	37	26
Vert.	21/VI/49	9.30	17.22		5	40	3	52
Vert.	25/VI/49	9.30	17.77		17	34	25	24
Vert.	4/XII/49	1.00				60	40	
Vert.	18/I/50	1.00				25	50	25
Vert.	15/II/50	1.00					100	
Vert.	1/IV/50	1.00			25	37	38	
Vert.	1/IV/50	1.00			67	33		
Vert.	5/V/50	1.00					100	

COPEPODA

Diaptomus oregonensis

LOCATION 1	DATE	TIME P.M.	Temperature Degrees Centigrade		Percentage of Egg-Bearing Females.	Percentage of other Females	Percentage of Males	Pecentage of Young
Surf.	8/V/49	7.15			46	46	6	2
Surf.	10/V/49	9.00			50	25	18	7
Surf.	13/V/49	7.15			11	57	32	
Surf.	15/V/49	7.15			27	57	12	4
Surf.	17/V/49	7.15			31	64	4	1
Surf.	19/V/49	7.15			24	57	19	
Surf.	21/V/49				30	32	33	5
Surf.	23/V/49	6.35			20	70	10	
Surf.	25/V/49	6.45			25	33	42	
Surf.	28/V/49	6.15			8	69	23	
Surf.	30/V49	6.15			16	58	5	21
Surf.	1/VI/49	6.25			14	80	6	
Surf.	3/VI/49	6.50			43	36	21	
Surf.	5/VI/49	6.30			25	38	12	25
Surf.	7/VI/49	8.15			11	61	7	21
Surf.	9/VI/49	6.00			18	18	9	55
Surf.	11/VI/49	7.45			7	24	5	64
Surf.	13/VI/49	7.00			14	38	10	38
Surf.	15/VI/49	7.00			13	47	4	36
Surf.	17/VI/49	6.45	14.44		7	52	7	34
Surf.	19/VI/49	9.30	15.55			56	5	39
Surf.	21/VI/49	9.30	17.22		6	50	11	33
Surf,	23/VI/49	9.30	16.66			83		17
Surf.	25/VI/49	9.30	17.77			75	5	20
Vert.	17/VI/49	6.45	14.44			45	10	45
Vert.	19/VI/49	9.30	15.55		16	42	8	34
Vert.	21/VI/49	9.30	17.22		15	21	32	32
Vert.	25/VI/49	9.30	17.77		8	75	17	
Vert.	4/XII/49	1.00			34	33	33	
Vert.	16/I/50	1.00				80	20	
Vert.	15/II/50	1.00			25	37	38	
Vert.	1/IV/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	5/V/50	1.00						

COPEPODA

Cyclops bicuspidatus var. thomasi

Location 1	Date	Time P.M.	Temperature Degrees Centigrade		Percentage of Egg-bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
Surf.	8/V/49	7.15			48	48	4	
Surf.	10/V/49	9.00			25	30	38	7
Surf.	13/V/49	7.15			63	32	2	3
Surf.	15/V/49	7.15			72	25	2	1
Surf.	17/V/49	7.15			49	37	10	4
Surf.	19/V/49	7.15			56	30	8	6
Surf.	21/V/49				45	21	6	28
Surf.	23/V/49	6.35			35	39	3	23
Surf.	25/V/49	6.45			22	55	9	14
Surf.	28/V/49	6.15			10	58	6	26
Surf.	30/V/49	6.15			14	32	4	50
Surf.	1/VI/49	6.25			9	53	4	34
Surf.	3/VI/49	6.50			4	79	8	9
Surf.	5/VI/49	6.30			2	5	2	91
Surf.	7/VI/49	8.15			6	26	1	67
Surf.	9/VI/49	6.00			3	27	3	67
Surf.	11/VI/49	7.45			5	64	5	26
Surf.	13/VI/49	7.00			7	28	2	63
Surf.	15/VI/49	7.00				63	7	30
Surf.	17/VI/49	6.45	14.44			33	13	54
Surf.	19/VI/49	9.30	15.55			94	6	
Surf.	21/VI/49	9.30	17.22			56	22	22
Surf.	23/VI/49	9.30	16.66			83	3	8
Surf.	25/VI/49	9.30	17.77		76		16	8
Vert.	17/VI/49	6.45	14.44			7	3	90
Vert.	19/VI/49	9.30	15.55			43	6	51
Vert.	21/VI/49	9.30	17.22			63	6	31
Vert.	25/VI/49	9.30	17.77			100		
Vert.	4/XII/49	1.00			1	15	2	82
Vert.	16/I/50	1.00			1	9	2	88
Vert.	15/II/50	1.00				35	3	62
Vert.	1/IV/50	1.00				27	9	64
Vert.	1/IV/50	1.00				45	14	41
Vert.	5/V/50	1.00				41	9	50

COPEPODA

Cyclops leuckart var. edax = M. edax

LOCATION 1	DATE	TIME P.M.	Temperature Degrees Centigrade		Percentage of Egg-Bearing Females.	Percentage of other Females	Percentage of Males	Pecentage of Young
Surf.	8/V/49	7.15						100
Surf.	10/V/49	9.00				5		95
Surf.	13/V/49	7.15			3	7		90
Surf.	15/V/49	7.15			4	12		84
Surf.	17/V/49	7.15			5	28		67
Surf.	19/V/49	7.15			8	31		61
Surf.	21/V/49					20		80
Surf.	23/V/49	6.35				20		80
Surf.	25/V/49	6.45				100		
Surf.	28/V/49	6.15			7	60		33
Surf.	30/V49	6.15				57		43
Surf.	1/VI/49	6.25				69	1	30
Surf.	3/VI/49	6.50			9	67	24	
Surf.	5/VI/49	6.30			8	23	8	71
Surf.	7/VI/49	8.15			7	57	11	25
Surf.	9/VI/49	6.00				33		67
Surf.	11/VI/49	7.45			6	41	8	45
Surf.	13/VI/49	7.00			10	65	5	20
Surf.	15/VI/49	7.00			14	50	7	29
Surf.	17/VI/49	6.45	14.44		52	37	11	
Surf.	19/VI/49	9.30	15.55		87	13		
Surf.	21/VI/49	9.30	17.22		25	50	17	8
Surf,	23/VI/49	9.30	16.66		43	29	14	14
Surf.	25/VI/49	9.30	17.77		23	61	5	11
Vert.	17/VI/49	6.45	14.44		23	38	16	23
Vert.	19/VI/49	9.30	15.55		85		5	10
Vert.	21/VI/49	9.30	17.22		43	43	14	
Vert.	25/VI/49	9.30	17.77		29	71		
Vert.	4/XII/49	1.00						
Vert.	16/I/50	1.00						100
Vert.	15/II/50	1.00						100
Vert.	1/IV/50	1.00						
Vert.	1/IV/50	1.00						100
Vert.	5/V/50	1.00						100

COPEPODA

Cyclops vernalis var. americanus

Location 1	Date	Time P.M.	Temperature Degrees Centigrade		Percentage of Egg-bearing Females	Percentage of other Females	Percentage of Males	Percentage of Young
Surf.	8/V/49	7.15						
Surf.	10/V/49	9.00						
Surf.	13/V/49	7.15						
Surf.	15/V/49	7.15				100		
Surf.	17/V/49	7.15				100		
Surf.	19/V/49	7.15				100		
Surf.	21/V/49							
Surf.	23/V/49	6.35			67	33		
Surf.	25/V/49	6.45			50	50		
Surf.	28/V/49	6.15				100		
Surf.	30/V/49	6.15			25	75		
Surf.	1/VI/49	6.25			50			50
Surf.	3/VI/49	6.50				100		
Surf.	5/VI/49	6.30						
Surf.	7/VI/49	8.15						
Surf.	9/VI/49	6.00						
Surf.	11/VI/49	7.45						
Surf.	13/VI/49	7.00						
Surf.	15/VI/49	7.00						
Surf.	17/VI/49	6.45	14.44					
Surf.	19/VI/49	9.30	15.55			100		
Surf.	21/VI/49	9.30	17.22					
Surf.	23/VI/49	9.30	16.66					
Surf.	25/VI/49	9.30	17.77					
Vert.	17/VI/49	6.45	14.44					
Vert.	19/VI/49	9.30	15.55			100		
Vert.	21/VI/49	9.30	17.22			100		
Vert.	25/VI/49	9.30	17.77					
Vert.	4/XII/49	1.00						
Vert.	16/I/50	1.00			14	86		
Vert.	15/II/50	1.00						
Vert.	1/IV/50	1.00				100		
Vert.	1/IV/50	1.00						
Vert.	5/V/50	1.00						

COPEPODA

Cyclops vernalis var. brevispinosus

= Cyclops vernalis Fischer

LOCATION 1	DATE	TIME P.M.	Temperature Degrees Centigrade		Percentage of Egg-Bearing Females.	Percentage of other Females	Percentage of Males	Pecentage of Young
Surf.	8/V/49	7.15						
Surf.	10/V/49	9.00						
Surf.	13/V/49	7.15			29	29	42	
Surf.	15/V/49	7.15			50	50		
Surf.	17/V/49	7.15			50	50		
Surf.	19/V/49	7.15						
Surf.	21/V/49							
Surf.	23/V/49	6.35						
Surf.	25/V/49	6.45						
Surf.	28/V/49	6.15						
Surf.	30/V49	6.15						100
Surf.	1/VI/49	6.25						
Surf.	3/VI/49	6.50						
Surf.	5/VI/49	6.30						
Surf.	7/VI/49	8.15						
Surf.	9/VI/49	6.00						
Surf.	11/VI/49	7.45						
Surf.	13/VI/49	7.00						
Surf.	15/VI/49	7.00						
Surf.	17/VI/49	6.45	14.44			100		
Surf.	19/VI/49	9.30	15.55					
Surf.	21/VI/49	9.30	17.22					
Surf.	23/VI/49	9.30	16.66					
Surf.	25/VI/49	9.30	17.77					100
Vert.	17/VI/49	6.45	14.44			100		
Vert.	19/VI/49	9.30	15.55			100		
Vert.	21/VI/49	9.30	17.22					
Vert.	25/VI/49	9.30	17.77					
Vert.	4/XII/49	1.00			33	67		
Vert.	16/I/50	1.00						
Vert.	15/II/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	5/V/50	1.00						

DISCUSSION

A study of the sex and age ratios of the Copepoda of Heming Lake shows that reproduction continues actively throughout the year, even though numbers of specimens are greatly reduced during the winter. The continuance of reproduction is shown by the presence of females bearing eggs and/or by the presence of young forms. *Epischura lacustris* and *Epischura nevadensis*, unlike the other copepods, were not found in any of the winter samples. *Epischura lacustris* was, however, found to be still active in the cool waters of Heming Lake (at a temperature of 5°C.) on October 4, 1948. As already suggested there is the possibility of adults of this genus burrowing into the mud and thus hibernating during the winter. The presence of adult males and females of *E. lacustris* on May 13, 1949 (about one week after the ice melted) would appear to somewhat confirm this possibility.

CLADOCERA

Bosmina longirostris

LOCATION 1	DATE	TIME P.M.	Temperature Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg-Bearing Females.	Percentage of other Females	Percentage of Males	Pecentage of Young
Surf.	8/V/49	7.15						
Surf.	10/V/49	9.00			100			
Surf.	13/V/49	7.15			100			
Surf.	15/V/49	7.15			33	67		
Surf.	17/V/49	7.15						
Surf.	19/V/49	7.15						
Surf.	21/V/49							
Surf.	23/V/49	6.35						
Surf.	25/V/49	6.45						
Surf.	28/V/49	6.15						
Surf.	30/V49	6.15						
Surf.	1/VI/49	6.25						
Surf.	3/VI/49	6.50						
Surf.	5/VI/49	6.30						
Surf.	7/VI/49	8.15						
Surf.	9/VI/49	6.00						
Surf.	11/VI/49	7.45						
Surf.	13/VI/49	7.00						
Surf.	15/VI/49	7.00						
Surf.	17/VI/49	6.45	14.44					
Surf.	19/VI/49	9.30	15.55					
Surf.	21/VI/49	9.30	17.22					
Surf,	23/VI/49	9.30	16.66					
Surf.	25/VI/49	9.30	17.77					
Vert.	17/VI/49	6.45	14.44					
Vert.	19/VI/49	9.30	15.55					
Vert.	21/VI/49	9.30	17.22					
Vert.	25/VI/49	9.30	17.77					
Vert.	4/XII/49	1.00						
Vert.	16/I/50	1.00				100		
Vert.	15/II/50	1.00				100		
Vert.	1/IV/50	1.00				100		
Vert.	1/IV/50	1.00				100		
Vert.	5/V/50	1.00						

CLADOCERA

Bosmina longispina

LOCATION 1	DATE	TIME P.M.	Temperature Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg-Bearing Females.	Percentage of other Females	Percentage of Males	Pecentage of Young
Surf.	8/V/49	7.15						
Surf.	10/V/49	9.00						
Surf.	13/V/49	7.15			100			
Surf.	15/V/49	7.15						
Surf.	17/V/49	7.15				100		
Surf.	19/V/49	7.15						
Surf.	21/V/49					100		
Surf.	23/V/49	6.35						
Surf.	25/V/49	6.45						
Surf.	28/V/49	6.15			50	50		
Surf.	30/V49	6.15			40	60		
Surf.	1/VI/49	6.25			100			
Surf.	3/VI/49	6.50			67	33		
Surf.	5/VI/49	6.30						
Surf.	7/VI/49	8.15						
Surf.	9/VI/49	6.00						
Surf.	11/VI/49	7.45						
Surf.	13/VI/49	7.00						
Surf.	15/VI/49	7.00						
Surf.	17/VI/49	6.45	14.44					
Surf.	19/VI/49	9.30	15.55					
Surf.	21/VI/49	9.30	17.22					
Surf,	23/VI/49	9.30	16.66					
Surf.	25/VI/49	9.30	17.77					
Vert.	17/VI/49	6.45	14.44					
Vert.	19/VI/49	9.30	15.55					
Vert.	21/VI/49	9.30	17.22					
Vert.	25/VI/49	9.30	17.77					
Vert.	4/XII/49	1.00			100			
Vert.	16/I/50	1.00				100		
Vert.	15/II/50	1.00			3	97		
Vert.	1/IV/50	1,00				100		
Vert.	1/IV/50	1.00				100		
Vert.	5/V/50	1.00				100		

CLADOCERA

Bosmina obtusirostris

LOCATION 1	DATE	TIME P.M.	Temperature Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg-Bearing Females.	Percentage of other Females	Percentage of Males	Pecentage of Young
Surf.	8/V/49	7.15			83	17		
Surf.	10/V/49	9.00			83	17		
Surf.	13/V/49	7.15			89	11		
Surf.	15/V/49	7.15			98	2		
Surf.	17/V/49	7.15			100			
Surf.	19/V/49	7.15			97	3		
Surf.	21/V/49				56	44		
Surf.	23/V/49	6.35			67	33		
Surf.	25/V/49	6.45			93	7		
Surf.	28/V/49	6.15			80	6		14
Surf.	30/V49	6.15			67	33		
Surf.	1/VI/49	6.25			97	3		
Surf.	3/VI/49	6.50			39	61		
Surf.	5/VI/49	6.30			41	31		28
Surf.	7/VI/49	8.15			60	40		
Surf.	9/VI/49	6.00			100			
Surf.	11/VI/49	7.45			100			
Surf.	13/VI/49	7.00			100			
Surf.	15/VI/49	7.00			100			
Surf.	17/VI/49	6.45	14.44		30	70		
Surf.	19/VI/49	9.30	15.55		100			
Surf.	21/VI/49	9.30	17.22					
Surf.	23/VI/49	9.30	16.66					
Surf.	25/VI/49	9.30	17.77					
Vert.	17/VI/49	6.45	14.44					
Vert.	19/VI/49	9.30	15.55		50	50		
Vert.	21/VI/49	9.30	17.22		20	80		
Vert.	25/VI/49	9.30	17.77					
Vert.	4/XII/49	1.00			78	3		19
Vert.	16/I/50	1.00			10	90		
Vert.	15/II/50	1.00				100		
Vert.	1/IV/50	1.00				100		
Vert.	1/IV/50	1.00			50	50		
Vert.	5/V/50	1.00				100		

CLADOCERA

Ceriodaphnia reticulata

LOCATION 1	DATE	TIME P.M.	Temperature Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg-Bearing Females.	Percentage of other Females	Percentage of Males	Pecentage of Young
Surf.	8/V/49	7.15						
Surf.	10/V/49	9.00				100		
Surf.	13/V/49	7.15						
Surf.	15/V/49	7.15						
Surf.	17/V/49	7.15						
Surf.	19/V/49	7.15						
Surf.	21/V/49							
Surf.	23/V/49	6.35						
Surf.	25/V/49	6.45						
Surf.	28/V/49	6.15						
Surf.	30/V49	6.15						100
Surf.	1/VI/49	6.25						
Surf.	3/VI/49	6.50						
Surf.	5/VI/49	6.30						
Surf.	7/VI/49	8.15						
Surf.	9/VI/49	6.00						
Surf.	11/VI/49	7.45						
Surf.	13/VI/49	7.00						
Surf.	15/VI/49	7.00						
Surf.	17/VI/49	6.45	14.44					
Surf.	19/VI/49	9.30	15.55					
Surf.	21/VI/49	9.30	17.22					
Surf,	23/VI/49	9.30	16.66					
Surf.	25/VI/49	9.30	17.77					
Vert.	17/VI/49	6.45	14.44					
Vert.	19/VI/49	9.30	15.55					
Vert.	21/VI/49	9.30	17.22					
Vert.	25/VI/49	9.30	17.77					
Vert.	4/XII/49	1.00						
Vert.	16/I/50	1.00						
Vert.	15/II/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	5/V/50	1.00						

