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FASCICULUS II—FRESH WATER FISH AND LAKE BIOLOGY

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PREFACE.

By Professor Edward E. Prince, *Dominion Commissioner of Fisheries, Chairman of the Biological Board of Canada, Canadian Representative on the International Fisheries Commission, and Vice-President of the Fourth International Fisheries Congress, Washington, D. C.*

The number of papers embodying researches carried on at the three Biological Stations of Canada on the Atlantic and Pacific Coast, and at the Great Lakes Station, Georgian Bay and now completed for publication, so considerably exceeds the number which were available for each of the three preceding volumes, that it has been found necessary to divide them into two parts or Fasciculi, as pointed out in my preface to Fasciculus I. Fasciculus I consists of the papers on the Sea-fisheries and marine Biology, while the present part, the second part, now issued as Fasciculus II, includes papers treating of the Interior Fresh-water Fisheries and the Biology of the Great Lakes.

Professor B. Arthur Bensley's paper entitled "The Fishes of the Georgian Bay" is the first technical account of the fish fauna of that important part of the Lake Huron waters known as Georgian Bay, and may be looked upon as the initial systematic contribution towards a history of the fishes in the Canadian portion of the Great Lakes system. Its numerous original illustrations add greatly to its value and interest.

Dr. E. M. Walker, who was Curator of the Georgian Bay Station for several seasons, summarises his study of that important group of insects, the Odonata, which contributes either in the aquatic larval condition, or in the adult dragonfly condition, to the insect-food of fishes. Dr. Walker's eminence as a specialist gives importance to this original study which is of high scientific as well as practical interest. Taken along with Mr. W. A. Clemens' three papers on the Mayflies of the same water areas, they meet the need prominently brought before the Commission of Conservation, in January 1913, by Dr. C. Gordon Hewitt, Dominion Entomologist, who said that reliable information was absolutely necessary upon the insects and other food supplies in the waters in which fish abound, or in which fish have been introduced. Dr. Hewitt had previously brought before the Entomological Society of Ontario, a resolution expressing very strongly this need, and in the resolution it was stated that as the food of many of our important commercial fishes consists of larvæ and adult insects, a study should be made of the available or possible food supplies in the way of insect life before attempts are made at replenishing or stocking waters. Otherwise by stocking waters in which the food supply is not suitable, or cannot be made suitable, large sums of money, and considerable time and energy, will be uselessly expended, owing to the fish being planted where the food is either insufficient or of the wrong character. The resolution concluded by emphasising the necessity of more knowledge being secured as to the feeding habits and requirements of fresh-water fishes, and of the insect or other

fauna and all available food supplies of the waters in which fish are living or which it is desirable to stock with fish.

As a matter of fact the Biological Board had already entered upon this field of research and Dr. Walker and Mr. Clemens have completed valuable researches on the very lines indicated, these appearing in the present volume.

The study of Insect Ecology, and the carrying on of experiments upon May-flies, and the rearing of this valuable fish food have yielded results which have direct practical bearing upon the welfare of our fish and fisheries.

Mr. A. D. Robertson, in his very detailed paper on the Mollusca of the Georgian Bay, furnishes a study similar in many ways as being a study of an important source of fish food. Sturgeon, for instance, have been found filled with the shells of many species of Mollusca such as Mr. Robertson describes, and it has been established that the spawn and the young of our fresh-water shell-fish are important as a food supply for young fishes, as well as for adults, while many of the larger bivalves have economic value owing to their producing pearls. Similarly Dr. Huntsman's able paper on the Crayfish and shrimp-like creatures of Ontario waters is really a study of fish food,—while the remarkable memoirs on a black-bass parasite (*Proteocephalus*) by Mr. Cooper and Miss Ryerson, the latter treating of leeches (*Hirudinea*), are of economic importance in relation to parasites, diseases, and enemies of fish, about which fish-culturists desire all the information that can be obtained.

Mr. White contributes a paper on a series of minute forms of fresh-water life (Lake Bryozoa) which must be also a source of food for small fishes,—while Professor MacClement and Mr. Bissonnette present botanical papers which have an intimate relation to fish studies, the plants and fungi are essential to insect life, and decaying fungi form an important *nidus* for insects, which are indeed of great moment to the fish and fisheries. Of similar interest is Mr. Klugh's paper on the Hydrophytes of Georgian Bay.

Such studies as those now collected in the present Biological Fasciculus not only indicate how fully the Great Lakes Station is carrying out the main purpose for which it was founded, (like the Marine Biological Stations), namely the benefit of the fishing industries generally, and the solution of pressing fishery problems, but all have contributed also to give an unequalled opportunity to young Biologists in the various Universities of Canada to carry on original scientific researches.

At these Stations the opportunity is offered, year by year, to all capable University students and members of University staffs, which was formerly wholly lacking, and which could only be supplied by resorting to foreign Biological Stations,—but the generosity of the Dominion Government has amply supplied the means whereby our scientific workers can carry on the highest researches, marine and fresh-water, within the limits of the Dominion and can thus contribute to our knowledge of the valuable fishery and other resources of these waters.

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THE FISHES OF GEORGIAN BAY.

By B. A. Bensley, B.A., Ph.D., F.R.S.C.

Associate Professor of Zoology, University of Toronto

Plates I and II and six figures in the text

INTRODUCTORY.

Since the establishment of the Georgian Bay Biological Station in 1901, a number of collections representing the local fauna and flora of Go Home Bay have been brought together in successive seasons by various workers associated with the laboratory. In this way a considerable amount of information has been accumulated which it is hoped first to incorporate in separate reports on the individual groups, and afterwards to extend and correlate in such a way as to give a comprehensive view of the life of the Georgian Bay area.

The present report on the fishes of the region applies especially to the water areas in and about Go Home Bay, where extensive collections and observations have been made at all points within working distance of the laboratory. A few observations, however, have been made on the more accessible parts of the Musquash River system, which is the Georgian Bay outlet for the drainage area represented inland by the Muskoka Lakes, and at various points along the east and north shores of Georgian Bay from its southern termination at Coldwater River northward to Killarney*.

In the study of these collections prominence has been given to the identification of the various species and to their characters as shown in this region. This analysis forms the basis of the present report, but there has also been included a discussion of the factors of distribution, and various observations have been made on the breeding habits of fishes and on their food-relationships.

In the identification of certain more difficult species the writer has received assistance which is here gratefully acknowledged. To Dr. S. E. Meek of the Field Museum of Natural History, Chicago, he is indebted for the identification of darters and *Cyprinidæ*. Dr. Barton W. Evermann of the United States Bureau of Fisheries, Washington, kindly undertook the identification of the whitefishes and lake herrings. In addition, Mr. G. A. Boulenger kindly gave him permission to examine the collections of Canadian fresh water fishes preserved in the British Museum.

* For the purpose of making the collections described in the present paper, permission was kindly given by Mr. Edwin Tinsley, Superintendent of Game and Fisheries for Ontario to use certain nets not commonly authorized for this area, or for which special license is required.

ENVIRONMENT AND DISTRIBUTION.

The information at present available concerning Georgian Bay fishes is not sufficiently extensive to permit of comparisons being made between Georgian Bay and other parts of the Great Lake system, or between the different parts of the drainage area of which Georgian Bay is the collecting basin. It is important, however, to recognize certain chief factors which may be operative in one locality or another and especially in that at present under consideration.

(1) Though forming an almost enclosed body of water, Georgian Bay is an integral part of the Great Lake system; conditions which apply to the Great Lakes will also apply to this area, except for local influences of antagonistic or modifying nature.

(2) With the exception of the North Channel of Lake Huron, and Lake Superior, Georgian Bay is peculiar in having its two principal shores underlaid by rock formations of fundamentally different type. Geological differences are the basis of topographic and environmental differences, and when pronounced, as in this area, may profoundly modify the distribution of species.

In explanation of this feature, it may be pointed out that the entire eastern and northern shore of Georgian Bay, extending from the mouth of Coldwater River, at the end of Matchedash Bay, northward to Killarney, falls within the ancient Archean area of the northern part of the province. The western and southern shore, on the other hand, including the south shore of Matchedash Bay, the Saugeen Peninsula, and Manitoulin Island, is underlaid by sedimentary strata of Silurian age. The southern part of this shore, especially in relation to Matchedash Bay, is also covered by an extensive deposit of glacial drift. The surface features of the two main shores are different in almost all respects.

(3) The Archean portion of the shore of Georgian Bay is part of an extensive eastern drainage area of which Georgian Bay itself is the common outlet. The water courses of this area are chiefly of the nature of basins, connected with other levels by rapids and waterfalls which act as barriers against upward migration. Differences in distribution have already been observed in this area, though only certain of them appear to depend on this factor.

(4) There is geological evidence that the area now occupied by this portion of the Great Lake system is smaller than in former times. The south and east shores were formerly situated at a considerable distance, respectively, south and east of the present boundaries, the water area including on the eastern side a part of the Archean district now occupied by an enormous number of more or less isolated lakes.

(5) This body of water had in former times, not only the outflow connection to the south and west as now represented by Lake St. Clair, but also temporary outlets eastward through the Trent and Mattawa valleys. The western parts of these areas are now parts of the Georgian Bay drainage (cf. Goldthwait '10).

Go Home Bay is a small indentation of the main eastern shore of Georgian Bay, lying within the Archean area, at a distance of approximately 25 miles northwestward from its southern border as recognized on the shore line by the mouth

of Coldwater River. Go Home Bay is connected inland with the Muskoka Lakes through the Musquash River. The latter, beginning at Bala Falls on Lake Muskoka, flows a short distance westward, and divides into two portions, known respectively as the Moon and Musquash. The Musquash, which is the more southern branch, on approaching the main shore of Georgian Bay, expands into a lake of several miles in extent, known as Flat Rock Lake. This lake has two outlets into Georgian Bay, one through the Go Home River into Go Home Bay, the other into Georgian Bay directly at Muskoka Mills, a few miles to the south.

For the general topography of the region about Go Home Bay, reference may be made to the series of maps issued by the Department of Indian Affairs and designated as "Plans 1 to 3 of the Islands south of Moose Deer Point, Georgian Bay." The inland watercourses of the entire eastern shore are sufficiently well shown in the township map issued by the Department of Lands, Forest and Mines, Ontario. The general hydrography of Georgian Bay is given in the Admiralty Chart No. 327, and the details of the offshore water for the southern part of Georgian Bay in Chart No. 2102, designated as "Western Islands to Waubaushene."

Like other parts of the Archean area, this region is characterized by extensive exposures of the underlying bed-rock, the latter consisting for the most part of semistratified gneisses, the planes of which are inclined at a small angle to the horizontal. The rock surface is extremely uneven and eroded, and is notable for its resistant character, scanty soil accumulation, and deficiency of vegetation in all elevated or exposed positions. The surface is loosely strewn with detached rounded boulders.

These features are accountable for a variety of conditions presented by the water areas, some of which may be mentioned. Owing to the inequalities of the surface all inland depressions of a closed character tend to form water basins. The number of such basins is very large in comparison with the surface area, and they are of all kinds from small sphagnum ponds to lakes of several miles in extent. Again, the main shore lines are very irregular and sinuous. They present as a rule the character of bold rocky stretches, points, or headlands, alternating with minor indentations. The latter, owing to their unexposed nature tend to form shore swamps. Another important feature is found along the main shore of Georgian Bay, where the rock surface inclines beneath the water, leaving exposed a fringe of islands, similar in character to the mainland, and lying outside of this a more or less definite zone of naked reefs and submerged shoals. This shoal area consists of clean, smooth, but gently undulating rock, showing here and there abrupt ledges or basins containing accumulated boulders.

The inland water areas, which are perhaps more typical of the Archean formation than those of the main shore, are distinguished by three principal features. First, they are of the nature of overflow basins. If small, they are connected with lower levels by temporary rock channels, which perhaps contain water only in the spring or exceptionally rainy periods. If large, and situated on water courses, their channels are permanent, but connected with lower levels by rapids and waterfalls, and not to any extent by natural drainage inclines. Second, they show a comparatively high content of organic detritus, and are deficient

in inorganic sediments, often to the point of exclusion. Third, the water itself, though free from finely divided inorganic sediments and therefore translucent, is colored in various shades from yellow to dark brown, and contains a considerable amount of finely divided organic matter in suspension. This water is of the kind commonly designated as "muskeg" water, and in some cases is opaque for depths of more than two or three feet.

Many of the smaller lakes and ponds are of the nature of shallow rock basins, the bottoms of which are occupied, often to a depth of several feet, by living and dead vegetable matter, for the most part in a suspended or semi-buoyant condition. Such areas are usually more or less filled with aquatic vegetation of the lower or higher orders, and are habitable in different degrees to various species of fishes. In the larger lakes, exposure to wind and wave action or to water currents, and the distribution of sediments made possible by greater depths, combine to produce a greater variety of environmental conditions than is possible in smaller areas. Here we find that the shores in exposed places usually consist of clean stretches of rock, while the smaller indentations, especially those connected with shore ravines are from their protected character transformed into swamps. They show the same features in general as the smaller inland lakes. In many places, where the amount of inorganic material is at all abundant, we find sand or sand and mud beaches, which are more apt to be formed where there is sufficient movement of the water to carry away the lighter organic materials.

The conditions prevailing along the main shore of Georgian Bay are similar to those of the larger inland bodies of water in respect of the alternation of bold rocky shores and shore swamps or sand beaches. There are, however, important differences, resulting from the greater degree of exposure to the action of wind, waves, and ice, and the dilution of the discolored inland water with that of the main body of Georgian Bay. On the main shore and among the shore islands and reefs, exposure to the prevailing westerly winds is naturally more direct than in inland situations, and the influence is to be seen not only in the diminished soil accumulation above water, but also in the more strenuous action of the waves on rocks and shoals. More especially, however, there are extensive movements of the entire body of inshore water, which moves in and out according to the temporary direction of the wind. In the inshore bays the difference in level often amounts to fifteen inches or more, the lower level being associated with offshore winds and the higher level with inshore winds. The movement of the entire body of water in this way produces currents in and out among the islands and assists in keeping the shore zone free from all sediments of a lighter nature. Shoal areas thus consist of cleaner rock than is found inland, and such sand beaches or channels as exist are likely to be formed of clean sand rather than a mixture of sand and mud.

The fact that the inland water courses connected with this Archean area are occupied by brownish muskeg water means in general that a large volume of this water, together with a considerable amount of organic detritus, is constantly being carried into Georgian Bay. Here it comes into contact with the clear, crystalline water of the main body of the bay, and quickly loses its identity. In general the shore water shows little of the inland or muskeg character, though it is slightly

Fig. 1. Narrows, Go Home River.

Fig. 2. Inland Swamp lake, Georgian Bay.

yellowish, and not so transparent for great depths as the purer water some distance offshore.

Referring to the factors of distribution for this particular region, it may be pointed out that no satisfactory scheme of classification can be constructed by which we may indicate a natural grouping of species with reference to environmental conditions. Each species shows in fact its own combination of factors, no two being exactly similar in habits, or especially in respect of the food supply, competitively in conflict. Some species, moreover, are intermediate in respect of certain factors, and the differences shown are more often of degree rather than kind.

If, however, we select out of the total number recognized, forty species, which are more characteristic as natural inhabitants of this region, and refer these species to the most general types of environment selected, we find that approximately 11 species are deep water fishes, 5 may be set down as shoal or rock-living fishes, 17 as inhabitants of swamp areas, and 6 as inhabitants of sand beaches. One species is characteristic of running water.

The characteristic deep water species include two species of whitefishes (*Coregonus clupeaformis* and *C. quadrilateralis*), two species of lake herring (*Leucichthys cisco huronius* and *L. harengus*), the lake trout (*Cristivomer namaycush*), the ling (*Lota maculosa*), the lake sturgeon (*Acipenser rubicundus*), the lake catfish (*Ameiurus lacustris*), and three species of suckers (*Moxostoma anisurum, Catostomus commersonii,* and *C. catostomus*). The list includes the important food-fishes, together with others of little or no value. Most species show inshore migrations for spawning purposes. In respect of the available food supply three orders are to be recognized. The two species of lake herrings feed at different levels on the plankton organisms or microscopic life of the water. Two species, the lake trout and ling are predaceous, living on smaller fishes. The remaining seven are bottom-living fishes, feeding on a variety of organisms such as molluscs, crustaceans and insects.

The extensive areas, of more or less exposed character, represented by rocky shoals and channels, are habitable to three chief species, all naturally protected and more or less predatory, including the small-mouthed bass or black bass (*Micropterus dolomieu*), the pickerel or doré (*Stizostedion vitreum*), and the rock-bass (*Ambloplites rupestris*). The former two are important game fishes, the doré also having a high commercial value. Shoal areas are especially characteristic for the black bass and rock-bass, both being only partly predatory and feeding for the most part on the crayfish which inhabit shoal areas in abundance. The doré, on the other hand is less characteristic of shoaly places, since, being almost wholly piscivorous and more or less nocturnal, it seeks its food in somewhat deeper or darker water and in places where small fishes are relatively more abundant. Two small species, finally, inhabit rocky areas chiefly for the purpose of concealment, the species being the long-nosed dace (*Rhinichthys cataractae*) and the small sculpin (*Uranidea franklini*).

The species inhabiting swamp areas of various kinds include the common pike (*Lucius lucius*), large-mouthed black bass or green bass (*Micropterus salmoides*),

perch (*Perca flavescens*), sunfish (*Eupomotis gibbosus*), catfish (*Ameiurus nebulosus*), fresh water dogfish (*Amia calva*), top-minnow (*Fundulus diaphanus*), blunt-nosed minnow (*Pimephales notatus*), bream (*Abramis crysoleucas*), six species of common minnows (*Notropis cornutus, N. hudsonius, N. cayuga, N. blennius, N. heterodon, and N. atherinoides*), mud-minnow (*Umbra limi*), and brook-stickleback (*Eucalia inconstans*). This list does not include the young of the small-mouthed bass, rock-bass, or common sucker, which temporarily inhabit such areas, or any species also found on sand beaches.

Swamp areas appear to offer very favorable conditions, as indicated by the large proportion of species inhabiting them. It will be seen, however, that eleven of these species are insignificant forms, doubtless seeking the protection afforded by such situations, other places being more or less barred to them. Nothwithstanding their diminutive size, these species are relatively of great importance, since the existence of the larger, predatory forms, desirable as food or game fishes, depends at all times on an adequate food supply provided by smaller fishes.

The conditions which prevail in swamp areas are undoubtedly selected by certain species according to certain factors, but it is not clear how these factors are to be differentiated. Natural protection, provided by the shape and size of the body, as in the common sunfish and rock-bass, doubtless enable such species to occupy a situation where food is abundant more or less in the face of predatory forms. The foregoing species and also the common perch and catfish have in addition the natural protection of spines. The environmental protection afforded by weeds or by less transparent water enables a variety of smaller fishes such as minnows, top-minnows, mud-minnows, and the young of larger types to maintain themselves also against predatory fishes. Predatory forms themselves find in swamp situations an abundant and convenient food supply. Some of them, however, as a result of the deterrent factors mentioned below, are apparently able to select this environment only within certain limits. Forms such as the green bass and pike, for example, tend to inhabit only the clearer portions of such areas, while the dogfish readily accepts the more confined situations. By way of comparison, small-mouthed bass and pickerel tend to avoid such situations entirely, or resort to them only temporarily for feeding purposes, nothwithstanding the fact that these areas contain an abundance of their favorite food.

This distinction of habitat, which also applies to many smaller species, must be based on conditions existing to a greater or less extent in swamp areas according to their more open or closed character. They possibly include excessive light, increased temperature in summer or cold in winter, deficiency of oxygen circulation pollution of the water with dissolved materials or mechanical pollution by organic detritus, stems of water plants or filamentous algae.

The fact that swamp areas of all types are present within this region makes it possible to institute comparisons as to their habitability for different species. For example, the smallest inland ponds habitable to fishes at all are as a rule occupied only by two insignificant forms, sticklebacks and mud-minnows. Somewhat larger ponds may contain in addition breams and sunfish. Swamp lakes will probably contain the latter two species, together with the commoner minnows, rock-bass,

Fig. 3. Zone of Reefs and Shoals.

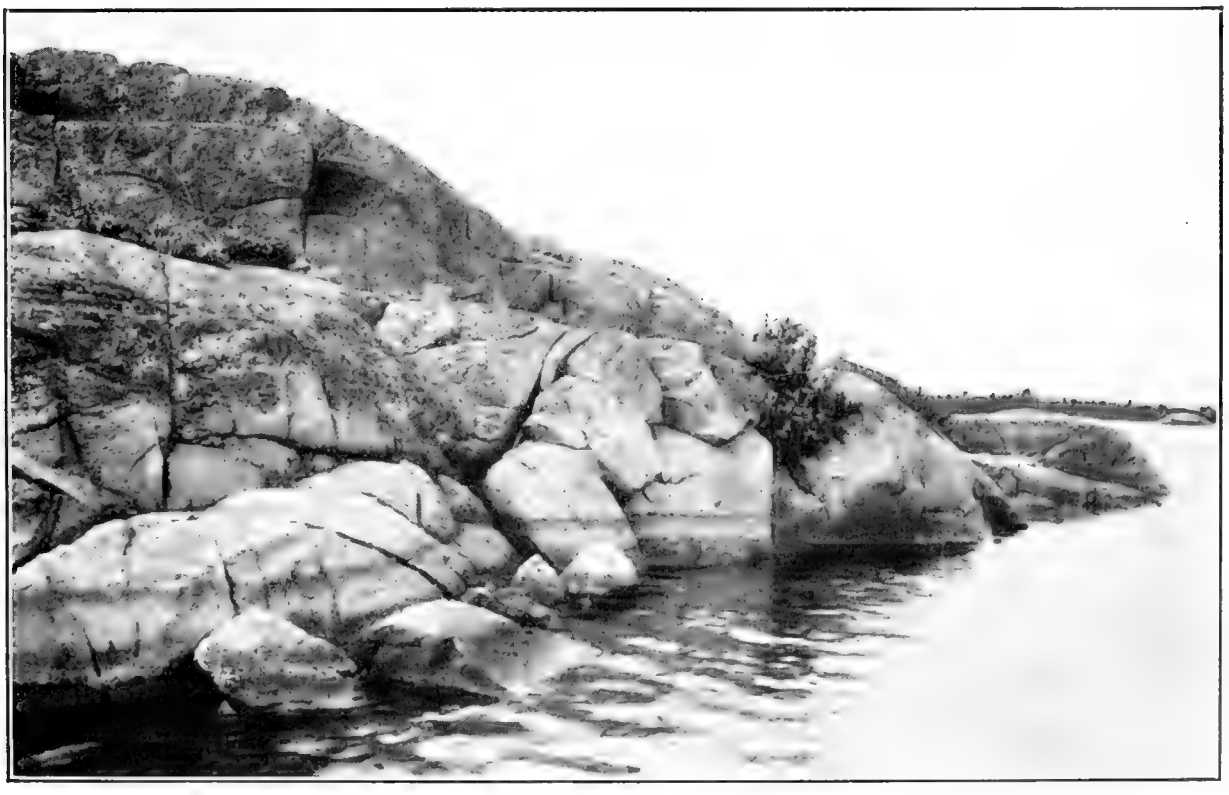

Fig. 4. Shore of Station Island.

green bass, perch, and catfish, in other words those species which are more or less characteristic of ordinary swamps. Such lakes, however, will not be likely to contain pike, and will not contain small-mouthed bass or pickerel. Moreover those species characteristic of the smaller inland ponds will be present only in the more confined situations, and will likely be in the minority. Undoubtedly food supply has something to do with these differences, but it is evident from a consideration of the facts that food supply is not one of the important factors. Apart from the general questions of distribution, the matter is of some practical importance, since it involves the question of the habitability of certain smaller lakes to small mouthed bass or other game fishes and the reservation of such lakes for stocking purposes.

Sand beaches, channels, or similar clean surfaces, tend to be occupied by five species, all of which, however, are also found in the more open swamps. These are the small perch-like forms known as log-perches and darters (*Percina caprodes*, *Boleosoma nigrum*, *Etheostoma iowae*), the silverside (*Labidesthes sicculus*), and the common garpike (*Lepisosteus osseus*). The maskinonge (*Lucius masquinongy*), an important game fish, and the largest of all the inshore predaceous species, may also be included in this category, since it shows a preference for sand banks or sandy river channels.

The food supply of swamp areas and sand beaches, like that of the deep water, is of three orders, namely, (a) plankton, or microscopic organisms living on the bottom; (b) bottom organisms of a higher order, such as crustaceans, molluscs, and insects, or surface insects; and (c) smaller fishes. The smallest species and the young of all species are obliged to feed upon minute or microscopic organisms. Fishes of intermediate adult size, and also the young of large fishes at a certain period of growth, depend on crustaceans, molluscs, and insects. They show on the whole a preference for insect diet, and augment the natural supply of aquatic insects by feeding upon terrestrial insects which fall into the water. Finally, all the smaller species and the young of all larger fishes not naturally protected form a general food supply for the larger predatory types. There are no shore fishes of larger dimensions which retain the plankton feeding habit after the manner of the lake herrings in deep water.

On the whole the shallow water zone in this region does not appear to favor either the presence of a large number of species or the attainment of large size. The majority of species in which the normal adult size is not great appear to be smaller in this region than elsewhere. They may be dwarfed by some combination of environmental conditions, but the indications are that they have fewer chances of reaching the normal size. The number of intermediate and larger fishes of more or less predatory habit is eight, and the destruction wrought by these on smaller species must be enormous. The smaller species themselves have to depend for shelter on weeds, rocks, or shallows, and possibly the fact that the water is at all times transparent tends to turn the balance in favor of their natural enemies.

Certain conditions of environment which in other situations, especially in sedimentary areas, may confer advantages on certain species are here unrepresented. For example, with the exception of the silver lamprey, a parasitic form which up to the present has only been taken on fishes temporarily inhabiting

running water, there are in this region no species of which this type of surrounding is characteristic. Some species, such as small-mouthed bass, pike, and pickerel, prefer running water, but all are distributed without reference to this factor. Such species as commonly inhabit running water elsewhere and are also present in this region appear to select other situations of an open character. There are in fact no permanent small streams, and no naturally flowing rivers in the entire region. It is possible also that the lack of similar advantages, such as either turbidity or exception purity, or minor conditions of food and shelter peculiar to sedimentary bottoms, may tend to restrict the development of a great variety of species in Archean waters.

Finally, we may refer to certain differences in distribution which distinguish parts of the Archean drainage area from one another or from Georgian Bay. On this question, unfortunately, detailed information is lacking, so that only fragments of evidence can be presented. Georgian Bay, for example, contains four species of fishes which are definitely known not to occur in the Muskoka Lakes, namely, the common pike, maskinonge, rock-bass, and green bass. Possibly a detailed study of these lakes would reveal the absence of other smaller species present in Georgian Bay, those named being the more conspicuous types. An important fact concerning these species is that they occur in various situations between the Muskoka Lakes and the Georgian Bay shore, and, moreover, that the first three of them occur in the Musquash River within a short distance of Bala Falls on Lake Muskoka. The absence of these species at the higher level has been attributed to the presence of waterfalls, a point which has been commented on by Meek and Clark ('02); but this factor would also affect the situation as regards many other lakes. Moreover, it is a well-known fact that certain of the inland lakes of the Muskoka and adjacent regions contain individually predominant types of game fishes, so that they are sometimes characterized as bass lakes, trout lakes or maskinonge lakes. This condition has led to the suggestion that the bass lakes have become so through the introduction of the small-mouthed bass in former times by Indians and through the tendency of this species to supplant the trout where the two species come into contact.