CLADOCERA

Chydorus sphaericus

LOCATION 1	DATE	TIME P.M.	Temperature Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg-Bearing Females.	Percentage of other Females	Percentage of Males	Pecentage of Young
Surf.	8/V/49	7.15				100		
Surf.	10/V/49	9.00						
Surf.	13/V/49	7.15						
Surf.	15/V/49	7.15						
Surf.	17/V/49	7.15						
Surf.	19/V/49	7.15						
Surf.	21/V/49				50	50		
Surf.	23/V/49	6.35			40	60		
Surf.	25/V/49	6.45			91	9		
Surf.	28/V/49	6.15			82	18		
Surf.	30/V49	6.15			75	25		
Surf.	1/VI/49	6.25			88	12		
Surf.	3/VI/49	6.50			67	33		
Surf.	5/VI/49	6.30			100			
Surf.	7/VI/49	8.15			88	12		
Surf.	9/VI/49	6.00			63	37		
Surf.	11/VI/49	7.45			100			
Surf.	13/VI/49	7.00			100			
Surf.	15/VI/49	7.00			100			
Surf.	17/VI/49	6.45	14.44		29	71		
Surf.	19/VI/49	9.30	15.55		100			
Surf.	21/VI/49	9.30	17.22		67	33		
Surf.	23/VI/49	9.30	16.66		67	33		
Surf.	25/VI/49	9.30	17.77		100			
Vert.	17/VI/49	6.45	14.44			100		
Vert.	19/VI/49	9.30	15.55		71	29		
Vert.	21/VI/49	9.30	17.22		86	14		
Vert.	25/VI/49	9.30	17.77			100		
Vert.	4/XII/49	1.00			100			
Vert.	16/I/50	1.00						
Vert.	15/II/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	5/V/50	1.00						

CLADOCERA

Daphnia longispina

LOCATION 1	DATE	TIME P.M.	Temperature Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg-Bearing Females.	Percentage of other Females	Percentage of Males	Pecentage of Young
Surf.	8/V/49	7.15						
Surf.	10/V/49	9.00						
Surf.	13/V/49	7.15			40			60
Surf.	15/V/49	7.15			25	75		
Surf.	17/V/49	7.15			65			35
Surf.	19/V/49	7.15			90			10
Surf.	21/V/49				43	21		36
Surf.	23/V/49	6.35			63	25		12
Surf.	25/V/49	6.45			55	3		42
Surf.	28/V/49	6.15			27	17		56
Surf.	30/V49	6.15			38	25		56
Surf.	1/VI/49	6.25			97	3		
Surf.	3/VI/49	6.50			100			
Surf.	5/VI/49	6.30			64			36
Surf.	7/VI/49	8.15			60			40
Surf.	9/VI/49	6.00			65	6		29
Surf.	11/VI/49	7.45		3	46	11		40
Surf.	13/VI/49	7.00			56	11		33
Surf.	15/VI/49	7.00			70			30
Surf.	17/VI/49	6.45	14.44		18	19		63
Surf.	19/VI/49	9.30	15.55		43	29		27
Surf.	21/VI/49	9.30	17.22			100		
Surf,	23/VI/49	9.30	16.66	6		88		6
Surf.	25/VI/49	9.30	17.77		25	63		12
Vert.	17/VI/49	6.45	14.44	2	10	8		80
Vert.	19/VI/49	9.30	15.55	10	45	45		
Vert.	21/VI/49	9.30	17.22	25	75			
Vert.	25/VI/49	9.30	17.77	20		80		
Vert.	4/XII/49	1.00			50	50		
Vert.	16/I/50	1.00				100		
Vert.	15/II/50	1.00			3	97		
Vert.	1/IV/50	1.00				100		
Vert.	1/IV/50	1.00				100		
Vert.	5/V/50	1.00				100		

CLADOCERA

Daphnia longispina var. hyalina form galeata

LOCATION 1	DATE	TIME P.M.	Temperature Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg-Bearing Females.	Percentage of other Females	Percentage of Males	Pecentage of Young
Surf.	8/V/49	7.15			82	9		9
Surf.	10/V/49	9.00				100		
Surf.	13/V/49	7.15			67	33		
Surf.	15/V/49	7.15			100			
Surf.	17/V/49	7.15			100			
Surf.	19/V/49	7.15			67	33		
Surf.	21/V/49				27	27		46
Surf.	23/V/49	6.35			40	60		
Surf.	25/V/49	6.45			38	24		38
Surf.	28/V/49	6.15						100
Surf.	30/V49	6.15			83	17		
Surf.	1/VI/49	6.25			50	50		
Surf.	3/VI/49	6.50						
Surf.	5/VI/49	6.30						
Surf.	7/VI/49	8.15						
Surf.	9/VI/49	6.00						
Surf.	11/VI/49	7.45						
Surf.	13/VI/49	7.00						
Surf.	15/VI/49	7.00						
Surf.	17/VI/49	6.45	14.44					
Surf.	19/VI/49	9.30	15.55					
Surf.	21/VI/49	9.30	17.22					
Surf,	23/VI/49	9.30	16.66					
Surf.	25/VI/49	9.30	17.77					
Vert.	17/VI/49	6.45	14.44					
Vert.	19/VI/49	9.30	15.55					
Vert.	21/VI/49	9.30	17.22					
Vert.	25/VI/49	9.30	17.77					
Vert,	4/XII/49	1.00						
Vert.	16/I/50	1.00						
Vert.	15/II/50	1.00						
Vert,	1/IV/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	5/V/50	1,00						

CLADOCERA

Daphnia longispina var. hyalina form typica

LOCATION 1	DATE	TIME P.M.	Temperature Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg-Bearing Females.	Percentage of other Females	Percentage of Males	Pecentage of Young
Surf.	8/V/49	7.15			57	30		13
Surf.	10/V/49	9.00			25	41		34
Surf.	13/V/49	7.15			57	29		14
Surf.	15/V/49	7.15			90			
Surf.	17/V/49	7.15			71	1		28
Surf.	19/V/49	7.15			93			
Surf.	21/V/49				12	12		76
Surf.	23/V/49	6.35			42	11		47
Surf.	25/V/49	6.45			59	2		39
Surf.	28/V/49	6.15			40	9		51
Surf.	30/V49	6.15			35	6		59
Surf.	1/VI/49	6.25			21	1		78
Surf.	3/VI/49	6.50			40	3		57
Surf.	5/VI/49	6.30			15	30		55
Surf.	7/VI/49	8.15			15	17		68
Surf.	9/VI/49	6.00			9	7		84
Surf.	11/VI/49	7.45		1	22	8		69
Surf.	13/VI/49	7.00			16	28		56
Surf.	15/VI/49	7.00			12	25		63
Surf.	17/VI/49	6.45	14.44		25	17		58
Surf.	19/VI/49	9.30	15.55	0.3	14	51.7		34
Surf.	21/VI/49	9.30	17.22	1	12	29		58
Surf,	23/VI/49	9.30	16.66	1	11	46		42
Surf.	25/VI/49	9.30	17.77			100		
Vert.	17/VI/49	6.45	14.44		4	10		86
Vert.	19/VI/49	9.30	15.55	1	4	32		63
Vert.	21/VI/49	9.30	17.22	2	53	18		27
Vert.	25/VI/49	9.30	17.77			36		64
Vert.	4/XII/49	1.00			50	50		
Vert.	16/I/50	1.00				100		
Vert.	15/II/50	1.00				100		
Vert.	1/IV/50	1.00			100			
Vert.	1/IV/50	1.00						
Vert.	5/V/50	1.00				100		

CLADOCERA

Daphnia retrocurva

LOCATION 1	DATE	TIME P.M.	Temperature Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg-Bearing Females.	Percentage of other Females	Percentage of Males	Pecentage of Young
Surf.	8/V/49	7.15						
Surf.	10/V/49	9.00						
Surf.	13/V/49	7.15						
Surf.	15/V/49	7.15						
Surf.	17/V/49	7.15						
Surf.	19/V/49	7.15						
Surf.	21/V/49							
Surf.	23/V/49	6.35						
Surf.	25/V/49	6.45						
Surf.	28/V/49	6.15						
Surf.	30/V49	6.15						
Surf.	1/VI/49	6.25						
Surf.	3/VI/49	6.50						
Surf.	5/VI/49	6.30						100
Surf.	7/VI/49	8.15						
Surf.	9/VI/49	6.00						
Surf.	11/VI/49	7.45						
Surf.	13/VI/49	7.00						
Surf.	15/VI/49	7.00						
Surf.	17/VI/49	6.45	14.44					
Surf.	19/VI/49	9.30	15.55					
Surf.	21/VI/49	9.30	17.22					100
Surf,	23/VI/49	9.30	16.66					100
Surf.	25/VI/49	9.30	17.77			100		
Vert.	17/VI/49	6.45	14.44					
Vert.	19/VI/49	9.30	15.55					
Vert.	21/VI/49	9.30	17.22		18	18		64
Vert.	25/VI/49	9.30	17.77		5	65		29
Vert.	4/XII/49	1.00						
Vert.	16/I/50	1.00						
Vert.	15/II/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	5/V/50	1.00						

CLADOCERA

Diaphanosoma brachyurum

LOCATION 1	DATE	TIME P.M.	Temperature Degrees Centigrade	Percentage of Ephippial Females	Percentage of Egg-Bearing Females.	Percentage of other Females	Percentage of Males	Pecentage of Young
Surf.	8/V/49	7.15						
Surf.	10/V/49	9.00						
Surf.	13/V/49	7.15				50		50
Surf.	15/V/49	7.15						
Surf.	17/V/49	7.15						
Surf.	19/V/49	7.15						
Surf.	21/V/49							
Surf.	23/V/49	6.35						
Surf.	25/V/49	6.45						
Surf.	28/V/49	6.15						
Surf.	30/V49	6.15						
Surf.	1/VI/49	6.25						
Surf.	3/VI/49	6.50						
Surf.	5/VI/49	6.30						100
Surf.	7/VI/49	8.15						
Surf.	9/VI/49	6.00				100		
Surf.	11/VI/49	7.45						
Surf.	13/VI/49	7.00						
Surf.	15/VI/49	7.00						
Surf.	17/VI/49	6.45	14.44					
Surf.	19/VI/49	9.30	15.55					
Surf.	21/VI/49	9.30	17.22					100
Surf,	23/VI/49	9.30	16.66					100
Surf.	25/VI/49	9.30	17.77					
Vert.	17/VI/49	6.45	14.44					
Vert.	19/VI/49	9.30	15.55					
Vert.	21/VI/49	9.30	17.22					
Vert.	25/VI/49	9.30	17.77					
Vert.	4/XII/49	1.00						
Vert.	16/I/50	1.00						
Vert.	15/II/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	5/V/50	1.00						

CLADOCERA

Holopedium gibberium

LOCATION 1	DATE	TIME P.M.	Temperature Degrees Centigrade		Percentage of Egg-Bearing Females.	Percentage of other Females	Percentage of Males	Pecentage of Young
Surf.	8/V/49	7.15						
Surf.	10/V/49	9.00						
Surf.	13/V/49	7.15						
Surf.	15/V/49	7.15				50	50	
Surf.	17/V/49	7.15				50	50	
Surf.	19/V/49	7.15			25	25	25	25
Surf.	21/V/49							
Surf.	23/V/49	6.35						
Surf.	25/V/49	6.45				83		17
Surf.	28/V/49	6.15						
Surf.	30/V49	6.15			100			
Surf.	1/VI/49	6.25			80	20		
Surf.	3/VI/49	6.50						
Surf.	5/VI/49	6.30			90		10	
Surf.	7/VI/49	8.15						
Surf.	9/VI/49	6.00			100			
Surf.	11/VI/49	7.45				100		
Surf.	13/VI/49	7.00			81	13	6	
Surf.	15/VI/49	7.00			100			
Surf.	17/VI/49	6.45	14.44		52	39	9	
Surf.	19/VI/49	9.30	15.55		57	43		
Surf.	21/VI/49	9.30	17.22		50	25		25
Surf.	23/VI/49	9.30	16.66		20	60		20
Surf.	25/VI/49	9.30	17.77		50	50		
Vert.	17/VI/49	6.45	14.44		89	11		
Vert.	19/VI/49	9.30	15.55			100		
Vert.	21/VI/49	9.30	17.22		100			
Vert.	25/VI/49	9.30	17.77		29	71		
Vert.	4/XII/49	1.00						
Vert.	16/I/50	1.00						
Vert.	15/II/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	5/V/50	1.00						

CLADOCERA

Leptodora kindtii

LOCATION 1	DATE	TIME P.M.	Temperature Degrees Centigrade		Percentage of Egg-Bearing Females.	Percentage of other Females	Percentage of Males	Pecentage of Young
Surf.	8/V/49	7.15						
Surf.	10/V/49	9.00						
Surf.	13/V/49	7.15						
Surf.	15/V/49	7.15						
Surf.	17/V/49	7.15						
Surf.	19/V/49	7.15				12		88
Surf.	21/V/49					100		
Surf.	23/V/49	6.35						
Surf.	25/V/49	6.45						
Surf.	28/V/49	6.15				67		33
Surf.	30/V49	6.15				67		33
Surf.	1/VI/49	6.25						
Surf.	3/VI/49	6.50						
Surf.	5/VI/49	6.30						
Surf.	7/VI/49	8.15						
Surf.	9/VI/49	6.00						
Surf.	11/VI/49	7.45						
Surf.	13/VI/49	7.00				100		
Surf.	15/VI/49	7.00				71		29
Surf.	17/VI/49	6.45	14.44					
Surf.	19/VI/49	9.30	15.55			67		33
Surf.	21/VI/49	9.30	17.22		5	77		18
Surf,	23/VI/49	9.30	16.66			100		
Surf,	25/VI/49	9.30	17.77					
Vert.	17/VI/49	6.45	14.44			100		
Vert.	19/VI/49	9.30	15.55			100		
Vert.	21/VI/49	9.30	17.22			100		
Vert.	25/VI/49	9.30	17.77			100		
Vert.	4/XII/49	1.00						
Vert.	16/I/50	1.00						
Vert.	15/II/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	1/IV/50	1.00						
Vert.	5/V/50	1.00						

DISCUSSION

A study of the sex and age ratios of the Cladocera of Heming Lake indicates that, for those organisms which persist throughout the year, reproduction is almost continuous. A few "ephippial females" were found late in June, especially below the surface. This indicates the onset of this condition before there is a drop in temperature of the lake water. Lowering of the water temperature cannot, therefore, be regarded as the only precipitating cause of this phenomenon.

Brooker Klugh (1929) tested experimentally the effect of increased salt concentration on species of Cladocera. In some cases the increase in salt concentration was combined with high or low temperature. The results of these experiments indicated that an increase in the salt concentration induced the ephippial condition, though excretory products of the animals may have also played some part. Lowering of temperature, when combined with increase of salts, was more effective in producing the ephippial condition than raising of temperature, though field observation demonstrated that exactly the opposite condition prevailed in spring pools, when they were drying up, and when under natural conditions ephippia were produced in large numbers.

It seems difficult to believe that either increased salt concentration or the accumulation of waste products can have been sufficiently present in the waters of Heming Lake to induce the ephippial condition. It would appear, therefore, that lowered temperature was probably the major factor in bringing about the ephippial condition in the *Cladocera* of Heming Lake.

A number of the *Cladocera* were not found in winter collections (Table VI, 1949-50), though some had been present in the collections of October 4, 1948 (Table IV, 1948). Of the "persistent" *Cladocera* a number continued to reproduce actively throughout the winter, even though their numbers were greatly reduced. On the other hand, a few showed a drop in both reproductive activity and numbers present.

PART III

STUDIES OF COPEPODA AND CLADOCERA OF LAKE WINNIPEG

STUDIES OF COPEPODA AND CLADOCERA OF LAKE WINNIPEG

During July, August, and October, 1949 collections of plankton were made from Lake Winnipeg. At most stations collections included surface samples (including some evening samples), horizontal samples taken at a depth of 15 feet, horizontal samples at a depth of 25 feet, and vertical samples. The vertical samples collected in July were all taken from a depth within one fathom of the bottom. The depth was previously ascertained by sounding. In order to follow the seasonal changes in abundance of these planktonts winter samples through the ice were also obtained on the following dates: January 20, 1950; January 31, 1950; and February 22, 1950. Samples taken in January and February were all vertical hauls from various depths.

Results of the sampling are tabulated in Tables I to VIII. The numbers shown in the tables indicate the number of specimens per cu. m. for each species of copepod or cladoceran. The stations listed in these tables are situated as follows: Station 1 about 0.5 miles west of mouth of Mukatawa River, (Fig. 30, Fig. 31); Station 2, 25 miles W.N.W. of Mukatawa River on summer fishing grounds (Fig. 32); Station 3, 12 miles W. of Mukatawa River on summer fishing grounds; Station 4, 13 miles west of Mukatawa River on summer fishing grounds; Station 5, 4 miles west of Mukatawa River; Station 6, 0.5 mile north of Hecla Island (Fig. 33, 34, 35) Station 7, near Black Bear Island on fall fishing grounds; Station 8 near

Gimli on winter fishing grounds; Station 9 at Doghead Point, The Narrows on winter fishing grounds; Station 10 near Hecla (village) on winter fishing grounds. These stations are shown on a map of Lake Winnipeg (Figure 29).

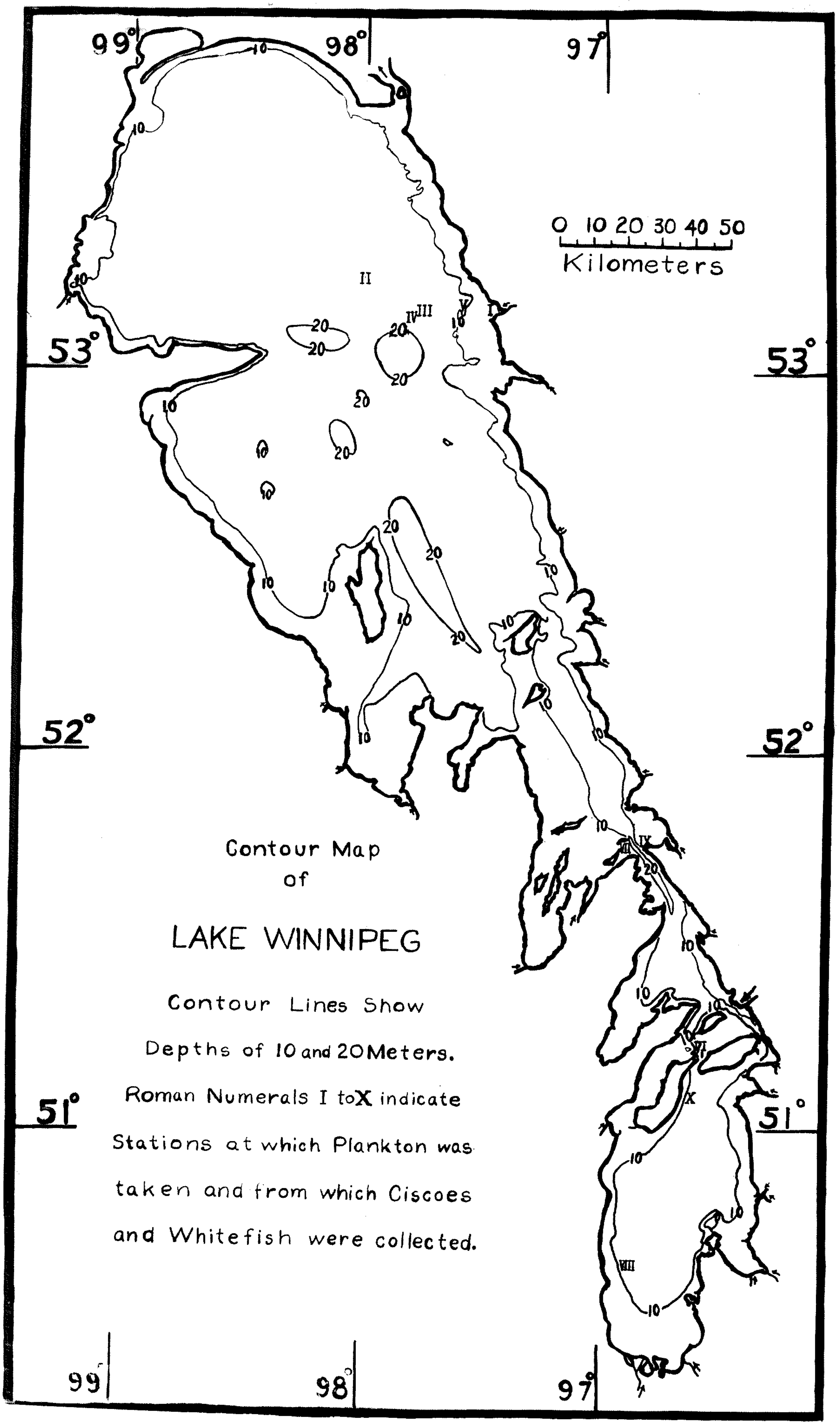
As shown in Fig. 24, Lake Winnipeg is bordered on the east by Precambrian granites and on the west by Ordovician limestone. Fig. 30 is a view of the summer fishing settlement at Mukatawa (Big Black) River, which was the base of operations for collections of plankton and ciscoes in July, 1949. Fig. 31 shows the shoreline and vegetation along the lakeshore near the mouth of Mukatawa River, while Fig. 32 shows a portion of a large granite outcrop (northwest of Mukatawa River) in the middle of Lake Winnipeg on which the fishing settlement of "Spider Island" is situated. Figures, 33, 34, and 35 are photographs taken at Hecla Island, Lake Winnipeg, which was the base of operations for collections made in August, 1949. Figures 33 and 34 show a "close-up" and more distant view of the limestone formation typical of this island and of the eastern shore of Lake Winnipeg. Figure 35 shows a typical grass and woods formation close to the Gull Harbour Hatchery, near the north end of Hecla Island. A comparison of Figures 30, 31, and 32 with Figures 33, 34, and 35 points out the remarkable contrast in rock formations and vegetation between the western (and northern) portion of this huge lake and the eastern (and southern) portion.

MATERIALS AND METHODS

All collections were made by the use of a Clarke and Bumpus plankton sampler. It was found, however, that the counting mechanism of the plankton sampler "froze up" at temperatures below -20°F. For collections made in January and February, 1950, it was, therefore, necessary to estimate the volume of water which passed through the sampler.

The same procedure was followed as for samples taken at Heming lake in killing, preserving and counting of plankters.

Fig. 29. Contour map of Lake Winnipeg showing Stations at which Plankton Samples were taken, and from which Ciscoes were collected.


99°
98°
97°
53°
52°
51°
0 10 20 30 40 50
Kilometers
Contour Map
of
LAKE WINNIPEG
Contour Lines Show
Depths of 10 and 20 Meters.
Roman Numerals I to X indicate
Stations at which Plankton was
taken and from which Ciscoes
and Whitefish were collected.

COPEPODA OF LAKE WINNIPEG

Limnocalanus macrurus Sars, 1863

Limnocalanus macrurus was found at 5 stations out of 10 at which collections were made. It was usually found below a depth of 25 feet, as was to be expected since it is typically a deep water form. It did, however, occur occasionally at the surface being found in a morning collection at Station 3 and in an evening collection at Station 6. *Limnocalanus macrurus* was found in 2 out of 13 surface horizontal collections; in 1 out of 7 horizontal collections at 15 feet; in 4 out of 9 horizontal collections at 25 feet; and in 12 out of 39 vertical collections. It was not found in samples collected during January or February, 1950, but was present late in October, 1949, being found in a single vertical sample, with about 139 specimens per cu. m. *Limnocalanus macrurus* was most abundant in a horizontal sample taken at 25 feet at Station 4 on July 29, 1949. Its abundance in this sample was nearly 28,000 specimens per cu. m. In four vertical samples taken at the same time, and at the same location, the numbers of specimens ranged from 458 to 13,843 per cu. m. The average number for the four vertical collections was over 5,000 specimens per cu. m. Males and females were about equally numerous when all samples are considered together, but there was great variation in individual collections. In some samples the male sex predominated, while in other samples females were more numerous. In the richest sample (for this species) 46 per cent of the specimens were females and 54 per cent were males. The absence of L. macrurus from collections made in January and February poses the question of winter survival of this species. It seems entirely possible that specimens of this species burrow into the mud at the bottom of a lake and hibernate as adults, as is true of some other copepods. This would explain the appearance of adults early in the spring. This explanation suggested by Dr. H. C. Yeatman is in accord with the author's observations.

Epischura lacustris Forbes, 1882

Almost every collection taken during July, August and October, 1949 contained this copepod which was often extremely abundant. The maximum number found in a single sample was 62,510 per cu. m. in a horizontal drag at 25 feet at Station 2 on July 15, 1949. Epischura lacustris was found in 56 of 68 collections at 10 stations being present in 13 of 13 surface collections; in 7 of 7 horizontal collections at a depth of 15 feet; in 9 of 9 horizontal collections at a depth of 25 feet; and in 27 out of 39 vertical collections. It was not found in the winter samples taken during January and February, 1950, but was found in reduced numbers in the samples taken on October 27, 1949. That the lethal temperature for this copepod is low is evident from the fact that at a temperature of 2.2° C. on October 27, 1949, some specimens of E. lacustris were still found; though it was not found in water at a temperature of 1°C. in the collections made during the winter. It seems probable that shortage of food as well as low temperature was a factor contributing to the elimination of this species from the winter samples. Winter hibernation of adults is also a possibility for this species.

In the collections of July 14, 1949, all of which were taken between 6:00 a.m. and 7:20 a.m. there was a rather interesting distribution of the specimens of this copepod. At the surface there were about 4,000 specimens per cu.m. while in the vertical samples there were about 5,500 specimens per cu. m. on the average. There was a concentration amounting to about 9,000 specimens per cu. m. at 15 feet while at 25 feet there were about 7 times as many or about 63,000 specimens per cu. m.

The effect of temperature in influencing the sensitivity of Epischura lacustris to light has been demonstrated by Langford (1938). He found that while in daylight this species would vacate surface waters at temperatures of 20° C. or greater, yet at night it would return to these warm upper strata. At Station 6 on August 9, 1949, we find confirmation of this view. With a water temperature of 22.2° C. (both at surface and bottom) there were only 436 specimens per cu. m. of E. lacustris in surface waters at 2:30 p.m., while at 10:20 p.m. there were 6,857 specimens per cu. m. (i.e. nearly 16 times as many). In vertical collections there were on the average 2,250 specimens per cu. m.; at 15 feet in a horizontal collection there were 3,438 specimens per cu. m.; and in a horizontal sample at 25 feet there were 5,137 specimens per cu. m. (Tables I, III, V and VII, also Fig. 29).

Epischura nevadensis Lilljeborg, 1889

Epischura nevadensis was found in 45 of 68 collections made at 10 stations. It was found in 11 of 13 surface samples, 6 of 7 horizontal samples at 15 feet, in 7 of 9 horizontal samples at 25 feet, and in 21 of 39 vertical samples. This species was not found in the collection made on July 8, 1949, and only occurred in two of five vertical samples taken on July 14, 1949, being absent from horizontal samples taken at surface, at 15 feet and at 25 feet. Thereafter, however, it was almost constantly present together with E. lacustris until October 27, 1949 and was considerably more abundant in most samples. Its greatest abundance was in an evening surface sample taken at Station 5 on July 29, 1949, there being over 46,000 specimens per cu. m. on that occasion. Its distribution at Station 6 on August 9, 1949, resembled that of E. lacustris. On that date it was over 20 times as abundant in an evening sample at the surface as in a day sample at the surface. It was nearly twice as abundant in the evening sample at the surface as in the horizontal day sample at 15 feet. E. nevadensis was only slightly more abundant in the evening sample at the surface than it was in the day sample at 25 feet. It was about five times as abundant in the evening sample as it was in day vertical samples. In general, similar factors appear to govern the diurnal migration of *E. nevadensis* and *E. lacustris* (Tables I, III, V, VII and Fig. 29).

Diaptomus ashlandi Marsh, 1893

This copepod was found in 67 out of 68 collections made at 10 stations (Tables I, III, V, and VII). *Diaptomus ashlandi* was the most abundant species of copepod in surface collections even exceeding *Cyclops bicuspidatus* var. *thomasi* in numbers per cu. m. There were on the average about 77 per cent more specimens of *ashlandi* than of *thomasi* at the surface. In vertical samples, however, *D. ashlandi* was only about 90 per cent as numerous per cu. m. as *C. b. thomasi*. A study of vertical samples undoubtedly provides the best indicator of their relative abundance. It is interesting to observe, however, that in horizontal collections at a depth of 25 feet there were on the average nearly 70 per cent more specimens of *D. ashlandi* than of *C. b. thomasi* per cu. m. On the other hand in horizontal collections at a depth of 15 feet there were on the average only about 33 per cent as many specimens of *D. ashlandi* as there were of *C. b. thomasi* per cu. m. On the average for all collections made there were about 8 per cent more specimens of *D. ashlandi* than of *C. b. thomasi* per cu. m.

Diaptomus ashlandi was present in greatest abundance in a horizontal sample taken at a depth of 25 feet on July 29, 1949. In this sample its abundance was nearly 515,000 per cu.

m. (Table V). In the same series of collections there were nearly eight times as many specimens of D. ashlandi per cu. m. in 3 horizontal collections taken at depths of 15 feet and 25 feet as there were in 4 vertical collections at the same location. On the average this species was nearly six times as abundant in 9 horizontal samples at a depth of 25 feet as it was in 39 vertical samples.

D. ashlandi was the only animal species found in 4 vertical collections made on February 22, 1950, from depths of 27 feet, 24 feet, 12 feet and 6 feet (Table VII).

Diaptomus minutus Lilljeborg, 1889

Diaptomus minutus was found in Lake Winnipeg only in the collections made at Black Bear Island on October 27, 1949, and at The Narrows on January 31, 1950. Of the October collections two 15 and 25 feet horizontal samples contained this copepod in small numbers. A surface sample and three vertical samples collected at the same location did not contain it. Of four vertical samples collected in January, 1950, two, namely those from 84 feet and from 36 feet contained small numbers of D. minutus. Two other vertical samples from depths of 24 feet and 12 feet did not contain this species. Black Bear Island is only about 5 miles north of The Narrows. Since these two locations are so close together it might be inferred that D. minutus had in Lake Winnipeg only a very local distribution. At any rate it may safely be said that D. minutus was found in very cool water in the deepest part of Lake Winnipeg. This would appear to justify the observations of Marsh (1909) who regarded _D. minutus_ as distinctly _stenothermal_. R. E. Coker, (1938) however, found this species in several warm shallow coastal plain lakes in North Carolina, and the author's observations at Heming Lake further confirm the ability of _D. minutus_ to survive in warm as well as in cold waters. One specimen of _D. minutus_ was found in the stomach of a cisco collected at Station 2 (Fig. 29).

Diaptomus oregonensis Lilljeborg, 1889

Diaptomus oregonensis was found in 43 out of 68 samples taken during the period of collection, i. e. during July, August and October, 1949, and during January and February, 1950. It was found in 11 out of 13 surface samples; in 3 out of 7 horizontal samples at a depth of 15 feet; in 5 out of 9 horizontal samples at a depth of 25 feet; and in 24 out of 39 vertical samples. It was generally more abundant per cu. m. in vertical samples than in horizontal samples whether taken at the surface, at a depth of 15 feet, or at a depth of 25 feet. In the horizontal samples this species was somewhat more abundant on the average at a depth of 25 feet than at the surface, but was also, on the average more abundant at the surface than at a depth of 15 feet (Tables I, III, V, and VII).

Diaptomus oregonensis was most abundant in vertical collections made at Location 2 on July 14, 1949. In 5 vertical collections made on that date there were on the average over 11,000 specimens of this copepod per cu. m. Diaptomus oregonensis appeared to be at its peak in numbers for the samples studied at this location and time. It was still quite abundant at a depth of 25 feet on October 27, 1949. It was present in reduced numbers in only one of three vertical samples, and was not found in a surface collection or in a horizontal sample at a depth of 15 feet at this location. It was only found in the vertical collections made on January 31, 1950, from depths of 36 feet and 84 feet at The Narrows. It was not found in vertical samples on the same date from depths of 24 feet and 12 feet. Neither was it found in the other vertical samples taken in January and February, 1950 (Fig. 29).

Diaptomus sicilis Forbes, 1882

Diaptomus sicilis was found in 32 of 68 samples taken at 10 locations. It was found in 7 of 13 surface samples, in 4 of 7 horizontal samples at a depth of 15 feet, in 5 of 9 horizontal samples at a depth of 25 feet, and in 16 of 39 vertical samples. Its greatest abundance in the samples taken was in a surface collection made at Location 5 about 4 miles from the mouth of Mukatawa River, on July 29, 1949. Its abundance in this sample reached nearly 14,000 specimens per cu. m. (Table I, III, V, VII, and Fig. 29).

In collections taken at the surface on August 30, 1949, there were over 15 times as many specimens in an evening sample as there were on the average for two surface samples taken in daylight. The abundance in the evening surface sample was about 14 times that at 15 feet, over 3 times that at 25 feet and over 12 times that found on the average in vertical samples. There seems to be a definite tendency for D. sicilis to congregate at the surface in the evening.

While Diaptomus sicilis was found in samples taken on October 27, 1949, it was absent from the collections made on January 20, 1950, and on February 22, 1950. It was, however, found in one of four vertical collections made on January 31, 1950. Oddly enough the vertical sample in which this copepod was found was taken from a depth of 12 feet, while three other vertical samples from depths of 24 feet, 36 feet, and 84 feet, respectively, did not contain this species. The only conclusion to be drawn is that D. sicilis is apparently like other copepods much reduced in numbers during the winter, and being rare at this season will often escape the sampling net.

Eucyclops agilis Koch, 1838

Eucyclops agilis appeared to be rare in Lake Winnipeg being found only in a surface sample at Location 1 in shallow water near the mouth of Mukatawa River on July 8, 1949, and in a horizontal collection at a depth of 25 feet on October 27, 1949. The latter collection was made at Black Bear Island (Location 9). Very few specimens were found in either of the samples which contained this species (Fig. 29).

Cyclops bicuspidatus var. thomasi Forbes, 1882

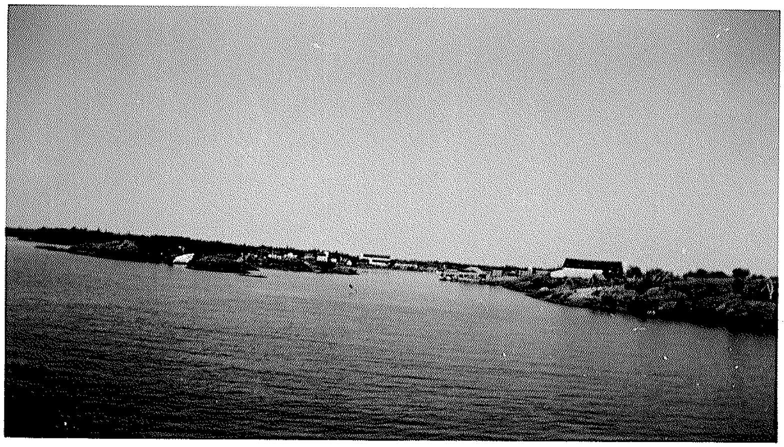
Cyclops bicuspidatus var. *thomasi* was, with the exception of *Diaptomus ashlandi*, the most abundant copepod found in Lake Winnipeg. It was found in 55 of 68 samples taken at 10 locations there being, on the average for all collections, nearly 23,000 specimens of *C. b. thomasi* per cu. m. Its greatest abundance on the overall average was at a depth of 25 feet with over 55,000 specimens per cu. m., though it was nearly as abundant at 15 feet with close to 54,000 specimens per cu. m. The overall average for surface samples was less than 9,000 specimens per cu. m. and for vertical samples just over 14,000 specimens per cu. m. This species reached its greatest abundance in collections made on July 29, 1949. On that date there were nearly 181,000 specimens per cu. m. at a depth of 15 feet, about 107,000 per cu. m. at a depth of 25 feet, and nearly 50,000 specimens per cu. m. on the average for 4 vertical collections.

In the vertical collections made in October, 1949, the numbers of *C. b. thomasi* averaged nearly 4,000 specimens per cu. m. These numbers were much reduced in the winter collections. Of 2 vertical collections made on January 20, 1950, one contained 139 specimens per cu. m. and the other none. Of four vertical collections made on January 31, 1950, three contained respectively 40, 185, and 278 specimens per cu. m. of this species. The four vertical samples taken on February 22, 1950, did not contain *C. b. thomasi*. That it was probably

Fig. 30. View of the Summer Fishing Village at the mouth of Mukatawa (Big Black) River, which was the center of operations for collections of Plankton and Ciscoes during July, 1949.

Fig. 31. View of the west shore of Lake Winnipeg, just south of the mouth of Mukatawa River.

Fig. 32. End of Granite outcrop in Lake Winnipeg, near Station II. Fig. 29, on which is situated Spider Island Fishing Station.