Whatever explanations may be brought forward either of natural barriers or of introduction by human agency, it can be shown that there are certain differences of distribution to which such causes cannot be assigned. These refer to the presence at higher levels of species not found at the lower levels. Several cases of the kind have come to light, the best example being certain species present in Muskoka Lake and absent in Go Home Bay. Muskoka Lake contains five species, namely, the speckled trout (*Salvelinus fontinalis*), found in some of the streams, the black catfish (*Ameiurus melas*), and three species of minnows (*Semotilus atromaculatus*, *Hybognathus nuchale*, and *Chrosomus erythrogaster*), all of which are reported by Meek and Clark ('02). These species either do not occur at all or if present do not occur naturally at the lower level of Go Home Bay. It thus appears that there are certain differentiating factors, which may be based on observed differences, such as soil content, food supply or water composition upon which the presence of certain species will be found to depend.

ANALYSIS OF THE SPECIES.

The total number of species here recognized is 48, representing 37 genera and 20 families. The number of species reported from Canadian localities, and including only fresh water forms, has been estimated by Evermann and Goldsborough ('07) at 145, representing 67 genera and 25 families. Probably more than one-third of the total number for Canada will be found either in Georgian Bay or in the streams entering it.

The majority of the families are represented by single species, the largest number of species belonging to a single family being 10 (*Cyprinidæ*). The complete list of families with the number of species representing them is as follows:—

Petromyzontidæ	2	*Umbridæ*	1
Polyodontidæ	1	*Luciidæ*	2
Acipenseridæ	1	*Pœciliidæ*	1
Lepisosteidæ	1	*Gasterosteidæ*	1
Amiidæ	1	*Percopsidæ*	1
Siluridæ	2	*Atherinidæ*	1
Catostomidæ	3	*Centrarchidæ*	4
Cyprinidæ	10	*Percidæ*	5
Anguillidæ	1	*Cottidæ*	2
Salmonidæ	7	*Gadidæ*	1

Family PETROMYZONTIDÆ.*

(Lampreys)

Representing the lower order of fish-like vertebrates (*Marsipobranchii*), animals with discoidal mouth, parasitic on other fishes. There appear to be two species represented in Georgian Bay, of which one has been collected, while the other is recognized from the evidence cited below.

Ichthyomyzon concolor, Kirtland.

(Silver lamprey)
(*Plate 1, fig. 5*)

A number of specimens taken on pike and garpike in running water below the first falls on the Go Home River. Specimens taken during July and August are from 4 to 5 inches in length, a single specimen of 6½ inches. The length of this

* The classification here employed follows the plan of Jordan and Evermann ('96), but is restricted to the family divisions, ordinal reference being for the most part omitted.

species is given by Forbes and Richardson ('08) for Illinois as 12 inches, and by Jordan and Evermann ('96) as 10. Go Home specimens are probably immature, none having been taken in the spring of the year.

Oral disc always expanded. Supraoral tooth bicuspid; infraoral with 7 cusps (sometimes 4 or 6). There are 11 lateral, oblique, curved rows of unicuspid teeth, of which 4 rows have their enlarged first cusps immediately lateral to the mouth. Dorsal fin continuous, with a broad notch.

For several years no specimens of the larva or *Ammocoetes* of this lamprey were discovered, but in August, 1910, a single specimen was found in a decaying submerged log at about the same place where all the metamorphosed specimens were taken. The larva is $3\frac{1}{4}$ inches in length, or approximately the size of the smallest metamorphosed specimens. The dorsal fin is continuous, this character differentiating the larva from that of the lake lamprey, the latter as described by Gage ('93) having the dorsal fin divided as in the adult.

Petromyzon marinus unicolor, DeKay.

(Lake lamprey)

This species is included provisionally. The dwarfed fresh water representative of the marine lamprey (*Petromyzon marinus*), described by Jordan and Fordice ('85), Meek ('85), and Gage ('93) occurs generally in the lakes of northern and central New York. A lamprey, evidently representing the same variety occurs abundantly in Lake Ontario, and is commonly taken by fishermen on whitefish and lake trout. In this lamprey the dorsal fins are separate, the four extraoral teeth bicuspid, the average length about 15 inches.

Though there is no reliable information as to the occurrence of lake lampreys in the upper lakes, and the whitefish and trout are practically free from lamprey marks, fishermen state that lampreys of about 15 inches in length are sometimes taken on whitefish and trout from deep water. This suggests that the lake lamprey is present in small numbers, and perhaps accidentally. The silver lamprey does not reach the size indicated, and up to the present has not been taken except in the limited area represented by the running water of the falls of the river. Fishes such as pike, on which the silver lamprey is commonly taken, are abundant elsewhere in shore waters, but do not have lampreys on them.

Family POLYODONTIDAE.

Polyodon spathula, Walbaum.

(Paddle-fish)

Naturally an inhabitant of the Mississippi valley, but occasional specimens taken in the Great Lakes. Noted here on account of two specimens reported by Nash ('08) taken near Georgian Bay waters, one at Sarnia*, the other at Spanish River on the North Channel.

* Vide, Prince E. E. Paddle-Nosed Sturgeon in Ontario. Ottawa Naturalist: Vol. XIII, No. 7, 1899.

Family ACIPENSERIDAE.

Acipenser rubicundus, LeSueur.

(Lake sturgeon)

This species was formerly abundant in Georgian Bay, but in the southern part is now rarely seen. Reported as ascending the Nottawasaga River in May and rivers of the east shore in June.

Though formerly considered of little or no value, and often in the earlier days of the Georgian Bay fishery taken from the water to be destroyed, the fish now commands a good price and a female which will yield caviare is a veritable prize to the fortunate fisherman. The quantity now taken in Georgian Bay is insignificant, the figures for 1909, as given by the Superintendent of Game and Fisheries for Ontario being 6,900 lbs. for Georgian Bay proper, and 14,155 lbs. for the North Channel.

The experiments carried on for several years in the United States ,looking to the artificial propagation of the sturgeon, yielded most promising results, though difficulty was experienced in obtaining spawn and milt at the same time. In view of the scarcity and increasing value of this fish, the matter of artificial propagation should be taken up at once by the Canadian hatcheries. There are doubtless many small details that would have to be worked out in handling fish of this size, and a suitable river must be found where the fish still ascend in numbers.

Family LEPISOSTEIDAE.

(Garpikes)

Lepisosteus osseus, Linnaeus.

(Long-nosed garpike. Bill-fish)

Not uncommon in swamps where there is more or less clean sand bottom. Probably not so abundant on any part of the typical Archean shore of Georgian Bay as in its southeastern arm, or elsewhere in sedimentary waters.

Length up to 5 feet, but the larger specimens in Georgian Bay are about 3. Body greatly elongated, slender, and little compressed. Depth 9.6 to 11.8. Head rounded posteriorly, extended anteriorly into the slender beak-like snout. Length of the head 2.9 to 3.2 in the length of the body; snout 1.3 to 1.4 in head. Eye in head 16.2 to 18.7. General coloration dark olive or greyish above, yellow or white below. Posterior part of the trunk and median fins spotted. Many of the smaller marks on the body give the impression of ink-stains run between the edges of the scales. Dorsal fin with 8 rays; anal with 8 or 9. Body covered with a hard thick armor of ganoid plates, the number of which is 9 to 11, 62 to 64, 9 or 10.

The fish is usually seen lying in the shallow water over sand bottoms and rising

occasionally to the surface for air. It feeds for the most part on minnows, top-minnows and young suckers, which it captures by a sharp, quick snapping motion of the jaws. Like the fresh water dogfish, it represents an archaic type, of considerable biological interest. It is of no value otherwise, and its extermination is frequently urged on account of its destructiveness to other fishes or on account of the damage it inflicts on the nets of the fishermen.

The nests of this species have been found only on two occasions at Go Home Bay. In both cases the nests were constructed with little care in about two feet of water, and on a bottom covered with the short stems of aquatic plants. The spawning time is towards the middle of June. Young fish of from two to six inches in length are commonly taken in swamps or on sand beaches. They make practically no efforts to avoid capture. Their coloration is much more striking than that of the adult. There is a broad lateral stripe of black, and immediately above it a white band with brownish spots in its lower portion. There is a median dorsal band of dark color, and the ventral surface is occupied by a dark band containing a median white stripe. The tail is also notably different in form, the fin portion being separated for a considerable distance from a lance-shaped filamentous lobe representing the continuation of the tail proper. This delicate lobe is in the natural condition kept in almost constant motion.

Family AMIIDAE.

(Dogfish)

Amia calva, Linnaeus.

(Dogfish. Bowfin)

Present in nearly all swampy situations, but more abundant in the south-eastern arm of the bay, in the vicinity of Waubaushene, where the more extensive swamp areas doubtless provide a more congenial habitat.

Length 2 feet. Body robust forwards, compressed and gradually tapering backwards to the tail. Depth 4·3 to 5·2. Head very stout, its length 3·5 to 3·8 in the length of the body. Eye small, 8·1 to 11·5 in head. Anterior nares opening on short tubes. Coloration above and on sides dark olive green, with more or less definite darker mottlings. A black spot on the upper margin of the tail, surrounded in the male by an irregular band or ring of yellow or orange. Lower parts white or yellowish. Opercle with two fairly distinct bands of black extending backwards from the eye. Lower jaw and jugular plate with dark mottlings. Males in the breeding season have the dorsal and caudal fins greenish black, but the lower fins are bright emerald green, and have a band of green connecting them on each side of the body. In the female all the fins are dark. Dorsal fin very long with 48 (to 50) rays. Anal with 10 or 11 rays. Scales large, with more or less angular edges, 8 or 9, 67 to 69, 11 to 14.

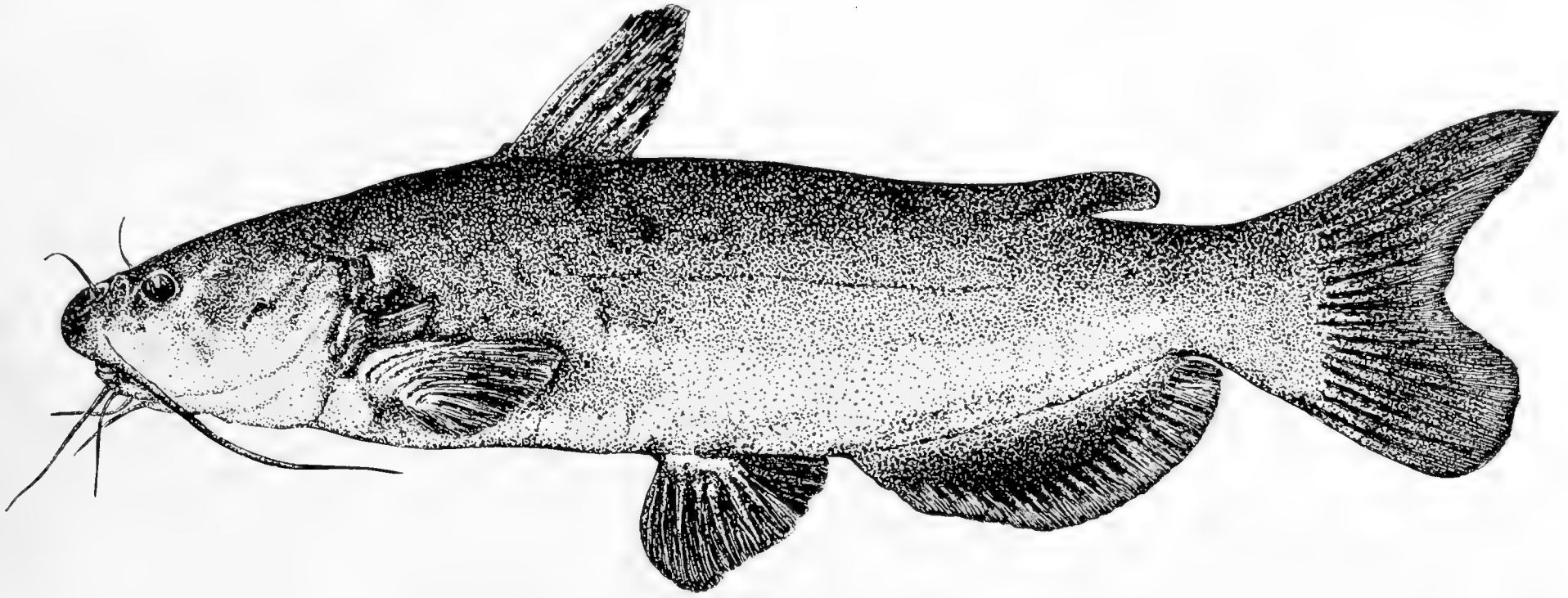

Fig. 5. The Great Lake Catfish (*Ameiurus lacustris Walbaum*). About one-third actual size.

Though a strong and vigorous swimmer, this fish is commonly seen lurking among the weeds in the shallow water of swamps, lying motionless on the bottom, or moving stealthily along by rhythmic undulations of the dorsal fin. It feeds on swamp living fishes such as minnows, suckers, perch or the young of the game fishes, but will eat crayfish, mud-puppies, or insects.

The spawning period is from May 24th to June 1st. The eggs are deposited in large open, but fairly deep depressions, scooped out of the mud among the flag roots by the male fish. The nest is also guarded during the hatching period by the male, which at this time will be found lying motionless in the bottom of the depression, unless disturbed by the presence of minnows or other small fish on the look-out for food. Young dogfish of about two inches in length are sometimes seen in schools, swimming about in the swamps accompanied by the parent fish. It appears, however, that the young fish are taken into deeper water immediately after hatching and that as a rule they spend a considerable time in the deeper situations. The fish taken inshore are most commonly large specimens, the young in various stages of growth being unusual.

Young dogfish of two inches in length show the general features of the adult, but the darker ground markings are more conspicuous. There are three prominent lines on the side of the head, one horizontal and passing through the eye, a second passing along the upper jaw and extending backwards beneath the eye, and a third on the lower jaw. The median fins have two bands of dark color, one marginal, the other a short distance inward; also present in the adult, but obscured by the general dark coloration.

Family SILURIDÆ.

(Catfishes)

This family is represented by two species, separable as follows:—

Genus **Ameiurus.**

a. Caudal fin rather deeply notched; anal fin with 23 to 27 rays. Catfishes of large size..... **lacustris.**

aa. Caudal fin at most slightly emarginate; anal fin with 21 or 22 rays. Small catfishes, usually 12 inches or less..... **nebulosus.**

The black catfish (*Ameiurus melas*) is reported by Meek and Clark ('02) as relatively more abundant than *A. nebulosus* in Muskoka and Gull Lakes, but this species has not been recognized in Georgian Bay. The yellow catfish (*Ameiurus natalis*) is suggested by Jordan and Evermann ('96) as possibly the species referred to by Richardson ('36) as *Pimelodus coenosus*, which was described from specimens taken at Penetanguishene. This species may occur in the sedimentary swamps or streams of the region, but has not been found northward. It is probable, however, that the fish described by Richardson is *A. lacustris.*

Ameiurus lacustris, Walbaum.

(Great Lake catfish)

(*Fig. 5*)

This species appears to be present along the main shore of Georgian Bay only in small numbers. It is said to be taken frequently in the Magnetewan River at Byng Inlet. A single specimen was taken near the biological station at Go Home Bay, in 1907, the weight of which was 37 lbs. In this region it occurs chiefly inland, being abundant in Flat Rock Lake and in the Musquash River immediately above the lake. The specimens taken here are commonly from 5 to 15 lbs. in weight. It may be taken in the darker water by ordinary rod-fishing during the day.

Length 2 feet or more. Body moderately elongated, the trunk very heavy forwards and laterally compressed towards the tail. Depth 4·2 to 5. Head broad and depressed, its length 3·2 to 4 in the length of the body. Eye small, 8·2 to 11 in head. Four pairs of barbels, of which the maxillaries are as long as or but slightly shorter than the head. Coloration uniformly dark ashy above, lighter below. Dorsal fin with 1 spine and 6 soft rays. Anal fin with 23 to 27 rays, its base 3·4 to 3·5 in the length of the body. Pectoral fin with 1 spine and 8 soft rays, the length of the spine 2·3 to 2·5 in that of the head. Fins all dark, except the ventrals, which are ashy at the tips.

The stomachs of several specimens examined contained nothing but crayfish. No reports are available concerning the spawning habits; but since the fish is not seen in shallow water at any time, after the manner of the smaller catfishes when spawning, it is assumed that the eggs are deposited in deep water.

Ameiurus nebulosus, LeSueur.

(Common or brown bullhead)

The small catfishes of Georgian Bay show considerable variation, but an examination of a large number of specimens indicates that there is but one species. Specimens from these waters are rarely more than 12 inches in length, and the general coloration, doubtless associated with the transparency of the water, tends to dark grey and black above with ashy shades below. The cloudy markings are present but concealed.

The fish is extremely common in all shore swamps and larger inland lakes of a swampy character, but is taken as a rule only at night. Throughout the summer the food consists almost wholly of Mayfly larvæ, for which the fish burrows in the mud of the bottom.

The following are the critical measurements of Go Home specimens indicating the reference to *A. nebulosus*. Depth of body 3·8 to 5, usually 4·1. Head 3·2 to 3·7, usually 3·4. Pectoral spine in head 2·1 to 2·5, usually 2·3. Rays of anal fin 21 or 22; length of anal base in length of body 4·1 to 5., usually 4·5 (25 specimens).

Though rarely seen in the daytime at other periods, the catfish are conspicuous objects in the swamps during the spawning season. The time of spawning varies greatly, but begins during the latter part of June and extends well into July. The nests are constructed in shallow water, often only two or three feet from the shore. In this region the fish do not make open nests as in other places, but burrow under flag roots or submerged sticks. The burrows are about eighteen inches or two feet in length, and the terminal chamber has a clean hard bottom on which the egg mass rests. The nests are chiefly made by the males, but sometimes both males and females participate in the construction. After depositing the eggs the female usually leaves the nest, the latter being then guarded by the male. As a rule he lies wholly concealed in the burrow and probably in the terminal chamber with the eggs, but darts forth when the bottom is disturbed. The eggs are hatched in a few days, and the fry gradually work their way to the outside of the burrow. Though at first unpigmented, they soon acquire a dense black coloration. For some time they move about in large schools, accompanied by the male, feeding on microscopic organisms, but later they are abandoned by the parent fish and disperse, working downwards among the bottom vegetation.

Family **Catostomidae.**

(Suckers and mullets)

Represented by two genera, separable as follows:—

a. Air-bladder divided into three compartments. Scales in lateral line less than 50..... **Moxostoma**

aa. Air-bladder divided into two compartments. Scales in lateral line more than 50..... **Catostomus**

Genus **Moxostoma.**

Moxostoma anisurum, Rafinesque.

(White-nosed sucker)

Occasionally taken in gill-nets in the southern part of the bay; more abundant towards fall. Not seen inshore in the region of Go Home Bay during the spring or summer. Many specimens were seen taken in the pound-nets at Killarney and Spanish River on the north shore. The following description is based on a single specimen, the only one thus far received for examination.

Length 15 inches (the size commonly much greater). Body heavy forwards, but moderately deep and compressed. Depth 3·2. Head short and broad, its length 3·8. Snout blunt; mouth inferior, the lips plicate, but with the folds slightly broken into papillæ. Eye 5·9. General coloration pale yellowish, darker above. Under parts and snout whitish. Dorsal fin with 16 rays. Anal with 8 rays. Scales large and coarse, 7, 44, 5.

Genus **Catostomus.**

Represented by two species, as follows:—

a. Scales small, those in the lateral line 102 to 117. Snout elongated, conical, projecting considerably beyond the mouth.....**catostomus**

aa. Scales larger, those in lateral line 64 to 72. Snout blunt, not projecting greatly beyond the mouth.....**commersonii**

A third species, described, but perhaps wrongly, as a fine-scaled sucker is thought to occur, but no specimens have been taken.

Catostomus catostomus, Forster.

(Long-nosed sucker. Red sucker)

Commonly taken in gill-nets in deep water and in the pound-nets on the north shore. Rather infrequent inshore in the southern part of the bay. Of the young suckers common in the shore swamps all identified belong to the next species, but a few specimens of the present species have been taken in shallow water near the Giant's Tomb Island.

Length 18 inches. Body moderately elongated, rounded. Depth 4·2 to 4·9. Head rather broad and rounded behind, tapering forwards into the slender conical snout. Length of head 3·7 to 4·2. Eye 6·2 to 8·2. Mouth inferior, with thick papillose lips. Coloration uniformly dark brownish or blackish above, light below. Sides with a reddish stripe, showing only in a few of the summer specimens, but present in all males in spring. Dorsal fin with 10 or 11 rays. Anal with 7 rays. Scales small, 18 to 21, 102 to 117, 12 to 17.

In this region the fish is considered to be of no value, and is destroyed in large numbers by the fishermen.

Catostomus commersonii, Lacépède.

(Common sucker. White sucker)

Commonly taken in the gill and pound-nets. The fish probably inhabits the shallow water of shore bays, but is not seen inshore in numbers except during the spring run into the rivers, and to a certain extent near shore on the spawning beds of the rock-bass and small-mouthed black bass. Young specimens of from 2 to 5 inches in length are very commonly taken in the shore swamps, where they sometimes make up a large proportion of the seine catches.

Length 18 inches. Body rather thick and heavy forwards, moderately compressed towards the tail. Depth 4 to 4·6. Head heavy, rather broad, its length 3·7 to 4·3. Snout short, squarish at tip. Mouth inferior, with strongly papillose lips. Eye 6·3 to 8·2. Coloration grey olivaceous above, light below.

Upper parts with more or less golden reflections. Dorsal fin with 11 to 13 rays, usually 12. Anal fin with 7 or 8 rays. Scales of medium size, but rather small and crowded forwards, 9 or 10, 64 to 72, 7 to 9. Young specimens taken in the shore swamps show blackish blotches on the sides.

Like the remaining members of this family, the common sucker is a bottom-feeding fish, subsisting ordinarily on molluscs and crustaceans, but very destructive to the spawn of other fishes. The present species is abundant on the shoals where the whitefish, trout, and herring resort in the fall for spawning purposes. It also runs into the rivers, to the foot of waterfalls in the early spring, feeding on the spawn of the doré, and afterwards spawning in the same situation. It is not infrequently seen swimming lazily about in the shallow water of the swamps in June, during the spawning time of the rock-bass and black bass, and on some occasions has been observed to enter the nests of these fishes, apparently with little resistance on the part of the occupants, and leisurely devour the contents.

Family CYPRINIDAE.

(Carps and minnows)

This family is represented in Georgian Bay waters by at least five genera and ten species. One species, the common or German carp, is an accidentally introduced species for these waters. In addition there are three species, representing two more genera, the normal occurrence of which is doubtful. These are the red-bellied dace (*Chrosomus erythrogaster*) and the black-nosed dace (*Rhinichthys atronasus*), single specimens of which appear in the collections; and a species of *Semotilus* or *Hybopsis*, represented by a single specimen, too minute for identification, which was taken with specimens of *Rhinichthys* in a rock pool.

With the exception of the carp, these species are all of small size, Georgian Bay specimens appearing in general small in comparison with those of other localities southward. The largest species in the region is the redfin minnow (*Notropis cornutus*), which is commonly $3\frac{1}{4}$ inches in length, and the smallest is *Notropis heterodon*, which is barely an inch in length.

Though of small size, the *Cyprinidae* are of the greatest importance, since they form the food of larger fishes such as the bass, pike, and doré, either directly, or indirectly through the crayfish, which feed on smaller fishes to a considerable extent, and themselves form the staple food of the small-mouthed black bass and rock-bass. The *Cyprinidae* are in fact the intermediates in the range of food supply, connecting the larger fishes with the fundamental plankton food of the water, since they live very largely on small or microscopic entomostraca, blue-green and green algae, and minute insects. They are not wholly benefactors, however, for it is probable that enormous numbers of eggs of nesting fishes are destroyed in the spring of the year by the various species infesting the shore swamps. They annoy the nesting bass and rock-bass by their enormous numbers, and the temporary departure of the fish from the nest is a signal for a swift attack on the contents, which are devoured in a moment. Specimens taken under such circumstances commonly have the stomach gorged with the stolen eggs.

Genus **Cyprinus.**

Cyprinus carpio, Linnaeus.

(German carp)

Abundant in the swamp waters of the southeastern end of Matchedash Bay, and reported as occurring elsewhere along the south and west shores of Georgian Bay. Very few specimens, in all probability stragglers, are reported by fishermen from any locality along the eastern and northern shores. It appears that the swamps of the Archean part of the shore are not suitable for the development of this species, which condition if true will be fortunate for the conservation of black bass and other game fishes in this region. It may be, however, that the carp is so recent an arrival in these waters that is has not had time to become distributed.

Specimens taken at Waubaushene by Capt. C. J. Swartman were chiefly of the scaled variety, but some were mirror carp, with a few large scales, and the naked or leather variety is said to be sometimes taken. The mud and sand areas of this part of Georgian Bay undoubtedly provide a suitable environment for the species, after the manner of sedimentary swamp lands elsewhere. Specimens of 10 lbs. and over are commonly taken.

Regarding the introduction of this fish into Georgian Bay waters, the general opinion is that the carp of Matchedash Bay gained access to this water through the Severn River. They are reported to have appeared in numbers about twelve years ago, at which time the fish were all small specimens of about 10 inches in length. Carp inhabit the head waters of the Severn River, Lake Simcoe, in large numbers, and the stock of this lake is thought to have been derived from specimens formerly kept in a pond near Newmarket. From this pond specimens are supposed to have escaped into the Holland River and thence into Lake Simcoe. It will be remembered, however, that the carp has had abundant opportunities to become distributed throughout the Great Lakes, and possibly those of the southern part of Georgian Bay gained access to the waters from another direction.

In the years from 1875 to 1879, the United States Fish Commission made several importations of German carp, with the object of stocking American waters with a type of fish that would thrive in waters unsuitable for other fishes and provide an abundant cheap food supply for the masses of the people. The carp were successfully bred, and were distributed in large numbers in successive years from 1880 to 1896. Between the years 1880 and 1893 several lots of carp were sent to applicants in Canada, including Mr. Samuel Wilmot, the Ontario Commission, and certain private individuals. In Ontario, the fish appear to have gained access to public waters chiefly through accidents to private ponds in which they were kept.

The carp has been greatly condemned on several scores, some of which undoubtedly have a strong basis of fact. It is a bottom-living form, and produces considerable havoc in swamps, making the water muddy and rooting up aquatic plants in search of the minute molluscs which form its staple food. It is accused of polluting the water, of eating the spawn of other fishes, of driving game fishes away,

and of destroying the wild celery of swamps frequented by ducks. It is also urged against the fish that it is a kind not acceptable as a table fish to the people at large. Such complaints, which are usually directed against the authorities responsible for the introduction of the fish, have been carefully investigated by Cole ('05), who finds on the whole in favor of the carp. There is no doubt that a great deal of foolish prejudice exists against the carp, and it is probable that when the matter is more fully understood, and especially when the necessity for a cheap class of fish food has become imperative, as it doubtless will, the work of stocking American waters will be more generally appreciated.