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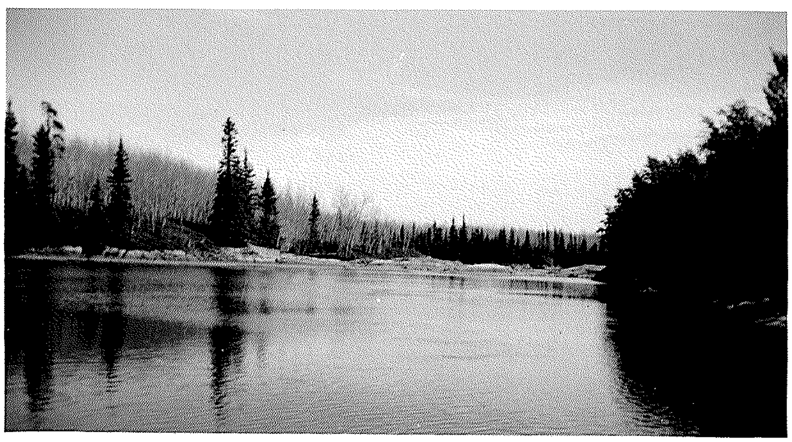

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still present though very scarce seems likely from studies made at Heming Lake. Using a much larger plankton net it was possible to demonstrate the continued presence of this copepod throughout the winter (Tables I, III, V, VII and Fig. 29).

Mesocyclops edax Forbes, 1891

Mesocyclops edax was found in only 28 of 68 samples collected at 10 stations in Lake Winnipeg. It was taken only at Stations 3 and 6. At Station 3 it was found in both vertical samples and in a surface collection, but was not found in horizontal collections made at 15 feet or at 25 feet. At Station 6 it was found in every collection. It was most abundant in a horizontal collection made on August 9, 1949, at a depth of 25 feet. In this sample it reached its peak in numbers with over 20,000 specimens per cu. m. (Fig. 29).

Mesocyclops edax was not found in the collections made in October 27, 1949, at a temperature of 2.2°C. nor in the samples taken in January and February, 1950. The absence of this species in these collections is no doubt the result of the low water temperature.

At Station 6 there was a definite drop in numbers of Mesocyclops edax in vertical collections between August 24, 1949 and August 30, 1949. The drop in temperature of surface waters was 4.5°C during the same period while the temperature at the bottom dropped 5.0° C. The drop in numbers per cu. m. is believed to have been a direct result of the drop in water temperature. In studies at Heming Lake this species was not found in winter samples but was present in the samples taken in October, 1948, the water temperature on this date being 5° C. It seems probable, therefore, that the lethal temperature for this species lies between 2° C. and 5° C.

Cyclops prasinus Fischer, 1860

Cyclops prasinus appeared to be very rare in Lake Winnipeg insofar as indicated by the samples taken. In 68 samples at 10 stations it was found only twice, once in a surface sample at Station 1 and again in a vertical sample at Station 3. In the latter sample its abundance was slightly over 400 specimens per cu. m. while in the same sample there were over 82,000 specimens of *C. b. thomasi* per cu. m. (Fig. 29).

Cyclops vernalis var. *americanus* Marsh, 1893

Cyclops vernalis var. *americanus* was found in 32 of 68 samples taken at 10 stations. It was present in 6 of 13 surface samples; in 4 of 7 horizontal samples at 15 feet; in 6 of 9 horizontal samples at 25 feet; and in 16 of 39 vertical samples. It was not found in any of the samples taken on October 27, 1949, nor in the collections made in January and February, 1950. Even in the collections made on August 30, 1949, it was found only in vertical samples. *C. v. americanus* reached its peak in abundance for the samples taken at Station 3 on July 23, 1949, with nearly 59,000 specimens per cu. m.

in a surface collection. At Station 1 a vertical collection from a depth of 12 feet yielded over 37,000 specimens per cu. m, though, at the same time, there were only 48 specimens per cu. m. at the surface. In the collections made in August, 1949 it was much more abundant below than at the surface. For example in afternoon collections made on August 9, 1949 there were over 20 times as many specimens at a depth of 15 feet, over 30 times as many at 25 feet, and about 18 times as many on the average in vertical samples as there were at the surface (Tables I, III, V, VII and Fig. 29).

Cyclops vernalis var. *brevispinosus* Fischer, 1853

Cyclops vernalis var. *brevispinosus* was found in 26 of 68 samples taken at 10 stations. It was not usually as abunsant as *C. v. americanus*. It was found in only 2 collections made in July, form *robustus* being found on July 14, 1949, in a drag at 25 feet, and typical *brevispinosus* in an evening surface drag on July 29, 1949. *C. v. brevispinosus* was absent from collections made in January and February, 1950, but was present in considerable numbers in the vertical samples taken on October 27, 1949. Its greatest abundance was in a horizontal sample taken on August 9, 1949 at a depth of 25 feet, with nearly 15,000 specimens per cu. m. (Tables I, III, V, VII, and Fig. 29).

Table I. Surface collections of Copepoda of lake Winnipeg, 1949.

Station	Time	Date of Collection	Temp. Deg. C.	Epischura lacustris	Epischura nevadensis	Limnocalanus macrurus	Diaptomus ashlandi	Diaptomus oregonensis	Diaptomus sicilis	Eucyclops agilis	Cyclops vernalis var. brevispinosus	Cyclops vernalis var. americanus	Mesocyclops edax	Cyclops prasinus	Cyclops bicuspidatus var. thomasi
1	10:30 a.m.	8/VII		21			114	15		9		48		75	51
2	7:20 a.m.	14/VII		3,777			9,052	65							34,774
3	9:06 a.m.	23/VII		219	175	132	73,422	5,921	3,947			58,816	44		66,711
5	9:35 p.m.	29/VII		13,726	46,132		29,434	3,915	13,726		1,981	27,453			10,802
6	10:20 p.m.	9/VIII		6,857	40,911	229	5,142	1,714	571		3,200	1,143	571		
6	2:30 p.m.	9/VIII		436	1,904		8,087				238	476	157		
6	3:25 p.m.	24/VIII		254	893		13,822	170			170		340		170
6	8:25 p.m.	24/VIII		2,900	5,120		7,200	100				100	900		300
6	8:35 p.m.	24/VIII		3,600	10,320		18,720	720	240				960		1,440
6	1:40 p.m.	30/VIII		138	943		4,355	184	207		23		368		
6	1:50 p.m.	30/VIII		242	463		1,936	110	44		23		154		22
6	7:40 p.m.	30/VIII		3,846	11,058		18,751	2,404	1,923		481		1,442		
7	9:30 a.m.	27/X	2.2	72	264		2,520				576				360

Table II. Surface collections of CLADOCERA from lake Winnipeg, 1949.

Station	Time	Date of Collection	pH	Leptodora kindtii	Bosmina c. longispina obtusirostris auct. Birge	Bosmina c. longispina auct. Birge	Daphnia pulex obtusa	Daphnia pulex pulicaria	Daphnia pulex form retrocurva	Daphnia longispina	Daphnia longispina hyalina galeata	Daphnia longispina hyalina mendotae	Daphnia longispina hyalina typica	Diaphanosoma brachyurum
1	10:30 a.m.	8/VII	7.6	129	120				15					
2	7:20 a.m.	14/VII		326		521				195	2,344			
3	9:06 a.m.	23/VII	7.7	833		1,184			6,711	789				
5	9:35 p.m.	29/VII		1,462					3,915	991				5,896
6	2:30 p.m.	9/VIII	8.0	20			119	735	2,854				277	972
6	10:20 p.m.	9/VIII	8.0						2,171	343				2,743
6	3:25 p.m.	24/VIII			254				7,716			339		848
6	8:25 p.m.	24/VIII		6,400					10,000			32,920		1,000
6	8:35 p.m.	24/VIII		760	30				25,200			16,560		1,920
6	1:40 p.m.	30/VIII		23	138				483			69	207	276
6	1:50 p.m.	30/VIII		22	44				22					66
6	7:40 p.m.	30/VIII		12					481				962	2,404
7	9:30 a.m.	27/X			48								48	

Table III. Horizontal collections of Copepoda taken at 15 feet from lake Winnipeg, 1949.

Station	Time	Date of Collection	Epischura lacustris	Epischura nevadensis	Limnocalanus macrurus	Diaptomus ashlandi	Diaptomus minutus	Diaptomus oregonensis	Diaptomus sicilis	Cyclops vernalis var. brevispinosus	Cyclops vernalis var. americanus	Mesocyclops edax	Cyclops bicuspidatus var. thomasi
2	7:00 a.m.	14/VII	8,893			2,025		254			107		10,917
3	8:50 a.m.	23/VII	42	42	169	3,686		1,441	297		25,846		174,607
4	11:15 a.m.	29/VII	441	625		55,140			6,801		4,227		180,712
6	2:20 p.m.	9/VIII	3,438	24,311		36,344				5,403	9,823	1,473	6,876
6	3:20 p.m.	24/VIII	3,522	9,561		9,060		503				2,013	1,510
6	1:30 p.m.	30/VIII	2,340	9,364		6,957			139	139		1,772	
7	10:40 a.m.	27/X	112	224		12,208	560		224				

Table IV. Horizontal collections at 15 ft. of CLADOCERA from lake Winnipeg, 1949

Station	Time	Date of Collection	Temp. Deg. C.	pH	Leptodora kindtii	Bosmina c. longispina obtusirostris auct. Birge	Bosmina c. longispina auct. Birge	Daphnia pulex pulicaria	Daphnia pulex form retrocurva	Daphnia longispina	Daphnia longispina hyalina typica	Daphnia longispina hyalina mendotae	Daphnia longispina hyalina galeata	Daphnia longiremis	Diaphanosoma brachyurum
2	7:00 a.m.	14/VII			2,025	4,327	254		127	3,295					
3	8:50 a.m.	23/VII		7.7	127	42			4,830	847					
4	11:15 a.m.	29/VII			1,691				23,747		2,978		845		441
6	2:20 p.m.	9/VIII		8.0	2,210			7,613	4,322	4,420	2,456				1,351
6	3:20 p.m.	24/VIII			4,026				23,149			18,115			7,548
6	1:30 p.m.	30/VIII			315	553			6,063	553		8,403		1,513	1,513
7	10:40 a.m.	27/X	2.2					14							

Table V. Horizontal collections of Copepoda taken at 25 feet from lake Winnipeg, 1949.

Station	Time	Date of Collection	Epischura lacustris	Epischura nevadensis	Limnocalanus macrurus	Diaptomus ashlandi	Diaptomus minutus	Diaptomus oregonensis	Diaptomus sicilis	Eucyclops agilis	Cyclops vernalis var. robustus	Cyclops vernalis var. brevispinosus	Cyclops vernalis var. americanus	Mesocyclops edax	Cyclops bicuspidatus var. thomasi
2	7:10 a.m.	14/VII	62,510			804		1,607			1,250		2,411		160,115
3	8:30 a.m.	23/VII	22		84	9,518		3,684					1,952		2,499
3	8:40 a.m.	23/VII	2,582	557	1,291	10,533		1,672	7,775				8,861		80,597
4	10:50 a.m.	29/VII	814	7,092		514,916		10,478	1,197				291		105,378
4	11:00 a.m.	29/VII	1,230	3,077	27,691	47,998			3,692				615		108,303
6	2:10 p.m.	9/VIII	5,137	38,529	734	226,035						14,678	14,678	20,549	38,162
6	3:15 p.m.	24/VIII	1,263	6,316		12,002						632		316	1,579
6	1:20 p.m.	30/VIII	1,115	7,397		6,080		203	608			101		608	101
7	11:10 a.m.	27/X	191	708		12,312	436	10,133	2,942	109		2,615			2,397

Table VI. Horizontal collections at 25 ft. of CLADOCERA from lake Winnipeg, 1949.

Station	Time	Date of Collection	Leptodora kindtii	Bosmina c. longispina obtusirostris auct. Birge	Bosmina c. longispina auct. Birge	Daphnia pulex obtusa	Daphnia pulex pulicaria	Daphnia pulex form retrocurva	Daphnia longispina	Daphnia longispina hyalina typica	Daphnia longispina hyalina mendotae	Daphnia longispina hyalina galeata	Diaphanosoma brachyurum
2	7:10 a.m.	14/VII	6,072	22,414	804			19,200	4,465			3,215	
3	8:30 a.m.	23/VII	395					7,610	592			395	
3	8:40 a.m.	23/VII	499	381				8,509					
4	10:50 a.m.	29/VII	2,209					23,950	898	3,892		297	
4	11:00 a.m.	29/VII	2,308					26,460		8,000		2,460	1,230
6	2:10 p.m.	9/VIII	4,036					99,441	22,383				110,082
6	3:15 p.m.	24/VIII	39					1,152			4,368		1,056
6	1:20 p.m.	30/VIII	82	304				3,850			9,805		507
7	11:10 a.m.	27/X		109	109	109	109						

Table VII. Vertical Collections of COPEPODA from lake Winnipeg, 1949-1950.

Station	Time	Date of Collection	Temp. Deg. C.	Depth. ft.	pH	Epischura lacustris	Epischura nevadensis	Limnocalanus macrurus	Diaptomus ashlandi	Diaptomus oregonensis	Diaptomus sicilis	Canthocamptus minutus	Cyclops vernalis var. brevispinosus	Cyclops vernalis var. americanus	Mesocylops edax	Cyclops prasinus	Cyclops bicuspidatus var. thomasi	Diaptomus minutus
1	10:20 a.m.	8/VII		12	7.6	833			9,996	1,666				37,485			44,982	
2	6:00 a.m.	14/VII		54	8.1	7,875		2,500	21,249	18,750	937						34,998	
2	6:40 a.m.	14/VII		54	8.1	7,154		692	12,923	14,076		38					42,691	
2	6:25 a.m.	14/VII		54	8.1	2,385		3,485		18,344				183			28,984	
2	6:20 a.m.	14/VII		54	8.1	5,638	1,208	1,812	8,659	3,625	1,611						28,797	
2	6:50 a.m.	14/VII		54	8.1	3,937	7,500	1,387	20,250	2,750	1,500						21,562	
3	8:10 a.m.	23/VII	16.1	54	8.1	2,037			15,925	4,352	2,407			12,037	833	417	82,405	
3	8:20 a.m.	23/VII	16.1	48	7.7	640	40	480	4,240	1,320	520			1,040	130		31,040	
4	10:10 a.m.	29/VII	16.1(S) 16.1(B)	48	8.0		104	458	3,645	833	208			729			25,933	
4	10:20 a.m.	29/VII		48	8.0	224	673	859	2,243	673	449			1,346			4,522	
4	10:30 a.m.	29/VII		48	8.0	556	556	5,277	15,277	5,555	694			6,944			109,715	
4	10:40 a.m.	29/VII		48	8.0	278	463	13,843	8,021	1,910				382			58,528	
6	1:50 p.m.	9/VIII	22.2(S) 22.2(B)	36	8.0	1,667	8,666		79,997	16,667			2,000	12,000	4,666		3,333	
6	2:00 p.m.	9/VIII		36	8.0	2,833	7,500	333	29,999	2,333			2,333	4,666	1,667		3,333	
6	2:45 p.m.	24/VIII	21.7(S) 21.1(B)	30	8.0	1,818	5,453		23,629	909					1,818		4,544	
6	2:50 p.m.	24/VIII		30		1,068	8,544		13,528				89	1,068	1,424		356	
6	2:55 p.m.	24/VIII		30		384	5,760		9,216	1,536			384	384	768		384	
6	3:00 p.m.	24/VIII		30		454	3,181		6,816	454			454		909		1,818	
6	3:05 p.m.	24/VIII		30		2,272	12,723		22,266	341			1,818	227	4,998		1,818	
6	3:10 p.m.	24/VIII					8,736		39,936						2,496		3,744	
6	12:20 p.m.	30/VIII	17.2(S) 16.1(B)	54		123	123		864						62			
6	12:30 p.m.	30/VIII		54		740	5,183		7,898		247				123		494	
6	12:40 p.m.	30/VIII		54		123	802		2,715		185			62	494		247	
6	12:50 p.m.	30/VIII		54		370	987		2,036	247	185			62	123		185	
6	1:00 p.m.	30/VIII		54		309	2,036		4,751	185	309		62		617		62	
6	1:10 p.m.	30/VIII		54		740	3,887		4,072	494			62	123	494		309	
7	11:30 a.m.	27/X/49	2.2°C	48	8.0	416			63,292	1,666	1,110		7,218				5,552	
7	11:50 a.m.	27/X/49	2.2°C	48		139	416		17,211		1,110		902				2,290	
7	12:10 p.m.	27/X/49	2.2°C	48		139	347	139	19,154		3,262		3,054				3,609	
8	3:00 p.m.	20/I/50		12					3,058									
8	3:20 p.m.	20/I/50		24					4,726								139	
9	9:00 a.m.	31/I/50	1°C	84	8.0				680	1,600							40	120
9	9:10 a.m.	31/I/50	1°C	36					2,593	3,148							185	370
9	9:20 a.m.	31/I/50	1°C	24					695									
9	9:30 a.m.	31/I/50	1°C	12					5,004		556						278	
10	3:00 p.m.	22/II/50	1°C	12					3,336									
10	3:15 p.m.	22/II/50	1°C	27					3,210									
10	3:30 p.m.	22/II/50	1°C	24					1,668									
10	3:45 p.m.	22/II/50	1°C	6					556									

Table VIII. Vertical collections of CLADOCERA from lake Winnipeg, 1949.

Station	Depth (ft.)	Time	Date of Collection	pH	Leptodora kindtii	Alona affinis	Bosmina longirostris brevicornis	Bosmina longirostris	Bosmina c. longispina obtusirostris auct. Birge	Bosmina c. longispina auct. Birge	Daphnia pulex form retrocurva	Daphnia longispina	Daphnia longispina hyalina typica	Daphnia longispina hyalina mendotae	Daphnia longispina hyalina galeata	Diaphanosoma brachyurum
1	12	10:20 a.m.	8/VII	7.6	833						833	833				
2	54	6:00 a.m.	14/VII		2,500	462		1,560	19,860	3,125	937	2,500			937	
2	54	6:40 a.m.	14/VII		4,615			38	14,999	38	1,154	2,538			1,846	
2	54	6:25 a.m.	14/VII		1,834		183	183	32,836	734	1,284	4,953				
2	54	6:20 a.m.	14/VII		1,410				5,236		403	604				
2	54	6:50 a.m.	14/VII		1,800				16,500	187	1,500	2,062			2,250	
3	54	8:10 a.m.	23/VII	7.7	833				3,611		14,351	4,352			1,574	
3	48	8:20 a.m.	23/VII	7.7	280				760		4,600	1,040			520	
4	48	10:10 a.m.	29/VII		229				21		1,542	271	208		417	
4	48	10:20 a.m.	29/VII		897						2,265	429	224		673	
4	48	10:30 a.m.	29/VII		1,111				278		13,194	3,472			694	
4	48	10:40 a.m.	29/VII		2,292						5,822	1,146	382			
6	36	1:50 p.m.	9/VIII	8.0	1,000						54,331		2,000			12,666
6	36	2:00 p.m.	9/VIII	8.0	500						59,997	2,000	2,000		3,333	10,500
6	30	2:45 p.m.	24/VIII		227						36,352		7,270	19,085		6,362
6	30	2:50 p.m.	24/VIII		89						22,428		2,848	8,188		4,272
6	30	2:55 p.m.	24/VIII		96						8,064		1,920	5,760	768	3,072
6	30	3:00 p.m.	24/VIII		114						17,721		1,818	5,453	227	3,181
6	30	3:05 p.m.	24/VIII		568						9,202		454	5,112		341
6	30	3:10 p.m.	24/VIII		936						26,208		7,488	22,464	3,744	4,992
6	54	12:20 p.m.	30/VIII						62		555					
6	54	12:30 p.m.	30/VIII		62						13,081			13,821		1,728
6	54	12:40 p.m.	30/VIII		123				62		864			1,789		185
6	54	12:50 p.m.	30/VIII						62		1,851			1,728		309
6	54	1:00 p.m.	30/VIII		62				62		3,702		432	926		494
6	54	1:10 p.m.	30/VIII		123				123		3,825		617	1,357		555
7	48	11:30 a.m.	27/X						278		138					
7	48	11:50 a.m.	27/X						278		138	139				
7	48	12:10 a.m.	27/X						278							

Canthocamptus minutus Claus, 1863

Canthocamptus minutus rarely occurs in the plankton, but a single female bearing eggs was found in a vertical haul from a depth of 54 feet at Station 2 on July 14, 1949 (Table VII, Fig. 29).

CLADOCERA OF LAKE WINNIPEG

Diaphanosoma brachyurum Lievin, 1848

Diaphanosoma brachyurum was found in 30 of 68 collections made at ten stations, though it was absent from 30 collections, namely those made at Stations 1 to 3 and 7 to 10 inclusive. The samples taken at Stations 7 to 10 were collected during the cooler months between the dates of October 27, 1949, and February 22, 1950. The surface water temperature on October 27, 1949 was 2.2° C. This species was, however, abundant at Heming Lake in collections taken on October 4, 1948, when the surface water temperature was 5° C. It would appear that the lethal temperature for *D. brachyurum* lies somewhere between 5° C. and 2° C. This species was generally more abundant in vertical samples than in those taken at the surface, at a depth of 15 feet, or at a depth of 25 feet. Yet in a single sample taken at a depth of 25 feet there were over 110,000 specimens of *Diaphanosoma brachyurum* per cu. m. This peak for the species was obtained on August 9, 1949 at Station 6 just north of Hecla Island. Local swarming would appear to be the explanation for the large numbers found in this sample.

Diaphanosoma brachyurum was found in vertical samples only at Station 6, though at this station it was found in 13 of 14 vertical samples collected. This species was found at Station 4 in a horizontal sample taken at 15 feet and in one of two horizontal samples collected at 25 feet. It was also found in an evening sample collected at the surface at Station 5, its abundance at this location reaching about 6,000 specimens per cu. m. In general *D. brachyurum* was abundant only at Station 6 and much less so at stations 4 and 5. At Station 6 judging from vertical samples there was during August, 1949, a rapid decline in the numbers of this species, with an average of 11,583 per cu. m. on August 9, 3,707 per cu. m. on August 24, and 654 per cu. m. on August 30 (Tables II, IV, VI, VIII and Fig. 29).

Daphnia longispina proper Muller, 1785

Daphnia longispina Muller was fairly common in vertical samples taken at Stations 1 to 4, and was also found in a surface horizontal collection taken in the evening at Station 5. It was found in only 4 of 28 collections taken at Station 6, and in 1 of 6 samples taken at Station 7. It showed a progressive drop in the average number of specimens per cu. m. and this decrease in numbers was correlated with a drop in the water temperature. The peak in numbers for this species was reached in a horizontal collection at 25 feet on August 9, 1949 with over 22,000 specimens per cu. m. No specimens of this cladoceran were found in the late fall or winter samples taken (Tables II, IV, VI, VII, and Fig. 29).

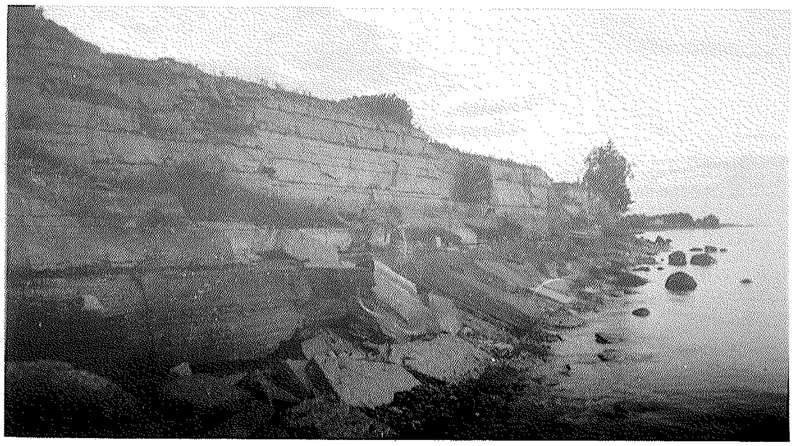
Daphnia longispina hyalina Leydig, 1860

Three *formae* of *Daphnia longispina hyalina* Leydig were found in the collections made from Lake Winnipeg, namely: *typica*, *galeata* and *mendotae*. *Mendotae* was found in collections made in August at Station 6 where it was present at all depths, but was not found at other stations. It was most abundant on the average in vertical samples, but reached a peak of nearly 33,000 specimens per cu. m. in a surface sample taken on August 24, 1949. There was an appreciable drop in average numbers per cu. m. in the vertical samples collected on August 30. *Galeata* was found in only 1 of 13 samples taken at the surface, in 1 of 7 samples taken at a depth of 15 feet, in 4 of 9 samples collected at 25 feet, and in 12 of 20 vertical samples taken between July 14 and August 24. It was not found in collections made after that date. *Typica* was on the whole less common than *galeata* or *mendotae*. It was, however, the only one of these *formae* found at Station 7 on October 27, 1949. Its presence in the cool lake water at this late date, together with the absence of the other two *formae* is held to confirm observations made previously at Heming Lake, where it was found that the crested *formae* disappeared as the water temperature dropped. The author is of the opinion that the crested condition is a direct result of higher water temper-

Fig. 33. View of shore near the northwest corner of Hecla Island, Lake Winnipeg, showing outcrop of Ordovician Limestone, the rock formation which underlies the east side of Lake Winnipeg.

Fig. 34. View taken further south along the west shore of Hecla Island showing Limestone formation and forest growth.

Fig. 35. View taken in August, 1949, near Gull Harbor Hatchery, Hecla Island, showing grasses and mixed growth of willows, poplar and pine.



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ature, and that reversion to the uncrested condition occurs as the water temperature drops. The peak in numbers for *typica* was found in a sample taken at a depth of 25 feet at Station 4 on July 29, 1949, there being 8,000 specimens per cu. m. in that sample. None of the three *formae* was found in the collections made in January or February, 1950, from waters of Lake Winnipeg. *Typica* at least may still have been present though in such reduced numbers as to escape the sampling net (Tables II, IV, VI, VIII, and Fig. 29).

Daphnia pulex obtusa Kurz, 1874

Daphnia pulex obtusa Kurz was found in only two collections. It was found once in a surface sample at Station 6 on August 9, 1949, and again in a sample at 25 feet at Station 7 on October 27, 1949. In each case there were only slightly over 100 specimens per cu. m. (Tables II and VI, Fig. 29).

Daphnia pulex pulicaria Forbes, 1882

Daphnia pulex pulicaria Forbes was found in only four samples two of which were collected at Station 6 on August 9, 1949, and two at Station 7 on October 27, 1949. At Station 6 it was found at the surface and at 15 feet while at Station 7 it was found at 15 feet and at 25 feet. It was numerous only in the sample taken at 15 feet at Station 6, in which there were over 7,600 specimens per cu. m. (Tables II, IV, VI, and Fig. 29).

<u>Daphnia pulex</u> form <u>retrocurva</u> Forbes, 1882

<u>Daphnia pulex</u> form <u>retrocurva</u> Forbes was found in all but one of the collections taken at Stations 1 to 6. It was not found in the samples taken at Stations 7 to 10, during the cooler months. From a study of vertical samples (Table VIII) this species reached its peak on August 9, 1949, at Station 6. The greatest number found in a single collection were obtained in a sample at a depth of 25 feet taken at the same station, which contained over 99,000 specimens per cu. m. As was done at Heming Lake counts were made of <u>retrocurva</u> forms to determine what percentage were the typical large-crested form and also the percentage of this form which were represented by small-crested specimens. The following table indicates percentage of specimens which were short-crested. No uncrested specimens were found.

Table IX. Percentage of short-crested <u>D. pulex</u> form <u>retrocurva</u> and water temperatures in vertical samples from Lake Winnipeg, 1949

Date	No. of vertical samples collected	Percentage of short-crested <u>D. pulex</u> form <u>retrocurva</u>	Water temperature degrees centigrade
July 8, 1949	1	100	13.1
July 14, 1949	5	100	14.8
July 23, 1949	2	97	16.1
July 29, 1949	4	97	16.1
Aug. 9, 1949	2	80	22.2
Aug. 24, 1949	6	7	21.4
Aug. 30, 1949	6	13	16.7
Oct. 27, 1949	3	50	2.2

Table IX shown above indicates, at least partially, that high temperature was a factor in the production of the large-crested form of retrocurva, since the largest percentage of large-crested specimens occurs at the period of highest water temperature. Though only the samples taken in August were all collected at the same location and though, therefore, only these are strictly comparable, yet we find for the July samples evidence of the same general tendency towards production of larger-crested forms as the water temperature rises. The amazing variation between the collections of August 9 (80 per cent short-crested) and August 24 (7 per cent short-crested) can only be explained as resulting from a great spurt in crest development during this period of high water temperature. There was then a reversion to the shorter-crested form as the water temperature dropped. That there should be as many as one-half the specimens with large crests on October 27, 1949 does seem at first remarkable. Examination of Table VIII shows, however, that remarkably few specimens of retrocurva were obtained in two vertical collections and a third vertical collection contained no specimens at all. Such small numbers were present that it is unwise to compare these collections made at Station 7 on October 27, with collections containing large numbers of specimens made in August at Station 6. There is a strong probability that, though high temperature may lead to a sudden spurt in crest production, yet low temperature will affect not the large-crested individuals themselves but only their progeny. In other words while a small-crested individual may develop a large crest because of high temperature, yet having once developed a large crest it cannot shrink it, no matter how low the water temperature may drop. This would explain the persistence of the large-crested specimens in cold waters in the autumn, while at the same time explain the great decrease in small-crested specimens when the waters are warmest. It also appears evident from studies made that high water temperature is most conducive to the greatest reproductive activity and the most rapid growth of these Cladocera, while colder waters act in the opposite way. Increased reproductive activity and more rapid growth will naturally tend towards a more rapid transformation of the population of small-crested retrocurva into large-crested specimens. On the other hand with a drop in water temperature there will be a greater lag in the production of the small-crested forms.

Daphnia longispina var. longiremis Sars, 1861

Daphnia longispina var. longiremis Sars was apparently rare in Lake Winnipeg, being taken only in a single collection. The sample which contained this variety was obtained from a depth of 15 feet at Station 6 on August 30, 1949, there being about 1,500 specimens per cu. m. (Table IV, Fig. 29).

Bosmina c. longispina obtusirostris auct; Birge

Bosmina coregoni longispina obtusirostris auct; Birge was found at Stations 1, 2, 3, 4, 6, and 7. It was not found at Stations 5, 8, 9, or 10. It was abundant only at Station 2 where it reached a peak of nearly 33,000 specimens per cu. m.

in a vertical sample. Lower water temperature found at Station 2 seemed to be more favorable to increase in numbers of this species, while it was rendered scarce by the higher water temperature found at Station 6. Though present at Station 7 in vertical samples and in a collection at 25 feet it was far from abundant. It was not found in vertical collections made in January and February, 1950 (Table II, IV, VI, VIII and Fig. 29). Studies made at Heming Lake showed that this form can survive winter conditions but becomes reduced in numbers. It is possible that obtusirostris was present in small numbers in Lake Winnipeg waters even though none were obtained by the sampling methods used. It would appear advisable to use a very large-mouthed plankton net to make winter vertical hauls rather than a small-mouthed net such as that attached to the Clarke and Bumpus plankton sampler. Even where this was done at Heming Lake only two specimens of obtusirostris were sometimes taken from over 300 liters of water, as in a collection made on May 5, 1950. Species which become much reduced in numbers during the winter are of course very likely to escape the sampling net.

Bosmina c. longispina auct; Birge

Bosmina coregoni longispina auct; Birge was taken in only 9 samples of which 7 were from Station 2, where it was found at all depths examined. The other two samples which contained this species were: a surface sample at Station 3, and a horizontal collection at a depth of 25 feet at Station 7. Though at Heming Lake this species was found in winter vertical samples taken through the ice, it was not found in winter vertical samples taken from Lake Winnipeg. Since it was never abundant even in summer samples it is not surprising that no specimens were obtained in winter sampling (Tables II, IV, VI, VIII, and Fig. 29).

Bosmina longirostris Muller, 1785

Bosmina longirostris Muller was found only in two vertical collections at Station 2. In one sample there were about 1,600 specimens per cu. m. while in the other there were only 38. Three other vertical samples taken at the same time did not contain it (Table VIII, Fig. 29).

Leptodora kindtii Focke, 1844

Leptodora kindtii Focke was found in almost all collections taken at Stations 1 to 6 and at all depths examined. It was usually rather scarce at the surface, except in evening samples. In an evening surface sample collected at Station 6 on August 24, 1949, it reached a peak for this species of 6,400 specimens per cu. m. A day sample taken at the sample location had only 23 specimens per cu. m. The tendency for this species to collect at the surface in the evening had been previously noted in studies made at Heming Lake. From a study of vertical collections Leptodora kindtii appeared to be most abundant at

Station 2. This species was absent from samples taken late in October, 1949 and also from collections made during January and February, 1950. This was held to confirm observations previously made at Heming Lake, which lead to the belief that this species is unable to survive winter temperatures, (Tables II, IV, VI, VIII, and Fig. 29).

Alona affinis Leydig, 1860

Alona affinis Leydig was found in only a single collection. It occurred in a vertical sample at Station 2 taken on July 14, 1949. In this sample there were nearly 500 specimens per cu. m. (Table VIII, Fig. 29).

PART IV

FEEDING OF SOME LAKE WINNIPEG CISCOES

FEEDING OF SOME LAKE WINNIPEG CISCOES

The following summarizes a study of the feeding of some Lake Winnipeg ciscoes undertaken for the Central Fisheries Research Station, Department of Fisheries, Winnipeg, Manitoba.

Most of the fish were collected by the author during the summer of 1949. Other specimens were collected for the author by Dr. W. A. Kennedy and L. C. Hewson. Fish were taken throughout July and August, 1949, on October 23, 1949, on January 19, 1950, and on February 23, 1950. Stations at which ciscoes were collected are shown on a contour map of Lake Winnipeg (Fig. 29). Fourteen ciscoes taken near Gimli, on October 27, 1948, by Dr. Kennedy were also examined, and results of analyses of the food of these fish are included in the tabulation. These fourteen ciscoes belonged to three species. Six were *Leucichthys zenithicus*; six were *L. nigripinnis*; and two were *L. nipigon*. The identification of these fish was made by J. J. Keleher.

MATERIALS AND METHODS

The gillnets used for capturing ciscoes varied in size from 1½" to 5¼" mesh. About 80 per cent of the ciscoes taken in July, 1949, were caught in nets of 5¼" mesh set for whitefish in commercial fishing areas within 25 miles of Big Black River. The remaining 20 per cent were all taken in 4½" mesh. Most of the fish captured in July were caught on the mouth in these nets, though large specimens of ciscoes, mostly one pound or over, were gilled. During October, 1948 and August, 1949 ciscoes were gilled in nets of smaller size, from 1½" to 3" mesh. Those taken in October, 1949, and in January, 1950, were caught in $3\frac{3}{4}$" mesh. Some of the smallest specimens were obtained by seining.

Fork length in cm. was noted for all specimens, and weight in grams was also noted for each specimen, with the exception of those collected on July 7, 1949, and August 12, 1949. Stomachs and intestines were placed in vials containing 3 per cent formalin until examined. Stomach and intestinal contents of ciscoes were examined in a Petri dish on the stage of a dissecting microscope. The Petri dish was marked off into 8 equal segments (by etching with hydrofluoric acid), cut again by circular lines dividing the dish into 40 parts. It was found that the various species of Entomostraca could be identified and counted under magnifications of from 20 X to 30 X. As a routine check, however, and to eliminate the possibility of error in identifying the species permanent mounts were made of organisms from each sample, and these were examined carefully under higher powers. Even where only traces of food were found in stomach or intestine a record has been made of the organisms present. Fish which were pronounced empty contained no traces of food in stomach or intestine. Careful counts were made of organisms present. Summaries included with the present paper show only the main groups of food organisms. A detailed study of the food species found is presented in Part V which deals with food selection by Lake Winnipeg ciscoes.

In most cases all the food material present in stomach and intestine was examined, and recorded. In fish which had stomachs packed with Entomostraca, representing very large numbers of organisms, it was, however, thought sufficient to examine a fraction of the food present. The organisms present in this fraction were counted and the total number estimated. The fraction examined was never less than 1/8 of the total volume of food and usually $\frac{1}{4}$ of that volume. The remainder of the food was examined more cursorily, but where organisms not previously found were discovered, a thorough search was made of the whole food mass. While such detailed study and enumeration of the food organisms is extremely tedious, it was felt that it was necessary for the purpose of obtaining an accurate picture of the feeding of ciscoes, and particularly with regard to their selection among the food species available.

The food of the ciscoes is tabulated in Table I. All fish which contained food in stomach or intestine are included. Tables II, III, and IV summarize information obtained with regard to feeding and non-feeding ciscoes. Percentages were calculated to the nearest whole number. Average weights are shown in pounds. Table V indicates the results obtained by random sampling of sixty-six ciscoes which contained food in the stomach. The average volume of the stomach contents is shown in cubic centimeters for each of six size groups of ciscoes. The Stations at which ciscoes were collected are shown on a map of Lake Winnipeg (Fig. 29).