The carp is now firmly established in Ontario waters, and is undoubtedly there to remain, whatever attempts made be may to eradicate it. There is, however, no necessity for allowing it to increase at the present time, even in places where its presence is more or less welcome. Undoubtedly in those areas where the conservation of game fishes is in the general interest of the people, facilities should be given to fishermen to take and market the fish, or if any damage is likely to be done to smaller swamp-living fishes, to eggs of nesting fish, or to the swamp-bottoms themselves, the work should be conducted by the authorities. Some discrimination is necessary in this matter, since there are many swamp areas which sportsmen will continue to want to have recognized as game fish preserves when they are in reality suitable for little else than carp or other coarse fishes. The method of taking carp which is least objectionable from a biological standpoint on shores frequented by game fish is the use of large-meshed gill-net, set in such a way that the fish may be driven into it and the net immediately lifted. Advantage may be taken of the larger girth of the carp, permitting other fishes to escape, and no damage is done to the swamp bottoms or to their ordinary occupants. No operations of this kind should be permitted during the time that the bass or other desirable fish are on the nests if the preservation of these fish is the first consideration. It is probable that in areas like the eastern arm of Matchedash Bay, and especially on its northern side no damage worth mentioning would ensue to the game fishes if carp were permitted to be taken in the manner described at any period of the year.

The four genera of small *Cyprinidae* here recognized are separable as follows:

a. Body deep and compressed, the depth contained less than 4 in the length (except in young specimens). Abdomen compressed to a sharp edge behind the ventral fins.....**Abramis.**

aa. Body at most only moderately deep, more than 4 in the length. Abdomen behind the ventral fins rounded:

b. Maxilla with a small barbel at its posterior end.....**Rhinichthys.**

bb. Maxilla without barbel.

c. Intestine considerably longer than body.....**Pimephales.**

cc. Intestine shorter than body.....**Notropis.**

Genus **Abramis.**

Abramis crysoleucas, Mitchill.

(Golden shiner. Bream)

(*Plate II, Fig. 6*)

Abundant, but confined to the ends of swamps and inland lakes, apparently preferring the smaller ponds where the water is dark, choked with vegetation or almost filled with bottom ooze. Nothwithstanding its unattractive habitat the fish is one of the most striking of all the minnows, and is easily recognized by its deep flat body, which is of a bright golden coloration, and by the very oblique mouth.

Length of the larger specimens $3\frac{1}{3}$ inches. Body thin, the depth 3·5 to 4·5, relatively greater in the larger specimens. Abdomen compressed behind the ventrals into a sharp edge. Coloration dark olivaceous above. Sides bright silvery with golden reflections. A dark lateral band, conspicuous only in small specimens. Head compressed, 3·9 to 4·3. Mouth terminal, very oblique. Eye 3·1 to 3·4 in head. Dorsal fin inserted behind ventrals, with 8 rays. Anal fin long, with 12 (sometimes 11) rays. Scales 10 or 11, 44 to 55, 3 to 5 (usually 4). Lateral line strongly decurved, sometimes broken or irregularly connected. Usually complete, but in some specimens, with pores only on a few anterior scales. Intestine as long or longer than the body, 1 to 1·3. The intestine commonly contains clean masses of green algæ.

Genus **Rhinichthys.**

Two species representing this genus are known to occur in Ontario waters, namely, the black-nosed dace (*R. atronasus*) and the long-nosed dace (*R. cataractæ*). Both species are reported by Meek and Clark ('02) from Hawkstone, Lake Simcoe, and from Sault Ste. Marie (*R. atronasus* being more common), but not from Muskoka Lake.

In the Georgian Bay collections there is one specimen of *R. atronasus* the presence of which may be accidental. *R. cataractæ* occurs in limited situations as described below.

Rhinichthys cataractae, Cuvier et Valenciennes.

(Long-nosed dace)

(*Plate II, Fig. 7*)

The species inhabits and appears to be confined to rock-pools on exposed reefs fringing the main shore of Georgian Bay. It is practically the only fish

inhabiting these pools, though those open to the outside water sometimes contain other species. The fish lurks under the stones and is only taken by strategy. It is easily recognised by the spindle-like body, general dark coloration, and very small scales, or if examined closely by the minute barbel placed behind the angle of the mouth.

Length 2⅓ inches, the specimens commonly taken much smaller. Body spindle-shaped, not compressed. Depth 5·1 to 5·8. Color very dark olivaceous above, with black vertebral streak and dark lateral band, the latter not conspicuous except in young specimens. Sides with dark points on the scales and with more or less of fine blotching. Head long and pointed, 3·3 to 4. Eye 4·3 to 4·6 in head; in snout 1·6 to 2·4. Snout in head 2·1 to 2·6. Mouth wholly inferior, the snout projecting well beyond the tip of the lower jaw. A minute barbel behind the fleshy lobe that forms the angle of the mouth. Dorsal fin with 8 rays, inserted distinctly behind the ventrals. Anal with 7 rays. Scales minute, 12 or 13, 68 to 72, 9 to 12 (usually 10). 35 to 37 oblique rows in front of the dorsal fin. Lateral line complete, almost straight.

Genus **Pimephales.**

Of the two known species, *P. promelas* and *P. notatus*, the latter is reported by Meek and Clark ('02) as more abundant in the inland localities examined, though *P. promelas* was found at Hawkstone, Lake Simcoe, and at Trout Creek, a tributary of Lake Nipissing. Up to the present only *P. notatus* has been taken in Georgian Bay. With the exception of the red-bellied dace (*Chrosomus erythrogaster*), the natural occurrence of which in Georgian Bay is doubtful, this species is the only representative in this region of the herbivorous or mud-eating group of minnows, represented elsewhere by the species of *Campostoma*, *Hybognathus* and other genera.

Pimephales notatus, Rafinesque.

(Blunt-nosed minnow)

(*Plate II, fig. 8*)

With the exception of the redfin minnow (*Notropis cornutus*), this is the most abundant minnow of the region. It occurs in collections from all points from Waubaushene to Byng Inlet, in inland waters, and from the Giant's Tomb Island. Georgian Bay specimens differ in some details from those described by Forbes and Richardson ('08) from Illinois. They are rather dark, and the usual number of scales before the dorsal fin is smaller by about two rows. The intestine, described by these authors as twice the length of the body, is in the specimens examined rather shorter, the combined length of stomach and intestine, or of the intraperitoneal part of the alimentary canal, being in none equal to twice the length of the body.

The minnow is easily recognized by its blunt snout, robust angular body, black lateral stripe, and crowded scales before the dorsal fin. Nearly all the scales have dark edges, giving the body a cross-hatched appearance.

Length 2⅞ inches. Body moderately elongated, but with the sides and back flattened, giving a somewhat rectangular appearance to the forward part of the trunk. Depth 4·7 to 6·2 in the length of the body. Color rather dark olivaceous above, all the scales except those about the pectoral and ventral fins with prominent dark edges. Sides dull silvery or leaden. A dark lateral stripe extending along the body and around the head, passing through the eye and the upper part of the snout; not conspicuous on the head in some specimens (spring males) on account of the dark coloration of its upper portion. A dark spot at the base of the caudal fin, and another at the anterior base of the dorsal fin, the latter spot often faint or absent. Head 4·2 to 4·5. Snout blunt, the mouth at its ventral angle, small and almost inferior. Eye 2·9 to 3·2 in head. Dorsal fin with one anterior short, swollen or club-like ray and 8 ordinary rays; situated a little behind the ventrals. Anal with 2 rudimentary and 7 developed rays. Scales 6 to 8, 42 to 49, 4 or 5; usually 7, 44, 4. Oblique rows before dorsal fin 18 to 23, usually 21, but sometimes 2 or more scales inserted between rows. Lateral line complete, slightly decurved in front, usually showing black specks above and below the pores, but the latter never conspicuous, and often very faint or absent. The length of the body is contained 1·1 to 1·9 in the length of the stomach and intestine.

The intestine commonly contains large quantities of vegetable material, for the most part green algæ in a mud-like basis, but the fish are by no means purely herbivorous. During the nesting season of the bass and rock-bass, they are commonly seen in large numbers waiting about the nests. If the latter are left for a moment the contents are quickly disposed of.

The eggs of this minnow are deposited during June and the early part of July on the under sides of stones, sticks or pieces of bark, and are watched and vigorously defended by the male fish, which at this season has the front of the head armed with 16 or 18 sharp tubercles.

Genus **Notropis.**

This characteristic American genus, containing in all about 100 species, is represented in this region by 6 species. The most abundant species is the redfin minnow (*N. cornutus*), which occurs everywhere in the shore swamps and in inland waters. The much smaller species, *N. blennius*, is probably next in frequency of occurrence, though more abundant in the more open swamps. Two species, *N. cayuga* and *N. heterodon*, show a tendency towards inland situations; more marked in the latter, which has been taken almost wholly in the Musquash River and in Flat Rock Lake above the first falls on the Go Home River. *N. hudsonius* is comparatively rare in the region, and appears to prefer situations where there is more sand or mud bottom. *N. atherinoides* is an extremely abundant minnow in the shore swamps in spring, but in summer appears as a rule only in small numbers.

The six species are separable as follows:—

a. Rays of anal fin 7 or 8;

b. Scales before dorsal in 12 to 15 oblique rows;

c. A black stripe along the side of the body, extending through eye to end of snout;

d. Chin white.....**cayuga**

dd. Chin black.....**heterodon**

cc. A diffuse plumbeous lateral band, only evident posteriorly. Lateral line with black specks above and below the pores.....**blennius**

bb. Scale before dorsal in 18 to 20 oblique rows, a prominent black spot at the base of the caudal fin.....**hudsonius**

aa. Rays of anal fin 9 to 11;

e. Dorsal fin immediately over the ventrals. Anterior scales on sides of body rather deep and narrow.....**cornutus**

ee. Dorsal fin distinctly behind the ventrals. Scales rounded normal.....**atherinoides**

Notropis cayuga, var. **muskoka,** Meek.

(*Plate II, fig. 9*)

Frequently taken in the shore swamps about Go Home Bay, and also appears in collections from Sans Souci and Pte. au Baril. It seems to prefer the less open swamps, but has not been found anywhere in abundance. The fish is easily recognized in comparison with other minnows of the region by the small crescentic markings along the sides of the body.

Specimens submitted to Dr. Meek were referred to the species *N. muskoka*, a form described by him ('99) from specimens taken in Muskoka and Gull Lakes, but with the suggestion that this form may be a variety of *N. cayuga*. In view of the intermediate characters presented by Georgian Bay specimens, the latter interpretation is here recognized.

Length commonly $2\frac{1}{3}$ inches. Body moderately elongated, only slightly compressed. Depth 4.3 to 5.3 in the length of the body. General coloration olivaceous, sometimes, in spring specimens, with a golden tinge. Scales above with prominent dark edges. Vertebral line scarcely evident. A dark line passing along the side of the body, through the opercle and snout, above the upper jaw. On the trunk this line is separated from the dark-edged upper scales by a lighter band. It is overlaid by a series of small crescentic marks, one at the base of every scale of the lateral line. Head somewhat conical 3.4 to 4 in length of body. Eye 3 to 3.7 in head. Mouth subterminal. Dorsal fin with 8 rays; anal with 7 or 8. Scales 5,34 to 37,3 or 4.15 (sometimes 16) rows of scales before dorsal fin. Lateral line incomplete, lacking pores on some of the scales. Stomach and intestine 1 to 1.3 in length of body.

The species *N. muskoka* is described by Meek as differing from *N. cayuga* in the reduced size of the scales before the dorsal fin, more slender body, less blunt snout, slightly larger and more oblique mouth, and more incomplete lateral line. Georgian Bay specimens cover the range of depth variation as described by Forbes and Richardson ('08) for *N. cayuga* (4.5 to 5.2), but 5 specimens of *N. cayuga* in the British Museum collection (Silver Lake, Iowa, Meek), which have been recently examined, are much deeper (4 to 4.3), and their appearance is quite different both from the Georgian Bay specimens and from specimens of *N. muskoka*. Georgian Bay specimens commonly show 15 rows of scales before the dorsal fin, but the number is occasionally 16, and in some specimens two or three extra scales are inserted between rows. The crowded appearance is, however, not nearly so marked as in *N. muskoka*. The lateral line characters seem to be quite variable, some specimens having the lateral line almost complete, and other showing pores only on a few scales. It appears that the Georgian Bay specimens deviate in some characters from the typical *N. cayuga*, and that these characters are accentuated in the inland form. The species described by Eigenmann ('93) as *N. heterolepis*, from a single specimen taken at Qu'appelle, is, as suggested by Forbes and Richardson, referable to *N. cayuga*. The specimen is superficially much more like *N. cayuga* than are those from Georgian Bay or Muskoka Lake.

Notropis heterodon, Cope.

(*Plate II, fig. 10*)

A small species, in fact the smallest of all fishes inhabiting the region, the largest specimens being barely 1½ inches in length. It appears in collections from Go Home Bay, but probably does not occur in any numbers along the main shore. It is very abundant inland, however, a large number having been taken from Flat Rock Lake, where small specimens have been seen in millions. On account of its very small size and superficial resemblance to *Pimephales notatus*, which is abundant in the same situations, this species easily escapes detection. It is recognizable by a numberof features, including a solid black lateral stripe, oblique mouth, black chin, and the small number of scales in front of the dorsal fin.

Length 1½ inches, commonly less than 1 inch. Body slender, slightly compressed Depth. 4.5 to 5. Color olivaceous, the scales above with prominent dark edges. Sides with a solid black longitudinal stripe, accentuated by overlaid specks, the anterior ones rather fainter and placed at a lower level. The stripe is continued around the head and tips the chin. Between the lateral stripe and the back there is a clear band in which the scales are not dark-edged. Head 3.4 to 4 in length of body. Mouth terminal, oblique. Dorsal fin with 8 rays; anal with 8 or sometimes 7. Scales 5, 37 or 38,3. Oblique rows before dorsal 15, sometimes 14. Lateral line developed only in front, with pores on a few scales.

Notropis blennius, Girard.

(Straw-colored minnow)

(*Plate II, fig. 11*)

Abundant in shore swamps, especially in the vicinity of open water. Often seen in schools containing hundreds of individuals. The species is easily recognized in the water by the short stout body and by the pale coloration, or, when examined closely, by the dark specks above and below the pores of the lateral line. The coloration on the whole is noteworthy for its lack of character.

Length 2⅜ inches. Body appearing short in comparison with its width and depth; moderately compressed, and for the most part evenly tapered at the ends, except that the ventral profile increases rapidly to the shoulder and little beyond that point. Depth 4.2 to 5.3 Coloration pale straw yellow. Scales with prominent dark edges. A narrow vertebral line, expanding in front of the dorsal fin into a more or less evident blotch. A faint broad plumbeous band, scarcely evident, along the side of the body. Lateral line decurved anteriorly, conspicuously marked out in its entire length by small black specks, one above and one below every pore. On the tail the specks tend to fuse and form small solid blocks of black. Some specimens show an extension of these lateral line specks to form faint crescentic marks as in *N. cayuga,* but the crescents are always indistinct. Lower surface of body pale. Head conical, 3.8 to 4 in body. Eye 2.6 to 3 in head. Mouth almost terminal. Dorsal fin with 8 rays; anal with 8. Scales 4 or 5,37,3. 15 oblique rows in front of dorsal fin. Stomach and intestine 1.1 to 1.3 in length of body.

The food of this species seems to be of a most general kind, the intestine containing plankton entomostraca, minute insects, and blue green or green algae, usually mixed with ingested sand-grains. Females heavy with eggs are common during the first two weeks of June.

Notropis hudsonius, DeWitt Clinton.

(Spot-tailed minnow)

(*Plate II, fig. 12*)

This species appears in small numbers in collections from Go Home Bay, Giant's Tomb Island, Sans Souci and Pte. au Baril, but on the whole is seldom taken. It appears to prefer solid-bottom swamps or shores such as are more characteristic of sedimentary regions. The fish is easily recognized by the pale or silvery coloration of the sides combined with the very conspicuous jet-black caudal spot.

Length 2⅞ inches. Body rather stout and laterally compressed, unlike other species of Notropis of the region, except N. cornutus, in this respect. Depth 4.2

to 4.7. Coloration in general pale yellowish, the sides silvery. A thin vertebral line. Scales of back and sides with faint dark edges. A faint plumbeous band on the side of the body showing narrower and fainter in its anterior portion. Sometimes specks above and below the pores of the lateral line but never pronounced (cf. *N. blennius*). Head short, 3.8 to 4.5 in length of body. Nose rather blunt, the mouth at its ventral angle and very slightly oblique. Eye large, 2.3 to 3.6 in head. Dorsal fin with 8 rays; anal with 8, sometimes 7. Scales 6,38 to 41,4. 16 to 19 oblique rows before the dorsal fin. Lateral line complete, decurved anteriorly. Stomach and intestine 1.1 to 1.3 in length of body.

Notropis cornutus, Mitchill.

(Common shiner. Redfin minnow)

(*Plate II, fig. 13*)

With the exception of the blunt-nosed minnow (*Pimephales notatus*) this is the most abundant minnow of the region. Represented by at least a few specimens in nearly all seine catches, and often present to the exclusion of all other species except that mentioned. It occurs in all swamps on the main shore and inland, specimens having been taken from Flat Rock Lake, Giant's Tomb Island, Waubaushene, Sans Souci, Pte. au Baril, and Byng Inlet. It is also the largest minnow in the region, though not reaching the size reported from other localities. The fish is easily recognized in the water by its somewhat deep body, silvery sides, and especially the dorsolateral gilt stripe, which is much more pronounced in this than in other species.

Length commonly to 3⅜ inches, a single specimen measuring 5 inches. Depth 4 to 4·6, the body in young specimens rather elongated, but in older ones appearing shorter and deeper. Laterally compressed, the sides quite flat. Coloration above olivaceous, with a conspicuous vertebral stripe of black. Back bordered by a gilt stripe which shows best in the water. Sides silvery, sometimes appearing blotched on account of extra pigment on groups of scales or single ones. An indistinct lateral plumbeous band, the anterior part of which is very faint and only about half the width of the posterior part. Spring males have the darker parts of the body more brilliantly expressed, and there is a bright rosy hue on the sides, especially above the pectoral fins. The lower fins are all red, and there is a flush of red on the tips of the dorsal and caudal fins and on the lower side of the head. Some males have the top of the head covered by minute tubercles. Females plain. Head 3·9 to 4 in length of body; somewhat compressed, the snout blunt. Mouth terminal, rather large and slightly oblique. Eye 3·1 to 3·8 (specimens to 3⅜ inches). Dorsal fin with 8 rays ; anal with 9. Scales 7 or 8, 41 to 43, 4 or 5. The exposed edges of the scales are very narrow and deep on the anterior end of the body at the sides, by which character alone the species would be readily recognized. 21 to 25 rows of scales in front of the dorsal fin. Lateral line complete, slightly decurved in front. Stomach and intestine 1 to 1·3 in length of body.

The large specimen mentioned above shows the body relatively much deeper (3·6 in length), and the eye relatively smaller (5 in head), its actual size being no greater than in smaller specimens.

The food of this species appears to consist largely of green and blue green algae, with some aquatic insects, and occasionally entomostraca. Specimens about to spawn have been taken as early as May 18th. During the spawning season the fish are extremely active and very tenacious of life.

Notropis atherinoides, Rafinesque.

(Shiner. Silver minnow)

(*Plate II, Fig. 14*)

This species occurs in small numbers in the shore swamps during the summer, but in spring is frequently seen in large schools near shore feeding for the most part on insects. It is easily distinguished from other minnows by its very slender, elongated body.

Length not usually exceeding $2\frac{5}{8}$ inches. Body moderately compressed, very slender, the depth 5·8 to 6·9 in the length of the body. Upper part of the trunk, except for a thin triple vertebral streak, clear translucent olive, in spring deep green to almost black, bounded below by a thin gilt stripe. Sides very silvery, with a broad ground band of plumbeous shade running from the upper margin of the opercle to the base of the tail. No caudal spot. Cheek and opercle bright silvery. Spring specimens with delicate orange red spots at the bases of the pectorals and ventrals, also at the posterior end of the maxilla and above the opercle. Head 4 to 4·7, conical. Mouth terminal, somewhat oblique, the jaws more like those of larger fishes. Eye 3·2 to 3·5 in head, appearing large in some specimens. Dorsal fin with 8 or 9 rays, its anterior margin considerably posterior to a vertical line drawn at front of ventrals. Anal fin with 10 or 11 rays. Scales rounded, very lightly attached, 6,38 to 43,3. 20 to 22 rows in front of the dorsal fin. Lateral line complete, strongly bowed downwards in its anterior part.

The fish is probably the most alert and active of all the minnows, and appears to live on insects to a much greater extent.

Family ANGUILLIDAE.

(Eels)

Anguilla chrysypa, Rafinesque.

(American Eel)

Specimens of this species are reported on reliable authority to have been taken occasionally at the mouth of the Severn River and at Waubaushene at the south-

east end of Georgian Bay. Since the eel spawns in the sea, and the Falls of Niagara offer an insuperable obstacle to the ascent of the young, such specimens as are taken in the upper lakes must be chance specimens that gain access through the canals.

Family SALMONIDAE.

(Whitefishes and trout)

This important family is represented in the southern part of Georgian Bay by at least three genera and five species. On the north shore an additional species is represented by the Manitoulin tullibee, recently described by Jordan and Evermann ('09) as *Leucichthys manitoulinus*, and the streams of the south and west shores contain the speckled trout (*Salvelinus fontinalis*). The latter fish also occurs in various lakes and streams inland from the eastern shore of Georgian Bay, including the streams entering Muskoka Lake. It does not appear to occur in any of the streams belonging to the Musquash River system. Speckled trout are said to have been taken occasionally in Georgian Bay, but such specimens were in all probability stragglers from the streams.

The three characteristic genera are separable as follows:

Salmoninae:

a. Mouth deeply cleft, as usual in fishes, the articulation of the lower jaw posterior to the eye. Jaws with sharp teeth.....**Cristivomer.**

aa. Mouth not deeply cleft, the articulation of the lower jaw below or in front of the eye. Jaws weak and toothless.

Coregoninae:

b. Mouth very small and inferior, the snout projecting beyond it.....**Coregonus**

bb. Mouth somewhat larger, terminal.....**Leucichthys.**

Genus **Cristivomer.**

Cristivomer namaycush, Walbaum.

(Lake trout)

Usually taken by commercial fishermen in pound-nets or gill-nets, especially the latter. Some are taken in the summer by deep trolling, but the fish is only taken in numbers by trolling when rising to the shoals preparatory to spawning in the fall. In Muskoka Lake the fish also appear on the surface in May.

The general run of fish taken by the commercial fishermen are between 2 and 8 lbs. Very small fish, however, which would otherwise go through the nets, are sometimes captured, being entangled in the thin twine of the gill-nets by the teeth and fins. The same is true of large specimens, individuals of 20 lbs. or over, and too large to gill, being frequently taken in this way.

The deep-bodied pale trout of the deep water of Lake Superior, known as the ciscowet, may possibly occur in Georgian Bay. Fishermen offer various reports as to very dark or pale trout, with short deep bodies, which are never taken in shallow water, and which they assume do not come inshore to spawn.

Length to 3 feet. Body elongated, moderately compressed, the depth 4 to 4·9. Head stout, with large mouth, the length of the head 3.5 to 4·1. Eye 7·3 to 9·1, in one specimen of 14 in., 5·3. Snout 3·2 to 4·1. Coloration deep grey to blackish, under parts light. Everywhere with small rounded white spots. Upper part of head and the median fins more or less vermiculated. Dorsal fin with 9 to 11, usually 11, fully developed rays. Anal with 10 or 11 rays. Scales very small. The above measurements are based on specimens of the usual run, and probably do not express the extreme variations for the species.

The lake trout is the chief predaceous species of the deep water. It feeds on herrings, young whitefish, perch or other small fishes, but has the reputation of eating almost anything that attracts its attention.

The fish is now the mainstay of the commercial fishery, the total catch of the Georgian Bay and North Channel for 1909, as reported by the Superintendent of Game and Fisheries for Ontario, being approximately $2\frac{1}{2}$ million lbs., almost three times the amount of the whitefish taken during the same period, and with a value approximately three quarters in excess of that of all other species taken together. The figures of several years seem to indicate that the lake trout is withstanding the drain of the commercial fishery much better than the whitefish. There are perhaps several reasons for this. This fish is a predatory type, swimming at all levels, and thus escaping to a greater extent the operations of the gill-net fishermen. It is probable also that it is not affected to any great extent by the pollution of the bottom through lumbering operations, while the latter would be fatal to the whitefish. There is a further possibility that the artificial propagation of this fish in the Great Lakes has had a larger effect both in numbers and natural distribution than in the case of the whitefish.

Genus **Coregonus.**

At least two species of whitefishes occur in this region, one being the round or frost whitefish (*C. quadrilateralis*), the other the common lake whitefish (*C. clupeaformis*). They are separable as follows:

a. Body rounded and elongated, the depth 4.8 to 5 in the length. Gillrakers few in number, 10 to 12 on the lower limb of the first arch, and short, their length about 5 in the length of the eye..... **quadrilateralis.**

aa. Body more or less compressed, elliptical, the depth 3.7 to 4.5. Gillrakers numerous, 16 to 18 on the lower limb of the first arch, and slender, their length only about 2 in eye..... **clupeaformis.**

Coregonus quadrilateralis, Richardson.

(Round or frost whitefish)

(*Plate I, fig. 4*)

A few specimens have been taken in shallow water in the early summer and later in the fall. It probably exists in numbers in the deeper water, but on account of its comparatively small size and slender body it is not commonly taken in the gill-nets.

Length 14 inches. Body elongated, somewhat cylindrical. Depth 4·8 to 5. Head 4·9 to 5·3 in length of body. Eye 4·7 to 5·9. Snout 3·8 to 4·2 in head. Maxillary from tip of snout 4 to 4·5 in head. Dorsal fin with 11 or 12 rays, anal with 10 or 11. Scales 9, 88 to 91, 7 or 8. About 32 or 34 rows of scales in front of the dorsal fin. The sides of the body are silvery, the dorsal surface darker, brownish or sometimes bluish. One specimen, a male taken in November, has the sides with about 7 rows of weak tubercles.

This fish is credited with the destruction of the eggs of trout and whitefish during the spawning season, and the intestines of specimens taken in the fall do contain fish eggs. The same statement, however, may be made with reference to the lake whitefish, the fact being that both fish are bottom feeders, and in all probability they add to their ordinary diet the eggs of their own and other fishes when occasion permits.

Coregonus clupeaformis, Mitchill.