Table V indicates not the total amount of food consumed but only the volume of food which was present in the stomachs of ciscoes at the time of collection. So many variable factors are here involved that this table can only be said to be somewhat indicative of the range of variation. It, necessarily, represents the resultant of rate of intake and rate of digestion, even if the fish was gilled shortly before the net was lifted, and had been feeding continuously up to the time of capture. If, however, the cisco remained alive in the net for some time, digestion and elimination may have continued so that there remained only a very small fraction of the food taken during the feeding period previous to capture. It may be of interest to note that fish collected in October, 1948 and October, 1949 showed greater stomach contents for most size groups, than did those collected at other periods, perhaps because food supply was still abundant and digestion may have been somewhat slower in the cooler lake water, than it was when the water was warmer. Only for the size group 16-20 cm. in length collected on October 27, 1948, were the stomachs bulged with food, and it is possible that 2.00 c.c. of stomach contents for this size of cisco approached a maximal value.

Table I. Food of Lake Winnipeg Ciscoes (Leucichthys)

Date	Station	Length in cm.	No. ciscoes containing food	Bosmina	Daphnia	Leptodora	Cyclops	Diaptomus	Epischura	Chironomidae Larvae	Chironomidae Pupae	Chironomidae Adults	Trichoptera Larvae	Trichoptera Pupae	Trichoptera Adults	Pontoporeia hoyi Smith	Mollusca	Miscellaneous
Aug.25/49	VI	7-8	2		33	5	1											
Aug.12/49	VI	10	3	3	166				25									Ostracoda 1.
July 7/49	IV	11-15	3	16	396		424		80									Colonial Algae 200, Diptera 80.
July 22/49	III	13-15	14		368	398												Rotifera, Diatoms, Plant structures.
July 7/49	IV	17	2	8	24		59											Colonial Algae 1968
July 15/49	II	16-20	27	9,996	66	32	7,397	5	52	34	6	3	52		3	2	34	Diaphanosoma brachyurum 3; Insect fragments 2; Diatoms 50; Plant structures 40; Limnocalanus 16.
July 22/49	III	19-20	9		63					108	12	28	6	2	7	2	18	Ostracoda 1; Ephemeridae nymphs 2; Hydracarina 1.
Aug. 12/49	VI	20	1		57					4								Ostracoda 1; Diatoms numerous about 5% of stomach contents.
Oct.27/48	VIII	16-20	6	421	4,183													

Table I. (cont'd.) Food of Lake Winnipeg Ciscoes (Leucichthys)

Date	Station	Length in cm.	No. ciscoes containing food	Bosmina	Daphnia	Leptodora	Cyclops	Diaptomus	Epischura	Chironomidae Larvae	Chironomidae Pupae	Chironomidae Adults	Trichoptera Larvae	Trichoptera Pupae	Trichoptera Adults	Pontoporeia hoyi Smith	Mollusca	Miscellaneous
Jan.19/50	VIII	19.1	1				46											Summer eggs of Daphnia 30.
Aug.28/49	VI	22	1		10													
Jul. 7/49	IV	23	2		280		16			16						68		Estheria mexicana 12; Hydracarina 4.
Jul.15/49	II	21-25	45	13,452	4	1	29,777	13	66	26	3	9	47		12	37	114	Ostracoda 1; Gammarus 2;Hydracarina 1; Diptera 44;Coleoptera adult 1.
Jul.22/49	III	22-25	2							51	2	1				4		Ostracoda 3.
Aug. 5/49	VI	25	1		10													
Oct.27/48	VIII	21-24	5	114	1,375		1,028		50									
Jan.19/50	VIII	21-25	4					538										Fish 1.
Feb.23/50	X	216-224	2															Fish 2.
Jul.15/49	II	26-30	32	40	4		2,846	2	21	31	4	1	60	1	28	5	279	Ostracoda 1; Coleoptera larvae 2; " adults 1; fly nymph 1;Dragonfly adults 2;Aquatic earthworm 1;Insect fragments 1;Arachnida 1; Fish 1.
Jul.22/49	III	26-30	10		12	34	27		30	248	5	12	4	2	12	505	44	Ostracoda 30;Limnocalanus macrurus 5; Gammarus 1;Dixa Midge Larva 1;Dixa Midge adult 1;Plant structures 10.
Oct.23/49	VII	26-30	7		3					36		1				165	54	Dragonfly numph 1; Fish 2.
Oct.27/48	VIII	25.8	1		40		24	1										
Jan.19/50	VIII	26.5-26.7	2					200										Fish 1.
Feb.23/50	X	29.3	1															
July 15/49	II	31-35	4		3					8			91		5		14	Dragonfly adult 1.
Jul.22/49	III	31	1										2		1			Fish 8.
Oct.23/49	VII	31-35	4		5		3	3	5									Fish 5.
Oct.23/49	VII	35.6	1															

Table II. Feeding and Non-Feeding Ciscoes listed by length and date of Collection.

Date of Collection	Length in cm.	Average Weight in grams	No. of Specimens Examined	No. Containing Food	No. Empty	Percentage Containing Food
Aug.25/49	5	4	1	0	1	0
Aug.25/49	7-8	13	2	2	0	100
Aug.12/49	10		3	3	0	100
Jul. 7/49	11-15		3	3	0	100
Jul.22/49	13-15	30	14	14	0	100
Jul. 7/49	17		2	2	0	100
Jul.15/49	16-20	101	31	27	4	87
Aug.12/49	20		1	1	0	100
Aug.29/41	20	85	1	0	1	0
Oct.27/48	16-20	97	7	6	1	86
Jan.19/50	17-20	82	4	1	3	25
Feb.23/50	16-20	51	11	0	11	0
Jul.22/49	19-20	83	9	9	0	100
Oct.27/48	21-25	189	6	5	1	83
Jul. 7/49	23		2	2	0	100
Jul.15/49	21-25	180	60	45	15	75
Jul.22/49	22-25	191	2	2	0	100
Aug.28/49	22-23	170	4	1	3	25
Jan.19/50	21-25	164	22	4	18	18
Feb.23/50	21-25	146	13	2	11	15
Aug.25/49	25	227	1	1	0	100
Jul.15/49	26-30	308	53	32	21	60
Jul.22/49	26-30	318	14	10	4	71
Oct.27/48	25.8	284	1	1	0	100
Aug.23/49	26-30	390	42	7	35	17
Jan.19/50	26-30	230	9	2	7	13
Feb.23/50	26-30	272	5	1	4	20
Jul.15/49	31-35	418	8	4	4	50
Jul.22/49	31-33	387	3	1	2	33
Oct.23/49	31-35	476	8	4	4	50
Oct.23/49	35.6	510	1	1	0	100
Jul.15/49	37-38	879	2	0	2	0
Total			345	193	152	56

Table III. Feeding and Non-Feeding Ciscoes listed according to length.

Length in cm.	Average Weight in grams	No. of Specimens Examined	No. Containing Food	No. Empty	Percentage Containing Food
0-15	24	23	22	1	96
16-20	96(51)	66	46	20	70
21-25	176(146)	110	62	48	56
26-30	332(267)	124	53	71	43
31-35	438	19	9	10	47
36-38	756	3	1	2	33
Total		345	193	152	56

Table IV. Feeding and Non-Feeding Ciscoes listed according to dates of collection.

Date of Collection	No. of Specimens Examined	No. Containing Food	No. Empty	Percentage Containing Food
July/49	203	151	52	74
Aug./49	13	8	5	61
Oct./48 & 49	65	24	41	37
Jan./50	35	7	28	20
Feb./50	29	3	26	10
Total	345	193	152	56

Table V. Average Volume (cc.) of Stomach Contents of Lake Winnipeg Ciscoes. (Random sampling of 65 stomachs)

	Fork Lengths of Ciscoes in Centimeters					
Date	0-15	16-20	21-25	26-30	31-35	36-40
Jul.15/49	-	.70	.69	.41	-	-
Jul.22/49	.09	.36	.95	.50	-	-
Aug.12/49	.12	-	-	-	-	-
Oct.27/48	-	2.00	1.00	-	-	-
Oct.23/49	-	-	-	.23	2.47	4.50
Jan.19/50	-	-	.21	-	-	-
Feb.23/50	-	-	-	1.20	-	-

DISCUSSION OF RESULTS

Lake Winnipeg ciscoes which were 15 cm. or less in length (average weight 24 grams), had fed almost entirely on *Entomostraca*, chiefly *Daphnia*, though one specimen had taken 80 *Diptera* adults. *Leptodora* and *Cyclops* were also important food items for some of these small ciscoes. Twenty-two out of twenty-three fish examined, of this size, had taken food, while one contained no traces of food in stomach or intestine. The latter fish was collected on August 25, 1949, at Gull Harbor and was taken by seining.

In the size range 16-20 cm. (average weight 96 grams), of sixty-six ciscoes examined, forty-six contained food while twenty were empty. Twenty-two ciscoes had fed entirely on *Entomostraca* and nineteen almost entirely on insects, chiefly *Chironomidae* and *Trichoptera*, while five had fed on both *Entomostraca* and insects. The number of insects taken by this size range appears to increase somewhat during July, with a corresponding decrease in the quantity of *Entomostraca* consumed. In samplings at Big Black River, Lake Winnipeg, two ciscoes (17 cm. long) collected on July 7, 1949, contained only *Entomostraca*, while on July 15, twelve out of twenty-seven ciscoes (or 44%) had fed on *Entomostraca*, thirteen had fed on insects, and two on a mixture of *Entomostraca* and insect food. On July 22, at the same location, of nine specimens examined in this size range, one (or 11%) contained only *Entomostraca*, one contained both *Entomostraca* and insects, and seven had fed almost entirely on insects. On August 12, 1949, one specimen of cisco 20 cm. long had fed on the following: 1 Ostracod, 4 Epischura, 57 Daphnia and large numbers of diatoms. It was estimated that the diatoms made up at least 5% by volume of the stomach contents. With the exception of this one individual which contained diatoms as well as Entomostraca, all the other ciscoes, in this size group, collected during August, October and January, and which contained food, had fed entirely on Entomostraca. All ciscoes, of this size, collected in February, 1950, were empty.

In the size range 21-25 cm. (average weight 176 grams) one hundred and ten ciscoes were examined of which forty-eight (or 44%) were empty and sixty-two (or 56%) contained food. Two specimens of ciscoes (23 cm. long) collected at Big Black River, on July 7, 1949, were examined and both contained food. One had fed on 12 Chironomidae larvae, 48 Pontoporeia and 12 Estheria mexicana; the other had taken 16 Cyclops bicuspidatus, 280 Daphnia, 4 Lynceus brachyurus, 20 Pontoporeia, 4 Chironomidae larvae and 4 Arachnida. Of forty-five specimens (of this size range) collected on July 15, 1949, at the same location, and which contained food: Eight (or 18%) had fed entirely on Entomostraca; four (or 9%) had fed almost entirely on Entomostraca but contained in addition some mollusks; seven had fed on Entomostraca and insects; twenty-four (or 53%) had taken insects almost entirely, though a few of these had added mollusks and Pontoporeia to their diet; one contained clams (Pisidium) only; and one contained insects, mollusks and fish remains. Two ciscoes collected on July 22, 1949, at the same location, had fed chiefly on Chironomidae and Trichoptera. In August, 1949, only one fish in this size group was collected. Five other ciscoes were obtained in the collection of October, 1948. These six fish contained only Entomostraca. Of four ciscoes collected on January 19, 1950, one contained fish remains and the other three only Entomostraca, a species of Diaptomus. The two ciscoes collected on February 23, 1950, which contained food, had fed on fish.

In the size range 26-30 cm. (average weight 332 grams) one hundred and twenty-four ciscoes were examined of which fifty-three (or 43%) contained food and seventy-one (or 57%) were empty. In the collection made on July 15, 1949, at Big Black River, thirty-three ciscoes, in this size range, contained food. Fourteen of these had fed entirely on insects. Fourteen contained chiefly insects, but with the addition of mollusks and Pontoporeia, and in one cisco stomach fish remains were also present. Of the remainder, three contained Entomostraca only, one contained Entomostraca and insects, while one contained 5 Pontoporeia and no other food. Ten ciscoes, in this size grouping, collected on July 22, 1949, at Big Black River, contained insects as the chief food of all specimens, but eight out of the ten contained traces of other food, including Entomostraca, Pontoporeia and mollusks. Of seven specimens collected on October 23, 1949, at Black Bear, Lake Winnipeg, all had food. One contained the remains of two fish, and the others had fed chiefly on Chironomidae and mollusks. The cisco collected on

October 27, 1948, and the two specimens collected on January 19, 1950, contained *Entomostraca* only. Only one of the four specimens collected on February 23, 1950, contained food, the partly digested remains of fish.

In the size range 31-35 cm. (average weight 438 grams) of nineteen fish examined, nine ciscoes contained food and the other ten were empty at the time of collection. The five specimens collected in July, 1949, at Big Black River contained chiefly *Trichoptera*, with lesser numbers of *Chironomidae* and traces of other food. The four specimens collected on October 23, 1949, at Black Bear, had fed either on *Entomostraca* or fish. Two of them contained 8 fish, while the other two ciscoes contained small numbers of various species of *Entomostraca*.

One cisco, collected on October 23, 1949, had attained a length of 35.6 cm. (weight 756 grams). Its stomach contents consisted of 5 fish.

The 14 ciscoes collected on October 27, 1948, merit some separate discussion. Two of these *L. nigripinnis* contained no food. Twelve of the fourteen contained food. Six of these ciscoes in the size group 16-20 cm. long (of seven) had fed on a total of 421 *Bosmina* and 4,183 *Daphnia* (Table I). Four of the six were *L. zenithicus* and two were *L. nigripinnis*. Not one of these fish contained *copepods*! Neither was there any notable difference between the food chosen by these two species. The five (of six) specimens of ciscoes containing food which were in the size group 21-24 cm. in length were assigned to three species. One was *L. zenithicus*; two were *L. nipigon*; and two were *L. nigripinnis*. These five fish had taken 114 *Bosmina*, 1,375 *Daphnia*, 1,028 *Cyclops* and 50 *Epischura*. Again, however, no separation of these species on the basis of feeding was possible. One specimen of cisco (*L. zenithicus*) was nearly 26 cm. long, and contained 40 *Daphnia*, 24 *Cyclops* and one *Diaptomus*. The predominant food of these twelve ciscoes was *Daphnia*, whereas for most of the other ciscoes examined in this study (Table I) *Daphnia* formed a relatively small part of the total food consumed.

These twelve ciscoes must be considered significant, since they, like those examined by Clemens and Bigelow (1922), had fed chiefly on *Daphnia*, (as had the Lake Winnipeg ciscoes in the size group 0-15 cm. long), and also because (as with the species studied by them) there was no appreciable difference in the nature of the entomostracan food among the three species of ciscoes here represented. Of course, since these particular fish were collected in 1948, it is impossible to make any valid comparison between their feeding and that of ciscoes collected in 1949 and during part of 1950. The whole picture with regard to available food organisms may have been completely changed in the interval (See Part II re. fluctuations in plankton populations at Heming Lake). Availability of *Daphnia* and perhaps relative unavailability of other food organisms may have determined the feeding of these twelve ciscoes. On the other hand the author was able to demonstrate selective feeding by ciscoes where there was a great abundance of a variety of food organisms readily available (Part V).

SUMMARY AND CONCLUSIONS

Copepods, including *Cyclops bicuspidatus*, the first intermediate host of *Triaenophorus crassus*, were an important food constituent in the diet of most ciscoes until mid-July, but, thereafter, generally formed a minor part of the food of all except the smallest specimens. Plankton *Entomostraca* formed almost the sole food of small ciscoes, of 15 cm. or less in length, and was an important part of the food of some ciscoes throughout. During July, ciscoes over 15 cm. long gradually turned more and more to insects, chiefly *Chironomidae* and *Trichoptera*, for food. The feeding on insects continued for some time and even in October, 1949, some ciscoes were still feeding on *Chironimidae*. Later there was an increasing tendency for ciscoes to feed upon fish. The tendency to take fish in the diet was an almost negligible factor in the feeding of ciscoes during July and August, 1949. Of two hundred and sixteen feeding fish, collected in those months, only one contained fish. In the collection of October, 1948, no ciscoes examined contained fish. In the collection of October, 1949, of twelve ciscoes which contained food, four (or 33%) contained fish. In the collection of January, 1950, of seven ciscoes which contained food, two (or 29%) had fed on fish prior to the time of capture. In the collection of February 23, 1950, the ciscoes which contained food, had fed entirely on fish.

The possible influence of increase in the size of fish on their changing habits of feeding must be noted. It is certainly true that, in general, those ciscoes which had fed on fish were in the larger size groups. Another factor, during January and February, 1950, was the scarcity of Entomostroca in the lake water. This was evident from plankton collections. It is probable that for ciscoes the alternative to feeding upon fish during these months, was starvation.

The author is inclined to believe that size and availability are the chief factors determining the nature of the animal food consumed by Lake Winnipeg ciscoes. In times of great plenty they may show an epicurean tendency to select certain plankton species from the abundance available. Evidence of such selection has been found by Langford (1938) in Lake Nipissing ciscoes (*L. artedi*), and is presented for Lake Winnipeg ciscoes in Part V of this Thesis. Under certain circumstances ciscoes may choose *Cyclops* and *Bosmina* in preference to *Daphnia* and *Epischura*. Under changed circumstances, however, *Daphnia* and *Epischura* or *Diaptomus* may form the chief food organisms. Insects, such as *Chironomidae* and *Trichoptera*, when available, certainly form an important part of the food of the larger specimens of Lake Winnipeg ciscoes, just as *Ephemeridae* do for ciscoes of Lake Erie (Clemens and Bigelow, 1922). Fish are usually taken as food by ciscoes only in times of comparative or severe food scarcity, though as pointed out already a few ciscoes show this piscivorous tendency even before being driven thereto by the pangs of hunger. That food scarcity reaches a "desperate" level during the winter is evident from a study of plankton collections made during the coldest months (when the temperature dropped below $-40^{\circ}C$) and when the plankton net (lowered through 6 or more feet of ice) sometimes collected only 3 or 4 Diaptonii per cu. meter. Clemens and Bigelow (1922) found that three of the 211 ciscoes they examined from Lake Erie (L. prognathus) had fed upon fish, but in each case digestion had proceeded too far to allow of identification. They also reported: A fisherman near Point Pelee has stated that one winter he found that some ciscoes, which he took through the ice, had eaten "minnows". If the fisherman's report can be accepted as accurate, then Lake Erie ciscoes, like those in Lake Winnipeg, turn to fish as an alternative to winter starvation. Evidently, at any rate, fish consumption by ciscoes is not limited to Lake Winnipeg.