(Labrador whitefish)

(*Plate I, fig. 3*)

Two kinds of large whitefishes, representing more or less separable species, but perhaps only developmental types, occur in the Great Lakes, one of them, the Labrador whitefish, or Musquaw River whitefish, having been recently recognised by Jordan and Evermann ('09) as the common whitefish of the lakes, excepting Lake Erie. The other is the common whitefish of Lake Erie (*C. albus*). The former species is a more or less elongated fish, of elliptical outline, and rather large and coarse head, the latter a pale, deep rather angular type, with small weak head and high nuchal elevation.

Specimens of the Georgian Bay whitefishes have been submitted to Dr. Evermann, who pronounces them fairly typical specimens of *C. clupeaformis.*

In the southern part of Georgian Bay there is a tendency on the part of fishermen to recognize two types of common whitefish, one being called the coarse-scaled, shore or shoal whitefish, the other the deep-water whitefish. There are no whitefish inshore in the summer, and those that appear on the inshore shoals in November are recognized as shoal whitefish. The deep-water whitefish inhabits

the deep water during the summer, but is thought to migrate northwards to the inshore shoals for spawning. It is an interesting fact that in the southern part of the bay at least these fish do not come up on the shoals nearest their summer home. The shoal whitefish is regarded as of a poorer kind, and of inferior keeping qualities. The studies of the fish up to the present seem to lend some weight to the opinion expressed, but it is extremely doubtful if distinct races should be recognized, or indeed whether any significance should be attached to the small differences appearing locally in this species.

The following enumeration is based on 5 specimens of the shore variety or run, taken in the fall. The males have the sides with longitudinal rows of weak tubercles, the surface being distinctly rough to the touch.

To facilitate comparisons with the typical specimens recently described by Jordan and Evermann ('09), the measurements have been indicated in hundredths of the body length. Length 18 inches. Dorsal rays 11 or 12. Anal rays 11 or 12. Scales, 10, 83 to 94, 9. Gill-rakers 16 to 18. Head ·20 to ·22. Depth ·22 to ·27. Caudal peduncle, length ·07 to ·08, depth ·08. Eye, ·03. Snout ·05. Maxilla ·05 to ·06. Distance from snout to occiput ·14 to ·16. Pectoral length ·15 to ·18. Ventral length ·12 to ·15. Dorsal height ·14 to ·16. Anal depth ·10 to ·12.

The following enumeration is based on 19 specimens of whitefish taken in deep water (16 fathoms) off the Giant's Tomb Island. Dorsal rays 11 or 12. Anal rays 11 to 13. Scales 10 or 11, 79 to 93, 8 (in three specimens 9). Head ·19 to ·21. Depth ·23 to ·27. Caudal peduncle, length ·08 to ·11, depth ·07 to ·08. Eye ·03 to ·04. Snout ·05 to ·06. Maxilla ·05 to ·06. Snout to occiput ·13 to ·15. Pectoral length ·14 to ·16. Ventral length ·12 to ·14. Dorsal height ·13 to ·15. Anal depth ·09 to ·11. The gill-rakers are 16 to 18, verified in about 50 specimens.

There are several points of possible error in comparing these groups of specimens, but taking the range of variation of the first group as a basis, we find certain figures not covered by the second group, notwithstanding the large number of specimens, and indicating for the latter group slightly shorter head, greater depth, longer caudal peduncle and smaller fins. In the shape of the body the deep-water fish vary from those of elliptical form, with even dorsal profile, to those rather deep and compressed, with a considerable nuchal elevation. The head appears small, but not as in the Erie whitefish.

Measurements of the head divided into the length of the body do not appear to give the best results in comparing the size of the head in the different kinds of whitefish, the reasons being that the characters of length of head and length of body are similar or analogous. Measurements giving the proportion of head length into depth of body might, however, yield dependable distinctions. A rough trial of this proportion indicates for the 19 specimens above mentioned a proportion of ·74 to ·93. By comparison, 13 specimens of *C. clupeaformis* reported by Jordan and Evermann ('09) show roughly a proportion of ·60 to ·90, but the exclusion of two extreme specimens from the Lake of the Woods and Waubegon puts the range from ·79 to ·90. The smaller size of the head in relation to the depth in *C. albus*, from 4 specimens reported by Jordan and Evermann, is shown by the range of ·66 to ·74.

In Georgian Bay whitefish are taken by gill-nets southward and by pound-nets northward. They are occasionally taken with baited hooks. The food consists of small, sometimes minute, lamellibranch and gastropod molluscs, and small crustaceans. Specimens taken on the shoals in fall are commonly found to have eaten fish eggs, which are evidently picked up from the bottom with the usual food.

Taking Georgian Bay proper, the total catch of whitefish for 1909, as reported by the Superintendent of Game and Fisheries, was 382,392 lbs., and including the North Channel, 856,521 lbs. The statistics of a period of years show a gradual falling off in the annual catch, for which it is probable that several conditions are responsible. This matter has been discussed by the Commission appointed in 1905 by the Dominion Government to investigate the fisheries of Georgian Bay, and remedial measures are proposed. Both whitefish and trout owe any advantage that they possess in respect of escaping the nets of the fishermen to the fact that they are deep-water forms, inhabiting largely situations where complete fishing is impossible. Whitefish, however, are bottom-living types, and considering both the great amount of gill-net fishing at present carried on in these waters, and the alleged fishing of net in excess of that granted by license, it is not surprising that fishes of this kind should become less plentiful year by year. It may be pointed out also that any balance of numbers in favor of the lake-trout, as at the present time, is distinctly a balance against the whitefish, whose smaller numbers are less able to withstand the natural drain of providing through the young fish, together with lake herrings and perch, the enormous food-supply required by the lake-trout. Finally, the waters of Georgian Bay have been continuously fished for a long period of years, and little constructive work has been done in the matter of artificial propagation and distribution of whitefish in this region, a condition which it is hoped will be remedied.

Genus **Leucichthys.**

Specimens of the lake herrings taken in the southern parts of Georgian Bay have been examined by Dr. Barton W. Evermann, by whom they are referred to two species, one being the Saginaw Bay or Georgian Bay herring (*L. harengus*), the other the Huron herring (*L. cisco huronius*). *L. harengus* occurs in Lakes Huron and Michigan, and occasionally in Lake Erie. It is the most important element in the fisheries of Saginaw Bay, Michigan. The species was originally described by Richardson ('36) from specimens taken at Penetanguishene on Georgian Bay, but has been only recently differentiated by Jordan and Evermann ('09) from the species *L. artedi*. Only a few specimens of this type of herring have been taken, and since these are for the most part immature specimens, no analysis can be given. In general the species is close to *L. cisco huronius*, but is distinguished by the small size of the adipose fin, less cylindrical body, and grey coloration.

The Huron herring, or blueblack herring, occurs in Lakes Huron and Michigan, and occasionally in Lake Erie. A few specimens, evidently of this type, have been taken in deep water during the summer off the Giant's Tomb Island, but the fish is only seen in numbers in the southern part of Georgian Bay during the inshore run in November.

Leucichthys cisco huronius, Jordan and Evermann.

(Huron herring)

Numerous examples taken in shoal water in November. Some females distended with eggs. Almost all male fish with rough tubercles, arranged in longitudinal rows on the sides of the body, one on each scale in the row. Length 9¼ to 12 inches.. Head ·20 to ·22. Depth ·21 to ·25. Caudal peduncle, length ·09 to 1, depth ·07. Eye ·04 to ·05. Interorbital distance ·06 to ·07. Maxilla from tip of snout ·07 to ·08. Snout to occiput ·14 to ·17. Ventral to pectoral ·29 to ·32. Length of pectoral contained in pectoral-ventral distance 2·03 to 2·82. Pectoral length ·12 to ·14. Ventral length ·13 to ·14. Dorsal height ·12 to ·14. Anal depth ·07 to ·09. Adipose length ·04 to ·06. Dorsal fin with 10 or 11 rays. Anal with 11 or 12 rays. Scale 8 or 9, 77 to 88, 8 or 9. 31 to 36 oblique rows before the dorsal fin.

The body is elongated, elliptical, with rather long and slender snout. Coloration of upper parts lustrous blue, the upper part of the head, maxilla and tip of the mandible dark. Lateral line almost straight.

Herrings are sometimes accused of destroying the spawn of other fishes, but there is no evidence of this in these specimens taken during the spawning time. The intestine was found to be filled with enormous numbers of minute entomostraca of the plankton, bottom materials of any kind and fish eggs being rare, and the latter probably ingested by accident.

Small meshed gill-nets operated for herrings may do considerable damage in places frequented by small whitefish of 9 inches or thereabouts in length. The taking of such fish is unlawful, and most undesirable for obvious reasons, but the regulation providing for their liberation, though evidently of preventive value, is unfortunately not very practical. The same is true of undersized whitefish taken in gill-nets of the authorized mesh for taking whitefish and trout. There are perhaps some fishermen who either cannot or do not wish to make the important distinction between adult herrings and young whitefish, and the relative numbers of small whitefish taken should be enquired into in localities where the herring fishery is permitted. While the herring fishery is admittedly valuable, it involves at least three objectionable elements, first the actual destruction of the young of larger fishes, second, the burden on the provincial authorities of inspecting for undersized fish, from the operation of small-meshed nets, and third, the removal from the waters of the food supply of the lake-trout, which should be estimated either on a basis of the amount of lake-trout taken from the water, or the damage likely to be done to small whitefish as a result of lack of abundance of herrings.

Family UMBRIDAE.

(Mudfishes)

Umbra limi, Kirtland.

(Mudfish. Mud-minnow)

(*Plate II, fig. 16*)

Taken in the smaller inland ponds and in the muddiest parts of shore swamps. It thrives in the most uninviting puddles, in association with sticklebacks, tadpoles and newt larvæ.

Length commonly to 2¼ inches, one specimen of 3½ inches. Body stout and compressed, caudal peduncle deep. Depth 4·2 to 4·8 in the length. Head rather heavy, its length 3·1 to 3·2. Mouth terminal, rather flattened. Eye 3·3 to 4·4. General coloration yellow or olive, but with the ground color almost obscured by dark mottlings, which form about 14 indistinct vertical bars. The sides show bluish and green reflections. A lateral stripe showing in most specimens, and a faint band through the opercle, eye, and snout. Ventral surface pale. Fins all with rounded margins, and with minute transverse striations on the rays. Dorsal placed far back near the caudal, 14 or 15 rays. Anal with 9 or 10, sometimes 8, rays. Scales rounded, 12 to 14 in oblique row from front of dorsal to anal. 34 to 36 in horizontal series. Imbedded scales on top of head, and large scales on opercles.

Family LUCIIDAE.

(Pikes)

Represented by two species, characteristic of northern waters generally; separable as follows:

a. Cheeks scaled, opercles with scales only on the upper half. Ground color dark, with yellow or white spots on sides.....**lucius.**

aa. Both cheeks and opercles bare of scales below. Ground color light, with dark vertical or oblique bars and spots.....**masquinongy.**

Lucius lucius, Linnaeus.

(Common pike)

Abundant in all places on the main shore of Georgian Bay and in the river courses. It inhabits weedy swamps and channels, where it lurks among the weeds, darting forth from time to time to capture small fishes such as black bass, rock-bass, perch or minnows. Small specimens of all stages of growth are taken in the shore swamps, but are not abundant. The fish is of some commercial value in those parts of the shore where inshore net-fishing is permitted, but it is not a fish that is greatly respected by anglers. As commonly taken it is from 3 to 6 lbs. in weight, but specimens of 15 lbs. are not infrequently captured.

Length up to 3 feet. Body elongated, slender and moderately compressed. Depth 5·5 to 6·5. Head 3·3 to 3·6, rather rectangular behind, tapering forwards into the shovel-like snout which is 2·2 to 2·3 in its total length. Eye 8 to 10·4. Coloration above dark olive to black, with light irregular cross lines alternating on the two sides and connected by a wavy vertebral line, giving a somewhat reticulated appearance. These markings are obscured in dark colored specimens. Sides with longitudinal rows of white or yellow spots. Scales with V-shaped golden marks. Under parts white, except tip of mandible. Median fins yellow with dark mottlings, the paired fins more faintly marked. Dorsal fin set far back, with 18 to 21 (usually 19) rays. Anal with 15 to 17 rays. Scales small, 13 (to 15), 120 to 132, 11 or 12. Lateral line broken, and with rows of accessory pores above and below.

Young specimens taken in the shore swamps have the general coloration dark, but with rounded or oblique white markings which tend to divide the darker color into oblique bars.

Lucius masquinongy, Mitchill.

(Maskinonge. Muskellunge)

This species occurs all along the shore of Georgian Bay, though not in large numbers anywhere. It is relatively more numerous in the sand areas at the southern part of Georgian Bay, and in sandy situations in the river courses. It also occurs in many inland lakes. Though specimens of great weight are sometimes reported, the general run of fish range between 3 and 25 lbs.

The measurements here given are based on five smaller specimens, and probably do not give the complete range of variation for this region. Body greatly elongated, slender, and moderately compressed. Depth 5.7 to 6·1. Head 3·2 to 3·6 in length of body. Snout shovel-like, 2·3 in length of head. Eye rather small, 9·5 to 11 in head. Ground coloration light. Sides with brilliant dark spots, which tend to run together into vertical or oblique bars. Back and upper portion of head a beautiful deep greenish black. Under parts light. The scales exhibit bronze, gold and green reflections. The median fins are dark, with obscure spots, the paired fins plain and dark greenish. Dorsal fin with 19 or 20 rays; anal with 16 to 18 rays. Scales 15 or 16, 134 to 152, 12 to 14.

Young specimens of a few inches in length are sometimes taken in shore swamps. The coloration is different from that of the adult. There is a broad longitudinal dorsal band, usually more or less broken on the occiput; also a dorso-lateral dark band which tends to break into spots. Below the latter there is a more or less definite light stripe, followed ventrally by a series of spots. The entire ground coloration is light.

Like the common pike, the maskinonge is a predaceous type, and is very destructive to the smaller fishes and to the young of larger ones, including the game fishes. Its comparative rarity, beauty and splendid sporting qualities make it the most highly esteemed of all the fresh water game fishes.

Family POECILIIDÆ.

(Killifishes)

Fundulus diaphanus menona, Jordan and Copeland.

(Menona top-minnow)

Frequently taken in somewhat weedy but rather open water near shore. The largest number of specimens taken in the gap separating the two parts of the Giant's Tomb Island, and in all probability the species favors sedimentary areas. It is the only species representing the genus or family in the region,and is one of the surface or top-minnows, interesting from their feeding habits and their value as destroyers of mosquito larvæ. The species is easily distinguished from other small fishes by its flattened wedge-like head, the top of which bears a rosette of scales, the flat tumid lips, and vertical bars of the sides.

Length 2⅜ inches. Body spindle-shaped, more or less compressed posteriorly. Depth 4·4 to 5. Head 3·2 to 3·6. Eye 3·2 to 4. Dorsal fin with 12 or sometimes 13 rays. Anal with 11, sometimes 10 rays. Scales in a longitudinal row 44 or 45; in oblique row around the sides of the body from the front of the dorsal fin, 12. Lateral line inconspicuous, represented by minute rounded depressions on some of the scales. The body scales are continued over the opercle to the head, the dorsal surface of the head being scaly, with a rosette of scales on the occiput. Males have 15 to 20 vertical bars on the sides of the body, somewhat narrower than the light interspaces. Females have 12 to 16 bars, thinner, less regular and less complete, represented by rounded spots posteriorly. Dorsal surface with black blotches, sometimes almost uniformly dark. Some males have a faint horizontal mark on the dorsal fin, and one specimen taken in June has two fairly definite bars separated by a light interspace.

The characters of the Georgian Bay specimens agree for the most part with those described for the most western variety *menona* as described by Forbes and Richardson ('08), though intermediate in some respects between this and the Atlantic coast form as described by Jordan and Evermann ('96).

The food of this species consists of aquatic and terrestrial insects, minute crustacea, and occasionally small molluscs.

Family GASTEROSTEIDÆ.

(Sticklebacks)

Eucalia inconstans, Kirtland.

(Five-spined or brook stickleback)

This species, apparently the sole representative of the family in this region, occurs in a few collections, all from comparatively closed swamps and inland ponds. It appears to be rare everywhere along the shore.

Length 1⅞ inches. Body fusiform, laterally compressed, with very slender

tail. Depth 4 to 5, in one specimen 3·7. Head 3·3 to 3·8. Mouth very oblique, its aperture almost dorsal. Dorsal fin with 5 spines as a rule, but sometimes with 4 or 6, followed by 10, sometimes 9 or 11, soft rays. Anal fin with 1 free spine and 10, sometimes 9 soft rays. Ventral fins placed far forwards, with 1 spine and 1 soft ray. Between their free portions the fused pubic bones form a projecting median ridge. Body without scales or surface plates. Coloration dark olivaceous, with minute rounded clear markings on a darker ground.

Family PERCOPSIDÆ.

(Trout-perches)

Percopsis guttatus, Agassiz.

(Trout-perch)

This species is one of two representing the peculiar family *Percopsidæ*, fishes which combine the characters of the perches and salmonoids. It is reported by Jordan and Evermann ('96) as abundant in the Great Lakes. The type was described by Agassiz ('50) from specimens taken in Lake Superior, and specimens are reported by Bean ('81) from Hudson Bay. The species is also reported from Hawkstone, Lake Simcoe, by Meek and Clark ('02), but not from Muskoka Lake. Considerable interest attaches to the species in that only a single specimen has appeared in the Go Home Bay collections, this having been found floating on the surface of the water. The fish inhabits deep cold water, and may be plentiful, but up to the present has not been taken in small-meshed nets, set especially for the purpose. The following description is based on the single specimen taken.

Length $3\frac{5}{8}$ inches. Depth 4·8. Head 3·4. Mouth slightly inferior, otherwise normal. Scales 6, 56, 8. Edges of the scales with minute teeth. Dorsal fin with 2 hard rays, the first rudimentary, and 9 soft rays. Anal with 1 hard and 6 soft rays. A small adipose fin between the dorsal and the caudal. General coloration pale, the dorsal parts with dark edges on the scales and more or less definite mottlings about the dorsal fin.

Family ATHERINIDÆ.

(Silversides)

Labidesthes sicculus, Cope.

(Brook-silverside)

(*Plate II, fig. 15*)

Commonly represented by at least a few specimens in most seinings from shore swamps. It shows a preference for localities where, in addition to aquatic vegetation, there is a considerable amount of clear sand. The largest number of specimens have been taken in the running water near the falls of the Go Home

River, but enormous numbers of the young fish of scarcely more than 10 mm. in length are commonly to be found swimming in large schools outside of the main shore, either in the vicinity of the reefs or in the deep water. It is a lithe, active species, and when feeding in schools, especially towards sundown, is often seen jumping out of the water, presumably in the act of taking insects from the surface.

Length of the largest specimens 3 inches; commonly much smaller. Body very slender, little compressed, the depth 7 to 7·7 in the length. Head 4·4 to 4·8, terminating in a blunt but beak-like snout. Jaws rather narrow, and when viewed from the side bowed upwards in their middle portions. General coloration olive, the body translucent, and allowing the air-bladder and vertebral column to show through the muscles. Dorsal surface with a dark vertebral streak and with fine dark edgings on the minute scales. Sides with a silvery band, more or less underlaid by a dark line which broadens into a band on the posterior part of the body.

Dorsal fins two, the anterior consisting of 4, rarely 3, weak spines, the posterior of 12 (sometimes 11 or 13) ordinary rays. Anal fin very long, its posterior portion shallow, with 25 to 28 rays (the number reported by Forbes and Richardson ('08) for Illinois is 22 to 25). Scales very small and rounded, about 95 in a longitudinal row.

The food consists of minute plankton entomostraca, together with small insects, the latter including terrestrial forms which are evidently taken from the surface of the water.

Family CENTRARCHIDAE.

(Basses and Sunfishes)

This family is represented by three genera and four species, probably the most familiar of all fishes inhabiting the region, and one of them, the small-mouthed bass, important as its chief game fish.

The three genera are separable as follows:

a. Base of the dorsal fin less than twice as long as that of the anal, the latter contained about 1.5.....**Ambloplites**

aa. Base of the dorsal fin more than twice as long as that of the anal

b. Body very short and deep, the depth 2.2 to 2.4.....**Eupomotis**

bb. Body more elongated, the depth at least 2.9 and usually 3.5.....**Micropterus**

Genus **Ambloplites.**

Ambloplites rupestris, Rafinesque.

(Rock-bass)

Extremely abundant in all situations along the main shore, in the larger inland lakes in the vicinity of Go Home Bay, and in the Musquash River, though not

reaching Muskoka Lake. It shows a preference for rocky ledges in the vicinity of open water, where it is commonly seen in large numbers.

Length usually 6 inches or less, specimens of 7½ inches being infrequent. Body short, deep, and compressed, the depth 2·2 to 2·4 in the length. Head 2·5 to 2·8. The general coloration varies from olive with more or less brassy reflections, in fish taken in lighter water, to almost black in fishes taken in muskeg water. Sides with rectangular blotches, more definite dorsally, and especially conspicuous in young specimens. Some of the scales below the lateral line with small dark spots, forming about 10 longitudinal stripes. A black spot on the opercle. The dorsal, caudal, and anal fins are more or less mottled or barred with pigment; lower edges of ventrals and anal black. Dorsal fin with 10 or 11 spines and 11 (sometimes 10 or 12) soft rays. Anal with 6 spines and 10 soft rays, the length of its base contained 1·5 to 1·6 in that of the dorsal. Lateral line high up on the body, and curved, the scales 40 to 46.

The food of the rock-bass consists of minnows, crayfish, and insects; the chief food depending on whether the fish is small and inhabiting swampy areas, or large and inhabiting more open shoaly places. During the period when mayflies are abundant, the smaller fish feed largely upon them, leaving their shelters after nightfall, and sucking the flies from the surface of the water.

The spawning period is for the most part during the month of June. The nesting habits are similar to those of other centrarchids. The nest is placed near shore in a swampy bay, often in only a few inches of water. It is prepared by the male fish, which usually works most energetically, fanning out the sediment with his fins, thus making a basin-like depression, clean of all debris, and of 8 or 10 inches in diameter. The female is driven into the nest and is carefully guarded until the deposition of the eggs is accomplished. During the process of spawning and fertilization the two fish lie side by side in the nest. Only a few eggs are extruded at a time, and at each period milt is extruded by the male. The operation continues for an hour or more, and at the end of the period the female leaves the nest and does not return. The eggs are carefully looked after by the male fish, which takes up a position over the nest, and every now and then sets up a fanning motion with the fins. In a few days, after the eggs are hatched, the fry gradually rise out of nest, and are soon left by the male fish to shift for themselves.

During the spawning period rock-bass nests are extremely common in the swamps. Some contain live eggs; some are empty and abandoned, and some are occupied by whitened, fungus-infested eggs which in many cases are still watched over by the male fish. The number of fish spawning at one time and the difficulty experienced by the males in getting the females into the nests, together with the lively competition for their possession sometimes results in confusion. A female for example has been observed to go alternately into two nests, and in some cases a male has been observed hopelessly trying to look after two nests, evidently undecided as to which is his own property.

The rock-bass is reported by certain authorities to reach a length of 12 inches. Possibly the decrease in number of the larger predaceous fishes, such as bass, doré, and pike, which is almost certain to take place as a result of the increase in game

fishing, will put this species in a more advantageous position. At the present time, however, it is a pest to the sportsman in search of the small-mouthed bass. It inhabits the same situations, is of insignificant size and of no fighting qualities; with a propensity for biting on all occasions, regardless of experience. As a destroyer of bait intended for other fishes, it has become notorious, the more so since the supply of this commodity has now reached the dignity of a commercial enterprise.

Genus **Eupomotis.**

Eupomotis gibbosus, Linnaeus.

(Common sunfish. Pumpkinseed)

Abundant in shore swamps and inland lakes. The only species representing the brillantly colored sunfishes in this region.

Length $5\frac{1}{4}$ inches, commonly much less. Body very short, deep, and compressed, the depth 2·2 to 2·4 in the length. Mouth small. Back olive green with brassy reflections, tinges of blue color, and reddish golden spots. Below the lateral line there are wavy and more or less irregular blue lines, alternating with series of prominent reddish golden spots, the latter arranged more or less definitely into four longitudinal lines. Under parts yellow, golden, or reddish. Cheek and opercle with five blue lines, alternating with reddish golden spots. Opercular flap with a large black spot, bounded above and below by bluish, and behind by scarlet. Dorsal fin with 10 or 11 spines, followed by 11 or 12 soft rays. Anal with 3 spines and 10 soft rays, the length of its base contained 2·1 to 2·3 in that of the dorsal. Pectoral fins reach the vertical of first anal spine. Scales 40 to 45.

The food of this species consists of insects and small molluscs. The spawning period is for the most part in July, though it extends from the latter part of June to the end of August. The nests are often no more than four inches in diameter, and are placed in very shallow water near the shore. The eggs are guarded by the male fish, which at this time exhibits great courage and pugnacity in warding off enemies.

Genus **Micropterus.**

This genus is represented by two important game fishes, one being the small-mouthed bass, or black bass (*M. dolomieu*), the other the large-mouthed bass, green, or Oswego bass (*M. salmoides*). Much has been written concerning the habits of these species, their sporting qualities, and distribution, though it is unfortunate that many popular accounts do not discriminate between the two types. Not only are the two species distinct, but in a region such as this where they occur together they differ very greatly in habits, fighting ability, and in their quality as table fish, the small-mouthed bass being in every way superior.

The two species are separable as follows:

a. Mouth very large, the posterior end of the upper jaw reaching past the vertical of the posterior margin of the eye. Scales large; 6 to 10 rows on the cheek..... .....**salmoides**

aa. Mouth smaller,the posterior end of the upper jaw reaching a point beneath the middle of the eye. Scales smaller, those on the cheek in 12 to 17 rows....**dolomieu**

Micropterus salmoides, Lacépède.

(Large-mouthed bass. Green bass)

(*Plate I, Fig. 1*)

Fairly abundant in weedy swamps, swamp channels, and inland lakes. It reaches a weight of $5\frac{1}{2}$ lbs. and possibly more, though as commonly taken it is from 1 to $1\frac{1}{2}$ lbs. The young of all sizes are abundant in the shore swamps and inland waters. This species is said to reach a weight of 14 lbs. in the southern parts of the continent.

Body moderately elongated, the depth 3 to 3·6. Head 2·8 to 3·3. General coloration dark olive green above, white below. More or less irregular blotching dorsally. A lateral band made up of more or less disconnected blotches, very conspicuous in the young fish; sometimes also in the adult, but usually in the latter much broken, obscure or even absent. Dorsal fin with 10 spines and 12 soft rays. Anal with 3 spines and 10 soft rays, its base contained 2·6 to 3 in that of the dorsal. Scales 8 or 9, 63 to 70, 12 to 14. 6 to 10 rows on the cheek.

The food consists of smaller fishes, some specimens containing insects and crayfish. The fish is commonly taken by bait-fishing or trolling but in this region is not sought after.

The spawning period is in the early part of June. The nests are commonly placed in swamp bottoms where there is a deep deposit of detritus. For this reason the fish construct, by fanning out with the fins, huge basins, sometimes of three feet in diameter and a foot into the bottom. The eggs are watched by the male fish. After hatching, the fry gradually rise out of the nest, and begin to swim around in large schools. They are light in color and have a conspicuous lateral stripe. Like the fry of the small-mouthed bass, they are commonly found with the abdomen greatly distended from the ingested entomostracan food.

Micropterus dolomieu, Lacépède.

(Small-mouthed bass. Black bass)

(*Plate I, Fig. 2*)

Abundant in its favorite habitat, frequenting during the summer season rocky shoals, channels, and runways among the islands, where there is more or less clear or moving water; also pools about the openings of swamps where minnows commonly wander to and fro. Frequent in running water at the foot of waterfalls.

As commonly taken in this region the fish is from 1 to 2½ lbs. in weight, specimens of 3lbs. or over being exceptional. Body moderately elongated, relatively shorter and deeper in old specimens, the depth 2·9 to 3·5. Head 3·1 to 3·4. General coloration varying from light olive green above and white below, to almost black, the difference depending on whether the fish is taken in the clear open water of Georgian Bay or from the dark water of inland localities. There are all gradations. Sides of the body with more or less irregular vertical bands, conspicuous in young specimens, but more or less obscure in older ones. Four green or dark bands on the cheek, radiating backwards from the eye and upper jaw. Fins rather light, a character by which the fish may be recognised in the water even if seen only for a moment. Young specimens have a conspicuous semicircular dark band on the tail, forming a somewhat heart-shaped figure, with a dark spot in the centre of the base of the tail. This marking is best shown in fish of two or three inches in length. Dorsal fin with 10 spines and 12 to 14 soft rays. Anal with 3 spines and 11 to 13 soft rays, the length of its base contained 2·5 to 2·7 in that of the dorsal. Scales rather small, 12 or 13, 77 to 91, 17 to 23. 12 to 17 rows on the cheek.

The staple food of the small-mouthed bass consists of crayfishes, which inhabit the rocky shoals frequented by the fish. The bass, however, shows a decided preference for minnows, and in the early part of the season when in the shore swamps, or later when in pools or channels which have swamp connections, minnows form a large portion of its food. It is an interesting fact that while swamp areas contain an abundance of minnows, the bass tend on the whole to avoid them, and in three cases in which individual fish have been enclosed by accident in such swamps they have been found dead in the water.

The spawning period is for the most part during June, though fish have been observed on the nests as late as July 20th. Towards the end of May the fish appear in the shore swamps, congregating in groups of sometimes a dozen, and basking lazily near the surface of the water, sometimes with the dorsal fin out of water. They have been observed to move out into deep water during days of colder weather and appear again later. During this early period the male fish apparently explores the shore in shallow water in search of nesting places, and having found one proceeds to put it in order. This process, as well as the deposition and care of the eggs is in all essentials as described by Lydell ('03) for the species elsewhere. The nest is constructed by the male, which is usually seen working alone. In a few cases both male and female have been observed, but the presence of the latter does not appear to be appreciated. The nest is a shallow basin of 15 or 20 inches in diameter, fanned out of the weedy or pebbly bottom, and carefully cleaned of all debris. The bottom of the nest may be of clean rock or pebble, but is more often of short stems of the aquatic plant *Eriocaulon*, which forms an ideal surface for the attachment of the eggs. It is questionable whether the female is selected before or after the construction of the nest, because she commonly remains in the deeper water some distance from shore. There are some indications, however, that in certain cases she is selected before the completion of the nest.

Before and in preparation for the actual process of spawning the male has

been observed to swim out into the deeper water, and return driving the female before him. She swims into the nest, and the male circles about her, always heading her into the centre of the nest, and biting her lightly but persistently on the side of the body. If at any time she darts away from the nest, he immediately follows and brings her back. During the spawning process the two fish differ very markedly in color, the male having a uniform bronze or greenish hue, while the female has a blotched appearance, the body spots standing out strongly on a lighter ground. At the time of desposition of the eggs the body of the female is turned somewhat obliquely in the water, so that one side tends to be uppermost. Only a few eggs, perhaps 10 or 12, are extruded at a time, the extrusion being momentary, and repeated at intervals of about half a minute. It is accompanied by a trembling motion of the body and especially of the dorsal fin. The male fish lies for the most part over the female, but with the body in a slightly different direction. The milt is extruded at intervals corresponding to the periods of deposition of the eggs. After the spawning operation is completed, which may be in one half to three hours, the female either leaves the nest voluntarily or is driven out by the male. The latter then takes up a position over the eggs, fanning them from time to time, or making short excursions from the nest in pursuit of other fish that venture in the vicinity. This is maintained for the few days necessary for the hatching of the eggs. The fry, at first confined to the bottom of the nest gradually rise upwards in the water and begin to separate forming a somewhat disorganized school within a certain radius of the nest. They are watched over by the male fish for a few days and are then abandoned to shift for themselves. They are almost pure black in color, and are conspicuous objects in the water. The first food consists of the smallest of the plankton entomostraca. After the feeding process is once established they are extremely greedy, and are often found with the abdomen rounded and distended from the large amount of ingested food.

Many attempts have been made to propagate this fish by the usual artificial methods, but without success, because of the difficulty of stripping the eggs from the female. The eggs are adherent in the ovary, and under natural conditions are only extruded a few at a time. Doubtless a method of caring for the female fish could be devised by which eggs could be obtained for fertilization, but it is improbable that the number obtained in this way would be sufficient to make the work profitable. A few eggs have been fertilized in the laboratory, and eggs taken from nests have been hatched in shallow pans. The method now in common use for obtaining a supply of young fish, and the only method which promises results is that of natural cultivation in retaining ponds. This method could be applied in the Georgian Bay region by reserving for the purpose a number of the larger lakes inland from the main shore. Ponds cannot be made by excavation on the east and north shores, and the natural ponds and smaller lakes of this region are unsuitable for this purpose in every respect.

From its wide distribution, abundance in localities not over-fished, and splendid sporting qualities, the small-mouthed bass is easily the foremost of American fresh water game fishes, and the shoal areas of Georgian Bay constitute an ideal environment for the species in a region which is most attractive to sportsmen.

The habits of the fish and the methods employed in its capture in Georgian Bay have been recently described by Loudon ('10). In the southern part of the bay the bass is taken only by natural baits, and by trolling with artificial lures, but it is reported on good authority that on the north shore at McGregor Bay the fish will rise to the artificial fly. There is probably no species which is more uncertain of capture. Though at some times biting promptly and vigorously the moment the bait is in the water, at other times it is wary, or refuses with stolid indifference to respond with more than a lazy movement to anything put before it. Places which on some occasions afford fish in abundance are at other times abandoned. The fish tend to run in small groups and move about from place to place, but apparently within comparatively small areas. During the summer of 1909, one hundred fish were caught, marked with a metal tag, and returned to the water. Seven of these were afterwards taken by different persons who reported them. Those reported had been free for different periods from 4 to 30 days, but all were taken within a short distance of the place where they were liberated.

Family PERCIDÆ.

(Perches)

This family is represented in Georgian Bay waters by five genera, each with one species. One species, the pickerel or doré (*Stizostedion vitreum*) is important both as a commercial and a game fish, the others being insignificant.

The genera are separable on several technical differences, but the following analysis will suffice for Georgian Bay species.

a. Pseudobranch gill structures on the underside of the opercle well developed; branchiostegal rays 7; preopercular bone with a spiny margin;
  b. Sharp canine teeth on jaws and palatines.....**Stizostedion**
  bb. No canine teeth.....**Perca**
aa. Pseudobranchs small or absent; branchiostegal rays 6; preopercular bone with its edge entire;
  c. Premaxillaries not protractile, connected with the skin of the forehead by a median ridge;
    d. Head broad and flat between the eyes.....**Percina**
    dd. Head compressed and rounded between the eyes.....**Etheostoma**
  cc. Premaxillaries protractile, separated from the skin of the forehead by a transverse groove.....**Boleosoma**

Genus **Stizostedion.**

The small blue pickerel, sauger, or sand pickerel (*Stizostedion canadense*), though reported by some fishermen, has not been identified in Georgian Bay, specimens taken for this species having proved in all cases to be small specimens of the ordinary doré. But one species is therefore described.

Stizostedion vitreum, Mitchill.

(Pickerel. Doré. Pike-perch. Wall-eye)

Generally abundant along the main eastern shore of Georgian Bay, though for some reason it has almost disappeared within ten years in the region of Go Home Bay. Abundant especially on the north shore, and the basis of a valuable commercial fishery in the North Channel. It is the most characteristic of the larger fishes in the darker inland waters. It inhabits the deeper places about rocky shores, projecting points, shoals or channels. It is fond of running water, and may be taken at the foot of waterfalls when other places fail. As commonly taken it is from 2 to 4 lbs. in weight, though the maximum is reported to be in the neighborhood of 20 lbs.

Body elongated and little compressed. Depth 4·1 to 5·5. Head conical, its length 3 to 3·8 in that of the body. Snout 3·4 to 4 in head. Eye large, 5 to 6·8 in head, the cornea whitish, giving the characteristic milky or wall-eye appearance. General coloration yellow or brassy, the upper parts both coarsely and finely blotched with black. Under parts white, yellowish or greenish. Anterior dorsal fin with dark margin and obscure dark spot at its posterior end. Posterior dorsal and caudal finely barred with dark flecks. Dorsal fin with 14 spines and 20 to 22 soft rays. Anal with 2 spines and 11 to 14 soft rays. Scales very small and closely set, 11 to 14, 80 to 110, 14 to 21.

In Ontario and westward this fish is usually and inaptly termed "pickerel". It has received a variety of names, however, of which the English term "pike-perch", French Canadian "doré" (Pic doré), or the commonplace "wall-eye" are more appropriate.

With the exception of the common pike and the maskinonge, it is probably the most predatory of all shallow water fishes. It lives on minnows, small black bass, rock-bass, sunfish, perch, and suckers, but will also take mud-puppies and crayfish. The fish is a strong, swift swimmer, and is well adapted for the capture of small fishes by its stout bony jaws and palatines, which are provided with strong canine teeth. Its large size, hard investment of closely set scales, and formidable spines defend it adequately against all natural enemies.

The doré is of considerable commercial value. In 1909 the total catch for Georgian Bay proper was valued at $4,566.00, and for the North Channel $25,-950.00. The much smaller amount taken in Georgian Bay proper is owing in part to difference in regulations, pound-nets being licensed in the North Channel, while on the eastern shore of Georgian Bay all inshore commercial fishing is prohibited.

The fish is also respected as a game fish, and though much inferior to the small-mouthed bass in sporting qualities, is quite as much in demand as a table fish on account of the firm white character of its flesh and its excellent flavor.

During the early spring, immediately after the ice disappears, the fish ascend the rivers to the spawning places at the foot of waterfalls. The eggs are deposited on sticks and stones in the running water, and are often deposited in such large

masses that they probably have little chance of hatching. Considerable attention has already been given to the artificial propagation of the species, but much more could be done with very moderate expense by utilizing the various waterfalls on the river courses where the fish now spawn in abundance. In some respects the eggs are more difficult to handle than those of whitefish and trout, but, on the other hand, relatively greater results may be had with little effort and cost. The small size of the eggs permits a jar capacity of three or more times that of whitefish, and the period of operations, including the capture of the parent fish, stripping, and hatching of the eggs involves only a short season of three or four weeks according to the temperature of the water.

During the late summer the doré are said to move out into the deep water, returning again into the rivers in the following spring. In the early summer they are commonly taken by sportsmen by trolling or by bait-fishing in moderately deep water near shore, on shoals, or in channels. In clear water they bite only in the early morning or towards sundown, but in the dark inland waters they may be taken at any time of the day, though better when the light is not intense.

Genus **Perca.**

Perca flavescens, Mitchill.

(Yellow perch)

Present in all situations, except the smallest inland ponds. Probably the most abundant and generally distributed species in the region. It is taken in shore swamps, inland lakes, on shoals, and in the open water of Georgian Bay at a depth of 20 fathoms. Whether from some feature of the environment, or the presence of a large number of predaceous enemies, the fish does not reach the size that it does elsewhere. The largest specimens are about 10½ inches in length, but the average is scarcely more than 5 inches.

Body moderately elongated, somewhat compressed, the back very convex. Depth 3·7 to 4. Head 3·2 to 3·4. General coloration yellow, light below. Sides with seven vertical dark bars. Ventral and anal fins pale yellow, bright yellow, or reddish. Specimens from the open water shoals and from deep water have the yellow of the sides replaced by grey or blackish, and the lower fins are red. Anterior dorsal fin with 12 or 13 spines. Posterior dorsal with 1 spine and 12, or sometimes 13, soft rays. Anal fin with 2 spines and 7 or 8 soft rays. Scales small and solidly attached, 6 to 8, 67 to 71, 11 to 14.

The perch is carnivorous and more or less predaceous according to its size. It feeds on small crayfish, molluscs and insects, and when large attacks smaller fishes. It seems to be more adaptive in respect of its environment than other species, and appears to be taking up the deep water area of the southern part of Georgian Bay that was formerly occupied by the whitefish. It is probably increasing rapidly in this situation, in spite of the fact that it now forms a large part of the food supply of the lake trout.

Sub-family ETHEOSTOMINAE.

(Darters)

The following three species, represent in this region an extensive division of perch-like fishes commonly designated as log-perches and darters, all fishes of diminutive size, and for the most part different in habit from the common perch and doré. They are non-predatory, living largely on minute insects and crustaceans. They inhabit sand beaches and sloping rocks in somewhat protected situations. They have the habit of lying motionless on the bottom, with the body slightly bent, and its anterior portion slightly raised on the pectoral fins, a posture which gives them an alert appearance. They move by quick jumps, rather than by swimming, the enlarged pectoral fins being used for this purpose and also for fanning up the bottom in search of food or concealment. They are characteristic of running water, but in this region have adapted themselves to a lacustrine habit.

Genus **Percina.**

Percina caprodes, Rafinesque

(Log-perch)

Usually taken on sand beaches where there is some aquatic vegetation. The fish is easily recognized by its yellow coloration, dark vertical or saddle-shaped bars, and pointed snout.

Length 3¼ inches. Body elongated, not compressed. Depth 5·7 to 6·8. Head very flat above, 3·6 to 5·2 (commonly 3·7). Snout 2·4 to 3 in head; slender and pig-like, overhanging the inferior mouth. General coloration yellow, the back and sides with 8 to 10 vertical bands or stripes, which tend to enlarge into darker spots below. Alternating with these are smaller bands or spots, either fused or disconnected with reference to the main stripes, making a somewhat irregular pattern. A definite black spot at the base of the tail. Dorsal and caudal fins barred with black or brownish. Ventral parts light. First dorsal fin with 14 or 15 spines, the second with 16 soft rays. Anal with 11 to 13 rays. Scales small, with ctenoid edges, absent before dorsal and on breast, except in young specimens, 6 to 8, 80 to 88, 15 to 17.

The food consists of minute chironomus larvæ, small amphipods, crayfish, and entomostraca.

Genus **Etheostoma.**

Only one species recognized, but some aberrant specimens suggest the character of *E. boreale*, which has been recognized by Meek and Clark ('02) as occurring in Muskoka Lake.

Etheostoma iowae, Jordan and Meek.

With the exception of the well-marked species *Boleosoma nigrum*, described below, and the doubtful species *E. boreale*, all the smaller darters, of less than two inches in length, appear to belong to a single species, identified by Dr. Meek as *E. iowae*. The specimens, however, show some variation in color pattern, especially larger specimens taken in the early part of the season.

Fairly abundant on rocks and sand beaches, but showing a more decided tendency towards the latter than *B. nigrum*. Though superficially much like the latter species, it is distinguishable in the water by the paler character of the saddle-like cross markings of the back. Spring males are easily distinguished from all other fishes by their brilliant blue and orange markings.

Length $1\frac{7}{8}$ inches, commonly barely more than an inch. Body elongated, tapering backwards from a point in front of the dorsal fin. Depth 5 to 5·7. Head 3·4 to 4. Snout rather blunt, the mouth at its ventral angle. Premaxillaries not proctractile, joined to the forehead by a median fleshy bridge. General coloration buff, the sides with about 10 irregular blotches of cinnamon color, arranged in a bead-like series. Dorsal surface finely punctate, with 8 or 9 faint cross bars of darker color. Portions of the lateral markings sometimes tend to fuse above. A bar forwards on the snout and another downwards from the eye. Dorsal and caudal fins more or less barred. Under parts pale. The lateral line is marked out forwards as a white streak, slightly bowed upwards in its middle portion. Anterior dorsal fin with 8 or 9 spines, posterior dorsal with 10 or 11 soft rays. Anal with 2 spines and 7 or 8, sometimes 9, soft rays. Scales minute and ctenoid, 4 or 5, 55 to 60, 8 to 11. Lateral line incomplete posteriorly.

Males in the breeding season are brilliantly colored. The anterior dorsal fin has the basal two-thirds deep blue green, darker between the rays. There is a narrow band of blue at the margin of the fin, separated from the basal band by a stripe of orange. Sides with the angular cinnamon blotches very bright and alternating with greenish black spots. More or less orange at the base of the pectorals, and extended backwards by four obscure blotches to and along the base of the anal. Basal membranes of the posterior dorsal, caudal and anal with diffuse greenish.

The breeding season includes the latter part of May and June. The eggs are deposited on stones, especially in sheltered crevices, often in water of only a few inches in depth. The animals are commonly found in groups, and there is a lively competition among the males for possession of the females.

Genus **Boleosoma.**

Boleosoma nigrum, Rafinesque.

(Tesselated darter. Johnny darter)

(*Plate II, fig. 17*)

Abundant in rocky situations along shore, and also common on sand beaches, or in swamps where there is some clean sand bottom. Resembling the foregoing

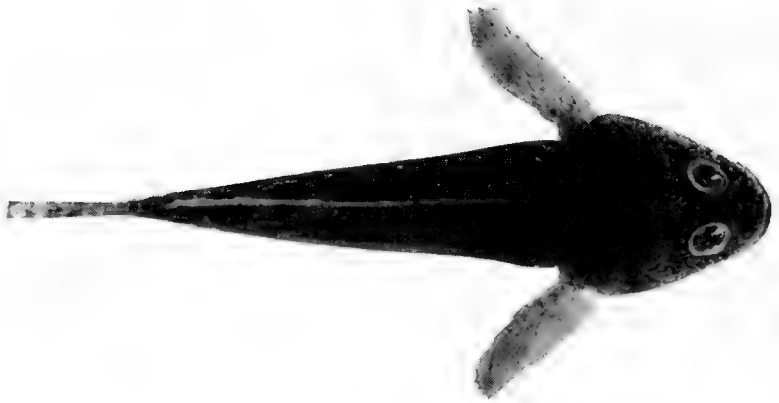

Fig. 6. Uranidea franklini. × $1\frac{1}{2}$.

species superficially, but distinguishable by the darker marks of the back, and by the W. or M-shaped flecks of the sides.

Length 2 inches or less. Body elongated, tapering backwards from the shoulder. Depth 5.4 to 6.1. Head 3·7 to 4·2. Snout blunt, the mouth at its lower angle. Premaxillaries protractile. Eyes dorsal and protruding. General coloration pale straw yellow. Back with 6, sometimes 7, cross bars of dark color. Scales more or less flecked, especially on the sides where there is a longitudinal series of W,M, or X-shaped marks. Head with a bar forwards from the eye and a spot beneath it. Spring males are dull sooty or inky black. Anterior dorsal fin with 8 to 10 spines, posterior dorsal with 12 (sometimes 10 or 11) soft rays. Anal with 1 spine and 7 to 10 soft rays. Scales 4, 43 to 48, 8 to 10. Lateral line almost complete, flexed downwards slightly in front.

Family COTTIDAE.

(Sculpins)

Represented by two genera, each with a single species. One of these is characteristic of the eastern shore, while of the other only a single specimen has been found, this from the sedimentary zone at the Giants's Tomb Island.

The two genera are separable as follows:

a. Ventral fins with 1 concealed spine and 3 soft rays.....**Uranidea**
aa. Ventral fins with 1 concealed spine and 4 soft rays.....**Cottus**

Uranidea franklini, Agassiz.

(*Fig. 6*)

Found lurking under stones in shallow water, and easily recognized by its wedge-shaped body and fan-like pectoral fins. It always seeks concealment, and if dislodged from one shelter darts rapidly to another.

Length 2 inches. Body very heavy forwards, tapering backwards to the slender tail. Depth 4·7 to 5·1. Head broad, its length 2·8 to 3 and its width 3 to 4·1 in the length of the body. Eyes dorsal in position, very large and protruding. Preopercle with an abruptly hooked spine which is directed backwards and upwards. General coloration yellowish or brownish, with dark mottlings and cross blotching above and on sides. Anterior dorsal fin with 8 slender spines, posterior dorsal with 17 soft rays. Anal fin very long, with 12 to 14 soft rays. Pectorals very large and fan-like, with 15 rays. Ventrals situated forwards, very small, with 1 weak spine and 3 soft rays. Body naked. Lateral line complete.

Cottus ictalops, Rafinesque.

(Miller's Thumb)

In habit similar to the foregoing species. Probably not rare, but no specimens have been taken on the eastern shore. The species occurs throughout the Great Lakes, and is said to be especially abundant in Lake Superior.

Length of the single specimen 1¾ inches. Body very robust forwards, and compressed towards the tail, Depth 4·3. Head stout and broad, its length 2·6. Eyes very large, dorsal, and protruding. Preopercular spine almost straight. Coloration dark brown or greyish above, mottled; white below. Dorsal and caudal fins finely barred with flecks of black: lower fins less so. Anterior dorsal low, with 7 weak spines. Posterior dorsal with 15 soft rays. Anal fin with 12 soft rays. Pectorals very large and fan-like, with 15 rays. Ventrals with 1 spine and 4 soft rays. Body naked, except for a few prickles behind the pectoral fins. Lateral line conspicuous anteriorly but absent posteriorly.

Family GADIDAE.

(Codfishes)

Lota maculosa, LeSueur.

(Ling. Burbot. Lake cusk)

Abundant in the deeper water of Georgian Bay, and commonly taken by fishermen in gill-nets.

Length 2 feet. Body rounded and heavy in front: greatly compressed towards the tail. Depth 5 to 7·7. Head broad and flat, its length 4 to 4·9. Snout 2·9 to 3·4 in head. Jaws and vomer with small, sharp teeth. A longer barbel below the chin, and shorter ones at the anterior openings of the nasal sacs. Eye small 6·7 to 10 in head.

General coloration olive or dark ashy above, with darker mottlings and scattered black spots. Lower parts light ashy or yellow. The general tone is darker and less yellow than in specimens from muddy waters. Anterior dorsal fin with about 10 concealed rays. Posterior dorsal very long, its base 1·9 to 2·3 in the length of the body; containing about 75 rays. Anal fin with about 68 rays, its base 2·4 to 2·7. Scales very minute and imbedded.

The ling is a voracious fish, living on perch, young whitefish, trout, herring, or on crayfishes. It is of no commercial value, is generally despised by fishermen, and is destroyed by them in large numbers. Its poor reputation is doubtless based on its slimy repulsive appearance and more or less unpleasant odor, the flesh being in reality of fair quality*.

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* The eggs of this species were discovered in 1906 and described in a paper in the "*Ottawa Naturalist*, Mar. 1906 by Prof. Prince and Mr. A. Halkett. The egg is of a very delicate character like the pelagic floating eggs of the marine ling, cod, haddock, etc.

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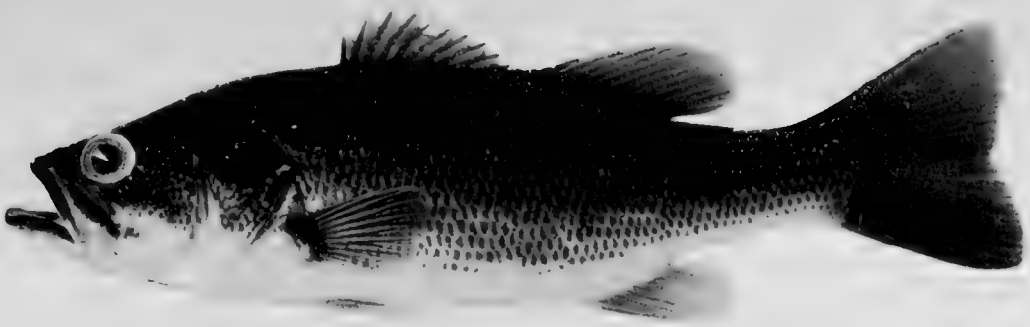

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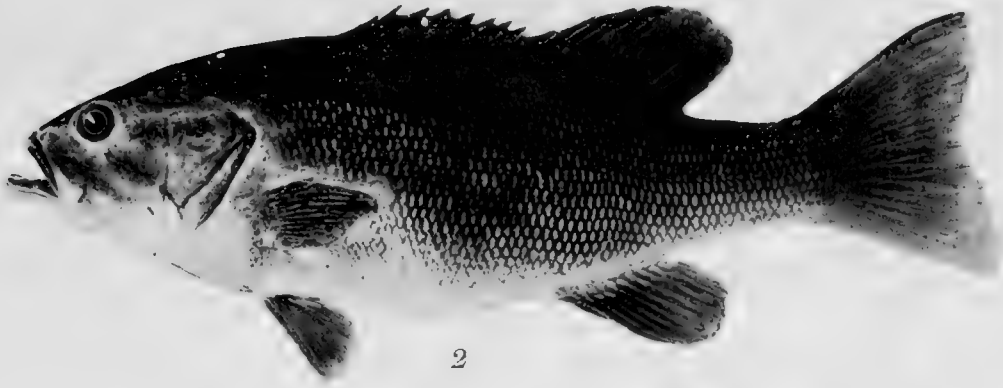

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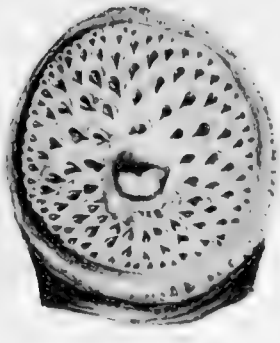

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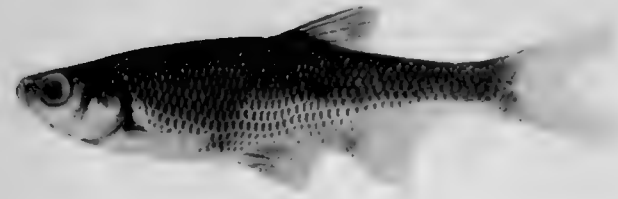

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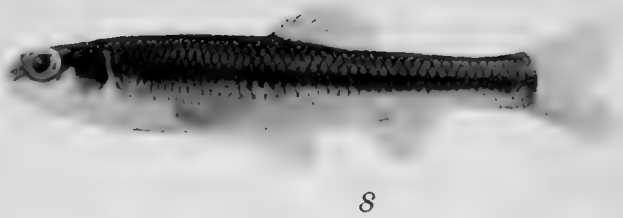

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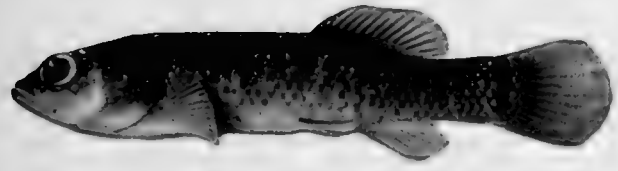

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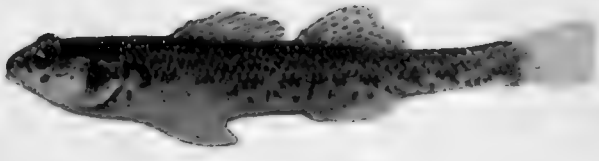

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II.