With regard to the difficulty in identification of the fish found in cisco stomachs the author suggests the following explanation. Perhaps ciscoes feed upon dead fish which have begun to decompose. This condition of the fish together with subsequent digestive action would account for difficulties experienced in attempting to make specific identifications of fish present in cisco stomachs. In one instance, however, (Part VI) a fish specimen present in a cisco (L. zenithicus) stomach could be identified as Notropis hudsonius hudsonius Clinton. This may have been a weakened but still living specimen when swallowed. It seems difficult to believe that ciscoes would be able to capture healthy and active fish and the explanation outlined above seems to satisfy present knowledge.

From a study of Table III it seems clear that the percentage of feeding ciscoes is significantly higher in the smallest size group, and that the percentage of feeding fish declines with remarkable regularity in the successive size groups. This is probably the resultant of a higher metabolic rate in the younger fish.

A study of Table IV reveals a definite variation in seasonal tendency with regard to feeding for all size groups of ciscoes examined. There appears to be a progressive decrease in the percentage of feeding fish in the five periods of collection (Table IV), perhaps correlated with a drop in water temperature and a corresponding diminution in food supply. While the percentage of feeding fish declines in the five periods of collection, there is, at the same time, a corresponding decrease in the average weight of the fish in each size group (Tables II and III). This is most noticeable if we compare the average weight of the fish in the size groups 2, 3 and 4, shown in brackets, in Table III with the average weight of fish in the same size groups, for the balance of the period of collection, shown unbracketed, in the same table. It is apparent that ciscoes collected in February are only from one half to five-sixths as heavy as the average weight recorded for fish during all the other periods of collection. This is strong circumstantial evidence of enforced fasting due to shortage of available food supplies.

PART V

FOOD SELECTION IN SOME LAKE WINNIPEG CISCOES

FOOD SELECTION IN SOME LAKE WINNIPEG CISCOES

Samples of lake water were collected by means of a Clarke and Bumpus plankton sampler from commercial fishing areas as whitefish nets were being set on the bottom. The following summarizes the results of a study of a series of plankton samples taken on July 14, 1949, about 42.0 kilometers (25 miles) W.N.W. of Mukatawa (Big Black) River, Lake Winnipeg, and of the stomach contents of 152 ciscoes collected next day. This location is shown as Station II on the contour map of Lake Winnipeg (Fig. 29).

The purpose of this study was to relate the feeding of these ciscoes with the quantity and kinds of limnetic Entomostraca available, and to determine whether selection of food was made at random or whether there was an element of choice from the food available.

The plankton samples taken consisted of 5 vertical tows from 18 meters, 1 surface drag, 1 horizontal drag at 5 meters, and a horizontal drag at 8 meters (25 ft.). These are tabulated in Table I. Time of collection was between 6.00 a.m. and 7.20 a.m. Examination of plankton samples was made to determine the species of Entomostraca present, and counts were made of each organism in measured volumes. In this report the number of organisms of each species represents the number per cubic meter. While the average of the 5 vertical hauls was regarded as best representing the numbers of each organism per cu.m. yet the horizontal drags did indicate some fluctuation of the numbers of various species with depth, perhaps as the result of vertical migration under the influence of light and temperature. They also revealed the presence of some Entomostraca in the plankton which had not been found in vertical collections.

The plankton samples were very rich in both copepods and cladocerans; included were Epischura lacustris at all depths with a maximum of 62,500 per cubic meter at 8 meters, and Epischura nevadensis averaging over 4,000 in two vertical samples. Cyclops bicuspidatus thomasi was extremely abundant at all depths examined, averaging over 31,000 even in vertical samples, but reaching a maximum of 160,000 in a horizontal drag at 8 meters. Cyclops vernalis robustus was common at 8 meters but was not found in other samples of this series. Diaptomus ashlandi was abundant in most vertical samples averaging over 12,600 in such samples, while D. oregonensis was nearly as common with 11,500 in vertical samples. D. oregonensis was relatively scarce in horizontal samples (65 at surface, 254 at 5 meters and 1,607 at 8 meters). Limnocalanus macrurus was not found in any horizontal drags, but was constantly present in vertical samples averaging almost 2,000 in these.

Of the cladocerans, Leptodora kindtii was very common in vertical samples averaging 2,400 specimens; about the same number were found in a horizontal drag at 5 meters; at 8 meters a maximum of 6,000 was obtained, while at the surface there were only about 300. Species of Daphnia and Bosmina were also

Table I. Numbers per cubic meter of Entomostraca found in plankton collections taken on July 14, 1949 at Station 2, Lake Winnipeg, Manitoba

Nature of plankton sample collected	Depth (Meters)	Time of Collection a.m.	Paracandona euplectella	Alona affinis	Leptodora kindtii	Daphnia pulex retrocurva	Daphnia longispina	Daphnia longispina hyalina galeata	Bosmina coregoni longispina obtusirostris	Bosmina coregoni longispina	Bosmina longirostris	Bosmina longirostris var. brevicornis	Limnocalanus macrurus	Epischura lacustris	Epischura nevadensis	Canthocamptus minutus	Diaptomus ashlandi	Diaptomus oregonensis	Diaptomus sicilis	Cyclops vernalis americanus	Cyclops vernalis robustus	Cyclops bicuspidatus thomasi
Horizontal	0	7.20			326		195	2344		521				3777			9052	65				34744
Horizontal	5	7.00			2025	127	3295		4327	254				8893			2025	254		107		10917
Horizontal	8	7.10			6072	19200	4465	3215	22414	804				62510			804	1607		2411	1250	160115
Vertical	18	6.00	38	462	2500	937	2500	937	19860	3215	1560		2500	7875			21249	18750	937			34998
Vertical	18	6.20	201		1410		604	403	5236				1812	5638	1208		8659	3625	1611			28797
Vertical	18	6.25	23		1834	1284	4953		32836	734		183	3485	2385				18344		183		28984
Vertical	18	6.40			4615	1154	2538	1846	14999	38	38		692	7154		38	12923	14076				42691
Vertical	18	6.50			1800	1500	2062	2250	16500	187			1387	3937	7500		20250	2750	1500			21562
Average Vertical Sample	18		51	92	2432	1056	2531	1007	17886	817	320	37	1975	4198	1742	8	12616	11509	810	37		31406

Table II. NUMBERS OF ENTOMOSTRACA PRESENT IN DIET OF CISCOES COLLECTED JULY 15, 1949, AT STATION 2, LAKE WINNIPEG

No. of Ciscoes containing food.	No. of Ciscoes containing Entomostraca	Fork Length of Ciscoes in Centimeters	Average Weight of Ciscoes in Grams	Paracandona euplectella	Candona candida	Leptodora kindtii	Daphnia longispina	Ephippia of Daphnia longispina	Daphnia longispina hyalina typica	Daphnia pulex pulicaria	Daphnia pulex retrocurva	Diaphanosoma brachyurum	Bosmina coregoni longispina obtusirostris	Bosmina coregoni longispina	Bosmina longirostris	Bosmina longirostris var. cornuta	Limnocalanus macrurus	Epischura lacustris	Spischura nevadensis	Diaptomus ashlandi	Diaptomus oregonensis	Diaptomus minutus	Cyclops prasinus	Cyclops vernalis americanus	Cyclops vernalis brevispinosus	Cyclops vernalis robustus	Cyclops bicuspidatus thomasi
27	14	16 to 20	98	5	1	32	91	6	16			3	9,859	13	92	32	16		52	5			592	2,422	16	1,886	3,089
45	15	21 to 25	180	1		1		5		2			13,294	102	56			62	2		9	1		8,137		10,209	11,431
36	6	26 to 31	328		1		4				3		39	1				21			2			83		568	2,193
108	35	16 to 31	98 to 328	6	2	33	95	11	16	2	3	3	23,047	116	148	32	16	83	54	5	11	1	592	10,542	16	12,563	16,607

very common and individuals of each species very numerous. *Bosmina coregoni longispina obtusirostris* Rylov (1935) (*Bosmina obtusirostris* auct; Birge) averaged nearly 18,000 in vertical samples, while the numbers of daphnids present ranged from about 1,000 to over 2,500 in most samples.

Of the 152 ciscoes examined, 108 contained food. Of these which contained food 27 were classified as small (group A) having a fork length of 16-20 cm; 45 were classified as medium (group B), having a fork length of 21-25 cm.; and 36 were classified as large (group C), having a fork length of 26-31 cm.

In all three groups most of the ciscoes had fed chiefly on insects and only 35 of the 108 ciscoes had fed entirely or partially on *Entomostraca*. The insects taken by each of groups A, B and C were mostly bottom forms and belonged chiefly to the *Trichoptera* and *Chironomidae*. A more detailed discussion of the feeding of Lake Winnipeg ciscoes is to be found in Part IV of this thesis. The *Entomostraca* taken by these ciscoes are tabulated in Table II.

Group A (Fork length 16-20 cm.)

Of the 27 ciscoes presently discussed, 13 or 48 per cent had fed chiefly on insects, including *Trichoptera* (larvae and adults), *Chironomidae* (mostly larvae, but a few pupae and adults), and *Diptera* (adults). Six of these ciscoes had taken a total of 6 ostracods (*Paracandona euplectella*-5, and *Candona candida*-1), 33 clams (*Pisidium*), 2 *Pontoporeia* and 1 fish (unidentified) along with insects. These 13 ciscoes had fed entirely or almost entirely on bottom organisms.

Of the 27 ciscoes 14 or 52 per cent had fed entirely or almost entirely on limnetic Entomostraca. The average dry volume of the stomach contents of this group was 0.64 c.c. This was, of course, no indication of the total feeding of these fish since some or much of the stomach contents may have been digested before the fish were caught or while they were in the nets.

The chief organisms selected in the diet of this group were: Bosmina coregoni longispina obtusirostris Rylov, (B. obtusisrostris auct; Birge), C. bicuspidatus thomasi, C. vernalis americanus and C. vernalis robustus. In 13 of the 14 ciscoes, these four organisms, with from 250 to nearly 900 specimens per stomach, were found most commonly and in greatest numbers. Two of the food organisms, C. bicuspidatus thomasi and B. obtusirostris, might appear to be present as a result of random feeding, since they were also abundant at all depths in the plankton samples. The other two organisms, C. vernalis robustus and C. vernalis americanus were, however, present in cisco stomachs in much greater numbers than might have been expected from a study of the plankton samples. There appeared to be a definite selection of these organisms by the young ciscoes. Moreover, species of Limnocalanus and Leptodora, though themselves large and abundantly present in company with the food utilized, were not found in stomach contents of these ciscoes. Only 4 specimens of Epischura nevadensis (none of E. lacustris) and 5 of Diaptomus ashlandi (none of D. oregonensis) were found in the stomachs of these 13 fish. It is interesting that one of these ciscoes contained 3 specimens of Diaphanosoma brachyurum which had not been found in the plankton collections at this station.

The last fish of the 14, which must be considered exceptional had fed on the following limnetic Entomostraca: L. macrurus(16), E. nevadensis(48), C. v. americanus(400), C. v. brevispinosus(16), C. v. robustus(288), C. prasinus(592), C. b. thomasi(160), L. kindtii(32), D. longispina(16), D. longispina hyalina typica(16), B. obtusirostris(2,448), B. longirostris(16), B. longirostris var. cornuta(32). This seems to indicate that this cisco, unlike the others fed almost at random. Even it, however, appeared to disdain species of Epischura, Diaptomus, and Limnocalanus. It is rather interesting that this fish contained 592 specimens of Cyclops prasinus, a species which was not found in any of the plankton collections at this station. Its presence may, however, be explained on the basis of local swarms of this Cyclops. This theory is borne out by the results of studies of other plankton series.

The 27 ciscoes of small size can be divided into at least two groups according to feeding 1. A group which fed chiefly on insects (mainly chironomids and caddis); 2. A group which fed on limnetic crustacea, chiefly four species. There was also a single specimen of the latter group which fed mostly at random on limnetic crustacea, but did not limit itself to the four species referred to above. Since the ciscoes used in this study were not separated on the basis of any specific or varietal differences between individuals, this variation in feeding might suggest that several species or sub-species of ciscoes occur in Lake Winnipeg, and that differences in food selection between species also occurs. It was found by the author, however, (Part IV) that among 12 specimens representing three species of Lake Winnipeg ciscoes collected in October, 1948, there was no appreciable variation in the food organisms selected. Confirmation of the presence in Lake Winnipeg of four species of ciscoes has been made in studies both by J. J. Keleher and by the present author. Studies of the variation in feeding of the different species found in Lake Winnipeg are, however, still continuing.

Mr. J. J. Keleher (Lake Winnipeg cisco investigation, 1947-1949. Appendix No. 22 Ann. Rep. Central Fish. Res. Stn. Fish. Res. Bd. Can. 1949) had made a study of the species of ciscoes present in Lake Winnipeg. His collections made near Mukatawa River, Lake Winnipeg between 1947 and 1949 included the following species: *Leucichthys artedi tullibee*(10), *Leucichthys nigripinnis*(119), *Leucichthys nipigon*(161), and *Leucichthys zenithicus*(422). The numbers in brackets after each species indicate the number of individuals examined. Of 14 ciscoes examined by the author from a collection made in October, 1948, 6 were *zenithicus*, 6 were *nigripinnis* and 2 were *nipigon*. From another collection of ciscoes made in October, 1950, of 29 specimens examined by the author 24 were *zenithicus*, 3 were *nigripinnis* and 2 were *artedi*. The author found that in these two collections made from Lake Winnipeg there were four species of ciscoes represented.

Group B (Fork Length 21-25 cm.)

Of the 45 ciscoes included in this group, 30 (or 67 per cent of this group) had fed mostly on insects, but with the addition of clams of the Genus Pisidium and of a few specimens of Pontoporeia hoyi; 5 specimens (11 per cent of this group) had fed on both Entomostraca and insects; while 10 ciscoes (constituting 22 per cent of this group) had fed entirely on Entomostraca.

Of the 15 ciscoes which had fed entirely or partially on Entomostraca it was interesting to note that again the four chief organisms present in their diet were B. obtusirostris, C. b. thomasi, C. v. robustus and C. v. americanus. The following additions were, however, made to the entomostracan diet of this group: L. kindtii (1), D. pulex pulicaria (2), Ephippia of D. longispina (5), B. longispina (102), B. longirostris (56), Paracandona euplectella (1), E. lacustris (62), E. nevadensis (2), D. oregonensis (9), D. minutus (1).

Addition of such supplementary items seemed to be the rule rather than the exception for this group, since almost all had fed on one or more of these larger species of Entomostraca in addition to the four smaller species which formed the staple articles of diet.

The presence in the diet of these ciscoes, of species of Entomostraca which had not been found in the plankton collections at this station, is of considerable interest. Two such were: D. pulex pulicaria, and D. minutus. It is presumed that these species were too rare to have been found by the sampling methods used.

Again group B, like group A, can be divided into at least two sections: 1. A section which fed mainly on insects (mainly chironomids and caddisflies); 2. A section which fed on limnetic crustacea, chiefly four species, though there was here evidence of a greater tendency to add larger Entomostraca to the diet.

Group C (Fork length 26-31)

Of the 36 ciscoes included in this group 30 (or 83.3 per cent of this group) had fed mostly on insects, but with the addition of clams of the Genus Pisidium, and 1 fish (unidentified), of a few specimens of Pontoporeia hoyi: 3 specimens (8.3 per cent of this group), had fed on both Entomostraca and insects; while 3 specimens (the remaining 8.3 per cent of this group) had fed entirely on Entomostraca.

Of the 6 ciscoes which had fed entirely or partially on Entomostraca the chief organisms present in their diet were again the same four species as previously noted. Of the four species, C. b. thomasi was over thrice as numerous as the three other species taken together. There were the following additions to the entomostracan diet of this group: Candona candida(1), Daphnia retrocurva(3), Daphnia longispina(4), Epischura lacustris (21), and Diaptomus oregonensis(2).

The significance of the large part played by C. b. thomasi in the entomostracan diet of ciscoes of all sizes must be apparent. It is well known as a result of the work of Miller (1944, 1945, 1946) that C. b. thomasi is the first intermediate host of the tapeworm parasite Triaenophorus crassus in that the procercoid develops within the body of this Cyclops. That C. b. thomasi is the first intermediate host of T. crassus has been confirmed by the author in studies made at Heming Lake. When the Cyclops is fed upon by a cisco the procercoid bores its way through the wall of the stomach and comes to lie between the layers of the body muscle of this fish. The presence of encysted intra-muscular plerocercoids in ciscoes has led to these fish being condemned for sale within the United States, and as the Canadian market is insufficient to support the production of these fish in any quantity there has resulted a serious monetary loss bearing heavily especially on the fishermen on Lake Winnipeg in Manitoba, and on their contemporaries in the United States. It is, therefore, peculiarly unfortunate that ciscoes seem to select C. b. thomasi in their diet even more than they do the other three species of Entomostraca which together with that species are their favorite articles of food. By doing so they tend to maintain their infestation with Triaenophorus crassus, and even to raise the rate of infestation to still greater heights.

SUMMARY

Samples of plankton were collected by means of a Clarke and Bumpus plankton sampler from a commercial fishing area about

42.0 Km. W.N.W. of Mukatawa (Big Black) River, Lake Winnipeg. The plankton samples were taken as whitefish nets were being set on the bottom on the morning of July 14, 1949. The stomach contents of 152 ciscoes collected next day as the nets were lifted were examined and were found to contain *Entomostraca*, *Insects* and *Entomostraca*, or *Insects*, *Pisidium* and *Pontoporeia*. Insects were mostly *Trichoptera* and *Chironomidae*.

Of the *Entomostraca* present in the stomach contents of these ciscoes four species formed the chief food. These were: *C. b. thomasi*, *C. v. americanus*, *C. v. robustus*, and *Bosmina coregoni longispina obtusirostris* Rylov. Other *Entomostraca* were present in some individual ciscoes in small numbers, though only one cisco had made a wide selection from the many species available in the plankton.

The percentage of ciscoes which were feeding entirely or partially on *Entomostraca* varied with the size group. In the smallest size group 52 per cent of the ciscoes had fed on *Entomostraca*; in the middle group this percentage had dropped to 33 per cent; while only 17 per cent of the largest size group had fed on *Entomostraca*.