NOTES ON THE ODONATA OF THE VICINITY OF GO HOME BAY, GEORGIAN BAY, ONTARIO.

By E. M. Walker, B.A., M.B., Assistant Professor of Zoology, University of Toronto.

(*Plates III—IX, and 1 figure in text*)

When I first visited the Biological Station at Go Home Bay, Ont., in June, 1907, I was struck by the great abundance of dragonflies there, and being specially interested in this group of aquatic insects, particular attention was given them during the two months that I spent there that year.

During this period an effort was made to collect both adults and nymphs of all the species native to the immediate vicinity of Go Home Bay and the Go Home River, and to determine as much as possible of their life histories, including their seasonal and ecological distribution, habits of flight, food, enemies, etc.

As practically nothing was previously known of the Odonata fauna of this locality, the preliminary work of collecting and determining species and rearing the nymphs formed the major part of the work and in this occupation the writer was ably assisted by Mr. W. J. Fraser of Toronto. A considerable quantity of material was also collected by Dr. A. G. Huntsman of the Biological Department, University of Toronto.

In 1908 I spent another period of two months at the Station, but being occupied with other work, little was added to the data already accumulated.

A third visit was paid to the Station in 1912, and as I arrived there on May 19th, nearly a month earlier than on either of the two previous occasions, and remained until Sept. 11th, I was able to add a number of observations to the seasonal distribution of some of the earlier and later species. No additions were made to the Go Home Bay fauna, but two species of *Sympetrum* previously unknown to this district were taken at the Giant's Tomb Island.

Mention is also made in this paper in the list of species, of a number of nymphs collected by Mr. R. P. Wodehouse at various other points along the shore of Georgian Bay.

Physical Features of the Go Home Bay District.

Go Home Bay (Bushby Inlet) is situated on the east side of Georgian Bay about fourteen and a half miles north of Penetanguishene and its topography is typical of a large part of the eastern shore of this body of water.

The physical characteristics of this region have been described in some detail by Bensley ('14) and it will only be necessary here to refer to a few of the more salient features.

The exceedingly irregular coast-line in this vicinity, with its innumerable bays, inlets and channels and its countless rocky islands and reefs, renders the region a very favorable one for the support of a varied and abundant aquatic fauna. Most of the types of environment in which dragonflies flourish are represented within a few miles of the Station Island, from the well-aerated waters of the Go Home River and the more exposed parts of the Bay to the sheltered, often shallow and marsh-bordered inlets, the shady woodland creeks and the small lakes and ponds, margined with sphagnum bogs. The shallow lagoons on the sandy beaches of Giant's Tomb Island offer still other conditions of environment.

General Characteristics of the Odonate Fauna.

Owing to the rocky topography of the country and the scantiness of the soil the drainage of the smaller lakes and ponds, where it exists at all, is poor and the aquatic vegetation in such stations is somewhat limited in variety, while the shore plants are largely of the type that prevails on bog-soils having an acid reaction, i.e., the plants of the sphagnum-bog society. In these ponds there is an absence of some of the commonest dragonflies of the ponds in agricultural districts. Some of these species are met with in the shallow bays connected with the open water, but even here they are not the prevailing species. As examples of such species we may take *Lestes unguiculatus, Enallagma ebrium, Leucorrhinia intacta, Sympetrum rubicundulum, Libellula quadrimaculata, L. pulchella* and *L. lydia*, all abundant species in the agricultural sections of Ontario, at least in the southern part. All of these species except two have been taken at Go Home Bay, but none are very abundant and none have been taken in the sphagnum-bordered ponds. How far this scarcity is due to soil conditions and how far, in some cases, to the comparatively northern latitudes we are unable at present to say. *Sympetrum rubicundulum* and *Libellula quadrimaculata* range far to the north of Georgian Bay.

There is also an entire absence of certain regional species that breed in gentle shallow rapids with sandy or gravelly bottoms. No species of *Ophiogomphus*, e.g., has been taken in this vicinity, though Mr. Wodehouse took a nymph of a species of this genus in the Shawanaga River and I have found *O. rupinsulensis* fairly common in Algonquin Park. *Gomphus scudderi* and *Lanthus albistylus* were also taken in Algonquin Park, flying over gentle rapids, but are apparently absent from the Go Home district. They are very likely to occur on the Musquash River. Other river species common in Algonquin Park but not represented at Go Home Bay are *Agrion aequabile* and *Boyeria vinosa*.

The total absence of Cordulegasters is also worthy of note and is doubtless due to the absence of the proper conditions of environment. *C. maculatus*, an inhabitant of creeks, and *C. diastatops* of spring bogs have been taken at Port Perry, Muskoka District (Walker '06) and the former at Heyden and Searchmont, near Sault St. Marie, Ont. (Williamson, '07).

The most prominent positive feature of the fauna, as one would be led to infer from the character of the country, is the abundance of individuals of those species which develop in the well-aerated waters of the bay and the adults of which patrol

the rocky shores or fly about over the islands and the open channels. These are all found also in the Go Home River, but characteristic river species are conspicuously lacking.

Another noticeable feature of the fauna is the great abundance in the sphagnum bogs at the edge of small lakes and ponds, of certain species that we have met with rarely or not at all elsewhere in Ontario. The most characteristic species of this group are *Nehalennia gracilis*, *Nannothemis bella* and *Leucorrhinia frigida*.

Ecological Distribution of Species.

The Odonata of the vicinity of Go Home Bay may be roughly divided into three principal ecological groups, according to the nature of their breeding-places, viz.,

Group 1:—Species inhabiting the well-aerated waters of the open bay and broader parts of the river.

Group 2:—Species inhabiting still waters, e.g., shallow bays, sluggish creeks in open marshes, small enclosed lakes and ponds.

Group 3:—Species inhabiting woodland creeks.

Two other groups might be added, namely, those species inhabiting the rapids and those breeding in the shallow sand-bottomed lagoons on the Giant's Tomb Island (Fig. 36), but no characteristic species have been found in the former, while the latter are for the most part identical with Group 2, there being but one or possibly two peculiar species.

These groups are not sharply distinguishable from one another, many species fall into more than one of them.

Group I.

These species may be further subdivided into two groups, (a) those which breed on exposed rocky shores, occurring also about the edges of currents (Figs. 26, 27, 28) and, (b) those which are inclined to occupy the lower, shallower and more sheltered parts of otherwise exposed shores (Fig. 29, 30). These sub-groups are not sharply separable, some species being equally well-placed in either.

(a)

1. Argia moesta putrida.
2. Gomphus brevis.
3. " lividus.
4. Dromogomphus spinosus.
5. Boyeria grafiana.
6. Basiæschna janata.
7. Macromia illinoiensis.
8. Didymops transversa.
9. Neurocordulia yamaskanensis.

(b)

1. Enallagma carunculatum.
2. Hagenius brevistylus.
3. Gomphus lividus.
4. " exilis.
5. Basiæschna janata.
6. Nasiæschna pentacantha? (rare).
7. Epicordulia princeps.
8. Tetragoneuria cynosura simulans.

Of the species in sub-group (a) No. 2 is mainly a species of the rapids but also frequents the exposed shores of the outer islands; No. 4, is chiefly a river form, likewise occurring about the outer islands though sparingly; the others are generally distributed, though No. 5 shows a distinct preference for slightly running water, while No. 9 is most at home in the deeper waters about precipitous rocky shores or in the neighbourhood of rapids.

The species of sub-group (b), with the exception of No. 6, which is included here with some doubt, are all abundant and generally distributed.

Group II.

The species belonging to this group are roughly divisible into (a) those which are more characteristic of the marshy coves along the shores of the inner bays and lakes, or at the outlets of sluggish creeks (Plates VII–VIII, Figs. 31, 32) and (b) those which are partial to the edges of sphagnum bogs bordering small lakes and ponds (Plates VIII–IX, Figs. 33, 34).

(a)

1. Lestes unguiculatus (rare).
2. " uncatus.
3. " disjunctus.
4. " vigilax.
5. Nehalennia irene.
6. Enallagma hageni.
7. " calverti.
8. " ebrium? (one specimen).
9. " exsulans.
10. " signatum.
11. " pollutum.
12. Ischnura verticalis.
13. Gomphus spicatus.
14. Gomphus exilis.
15. Aeshna eremita.
16. " elepsydra.
17. " canadensis.
18. " verticalis.

19. Anax junius.
20. Epicordulia princeps.
21. Tetragoneuria spinigera.
22. " cynosura simulans.
23. Dorocordulia libera.
24. Celithemis elisa.
25. Leucorrhinia frigida.
26. " proxima.
27. " intacta.
28. Sympetrum costiferum.
29. " vicinum.
30. " semicinctum.
31. " obtrusum.
32. " corruptum.
33. Libellula quadrimaculata.
34. " exusta julia.
35. " pulchella.
36. " vibrans incesta.

(b)

1. Lestes disjunctus.
2. " inaequalis (one specimen).
3. Nehalennia gracilis.
4. Enallagma hageni.
5. Gomphus spicatus.
6. Tetragoneuria spinigera.
7. Cordulia shurtleffi.
8. Dorocordulia libera.
9. Nannothemis bella.
10. Leucorrhinia frigida.
11. Libellula exusta julia.

The abundant species of sub-group (a) are Nos. 3, 4, 6, 12, 13, 14, 20, 21, 22, 24, 25, 28, 29, 31 and 34. Nos. 7, 10, 11, 16, 17, 19, 23, 30, 33 and 35 are also common, while Nos. 2, 5, 9 and 27 are not infrequently met with. The others are rare in this district, Nos. 8, 18 and 32 being doubtfully included in this group. Nos. 9, 10 and 11 form a sub-group by themselves, intermediate between Groups I and II. They seem to prefer the low parts of the shores of the river and the quiet inlets where there is a marshy tendency, but little or no growth of reeds or similar marsh vegetation. This type of habitat grades on the one hand into sub-group (b) of Group I and on the other hand into sub-group (a) of Group II, in which they have been included.

No. 32 is peculiar to the lagoons of Giant's Tomb Island.

Of sub-group (b) Nos. 1, 3, 4, 9, 10, and 11 are abundant, 9 being, however, local. Nos. 5, 6 and 11 are more characteristic of sub-group (a). Nos. 3 and 9 breed in the sphagnum bog some distance from the edge of the open water.

Helocordulia uhleri, *Leucorrhinia glacialis* and *L. hudsonica* probably also belong to Group II, but we have never found their nymphs.

GROUP III.

1. Agrion maculatum.
2. Ischnura verticalis.
3. Aeshna umbrosa.
4. Somatochlora williamsoni.

No. 1 is a characteristic creek and river species. It has not been taken below the "Chute" on the Go Home River, the smaller creeks in this vicinity being too sluggish to suit its requirements. No. 2 is commoner about creeks than about the swampy bays; No. 3 is essentially an inhabitant of shady creeks and ditches, while No. 4 is included here with some doubt (vide p. 85).

SEASONAL DISTRIBUTION OF ADULTS.

When we arrived at Go Home Bay on May 17, 1912, no dragonflies were abroad in the vicinity of the Biological Station, nor were any observed until we visited the Giant's Tomb Island on May 26th, when a single example of *Anax junius* was seen flying over an open bushy slope. On the 29th exuviæ of *Didymops transversa* and *Gomphus spicatus* were found on the shore of the "Pittsburgh Channel", a single example of each. During the next three days tenerals and exuviæ of *G. spicatus*, *Tetragoneuria spinigera*, and *Ischnura verticalis* were taken about Galbraith Lake. A single teneral *Leucorrhinia frigida* was also seen, while *Anax junius* and *Enallagma calverti* were both common and fully mature. On the 8th of June the first specimen of *Basiaeschna janata* emerged in the laboratory, followed by another on the 9th. By this time *Gomphus spicatus* was numerous and *Libellula exusta* was becoming common. By the 13th both of these species had become abundant and *Tetragoneuria cynosura simulans* was emerging. On the 15th the first tenerals of *Gomphus brevis* were found about the "Chute," followed next day by *G. lividus* at the Station Island. *T. cynosura simulans* was already abundant while a single specimen of *Helocordulia uhleri* was taken at Sandy Gray Falls on the Musquash River. It was also about this time that *Enallagma hageni* first made its appearance, and a few days later, on the 18th, the first young adults of *Gomphns exilis* were observed, while those of *G. lividus* were still transforming.

In 1907 these four species of *Gomphus* appeared in about the same order, but somewhat later. When we arrived on June 15th, 1907, *spicatus* was already common, but all the individuals were as yet teneral, while *G. lividus* and *brevis* did not appear until the 22nd and 23rd respectively and *G. exilis* was first found transforming on the 25th. By June 19th, *Nehalennia gracilis* and *Dorocordulia libera* had appeared and from the 22nd to the 25th (1912) three more species were added, viz., *Celithemis elisa*, *Neurocordulia yamaskanensis* and *Lestes vigilax*. On the next day the first Aeshna, *Ae. canadensis*, was recorded together with the first specimen of *Epicordulia princeps*, a species which shortly afterwards became very numerous. On the 27th *Libellula quadrimaculata*, which was first seen in 1907 on the 18th, was found in large numbers, all more or less teneral, about a rocky pond on a small island far out in the Bay. *E. hageni* and *I. verticalis* were

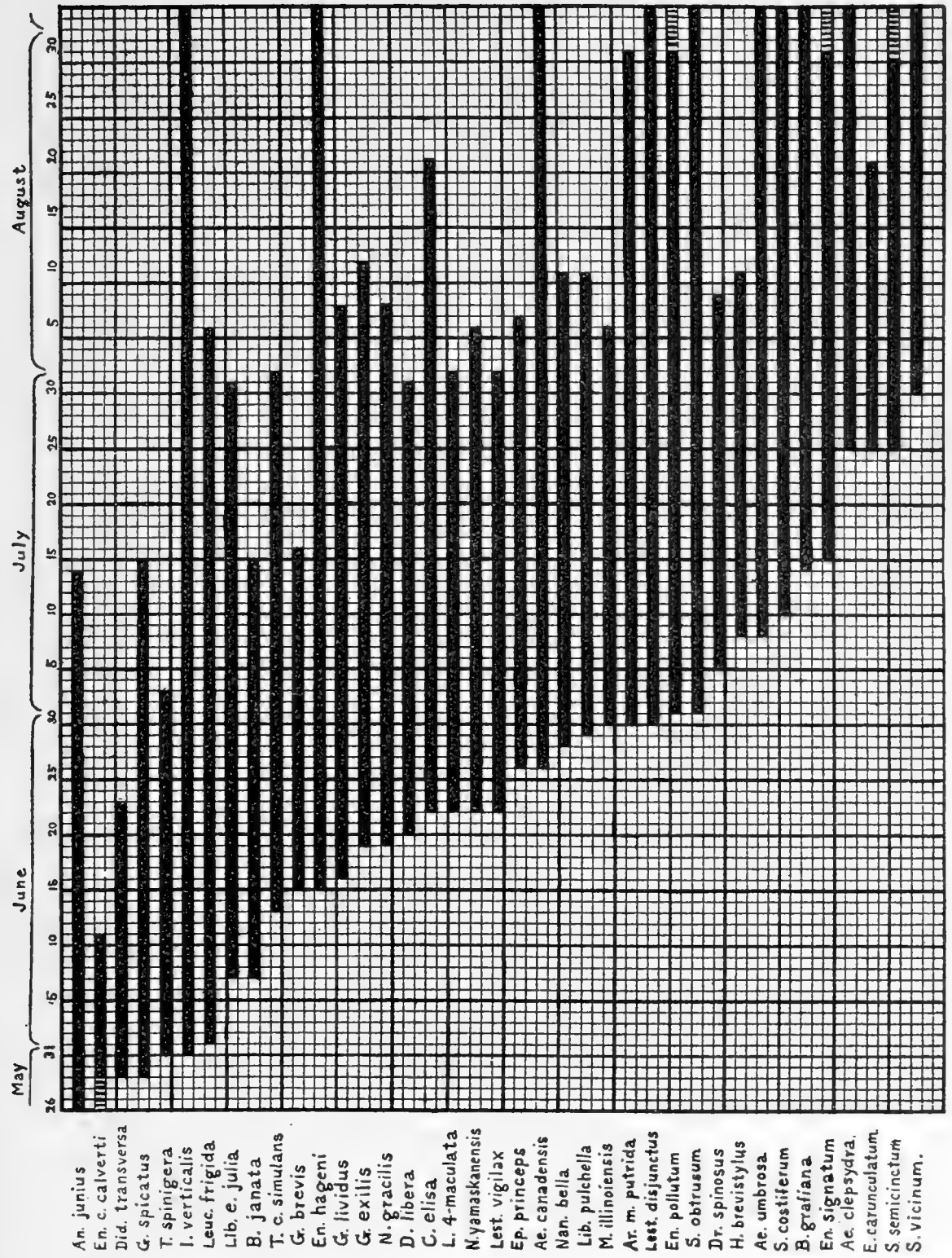

Fig. 1. Plan showing seasonal distribution of adult dragonflies.

also abundant here and all three species were still transforming. By this time *E. calverti*, *D. transversa* and *T. spinigera* had about disappeared, though the last-named species was taken in 1907 on July 1 and 4. All the other species mentioned were common. During the last few days of the month several other species appeared and speedily became abundant. These were *Lestes disjunctus*, *Argia putrida*, *Nannothemis bella*, *Libellula pulchella* and *Macromia illinoiensis*. The last-named species was first observed on the 30th and during the first few days of July it came out in some numbers about the Station Island and neighbouring parts. *N. yamaskanenis* could now be taken any evening in plenty. Tenerals of *Sympetrum obtrusum* now began to appear and *Enallagma pollutum* was first noticed about some of the marshy bays. It had probably, however, been on the wing for some days as all the individuals seen were quite mature. The next species to appear in 1907 was *Dromogomphus spinosus* which was first observed in transformation on July 5. This species was not seen at all during 1912. On the 9th *Aeshna umbrosa* emerged in the laboratory and on the same day *Hagenius brevistylus* appeared on the Island, becoming common almost immediately afterwards. On the 10th the first tenerals of *Sympetrum costiferum* and one of *S. danae* were taken on the Giant's Tomb Island, but the former species did not appear at Go Home Bay until the 24th, while *danae* does not occur there at all. Mature specimens of *S. corruptum*, likewise absent from Go Home Bay were also taken at the Tomb on this date. On July 14th the last *Basiaeschna* was taken while the first *Boyeria grafiana* emerged in the laboratory, and about the same time in 1907 the first specimens of *Enallagma signatum* were seen, though these were not noticed until some time later in 1912. No other new forms appeared until the 24th when *Enallagma carunculatum* was found about the Station Island, most examples already mature, while *Sympetrum semicinctum* was added to the species of marshy habitat. The predominant species about the Island were now *Argia putrida*, *E. carunculatum*, *Epicordulia princeps*, and *Hagenius brevistylus*, while those about the marshes were chiefly *Lestes disjunctus* and a few *L. vigilax*, *Enallagma hageni*, *Nehallenia gracilis*, *Libellula pulchella*, *Celithemis elisa*, the various species of *Sympetrum* and *Leucorrhinia frigida*, though the last had become greatly reduced in numbers. On July 30, the first teneral of *Sympetrum vicinum* was noticed and after this date no new forms appeared. The Gomphi had practically gone and very few *Macromia*, *Libellula exusta* and *Dorocordulia* were to be seen. *Epicordulia princeps* had also diminished greatly in numbers and the last *Tetragoneuria cynosura simulans*, was taken on the 31st. By August 6th but little change could be noted. The Sympetrums were still emerging, most of the individuals of *S. costiferum* and *S. vicinum* being still teneral. The Aeshnas had apparently all emerged, though very few were seen in 1912. A single *Nannothemis* was observed on this date. On Aug. 25 and 26 *Sympetrum costiferum* and *vicinum* were abundant and a few *S. obtrusum* were seen. Many pairs were observed in copula. *Aeshna canadensis* and *clepsydra* were also fairly common and *Somatochlora williamsoni* was twice observed. Several Enallagmas were also still abroad, viz., *E. hageni*, *carunculatum*, *exsulans* and *pollutum*. *E. carunculatum* was abundant along the shore of some of the bays and *E. pollutum* was

also common. *Ischnura verticalis* and *Lestes disjunctus* were also observed, the latter in greatly reduced numbers.

No changes were noted after this date.

Geographical Distribution of the Species.

Go Home Bay is situated at about the northern limit of the Transition (Alleghanian) Life Zone and its Odonate fauna thus exhibits an intermingling of Boreal and Austral elements. Many of the species range a considerable distance both north and south of this locality, being common to both the Canadian and Carolinian Zones, and therefore occurring throughout the Alleghanian (Transition) Zone. A few Carolinian forms probably find the northern limit of their geographical distribution at about this latitude, while some of the characteristic species of the Canadian Zone do not seem to occur much farther south.

The species which are generally distributed in Ontario as far or farther than the north shore of Lake Huron are the following:—

1. Agrion maculatum.
2. " aequabile.
3. Lestes unguiculatus.
4. " uncatus.
5. " disjunctus.
6. Chromagrion conditum.
7. Nehalennia irene.
8. Enallagma hageni.
9. " carunculatum.
10. Ischnura verticalis.
11. Hagenius brevistylus.
12. Gomphus lividus.
13. " exilis.
14. " spicatus.
15. Dromogomphus spinosus.
16. Boyeria grafiana.
17. Basiaeschna janata.
18. Aeshna canadensis.
19. " umbrosa.
20. Anax junius.
21. Didymops transversa.
22. Tetragoneuria spinigera.
23. " cynosura simulans.
24. Helocordulia uhleri (?).
25. Dorocordulia libera.
26. Sympetrum costiferum.
27. " vicinum.
28. " semicinctum.
29. " obtrusum.

30. Libellula exusta julia.
31. " quadrimaculata.
32. " pulchella.

Some of these, such as Nos. 10, 20 and 32 are commoner in the Carolinian and Alleghanian Zones, while others, such as Nos. 18, 22, 25 and 30 are more frequent in the Canadian Zone. The others are generally distributed as far as known.

The following are Alleghanian and Carolinian:—

1. Lestes vigilax.
2. " rectangularis.
3. " inaequalis.
4. Argia moesta putrida.
5. Nehallenia gracilis. (?)
6. Enallagma exsulans.
7. " signatum.
8. " pollutum.
9. Gomphus fraternus.
10. Aeshna clepsydra.
11. " verticalis.
12. " tuberculifera. (?)
13. Nasiaeschna pentacantha.
14. Macromia illinoiensis.
15. Epicordulia princeps.
16. Nannothemis bella.
17. Celithemis elisa.
18. Leucorrhinia intacta.
19. Sympetrum corruptum.
20. Libellula vibrans incesta.

Nos. 4, 7, 8, 9, 13 and 15 range also into the Austroriparian Zone, No. 13 reaching the Gulf Strip. No. 19 is chiefly Western (Transition and Upper Sonoran).

The following are chiefly Transitional and Canadian:—

1. Enallagma cyathigerum.
2. " calverti.
3. Gomphus brevis.
4. Aeshna eremita.
5. Neurocordulia yamaskanensis.
6. Cordulia shurtleffi.
7. Somatochlora williamsoni.
8. Leucorrhinia frigida.
9. " glacialis.
10. " proxima.
11. " hudsonica
12. Sympetrum danae.

No. 3 extends into the Carolinian Zone, No. 5 is mainly Alleghanian. The others are all more abundant in the Canadian Zone, Nos. 1, 2, 4, 6, and 11 ranging far into the Hudsonian Zone.

Notes on the Species.

Calopterygidae.

1. **Agrion maculatum** Beauvais.

Syn. *Calopteryx maculata* (Beauv.) Burm.

A male was taken in the woods, just above the "Chute" on the Go Home River, July 7, 1907. A few others were also seen along the river shore. Another male was seen at the "Chute" on July 22, 1912. It will doubtless be found more commonly farther up the river.

The nymph has been described by Needham ('03).

2. **Agrion aequabile** (Say) Kirby.

Syn. *Calopteryx aequabilis* Say.

This species has not been taken in the immediate vicinity of Go Home Bay but a female was captured by Dr. Huntsman near Victoria Harbour, June 25, 1907. It has also been taken in Algonquin Park and I have an exuvia from Shawanaga River, taken by Mr. Paul Hahn, which I believe belongs to this species. The basal joint of the antennae is fully a third longer than the width of the head, this being the diagnostic character given by Needham for the nymph, that he referred to *aequabile* by supposition. In the nymph of *A. maculatum*, the basal joint of the antennae is scarcely longer than the head is wide. These two species are the only ones of this genus that occur in Ontario, so that there seems to be little doubt that the nymph referred to *aequabile* belongs to that species, particularly as the measurements are larger than those of *maculatum*, as is also the case with the adults.

My exuvia measures as follows*: Length of body 27; gills 13.5 additional; antennae 6·5; outer wing-pad 7; hind femur 10.

Coenagrionidae.

Lestinae.

3. **Lestes unguiculatus** Hagen.

Rare in this vicinity. A few individuals were taken in an open marsh near a small lake, on Aug. 6, 1907.

The nymph has been characterized by Needham ('03) and the writer ('14).

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* All measurements are given in millimetres.

4. **Lestes uncatus** Kirby.

A few specimens of this species were captured at the lagoon on the Giant's Tomb Island on July 14, 1912. A pair was observed in copula and the male was captured.

The nymph has been characterized by Needham ('03)). and the writer ('14).

Full-grown nymphs were taken in large numbers by Mr. Wodehouse from a small lake on Fitzwilliam Island, Georgian Bay, on June 29, 1912.

5. **Lestes disjunctus** Selys.

A very common species in all still marshy waters. It was the commonest Lestes in 1912. The first adults captured in 1907 were taken on July 23 but they had probably been on the wing for a week or more. In 1912, they were first noted on July 13.

The nymph has been described by the writer ('14).

6. **Lestes rectangularis** Say.

This species is rare in this vicinity. A male and two females were taken in a marshy spot on the Go Home River on July 7, 1908, and another somewhat teneral male was captured at the Giant's Tomb Island, July 14, 1912.

The nymph is described by Needham ('03) and the writer ('14). A number of them were taken by Mr. Wodehouse from a small lake on Fitzwilliam Island, Georgian Bay, on June 29, 1912.

7. **Lestes vigilax** Hagen.

This was by far the most abundant Lestes in 1907 and 1908, frequenting the same stations as *L. disjunctus*, which it far outnumbered during these years. It was very much scarcer in 1912.

We have found the long slender nymphs in abundance and have bred a number of them. They have been described by Needham ('08) and the writer ('14).

The first adults taken in 1907 are dated June 28th and it was abundant in the latter half of August. In 1912, on the other hand, it was not noticed until July 16 and had practically disappeared by the end of the first week in August.

8. **Lestes inaequalis** Walsh.

A single male was captured while flying over a sphagnum bog on the edge of a small lake, July 3, 1907. Much further search on this and subsequent occasions failed to reveal another specimen.