CONCLUSION

Lake Winnipeg Ciscoes selected four species of *Entomostraca* from the plankton available to a greater extent than could be justified by the numbers of these species present as judged from plankton collections. They were: *Cylops bicuspidatus thomasi*, *Cyclops vernalis americanus*, *Cyclops vernalis robustus*, and

Bosmina coregoni longispina obtusirostris Rylov. The selection of one of these four species, *Cyclops bicuspidatus thomasi* by fish of all sizes including even the largest specimens of ciscoes indicated that size was not the chief factor determining the selection of this species of entomostracan. The unfortunate effect of selection of *C. b. thomasi* by ciscoes of all sizes is to assist in maintaining the life cycle of the tapeworm parasite *Triaenophorus crassus*. It was undoubtedly true that the large numbers of *Cyclops bicuspidatus thomasi* found in all plankton collections must have been of assistance to ciscoes in feeding on this *Cyclops*. It is thought by the present author that possibly this species tended to collect in dense swarms at certain times and levels. Such a concentration would, undoubtedly, attract feeding ciscoes but, pending confirmation, this is put forward as only a suggested explanation. Some confirmation of this view was found in the large numbers of *C. b. thomasi* at the 8 meter level (Table I). Further confirmation of this view was found in studies made of plankton collections from Heming Lake and from Lake Winnipeg.

PART VI

AN EXPERIMENTAL STUDY OF MECHANICAL FILTRATION OF PLANKTON ENTOMOSTRACA BY GILL RAKERS OF SOME LAKE WINNIPEG CISCOES

AN EXPERIMENTAL STUDY OF MECHANICAL FILTRATION OF PLANKTON ENTOMOSTRACA BY GILL RAKERS OF SOME LAKE WINNIPEG CISCOES

The following summarizes the results of an experiment carried out at the Central Fisheries Research Station, Fisheries Research Board of Canada, Winnipeg, Manitoba. Its purpose was to determine to what extent the taking of certain species of Entomostraca from the plankton available is the result of purely mechanical filtration by the gill rakers of ciscoes. The experiment was first suggested to the author by Dr. Samuel Eddy, to whom sincere thanks are extended. Thanks are also due to Miss. E. Johanson, Central Fisheries Research Station, for examining scale samples of some of these fish to determine age. The author wishes also to acknowledge the kindness of G. F. Jonasson, President of Keystone Fisheries, for arranging for the collection and repid transportation of these ciscoes to Winnipeg.

The 29 ciscoes used in this experiment were all collected near Hecla Village, Lake Winnipeg, during the autumn fishing season. Three species were present in the collections: Leucichthys artedi tullibee Richardson (2); Leucichthys nigripinnis Gill (3); and Leucichthys zenithicus Jordan and Evermann (24). Dates of collection were October 17, October 24, and October 31, 1950. Scale samples of eleven ciscoes (L. zenithicus) collected on October 17, 1950, were examined by E. Johanson to determine age. Of these specimens five were four years old, and six were five years old. The ciscoes were packed in ice on removal from the nets and brought (unfrozen) into Winnipeg. They were utilized in this experiment immediately they reached Winnipeg, and within 12 hours of collection.

The author had on hand collections of Entomostraca taken from measured volumes of lake water by means of a Clarke and Bumpus plankton sampler. Most of the plankton samples used in this experiment had been collected just north of Hecla Island during August, 1949. One sample collected from Heming Lake in July, 1949, was also used in this experiment. In general, it was intended to pour these plankton samples into the mouths and across the gills of ciscoes to see which organisms were retained by the gill rakers.

One value of using these samples was that careful counts of the different species of Entomostraca had been made for each sample. Since each of the plankton samples contained all the Entomostraca collected by means of a Clarke and Bumpus plankton sampler from 10 to 100 or more liters of lake water, it was a concentrated mixture somewhat of the consistency of soup. To pour such a mixture, containing from several hundreds to several thousands of Entomostraca through the mouths and across the gills of ciscoes, would, obviously, have been no satisfactory test of the filtering power of the gill rakers in a natural situation. The concentrated samples were, therefore, poured into a large glass container and sufficient filtered tap water added, to restore the original volume from which these organisms had been obtained. Then, after preliminary shaking the diluted sample was poured through a funnel into the mouth of a cisco. The

Table I. ENTOMOSTRACA FILTERED OUT BY GILL RAKERS OF CISCOES FROM PLANKTON SAMPLES CONTAINING KNOWN NUMBERS OF SPECIMENS, AND ORGANISMS PRESENT IN STOMACH CONTENTS OF CISCOES.

					Numbers of Entomostraca Retained by Gill Rakers of Ciscoes							Numbers of Organisms Present in Stomach Contents of Ciscoes						Numbers of Entomostraca Present in Plankton Samples			
Cisco No.	Species	Date of Collection October, 1950	Fork Length in mm.	Weight in grams	Daphnia	Diaphanosoma	Holopedium	Leptodora	Cyclops	Diaptomus	Epischura	Trichoptera Adults	Odonata Adults	Corixidae Adults	Notropis hudsonius hudsonius	Cyclops bicuspidatus thomasi	Diaptomus Ashlandi	Leptodora	Other Cladocera	Copepoda	Percentage Filtering Efficiency
1	Zen.	17	185	115	1													2	605	335	.1
2	Zen.	17	210	140															356	276	0.0
3	Zen.	17	200	140				1	2	4								1	205	196	2.0
4	Zen.	17	200	145	5					8		2	2					1	294	124	3.0
5	Zen.	17	180	110						2								4	140	408	0.4
6	Zen.	17	190	115	1										1			3	211	176	0.2
7	Zen.	17	195	125												20	30	1	184	94	0.0
8	Zen.	17	195	135															30	44	0.0
9	Zen.	17	200	140	11	1				9									55	59	20.0
10	Zen.	17	195	145	1					1									91	134	1.0
11	Zen.	17	195	170							1								165	255	0.2
12	Zen.	24	210	175														3	1813	324	0.0
13	Zen.	24	205	165	9	1	1		8	11								1	1071	574	2.0
14	Zen.	24	210	170														4	1684	608	0.0
15	Zen.	24	210	175														1	224	82	0.0
16	Nig.	24	200	165														1	83	277	0.0
17	Zen.	24	203	145										1					83	277	0.0
18	Zen.	24	205	160															83	277	0.0
19	Nig.	24	220	175															83	277	0.0
20	Zen.	24	200	145	1				2	1									83	277	1.3
21	Zen.	24	190	135															83	277	0.0
22	Zen.	24	195	140	8						1								83	277	2.5
23	Zen.	31	195	115															83	277	0.0
24	Zen.	31	190	110															83	277	0.0
25	Art.	31	200	140															83	277	0.0
26	Art.	31	200	140	25														83	277	7.0
27	Zen.	31	205	145															83	277	0.0
28	Zen.	31	210	150															83	277	0.0
29	Nig.	31	210	145										2					83	277	0.0

Art.---- *Leucichthys artedi tullibee* Richardson
Nig.---- *Leucichthys nigripinnis* Gill
Zen.---- *Leucichthys zenithicus* Jordan and Evermann

volume of liquid poured through each fish was about 10 liters.

The ciscoes were prepared for this experiment as follows: each cisco was cut open, the stomach and intestine being removed, and placed in a vial containing 4 per cent formalin to be examined later. The cut end of the gullet was tied off as close to the throat as possible. Into the mouth of each cisco, in turn, was inserted a one-holed rubber stopper through which passed the end of a small glass funnel. The cisco was held immersed in a cellophane bag full of filtered tap water during the course of this experiment.

The samples of plankton, diluted as outlined above, were then poured through the funnel into the mouth of each cisco in turn, and the water of course poured over the gills and across the gill rakers. The organisms, which adhered to the gills, indicated the ability of ciscoes to sort out these Entomostraca as the result of purely mechanical filtration. The Entomostraca thus sorted out are shown in Table I.

It is notable that the filtering efficiency of the gill rakers, as tested in this experiment, was very low, ranging from less than one per cent up to nearly 20 per cent. In 17 of the 29 ciscoes no Entomostraca were found adhering to the gill rakers. Of the 12 ciscoes, which had Entomostraca retained by the gill rakers, 11 were *Leucichthys zenithicus* and one was *L. artedi tullibee*. The number of Entomostraca ratained by these 12 ciscoes varied from one up to 27 specimens.

In general those Entomostraca, which were retained by the gill rakers of these ciscoes, were larger species such as Diap-

tomus and *Epischura* of the *Copepoda*, and *Leptodora* and *Daphnia* of the *Cladocera*. Of the smaller species, *Cyclops bicuspidatus thomasi* was retained by the gill rakers of only 3 of the 29 ciscoes, and *Cyclops vernalis americanus* by only one of the ciscoes examined. These two species of *Cyclops* were present in considerable numbers in all but one of the plankton samples used in this experiment. Other studies by the author have shown that these species of *Cyclops* usually form a considerable part of the food of Lake Winnipeg ciscoes.

A study of the stomach contents of the 29 ciscoes was made by means of a dissecting microscope. The results showed that only five of the fish contained food, and only one cisco contained *Entomostraca*. The *Entomostraca* present in this specimen were: (20) *Cyclops bicuspidatus thomasi* and (30) *Diaptomus ashlandi* (Table 1). Of the remaining four, once cisco contained the remains of a small fish (*Notropis hudsonius hudsonius* Clinton), and the other three ciscoes contained adult insects. Of the five ciscoes which contained food, four were *Leucichthys zenithicus* and one was *L. niggripinnis*.

CONCLUSION

Only one species of cisco, *Leucichthys zenithicus* Jordan and Evermann, was utilized in sufficient numbers in this experiment to warrant even tentative conclusions. Only a small percenttage of the *Entomostraca* available was sorted out by the gill rakers of this species of cisco. It was to be expected that mechanical filtration would sort out from the plankton more specimens of the larger than of the smaller species of Entomostraca, and such was indeed found to be the case. It would appear that availability and size are the most important factors determining mechanical filtration of Entomostraca from the water by the gill rakers of this species of cisco.

From examination of the gill rakers of ciscoes of this size the author would have expected that organisms of the magnitude of most species of Diaptomus (or larger) would be retained, if mechanical filtration were the only factor involved, and that smaller organisms such as most species of Cyclops and Bosmina would either pass through this type of sieve, or be only occasionally filtered out. This expectation was confirmed by the fact that in these dead ciscoes, it was the larger organisms, in general, which were sorted out, while the smaller organisms were seldom retained by the gill rakers. This was what we might have expected to happen with a purely mechanical filter. This experiment greatly strengthened the finding obtained in Part V of this thesis that Lake Winnipeg ciscoes chose certain organisms intentionally, since they sorted out from the plankton small species of Entomostraca, such as Cyclops and Bosmina, and usually refrained from taking equally abundant but larger organisms such as Diaptomus ashlandi.

Dr. Eddy informs me that he has observed that stomachs of other fishes with very coarse gill rakers, such as crappies, sometimes contain Entomostraca. He states: "Usually these are taken inadvertently with other food. However, I have seen crappies with stomachs gorged with *Diaptomus* indicating that they pick these up intentionally, as their gill rakers are not suitable for straining such small organisms. It must be a tedious job".

The author found that there appeared to be no correlation between the straining efficiency of the gill rakers of these ciscoes and the numbers of gill rakers present, as *L. artedi* and *L. nigripinnis* have 43-52 rakers, while those of *L. zenithicus* are coarser numbering 34-43, yet there was no observable difference in the straining efficiency of the gill rakers of the three species. The data is, however, somewhat warped statistically as many more specimens of *zenithicus* were present than of the other two species.

During 1949 and 1950 the author collected some 345 specimens of ciscoes of mixed species from Lake Winnipeg. Examination of the stomach contents showed (Part IV) that these ciscoes, while feeding on all the kinds of Entomostraca available, did select more of the smaller species such as *Bosmina* and *Cyclops*, and less of the larger species such as *Leptodora*, *Epischura* and *Diaptomus* than might have been expected. Not only was this true in terms of absolute numbers present in the stomachs of these ciscoes, but also relative to the abundance of these organisms in the plankton. Examination of stomach contents showed that even large ciscoes were able to filter out *Cyclops* from the lake water. The average number of Cyclops present in these ciscoes was 266 per cisco containing food. From a comparison of this study and the present experimental evidence, it seems obvious that in living ciscoes the efficiency of the gill rakers was much higher than it was in dead specimens. It must be pointed out that in live ciscoes straining of Entomostraca by the gill rakers is followed by swallowing of organisms caught, thus preventing the escape of these organisms either through the mouth or past the gill rakers. Since swallowing could not be done by the dead ciscoes there was the possibility that some of the Entomostraca first caught by the gill rakers may have been subsequently washed past them. That dead fishes utilize the gill rakers in the same manner as live fishes is questionable. It is probable that live ciscoes can erect the gill rakers so as to make them a more efficient filtering mechanism, and that the low efficiency of the gill rakers of dead ciscoes is partly due to their relaxed condition. Mechanical filtration of the Entomostraca available is certainly an important factor in food selection, but ciscoes can only filter out the Entomostraca they can catch, and many additional factors enter into the situation.

Other factors, besides abundance and mechanical filtration, which may determine food selection include: (1) The ability of Entomostraca to escape capture by suddenly dodging and swerving about. Many species of Diaptomus, as well as Epischura and Limnocalanus, are extremely adept at escaping capture by such means, (2) Dr. Samuel Eddy states (in correspondence with the author: "The larger *Entomostraca* react negatively to currents. This was demonstrated by the old pump method for collecting plankton which was standard procedure 25 years ago, and which we abandoned for the plankton trap, as the pump did not give a valid sample of the *Entomostraca*." The larger *Entomostraca*, which could escape the strong current produced by a powerful pump, would certainly be able to avoid the weaker current at the mouth opening of a cisco. (3) Transparency or lack of coloration, or protective coloration, are other factors. *Leptodora*, for example, is almost invisiable in the living condition. *Cyclops* of ponds are often so covered by green algae as to be almost invisible against a background of water plants.

(4) Many *Entomostraca* tend to collect in dense swarms, sometimes under the influence of changing conditions of light and temperature. This, together with the fact that they are not powerful enough to resist currents, is believed to account for the large numbers of *Cyclops* and *Bosmina* found in stomachs of Lake Winnipeg ciscoes. (5) There may be some taste selection, as Dr. H. C. Yeatman informs me that he has seen some minnows release some food organisms after they have been taken into the mouth. In the same connection Dr. Samuel Eddy states: "In regard to tasting by fishes, my experience has shown that the taste varies greatly in different species. Minnows and suckers probably have a well developed sense of taste in the mouth. Many game fishes have practically no sense of taste in the mouth. Bullheads have theirs in their barbels. I rather expect that the

sense of taste in Leucichthys is not highly developed although this needs verification. Fishes which feed chiefly by sight or by mechanical means usually do not have much sense of taste. Consequently I would be suspicious until proven". (6) The time and level at which feeding takes place in each species of cisco may be another factor. The food organisms available at different times and levels may show wide fluctuations. Leptodora, for example, is often plentiful at the surface at night, while ciscoes may not be feeding at that time or may be feeding at depth.

SUMMARY

1. Sixty-two species of <u>Entomostraca</u>, as well as a number of subspecies, varieties, races and forms are recorded from many localities in Manitoba, including 76 lakes, 20 rivers and creeks, and over 100 ponds, ditches, and sloughs. Twenty-eight species of <u>Copepoda</u>, 4 species of <u>Phyllopods</u>, 23 species of <u>Cladocera</u>, and 7 species of <u>Ostracoda</u> are reported. Many of these records greatly extend the known range of distribution of these species. Most of the species reported have not previously been recorded from Manitoba.
2. A species of <u>Diaptomus</u>(<u>D</u>. <u>manitobensis</u>) new to science has been figured and described.
3. The summer encystment stage of <u>Cyclops bicuspidatus thomasi</u> is reported as occurring in Manitoba.
4. The percentage infestation of <u>Cyclops bicuspidatus thomasi</u> with procercoids of tapeworms of the genus <u>Triaenophorus</u> was estimated at Heming Lake.
5. The work of Coker and Addlestone (1938) and of Brooks (1946, 1947) as to the effects of temperature on crest development in <u>Daphnia</u> has been confirmed.
6. The effect of lowering of temperature in inducing the ephippial condition in <u>Cladocera</u> was noted at Heming Lake.
7. A study of the fluctuation in numbers of <u>Entomostraca</u> present at various periods throughout the year was made at

Heming Lake and at Lake Winnipeg. Fluctuations of numbers of species present, as well as of numbers of individuals of each species, were observed and noted. At Heming Lake counts were also made to determine sex and age composition of samples of most species. The percentage of females bearing eggs (or ephippia) was also noted as an index of reproductive activity.

8. Food studies of Lake Winnipeg ciscoes were made to determine the variation in feeding of different size groups, and also the seasonal variation in feeding. During the summer ciscoes of small size fed chiefly upon Entomostraca; those of medium size fed upon insects and Entomostraca; while those of large size fed chiefly upon insects, though a few of these large specimens fed upon fish. There seemed to be a greater tendency by ciscoes towards feeding upon fish during the winter, probably as an alternative to starvation, since at that time insects were not available as food and Entomostraca were present only in negligible quantities. Evidence of winter starvation was seen in the fact that ciscoes collected in February were only from one-half to five-sixths as heavy as the average weight recorded for fish during all other periods of collection.

9. A study was made of the correlation existing between the species of Entomostraca available as food and the species of Entomostraca actually utilized as food by Lake Winnipeg ciscoes. As a result of this study it was concluded that

there was intentional selection of certain species of Entomostraca by Lake Winnipeg ciscoes. That one of the Entomostraca selected by ciscoes of all sizes should be *Cyclops bicuspidatus thomasi* was regarded as peculiarly unfortunate since this *Cyclops* is the intermediate host of the tapeworm *Triaenophorus crassus* which infests these fish.

10. A study was made of the ability of gill-rakers of ciscoes to filter out Entomostraca from plankton samples containing known species and numbers of microcrustacea. This study showed that the Entomostraca filtered out were chiefly the larger organisms, showing that the gill-rakers acted simply as a crude mechanical sieve. Hence the importance of intentional selection of small Entomostraca by ciscoes, as noted above, was further emphasized as the gill-rakers of these fish were too coarse to filter out the small organisms found in such numbers in cisco stomachs.

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