This is the only Canadian record for this species.

Coenagrioninae.

9. **Argia moesta putrida** (Hagen) Calvert.

This is a very abundant dragonfly about rocky shores during July and August. Though common everywhere on the open bay and river, it is rather more abundant on the latter, especially in the neighbourhood of rapids. The nymphs are common

under stones near the shore. We found them particularly numerous at the "Chute" in part of the river which earlier in the season had formed part of the rapids, but which later had been almost cut off from the main current as a result of the diminished flow. They are commonly associated with nymphs of *Boyeria grafiana* and *Neurocordulia yamaskanensis* and Ephemerid nymphs of the genera *Heptagenia* and *Baetis*.

Transformation takes place on the rocks near the water's edge, and the season for emergence lasts for three weeks or more. In 1907, the first teneral individuals were taken on the inner bay on June 26, but imagoes did not appear on the Station Island until nearly a week later, continuing to emerge in considerable numbers during the succeeding week. By this time many individuals on the inner bay were already pruinose. In 1912, the earliest individuals were not observed, but they were undoubtedly later in emerging than in 1907. The first specimens were taken on July 9, and a day or two afterwards pruinose individuals were seen. Tenerals kept appearing until at least the end of the first week in August. This species flies over the barer parts of the rocky shores and is the only damsel-fly met with here, except *Enallagma carunculatum*, which breeds about the Station Island and in similar places. We have repeatedly observed pairs of this species engaged in oviposition, for which act the female often selects an almost bare rock. Her peculiar habit of descending under water and remaining there for a considerable length of time, usually accompanied for a few minutes by the male is well known and need not be described in detail here.

10. **Chromagrion conditum** (Hagen) Needham.

Syn. *Erythromma conditum* Hagen.

A decidedly rare species in this locality. A few individuals were taken on July 3, 1907, along a small sluggish creek, bordered by a grassy marsh. We have not met with the nymph, which has been described and figured by Needham ('03).

11. **Nehallenia irene** (Hagen) Selys.

This usually common species is scarce in this region, but is occasionally found in shallow quiet bays in which there is a moderately abundant aquatic vegetation. The only place where it was found in any numbers was the Giant's Tomb Island, where it was common about a very shallow reedy pond in close proximity to a shallow reedy bay. The pond had probably been connected with the bay earlier in the season when the water was at a higher level. The bottom in both cases was sandy. On the day on which the insects were collected (July 29, 1908) the water of the pond must have had a temperature of 37 or 38°C., having been heated to this extent by the sun, but the nymphs of the various species of dragonflies found in it, including *N. irene*, displayed their usual activity.

The nymph of this species has been described by Needham ('03).

12. **Nehalennia gracilis** Morse.

Very abundant on all sphagnum bogs bordering lakes and ponds; the most characteristic damsel-fly of such stations. It also occurs in smaller numbers in open marshes. It was first noticed on June 18, 1907, and was found in abundance throughout July. In 1912 it was still common on August 6, but had about disappeared by Aug. 25. Several imagos emerged in the laboratory during July.

The nymphs are found in floating sphagnum bogs and are somewhat difficult to detect. I have compared them carefully with nymphs of *N. irene* from Toronto and the only differences that I can find are the smaller size, less spinulose hind margin of the head and entire absence of spots on the gills. It is not improbable that none of these characters are constant as I had but few specimens of either species for comparison.

In *N. gracilis* the convex posterior margin of the head has only 4 to 6 slender inconspicuous, colourless spinules; in *N. irene* there are a dozen or more spinules which are somewhat coarser and blackish at base (Figs. 2, 3). Gills very slender, widest in the distal third, tapering somewhat more gradually than in *N. irene*, without any indication of spots. (Pl. III, Fig. 1).

Length of body 8·25-9; gills 3–3·75 additional; hind wing 2·2–2·7; hind femur 2–2·33; width of head 2·33–2·4.

13. **Enallagma cyathigerum** (Charpentier) Selys.

A single male was taken from an open marsh on June 21, 1907.

This is the form described by Hagen as *E. annexum* ('61). I have stated elsewhere (Walker,'12b) my belief that this form and the following are but variations of the same species, but I find on further study that this conclusion was reached too hastily; the two forms are distinct species.

14. **Enallagma calverti** Morse.

In 1907 only one specimen of this form was taken, on June 16, but in 1912 it was found in considerable numbers early in the season but had seemingly disappeared before the middle of June. Fully matured imagos were found in the marsh at the outer end of Galbraith Lake on June 1, many of them flying in pairs. The season for transformation was not yet over, however, for several full-grown nymphs were found, four of these emerging on June 3 and 4. Mr. Wodehouse also took a full-grown nymph at Victoria Harbour on June 1.

The nymph (Pl. III, Figs. 4, 5) is very similar in form to that of *E. hageni*, but is considerably larger with much darker gills. Eyes as in *hageni*, less prominent than in *E. signatum* and *pollutum*, the curve of the posterior median excavation of the head somewhat more flattened than that of the rather strongly convex margins on each side, the latter with a dozen or more spinules. Labium with 4 mental setae and 6 (occasionally 5) lateral setae; end-hook of lateral lobe preceded by 3 teeth of moderate size, which are preceded by 3 or 4 smaller, somewhat incurved, denticles. Gills lanceolate, widest a little beyond the middle, ventral margin straight at base dorsal margin convexly curved, apices bluntly pointed with convexly curved mar-

gins or rounded; across the middle of the gill is a distinct joint, proximad of which the margins are spinulose, the spinules of the ventral margin stronger than those of the dorsal; distad of the joint the margins are beset with a fringe of delicate hairs, much longer than those of *E. hageni*. Colour dark brownish (probably olivaceous in life), each abdominal segment except 10 with a dark lateral blotch, not seen in the exuviae; femora with a pale ring just before the apex, preceded by a dark ring.

Length of body 15·5 (exuvia)–21·5; gill 6·5–8; outer wing-pad 4·5–5; hind femur 4; width of head 3·5–3·7.

I have also bred this species at DeGrassi Point, Lake Simcoe.

15. Enallagma hageni (Walsh) Selys.

Abundant about all still waters throughout the latter half of June and July and in small numbers in August. They were first noticed about the middle of June, and were common by about June 20. They thus begin to appear about the time when *E. calverti* has nearly disappeared. On June 27 we found this species in large numbers about a small pond on an island in the open waters of Georgian Bay, about 3½ miles west of the Station Island. This island is largely bare rock but supports a thick tangle of small cedars, red and black cherry and willows in its middle part. The pond occupies a long narrow depression in the rock, emptying by a very small trickle of water at one end. The shore and bottom of this pond over the greater part of its area is bare rock, or rock covered with a thin deposit chiefly consisting of decaying vegetable matter. At a few points along the margin there are dense clumps of small reeds and at the western end, next to the outlet, is a patch of cat-tails. Owing partly to its exposed and isolated position, but few species of aquatic insects were found in this pond and these included but three species of dragonflies. These were *E. hageni*, *Ischnura verticalis* and *Libellula quadrimaculata*. All of these, however, were very abundant and *E. hageni* most of all. Some of the reeds were covered with their exuviæ and transforming nymphs. Most of the imagoes seen were more or less teneral, the season being apparently a little later here than on the mainland and inner islands. I also found this species in several other rock-pools on the outlying islands. It was generally the only species of Odonata present.

The nymph which has been described by Needham ('03) is exceedingly common in all swamp waters in the vicinity of Go Home Bay. Numerous specimens were also taken by Mr. Wodehouse at Matchedash Bay, Killarney and Fitzwilliam Island, Georgian Bay.

This species outnumbers all the other Enallagmas of the district taken together, at least twenty times.

16. Enallagma ebrium (Hagen) Selys.

A single specimen, a male, was taken near a small lake close to the mouth of Go Home Bay on June 20, 1907. This species is indistinguishable from *E. hageni*

in the field, so that it might readily be overlooked. I have examined hundreds of individuals in this locality, however, without finding another specimen. *E. ebrium* is very abundant at Toronto but seems to prefer ponds on a clay or alluvial soil. Such stations are wholly lacking at Go Home Bay.

17. **Enallagma exsulans** (Hagen) Say.

This is one of the very abundant species of the Carolinian Zone but it is not very numerous in the Georgian Bay region. It does not occur about the small lakes and marshy bays but is not uncommon along the muddier parts of the river shore and along more or less shady creeks. It also occurs occasionally on the muddier parts of the shores of sheltered inlets, but as a rule not where there is a dense growth of reeds.

The earliest capture of this species was on July 2, 1907; the latest Aug. 26, 1912.

The nymph of *exsulans* has been described by Needham ('03).

18. **Enallagma carunculatum** Morse.

Next to *E. hageni*, this is the commonest Enallagma in the region under discussion, but it reaches maturity later in the season than other species, the first examples noted having been seen about the 25th of July, 1907. On Aug. 26, 1912, they were still abundant. This species it particularly characteristic of the marshier and shallower parts of the shores of otherwise open waters. It frequents also the narrow reed-beds which are very frequent in this region along many rocky shores of inlets and channels. It is the only Enallagma of our fauna which develops in water that is subject to any considerable wave-action and is thus the only species that breeds about the Station Island. The nymphs are also found at much greater depths than those of other species of this genus. At Lake Simcoe I have found the exuviæ clinging to reeds in water five feet deep. A description of the nymph is given by Needham ('03).

19. **Enallagma signatum** (Hagen) Selys.

This species, which is very abundant at Toronto, occurs somewhat sparingly at Go Home Bay, where it may be observed flying over lily-pads on sluggish creeks. It was first noticed on July 16, 1907, but became commoner after that date.

A number of specimens of the nymph (Pl. III, Fig. 7, 8) at various stages, including full-grown examples, were collected by Mr. Wodehouse at Waubaushene, May 29, at Killarney June 24th and in a small lake on Fitzwilliam Island, June 24, 1912. The nymph has been described and figured by Needham ('03).

19. **Enallagma pollutum** (Hagen) Selys.

This beautiful species is common on the river and the inner parts of the bay,

where it frequents the marshier parts of the shore, but, like the preceding species, does not usually fly among the reeds and sedge of the marshes., but over the lily-pads and pond-weed, keeping so close to the water that it is very difficult to net. It may also be found in the more open reed-beds, where it is more easily captured.

Among the nymphs taken by Mr. Wodehouse at Waubaushene and Fitzwilliam Island are a number of specimens of an undescribed form, which is so unmistakably nearly related to *E. signatum* that we have little hesitation in ascribing it *E. pollutum.* This species is, moreover, the only Enallagma of the region except the rare *E. ebrium*, whose nymph has not been reared.*

Nymph (Figs. 9, 10);—Long and slender; eyes very prominent laterally, their postero-lateral margins forming with the sides of the head a distinct excavation. Hind angles of head with numerous slender setæ, rounded but very prominent and narrower than the median concavity. Abdominal segments 2-7 with prominent postero-lateral angles. Gills large, broad lanceolate, widest at the distal third, with a transverse median joint, basal half dark except at the base, apical half whitish or grey except a broad dark anteapical band.

Labium with 3 mental setæ; lateral setæ 5; lateral lobes, before the end-hook, with three well-marked teeth, preceded by a feebly denticulate, almost truncate margin.

Colour brown (alcoholic, probably greenish in life), sides of head and thorax with a pale longitudinal band between two dark bands, the most ventral of which passes dorso-caudad to the bases of the front wing-cases. There are usually also a few dark spots on the head and thorax. Abdomen rather dark brown, almost uniform. Legs pale, femora with a very narrow but usually well-defined dark ring at the distal fourth.

Length of body 13 (contracted) to 18 (extended); gills 5-6·5; hind wing 4·3-5; hind femur 3·5; width of head 5·23-3·4.

21. **Ischnura verticalis** (Say) Selys.

This ubiquitous species is not particularly abundant at Go Home Bay. It is the second species of damsel-fly to appear in the spring, being preceded only by *Enallagma calverti.* We found them in considerable numbers on June 1, 1912, on the marsh at the outer end of Galbraith Lake, where they were transforming. Nearly all the individuals seen were tenerals, while *E. calverti* was for the most part fully mature.

This species seemed to become scarcer in July, but many fresh adults appeared in August. In this district, *I. verticalis* is more frequently met with about the margins of sluggish creeks than in the marshy bays. We have not observed it in sphagnum bogs.

The nymph has been described and figured by Needham ('03).

*Since the above was written I have reared *E. ebrium* at Toronto. The nymph is described in Can. Ent., 46, Oct. 1914.

Aeshnidae.

Gomphinae.

22. **Hagenius brevistylus** Selys.

The full-grown nymphs of this large Gomphine are not infrequently met with during the first half of summer among roots and debris along the edge of the lake shore. They breed in the bay and river but do not occur in the smaller inland lakes. They do not, however, frequent the barest or most exposed parts but show a preference for the more sheltered spots, where the bottom is more or less sandy. The younger nymphs are occasionally dredged from depths of six or eight feet. Four sizes of nymphs were found, including the full-grown stage, and it would thus appear probable that the nymphal life extends over a period of three years or more.

To ensure success in rearing the nymphs of this species, the water in the breeding-jar should be kept as fresh as possible. In our first efforts, this point was not strictly observed and the two full-grown nymphs which we were attempting to rear died shortly before the usual time for emergence. They had crawled out of the water and remained out for about four days, when we replaced them in fresh water, but they soon died. They had evidently not emerged for the purpose of transformation as we had at first supposed.

The large formidable-looking imagos are first seen early in July, becoming common a few days after their first appearance. In 1907 they began to emerge on the Station Island on July 2nd, but in 1912 they were not observed until July 9th. They were still not infrequent on Aug. 10th of the latter year, but by the 20th they had nearly disappeared.

During the period of emergence and for a short time afterwards, this huge, conspicuously-coloured dragon-fly may be seen about the Station Island, flying rather slowly and within a few feet of the ground. It is fond of basking in the sun in sheltered openings in the thickets along the shore, and when disturbed it does not usually fly very far. It is also frequently seen flying swiftly over the water, close to the shore.

The food of the adult Hagenius consists chiefly, if not wholly, of other dragon-flies. We have not observed it feeding on any other kind of insect. We have taken it while devouring *Gomphus lividus, G. exilis, Neurocordulia yamaskanensis* and *Tetragoneuria cynosura simulans.*

23. **Gomphus brevis** Hagen.

This is the rarest of the four species of Gomphus found in the vicinity of Go Home Bay. The adults are most frequently seen in the neighbourhood of rapids, but also occur in the more exposed shores of the bay, and one was observed on South Pine Island, which lies in the open water of Georgian Bay, about 3 miles out from the coast. Another was taken on the Giant's Tomb Island. The nymphs

inhabit the well aerated waters at the foot of the "Chute" and other stations where the imagos occur. They transform on the rocks close to the water's edge, generally early in the morning. In 1907 the first newly-emerged specimens appeared on the Station Island on June 23rd and the last adult was taken on August 14th. In 1912 they were somewhat earlier, appearing at the "Chute" on June 15th.

24. **Gomphus lividus** Selys.

Syn. *G. sordidus* Hagen.

This is a very abundant dragonfly, frequenting the shallower waters of the bay where the aquatic vegetation is scanty and the shores more or less wave-beaten. It is absent from the marshy bays and inland lakes and also from the steep rocky shores where the water is of considerable depth. The nymph lives in a more or less muddy or sandy bottom.

Transformation begins at almost exactly the same time as that of *G. brevis*, and usually takes place before 8 o'clock in the morning. The nymphs of these two species may be found together but on the whole those of *G. lividus* prefer quieter water than those of *brevis*.

In 1907 this species began to emerge on Station Island on June 22, becoming abundant in two or three days. In about a fortnight, however, they were nearly gone though a few females were seen as late as July 20. In 1912 the first young adults were observed on June 16 and they continued to emerge for at least 10 days, subsequently. By this time the species was very abundant and many pairs were seen in copula. By the end of the month all were mature, and shortly afterwards their numbers began to thin out, though occasional individuals were seen until the end of July. The season of flight is nearly coincident with that of the may-flies *Ephemera simulans* and *Hexagenia bilineata*, upon which they largely feed. They also devour small moths, caddis-flies, etc.

The flight of the adult males of this species is peculiar and is easily distinguishable from that of the other species of Gomphus occurring about Go Home Bay. It consists of a series of ascending and descending or dipping movements, the insect describing a series of deep curves, with the convexities downwards. These motions are not seen during the teneral state.

G. lividus is frequently captured and eaten by *Hagenius brevistylus*, but by the time the latter is common, *lividus* has already considerably diminished in numbers.

Gomphus exilis Selys.

This is the most generally distributed Gomphine of the Go Home Region, being associated with both *G. lividus* and *G. spicatus*. It is most abundant in the shallow marshy bays, but it is quite common on the Station Island, where the nymphs live in the comparatively shallow water on the south-east shore, associated with *G. lividus*, *Macromia illinoiensis*, etc.

It is the latest of the four species of Gomphus to appear in the adult state, the first tenerals emerging a few days later than those of *G. lividus* and remaining for some time after the other species of Gomphus have disappeared. In 1907 the first adults on the Station Island emerged on June 22, continuing to appear until about the 30th, while in 1912 they were first observed on the 19th. In 1907 and 1908 they were exceedingly abundant, apparently outnumbering both *lividus* and *spicatus*; in 1912, however, they were scarcer, their numbers being distinctly smaller than those of either of these species. In 1907 a few individuals lingered as late as Aug. 12.

Though usually transforming early in the morning, this process may sometimes be observed at other times of the day.

Like its associate, *G. lividus*, this species often falls a victim to *Hagenius brevistylus*.

26. **Gomphus spicatus** Hagen.

This is distinctly the earliest Gomphine and one of the earliest dragonflies to appear in the adult state in the spring. When we arrived at the Station in 1907, on June 15, tenerals were already common in the neighbourhood of the small lake near the outer coast, and in 1912 they were much earlier, an exuvia having been taken on May 29th, and a very large number on the 31st. These were found floating among the reeds in the marshy outer end of Galbraith Lake. On June 15 of same year, large numbers of tenerals were flying about the same marsh and many more mature individuals in the open rocky woods nearby. On June 5 great numbers of *spicatus* were seen about one of the shallower lagoons on the Giant's Tomb Island, all apparently beyond the teneral state. By the 15th its numbers had about reached their climax in the vicinity of Go Home Bay. They did not wholly disappear until somewhat after the middle of July. The last pair in copula was noted at the Giant's Tomb Island on July 15.

G. spicatus is strictly an inhabitant of marshy places in this locality, though Kellicott ('99) states that it frequents the "borders of wave-beaten shores or rushing rivers," and Needham refers to it as an inhabitant of "all sorts of waters." These statements, especially the former, are difficult to associate with this Gomphus and it seems to me probable that Kellicott's may refer to some other species. The nymph is a very common object in dredging from the soft bottoms, consisting chiefly of rotten vegetation, of ponds and still marshy bays.

Transformation takes place close to the waterline, the nymph frequently not emerging completely. The exuviae are thus often found floating.

27. **Gomphus fraternus** (Say) Selys.

This species does not occur in the immediate vicinity of Go Home Bay, but it is included here on account of the capture of a male specimen by Dr. A. G. Huntsman, near Victoria Harbour (Hog Bay), June 25th, 1907.

28. **Dromogomphus spinosus** Selys.

On July 5, 1907, a newly-emerged male of this species with its exuvia was found on the Station Island. A few other exuviae were also found here subsequently and adults were occasionally observed though not frequently. They were apparently much more numerous on the river above the Chute, judging from the large number of exuviæ found there.

In 1912 we did not come across this species at all, but Mr. Wodehouse dredged up a number of nymphs of various stages from Shawanaga Bay and the Shawanaga River on June 9 and 13, including several full-grown ones. Those from Shawanaga Bay were taken from weedy shallow water with a sandy bottom. Usually the nymph occurs where there is little aquatic vegetation. This is the case at De Grassi Point, Lake Simcoe, where this species is the only common Gomphine. Here it lives in a bottom of very fine sand and transforms on the boulders along the shore. The imagoes fly freely over the water and often settle on passing boats and on the boulders of the shore. They may also be taken quite frequently on roads through the woods within a few hundred yards of the lake.

29. **Boyeria grafiana** Williamson.

This is one of the late-appearing dragonflies, August being the month in which it is most abundant. Full-grown nymphs were collected on and after June 4, and the first adult emerged in the laboratory on July 14, followed by several others during the succeeding fortnight.

Teneral adults are often found clinging to the trunks of trees or the sides of houses in the shelter of the verandah. When mature they may be seen flying up and down the lake shore, close to the water, and following a more or less regular beat. Sometimes this is limited to a little cove two or three yards across, but generally they cover a much greater distance at a time.

They are most active in the evening, but fly also during the day. In their crepuscular habits they recall *Neurocordulia yamaskanensis* which they also resemble a good deal in general appearance, especially in the dull brownish coloration. They are less swift than the latter, however, and their flight is practically restricted to a narrow littoral zone. The season of adult life extends until about the end of September.

Williamson's description of the coloration of this species does not fit the majority of specimens that we have seen, in all respects. The light markings are bright yellow at first, but become dull with age. I have never seen blue-spotted individuals such as those described by Williamson, but the colour is always distinct from that of *B. vinosa.* The fulvous tone of the wings in the latter and the dark markings at their bases are not seen in *B. grafiana.*

The dark-coloured nymphs are found rather commonly under stones, along more or less wave-beaten places or wherever there is a perceptible current. They are generally distributed along the shores of Go Home Bay and River, except in marshy places. They show a preference for the neighourhood of rapids or narrow channels wherever there is a free circulation of water. They are perhaps most nu-

merous along the edges of gentle rapids, such as those above "Sandy Gray Falls" on the Musquash River. The nymphs are commonly associated with those of *Neurocordulia yamaskanensis*, *Argia moesta putrida* and *Basiaeschna janata*.

When ready to transform they climb upon rocks, wharves, boathouses, etc., sometimes to a height of five or six feet from the water, but often much nearer.

As the nymph of *Boyeria vinosa* was described before *B. grafiana* had been recognized as a distinct species, (Cabot, '81; Needham '01; Needham and Hart, '01), it is impossible to be certain whether these descriptions all refer to *B. vinosa* or not, but Needham's description belongs with scarcely a doubt to that species.

We have reared a number of nymphs of *B. grafiana* and collected many exuviæ as well as nymphs in several localities. We have also received a series of exuviæ of a Boyeria from the Shawanaga River, collected by Mr. Paul Hahn, which differ very slightly from those of *B. grafiana*. The latter were also found on the same river. As *vinosa* and *grafiana* are the only North American species of Boyeria and are both common in this region, there can be no doubt that the species not yet reared is *B. vinosa*.

The nymphs of these two forms may be separated as follows:

Mentum of labium 5·5 mm. long, its middle breadth scarcely less than half its length (Pl. III, Fig. 11); fourth abdominal segment without lateral spines; lateral abdominal appendages of female one-fourth to one third as long as the inferior appendages, and usually about as long as the dorsum of segment 10....*B. vinosa.*

Mentum of labium 6·5–7 mm. long, its middle breadth distinctly less than half its length (Pl. III, Fig. 13); fourth abdominal segment generally with distinct though very small lateral spines; lateral abdominal appendages of female one-fifth to one-fourth as long as the inferior appendages and one-half to three-fifths as long as the dorsum of segment 10.....*B. grafiana.*

B. grafiana also differs from *B. vinosa* in the slightly stouter inferior abdominal appendages which are less incurved at the tips (Figs. 12, 14) and in the slightly larger size as shown by the following measurement:

B. vinosa: Length of body 34–36·5; hind wing 6–7·5; hind femur 5–6; width of head 7·5–8.

B. grafiana: Length of body 37–39; hind wing 7·5–8; hind femur 6·6–5; width of head 8–8·5.

In coloration the nymphs of these two species are quite similar, except that the pale, wavy, dorso-lateral streak on each side of the abdomen is usually quite distinct in *grafiana* but more or less obscure in *vinosa*. In both species the depth of coloration varies considerably, usually being a rather dark brown. All the nymphs from the Go Home Bay district are very dark in colour, but the pale bands of the abdomen and legs are quite sharply defined. The most characteristic mark of Boyeria nymphs is a pale oval or diamond-shaped median blotch in the dorsum of segment 8.

Basiaeschna janata Say (Selys).

This species considerably resembles the preceding in its habits both in the nymph and adult states, but flies during the first instead of the second half of sum-

mer. The dark-coloured nymphs cling to the under-sides of stones near the shore, and are rather more generally distributed than those of Boyeria, as they also occur in the smaller recesses or quiet places, where a few reeds and other water-plants grow. They probably feed largely on Mayfly nymphs, particularly *Heptagenia*, *Blasturus* and *Ephemerella*, which are abundant in places frequented by *Basiaeschna* and *Boyeria*. The exuviæ may be found, like those of *Boyeria*, on logs, wharves and boathouses, sometimes at a height of six feet, but they also occur, like those of *Anax* and *Aeshna*, on reeds.

Full-grown nymphs were found on our arrival at the Station in 1912, on May 20, and continued to be found until June 10. The first adults seen were those which emerged in the laboratory on June 8th. Adults were taken until June 25th, but were not noticed after this date. They probably were on the wing for some time afterwards, however, for in 1907 we captured specimens repeatedly until July 17th.

This species may often be seen patrolling the margins of the bay and the Go Home River, usually flying higher than Boyeria. It may also be found in the open rocky woods, a short distance from the water. It is active during the day but also flies until well after sundown.

On June 24, 1907, a female was taken in the act of carrying off a teneral specimen of *Gomphus spicatus*, upon which she was feeding.

The egg-laying habits of this species, which we have not observed at close range, have been described in detail by Needham ('01).

Aeshna eremita Scudder.

This large boreal species is quite scarce in this locality, though I found it common in Algonquin Park in 1902 and it has been taken occasionally as far south as Toronto. In the Canadian zone it is an abundant and wide-spread species, ranging across the continent and northward to the Arctic Circle.

The only adults observed at Go Home Bay were a pair taken by Dr. A. G. Huntsman on Aug. 17, 1907. A few nymphs have been taken from reed beds along the shores of ponds. Two of these taken early in August were full grown. The nymph has been described by Cabot ('81) and by the writer ('12a). The ovipositing habits have also been described by the writer ('12a).

Aeshna clepsydra Say.

Next to *Ae. canadensis*, this species has been found more frequently than any other Aeshna in the vicinity of Go Home Bay, although, generally speaking, it is one of the rarer species of the genus.

The nymph, which has been described by the writer ('12a), is occasionally dredged from reed beds along the borders of shallow ponds or bays. Two males were reared by Mr. A. R. Cooper in 1910 emerging on July 25th and 28th. Two other nymphs taken in July were nearly ready to emerge.

The adults may be taken during the latter part of July and August, flying over the reeds and sedge of their breeding-grounds or in the open woods farther

away from the water. Like most species of Aeshna they often follow the shoreline more or less closely while foraging around a bay or pond.

Aeshna canadensis Walker.

This is the most common Aeshna of the Go Home district and probably of the entire Transition Zone in Ontario. It is also the earliest species to appear on the wing, the period of emergence commencing about June 25th and usually concluding before the middle of July. The adults fly until the middle of September or even later.

The nymphs (Walker, '12) are very similar to those of *Ae. clepsydra* and are found under apparently precisely similar conditions. On July 29, 1908, a number of half-grown nymphs of this species were found in a very shallow pool in the sand on Giant's Tomb Island. This pool was close to a lagoon with which it had been connected earlier in the season. The water was only a few inches deep and had been heated by the sun to a temperature of perhaps 37° degrees C. The nymphs were quite active but died the following night in the laboratory, not being able to accommodate themselves to the rapid change of temperature following their removal.

Aeshna verticalis Hagen.

This species is very scarce at Go Home Bay, only three specimens, two males and a female, having been taken. These were captured by Dr. Huntsman on August 26th and 30th, 1907. It is a common species southward, being not infrequently met with at Lake Simcoe and at times very numerous at Toronto. It has also been taken more or less commonly in many of the Northern and Middle States east of the Mississippi and has been recorded from Florida by Muttkowski ('10). It is thus an Austral species, Go Home Bay being the most northerly point from which it has been taken in Ontario.

In habits it resembles the preceding species in the adult state, but first appears as a rule nearly a month later and is commonest in the latter half of August and the first half of September.

Its nymph is still unknown.

Aeshna tuberculifera Walker.

This is an insect of which the habits are quite unknown. It is distributed from New England to Wisconsin, but is apparently nowhere common. Only a single male has been taken at Go Home Bay, by Dr. Huntsman, on August 26, 1907.

Since the above was written this species has been reared by the writer on Vancouver Island, B.C. The nymph will be described shortly in the Canadian Entomologist.

Aeshna umbrosa Walker.

This appears to be the most widely distributed and abundant Aeshna in North America.

It differs decidedly from the other species of the genus, the habits of which are known, in that the nymph develops in small woodland creeks, ditches and spring-fed pools, never being found in open, weed-grown, marshy waters. The imago is also decidedly partial to somewhat shady localities and flies as readily during dull as bright weather. It flies habitually until late dusk, coursing up and down the ditches or creeks in which it breeds, or foraging in open spaces away from the water, in search of Diptera and other small insects.

On account of this type of habitat *Ae. umbrosa* is not very common about Go Home Bay. A few full-grown nymphs were taken during August in two small shady creeks, emptying into Go Home Bay and on June 10, 1912, two other grown nymphs were taken from beneath boulders in the short outlet of a small lake. These were thickly covered with brown hydras. One of them emerged on July 14th. The nymph has been described by the writer ('12a).

The imagos were not seen very often, but are by no means rare. A single female was taken on the Station Island, where it must have flown from the mainland or one of the larger islands.

Anax junius (Drury) Selys.

This common and widespread species was the first dragonfly to be seen in flight after our arrival at the Station in 1912, a single individual having been observed on the Giant's Tomb Island on May 26. On June 1 a considerable number were seen flying about the inner end of Galbraith Lake. Several couples were observed, but none actually in copula, the males adhering only by the abdominal appendages. The female of one of these couples was observed ovipositing on the under surface of water-lily pads. She remained only a few seconds at each lily-pad. A similar pair was seen at Muskoka Mills on June 31, and the male captured.

Two stragglers were taken on the Station Island, a female in good condition on June 26, '12, and a worn male on July 7. This is the latest date on which an adult of the spring brood was observed.

The nymphs are taken quite frequently with the hand-dredge and dip-net, along the marshy borders of ponds and sheltered bays, their haunts being quite similar to those of *Aeshna canadensis* and *clepsydra.*

They are not nearly so abundant here as in the vicinity of Toronto and southward.

No individuals of the fall brood had yet made their appearance at the time the Station was closed in 1912 (Sept. 11).

Nasiaeschna pentacantha (Rambur) Selys.

On August 28, 1906, Mr. W. J. Fraser found three of the strange-looking nymphs of this interesting species near Bala Falls, Muskoka, Ont. He attempted to rear them, but although easily kept in captivity they were all killed by accident. One of them was kept through the winter and brought to the station at Go Home Bay in 1907, but on crawling out of the breeding jar, probably to transform, it was accidentally crushed.

Two nymphs were found at Go Home Bay during 1907. One of these I found clinging to my paddle while passing through the outlet of Galbraith Lake. The other was dredged from among the reeds along the edge of the "Sand Run," a shallow, sand-bottomed channel in which a more or less distinct current is usually perceptible. Following both of these captures, prolonged search was made for more specimens, but without success. These two nymphs were kept alive until late in the winter of 1908, one of them, in the meantime, having reached the final stage, but on one unusually cold, windy night, the water in the breeding-jar, though inside the room, froze solid, and the nymphs were killed.

The only other nymph we have seen was taken by Mr. Wodehouse in a marshy bay near Waubaushene, June 1912.

The full-grown nymphs measure as follows:

Length of body 48; mentum of labium 7·3-7·5; hind wing case 10-10-5; hind femur 6·5; width of head 8·5 9.

The only adult taken in the vicinity of Go Home Bay was a fine male, captured by the writer, while flying over the marshy outlet of a small stream at the inner end of one of the sheltered bays. A colour sketch was made of this specimen, as the colours of the living insect seem not to have been recorded. The face was light grey with a slightly bluish tinge, deepening to dark brown on the frons next to the eyes. Frontal vesicle and occiput whitish, eyes brilliant blue. Thorax rather light reddish brown, the pale markings grass-green. Abdomen dull greenish black, the paler areas dull green of a somewhat bluish shade.

Go Home Bay is the most northerly locality from which this species has been obtained. It is an Austral species, being distributed as far south and west as Florida and Texas.

Libellulidae.

Corduliinae.

Didymops transversa (Say) Hagen.

With the exception of *Anax junius* this species, together with *Tetragoneuria spinigera* and *Gomphus spicatus*, is the earliest dragonfly of the sub-order Anisoptera to appear in the spring. The first exuvia was found on the shore of one of the inner channels on May 29, 1912. A specimen emerged in the laboratory on June 12, 1912, and in 1907 one was found emerging on June 16, the day after the Station was opened. The latest date of emergence we have recorded is June 19, 1907.

The time of flight of this species seems to be unusually short, as none have been seen at large after June 21. The males patrol the margins of lakes and bays, resembling Basiaeschna on the wing, but flying more swiftly. The females are apparently secretive and are seldom seen.

The nymphs are found sprawling on the sand near the shore in clear, well-aerated water. They are not rare about the Station Island, where the imagoes have also been occasionally taken just after transforming. The nymphs sometimes

crawl to the verandah of the dwelling-house, forty or fifty feet from the water before transformation takes place. Under the edge of the boathouse roof is another favorite spot. They may also transform on bushes. Two well-grown nymphs of this species were found in the stomach of a channel catfish (*Ameiurus nigricans* Lesueur) by Mr. A. R. Cooper. Full-grown nymphs were taken by Mr. Wodehouse at Shawanaga Bay, near Skerrevore, June 9, 1912, in "weedy shallow water, sand bottom."

Macromia illinoiensis Walsh.

The long-legged, spider-like nymphs of this dragonfly closely resemble those of the preceding species, but are somewhat larger and less distinctly marked, besides differing in the characters given by Needham ('01). Like *D. transversa* they frequent well-aerated waters, being common everywhere along the shores of Go Home Bay, except in the sheltered bays and are absent from the enclosed lakes. They generally occur among boulders on a sandy or somewhat muddy bottom. The nymphs are not infrequently seen sprawling on the surface of the sand or mud bottoms or on the stones. The exuviæ are often more or less muddy, differing in this respect from those of *D. transversa* which are always clean.

Like *transversa* they often travel a considerable distance from the water prior to the emergence of the imago. I have found exuviæ on the verandah of the dwelling-house, and under the eaves of the boathouse, on rocks along the shore a few feet or several yards from the water's edge or on tree trunks 3-6 feet from the ground.

The period of transformation commences about the end of June and continues throughout the first week in July. The first adult observed in 1907 emerged on the Station Island on June 28, while in 1912 the first individual was noticed on June 31. In about a week's time they were common about the island, flying rather low and frequently resting on the branches of trees. Both sexes appeared in about equal numbers and were easy to capture. In about a fortnight they had spread over the country and were no longer so easily obtained.

During the latter half of July and throughout most of August they may be found in sunny weather flying back and forth along the edges of woods or in small open places partly enclosed by trees. They fly swiftly, but as a rule not beyond reach of the net, and as they follow a more or less regular beat they are not very difficult to capture. Flight ceases at sundown and during dull weather.

Neurocordulia yamaskanensis (Provancher) Selys.

In the 36th Ann. Rep. Ent. Soc. Ontario, 1905, p. 69, exuviae of a Neurocordulia, referred to this species by supposition, were recorded from Algonquin Park, Ont. Shortly after the Station was opened in 1907, exuviæ of the same kind were found on the sides of the Go Home Bay Dock. On the morning following this discovery (June 28th) the dock and the steep rocks of the neighbouring shores were carefully searched for newly-transformed adults and one was finally detected

with its exuvia in a crevice of a steep rocky bank. It proved to be *N. yamaskanensis*. Subsequently a number of others were found with their exuviæ on Station Island. Generally they were found between 7 and 8 a.m., but a few were taken late in the evening. Early morning appears to be the usual time for transformation. For some days adults could only be obtained in this way, but they were at last discovered by Mr. Fraser flying about the island at dusk. It was soon ascertained that their time of flight is limited to about half an hour a day, commencing soon after sundown (a little after 8 p.m.), and continuing until shortly after 8.30, after which they retire to the shelter of the trees. It is thus nearly coincident with that of the mayflies, *Ephemera, Hexagenia, Heptagenia,* etc., upon which they appear to feed exclusively.

During this short time of flight they are extremely active. They dash about erratically over the rocks among the swarms of mayflies and when one of these is captured they retire with their prey to a neighbouring tree to consume it in peace.

The majority of the individuals thus engaged are females. The males will be found at the same time flying over and within a few inches of the water close to the shore which they follow very closely. They fly back and forth in a regular beat and with extraordinary swiftness. During these flights the males apparently do not feed, but seem to be on the watch for females, for now and then a male is seen to pounce upon a female, the pair then sailing off over the water or up into the trees, where copulation takes place at rest. Except when thus seized by the males, no females were observed close to the water though plenty of them could always be seen flying over the rocks nearby.

Nymph: (Fig. 15-17) short-legged and of stouter build than most Corduliines.

Head broadly convex above and on the sides, eyes not very prominent, frontal ridge with a scurfy pubescence, the anterior margin convexly curved, hind angles of head prominent, distance between them a little greater than half the greatest width of the head; hind margin distinctly excavate.

Labium extending very slightly behind the bases of the front legs; mentum somewhat broader at the distal margin than long, the middle lobe somewhat abruptly deflexed, bluntly obtusangulate; mental setæ 9-11, the innermost 3 or 4 much smaller than the others; lateral lobes triangular, their distal margins produced into seven semi-elliptical teeth; lateral setae 6; movable hooks very slightly arcuate.

Marginal ridge of pronotum produced on each side behind the posterior angles of the head as a prominent process which is somewhat smaller than the very prominent supra-coxal processes.

Legs short, the length of the hind femora being slightly less than the width of the head.

Abdomen ovate, its greatest breadth, at segs. 6 or 7, slightly greater than two-thirds of its length; curve of the lateral margins somewhat stronger in the distal than in the proximal half; lateral spines on 8 and 9, in each case about one-third to one half as long as the corresponding segment, those on 8 strongly divergent, on 9 parallel and extending caudad scarcely or not at all beyond the tips of the appendages.

Dorsal surface rather strongly convex, dorsal hooks present on 1-9, those of the basal segment slender, nearly erect and slightly hooked, becoming gradually broader and lower caudad, and, on 7-9 reduced to scarcely more than a short ridge. Superior appendages triangular, equilateral, very slightly shorter than the somewhat divergent inferior appendages and somewhat longer than the lateral appendages.

Colour yellowish or orange brown, variegated with dark brown. Head dark brown above, generally somewhat paler in the centre and on the frontal ridge. Thorax and wing-cases variegated with pale and dark markings; femora and tibiae with two pale rings, a median and anteapical. Abdomen yellowish brown, more or less distinctly blotched with darker brown, especially on the dorsal hooks, the lateral margins and spines and the dorso-lateral scars.

Measurements: Length of body 22–24·5; hind wing, 6–7; hind femur 5–5·6; width of head 6·5; width of abdomen 9–10; mentum of labium 4.

The nymph of this species shows the following differences from that of *N. obsoleta*, two exuviæ of which I have from Lake Hopatkong, Pa., received from Professor P. P. Calvert.

Somewhat larger, more elongate and less depressed; eyes somewhat less prominent, mentum of labium a little longer and more narrowed at base, middle and hind legs somewhat less widely separated at their bases; abdomen narrower, the sides less strongly curved on the middle segments; lateral spines on segment 9 much shorter than those of *obsoleta*, in which they are fully as long as the segment and extend far beyond the tips of the appendages; dorsal hooks also less developed than in *obsoleta*, in which they form quite prominent tubercles on segs. 7–9. (Pl. IV, Figs. 16–19).

Besides the full-grown nymph we have taken specimens of two earlier instars, measuring 8 and 18 mm. in length respectively. Judging from the great difference in size between these three instars, it would seem probable that the larval period must be at least two, if not three, years long. In the youngest instar the lateral spines are relatively much longer than in the older ones.

The nymphs of *N. yamaskanensis* cling to the undersides of boulders along the more exposed shores. As the exuviæ are most commonly found on steep rocky shores, rising almost perpendicularly from the water, (Pl. V, Fig. 27) it would seem that the nymphs prefer water of considerable depth, i.e., 8 or 10 feet or more, but we have often taken nymphs of several stages in water less than two feet deep. They occur along the outer coast as well as in the river, in fact wherever the water is kept more or less constantly in motion. They are common in the vicinity of falls and rapids. One exuvia was found on a log overlying the falls at Muskoka Mills. The nymph had evidently crawled out of a comparatively quiet spot close to the swiftest part of the fall, where the water was thoroughly aerated.

The nymphs are associated with the nymphs of mayflies of the genera *Heptagenia*, *Blasturus* and *Baetis* and of the damsel-fly *Argia moesta putrida*, upon which they probably feed. I found one at the "Narrows" of the Go Home River, supporting a growth of a Polyzoan, *Plumatella* sp.

In 1912 adults emerged in the laboratory from June 23 to July 8. Their season

is at its height during the second week in July and is over before the end of the month. July 23 is the latest date on which we have taken this species.

N. yamaskanensis is abundant and of general distribution in this locality and probably throughout the Muskoka and Parry Sound Districts. I have received exuviæ from various parts of Muskoka and from the Shawanaga and French Rivers, collected by Mr. Paul Hahn. They are not known north of the French River.

Epicordulia princeps (Hagen) Selys.

This large insect is very common about Go Home Bay, where it is the species most frequently observed flying far over the open water.

The nymphs live among the bottom debris of shallow bays and inlets and the larger ponds, associated with Tetragoneuria. They are quite often found clinging to the undersides of stones. None were reared in 1907 but tenerals began to appear on June 25 and in a few days became quite numerous. They appeared at the same time in 1912, the first imagoes having been observed on June 26th, this being also the date on which the first specimens emerged in the laboratory. In the first week or so of their imaginal life, they no not fly very swiftly and rest frequently so that they are easily captured, but later they wander far from their breeding-places and during the day in fine weather they seem to be in constant flight from early morning until dusk. During the evening they may be seen flying, usually rather high, in pursuit of mayflies like Neurocordulia.

This is one of the later Cordulines to remain on the wing, individuals being met occasionally as late as Aug. 6.

In specimens from Georgian Bay the dark wing markings are usually greatly reduced as compared with specimens from the Upper Austral Zone (Toronto and southward). While in some females these spots are almost as large as in southern specimens, in the great majority of both sexes they are all much smaller. The nodal spot is frequently a mere trace or it may be absent altogether, as indeed is generally the case in the males. The apical spot is also frequently a mere trace and such individuals look much like large Tetragoneurias.

Tetragoneuria spinigera (Selys) Selys.

When we arrived at the station in 1907 (June 16) this species was already flying in considerable numbers in the open woods of the mainland near a small lake, and the season for emergence was apparently over, though that of *T. cynosura simulans* had scarcely begun. We therefore watched for the appearance of *spinigera* in 1912 as we were at the Station before the period of emergence for either species had begun.

On May 29th a single Tetragoneuria exuvia was found on the shore of Big Island and on June 1 we found large numbers of them clinging to the reeds and floating on the water in the open marsh at the outer end of Galbraith Lake. No imagos were found except a single crippled teneral with its exuvia. This was a male, however, and could be diagnosed with certainty as *T. spinigera.* Much

search was made for nymphs but without success at this spot. A number of Tetragoneuria nymphs, however, were taken from beneath stones along the shore of a channel and two of these yielded female imagoes of *T. spinigera*, emerging on June 2. The other nymphs proved to be *T. cynosura simulans*. Thus, although the nymphs of these two species may bè associated with each other we are inclined to the opinion that *T. spinigera* is most at home in somewhat marshier stations than those preferred by its congener.

A careful comparison was made between the exuviæ of these two species but no differences could be detected between them except that in *spinigera* the lateral abdominal appendages average slightly longer than those of *cynosura*. The difference, however, does not appear to be constant. Prof. Needham, who referred certain nymphs to this species by supposition, employed as differential characters the length and amount of divergence of the lateral spines of seg. 9. The two species discussed here are quite alike in respect to these features, which vary considerably among individuals of the same species.

The adult life of this insect appears to be rather short, July 4 (1907) being the latest date upon which it has been observed.

Tetragoneuria cynosura simulans Muttkowsky.

Syn. *T. semiaquea* (Burm.) Auctt.

In 1907 this species was exceedingly abundant. Tenerals were just beginning to appear on our arrival at the Station and by June 25 their numbers had about reached their height. Specimens were taken until July 22. In 1912 they were much less numerous and though common were not abundant. Mature nymphs were collected on May 29th, the first imago emerging on June 13, and four others on the following day. The latest date of emergence that we have recorded is June 19th and the last day on which we observed an adult is July 31. The single individual seen on this day was a female and was taken with a female of *Hagenius brevistylus* which was feeding upon it.

The nymphs of this insect are very common in sheltered bays and channels where there is a certain quantity of marsh vegetation but where the water is not stagnant. The small marshy coves which are very common along the rocky shores everywhere in this district seem to be the favorite haunts of this species. On the slender reeds which grow in such situations the exuviæ may be very numerous during the season of emergence.

I have seen half a dozen or more exuviæ on a single reed. They also frequently transform on boathouses. Full-grown nymphs are quite often taken from the undersides of stones close to the shore.

This species is most abundant about June 25. It flies everywhere on land, but is most common about the shore in sheltered places or in sunny openings in the woods. On a small, somewhat bare island just outside the outer coast we found it on June 25th, 1907, almost in swarms. They were flying about in the sunshine apparently quite aimlessly and seemed not to be feeding.

Helocordulia uhleri (Selys) Needham.

This is a very rare dragonfly in this vicinity, where it has been taken but twice, both occasions on the Go Home River. The first capture was that of a male on June 23rd, 1907, taken by Mr. W. J. Fraser at the "Chute"; the other was a female taken by Mr. W. A. Clemens on the river near Sandy Gray Falls.

Cordulia shurtleffi Scudder.

This boreal species, which is common at Nipigon and probably throughout northern Ontario, is a rare insect in the Go Home Bay district, only a single imago having been captured there. This was a male, taken by the writer on July 7, 1907, in the rocky woods close to the Go Home River, just above the "Chute."

Of the nymph, which is described by Needham ('01), we have taken half a dozen specimens, all from the bottom debris of swamp waters, particularly ponds of little or no drainage.

On account of this type of habitat they are very easy to keep alive in the aquarium. Besides the nymphs from Go Home Bay one was taken from Mud Lake, Midland, and another at Killarney, Ont., by Mr. Wodehouse. Only two exuviæ were found, one dated June 16, 1907; the other has no date attached.

Dorocordulia libera (Selys) Needham.

This beautiful insect is often to be seen coursing back and forth over open marshes and sphagnum bogs, often following the course of a small stream or the edge of a pond. It is also sometimes met with in openings in woods or along their borders. It is usually seen moving rather slowly, but with rapidly vibrating wings, the body slightly tilted with the end of the abdomen uppermost. When approached it darts away swiftly, but if the collector be stationed on its regular path of flight and strikes with the net from behind, it is not difficult to capture.

The sexes occur in about equal numbers, but the females, being more retiring and more often at rest, are somewhat less frequently taken.

The few nymphs we have secured were found at the bottom of sphagnum-bordered ponds and marshy bays, such as are frequented by the imagoes.

The earliest date on which we have found the adult was June 18, 1907, and the only freshly-emerged individual that we have taken was found with its exuvia on June 27th of the same year. On June 28 they were quite numerous. Our latest capture for the Go Home district was July 30, 1912, a single male having been taken on this date, flying over a sphagnum bog on the edge of a large pond.

Somatochlora williamsoni Walker.

Like most of the Somatochloras this is a species of mainly boreal distribution, though it is not uncommon at Lake Simcoe and has once been taken at Toronto. It is not infrequently seen at Go Home Bay during August, flying rather low

along the edge of ponds and creeks, or at a height of twenty feet or more in sunny openings in woods.

The dates on which it has been observed in flight at Go Home Bay range from July 21 (1907) to Aug. 26 (1912).

The nymph of this species has been described by Needham ('01) under the name *S. elongata*, Scudd. It has not been taken at Go Home Bay, but on Aug. 2, 1912, we found an exuvia belonging to this genus on a log at the mouth of a small forest stream emptying into the Go Home River. A similar exuvia was taken by Mr. Paul Hahn in Algonquin Park and erroneously recorded by the writer ('06) as *Cordulia shurtleffi*. These exuviæ agree with Needham's description, except in the somewhat smaller size and narrower abdomen. Width of abdomen, however, is a somewhat variable feature in exuviæ, depending much on the state of contraction, and it seems most probable that these exuviæ belong to *S. williamsoni* as this is the only Somatochlora we have observed in the vicinity of Go Home Bay.

They measure as follows (the smaller figures belonging to the Go Home specimen); Length of body 22–23; abdomen 13–15; hind femur 7–7·5; width of abdomen 7·5–8.

Libellulinæ.

Nannothemis bella (Uhler) Brauer.

This diminutive species is quite locally distributed but we have found one station where it is extremely abundant. This is a small floating sphagnum bog occupying a somewhat triangular space between two masses of rock on the edge of a small lake near the mouth of Go Home Bay. Here, in company with *Nehalennia gracilis, Leucorrhinia frigida, Lestes disjunctus* and some other less characteristic forms, it flits about among the low vegetation, settling frequently on the cotton grass, cassandra and other low plants that grow in the bog; the wings, when at rest, being bent strongly ventrad on each side of the supporting stalk.

We have not determined the time when this species begins to emerge. When first observed in 1907 on June 28, most of the males were already pruinose, though younger black individuals continued to appear for some time later. The latest capture was made at the same bog on August 6, 1912, a single male having been taken.

Careful search was made for the nymph, but without success. One exuvia, however, was found clinging to a cranberry twig, many feet back from the water's edge. The nymph had evidently emerged from the bog itself, having lived like *Nehalennia gracilis* in the water in which the sphagnum and other bog-plants were partly immersed. The nymph has been described by Needham ('01a).

Celithemis elisa (Hagen) Walsh.

This is a species of the marshes, which first makes its appearance on the wing in the latter half of June and flies until about the end of August though our latest

capture bears the date August 14, 1912. The earliest dates of its occurrence are June 22, 1912, and June 28, 1907.

It is most often seen hovering over patches of Sweet Gale (*Myrica gale*), which are common in the dryer parts of the open marshes of this region, especially near the edge of the woods.

According to my observations this species does not often stray far from its breeding-grounds, as the allied species of *Sympetrum* frequently do.

Strangely enough we have not found the nymph of this common species. It has, however, been bred and described by Needham ('01a).

Leucorrhinia frigida Hagen.

One of the most abundant and generally distributed of the marsh dragonflies of this district. Though found in all the open marshes and bays it is most abundant in the sphagnum bogs on the edges of small lakes and ponds. Its numbers appear to vary to some extent inversely as those of the larger dragonflies with which it is commonly associated, e.g., *Libellula exusta julia* and *Gomphus spicatus*. Thus it is extremely abundant in the pond on "Split Rock Island" (Pl. VIII, Fig. 33) where these species are absent or very rare.

The nymphs may be dredged in large numbers from the aquatic vegetation and submerged trash along the edge of this pond and are common along the margins of all such lakes and ponds.

Teneral imagos were already common when the Station was opened in 1907 (June 16) but full-grown nymphs were still easily obtained and adults continued to emerge for at least a week. In 1912 the first tenerals were observed on June 1 and by the 17th were very common, though a specimen emerged in the laboratory as late as June 24. On August 6 this species was still fairly numerous but all the individuals were old and pruinose. None were noted after this date.

Needham's ('05) description of the nymph of *L. frigida*, belongs to another species, probably *L. hudsonica* (vide infra). In a letter to the writer, he stated that the species had not been reared but that tenerals of *L. frigida* had been found at the spot where the exuviæ were gathered. The nymph of *frigida*, unlike Needham's species, possesses large dorsal hooks, such as are present in all the species of *Leucorrhinia* that have been reared.

Nymph:—(Pl. IV, Figs. 20-22).

Very similar to that of *L. intacta*, but somewhat smaller and the legs slightly slenderer. Head similar to that of *intacta* except in the somewhat more prominent eyes. Labium of similar size and form, the lateral lobes somewhat more deeply concave within, the teeth on the distal margin obsolescent, crenate, each with a single spinule, lateral setæ 9 or 10; mental setæ 10-13, the fourth or fifth from the outside longest, the inner four smaller than the others.

Abdomen broadest at seg. 6; scarcely narrowing on 7; slightly on 8; more abruptly on 9; lateral spines on 8 one-half to three-fifths as long as the segment; subparallel, those on 9 reaching about to the tips of the inferior appendages, their inner margins straight and parallel. Superior appendages somewhat less elongate

than in *intacta*, acuminate, about twice as long as the lateral appendages and one-fourth shorter than the inferior appendages. Dorsal hooks on segs. 3-8, larger on 3 and 4 than in *intacta*, less erect and more curved, very slender; those on 5-7 of about the same size as in *intacta* or somewhat larger and slightly more elevated, the curve of the upper margins much stronger proximally. The apices sharp and directed straight back, reaching about the middle of the following segment; on 8 similar to those of the preceding segments, but less elevated, directed straight back

The coloration, when well marked, is so exactly similar to that of *intacta* that it seems unnecessary to describe it. It is usually, however, rather obscure, though the legs are always distinctly banded.

Length of body 15-16; abdomen 9-10·6; hind wing 4·6-4·75; hind femur 4; width of abdomen 6-6·8; width of head 4·7-4·8.

The chief characters by which the nymph of *L. frigida* differs from that of *intacta* are thus the slightly smaller size, the more prominent eyes, the longer lateral spines on seg. 9, and the more sharply curved dorsal abdominal hooks.

Leucorrhinia proxima Calvert.

A few specimens of this species were taken in a marsh at the mouth of a small sluggish creek opening into Go Home Bay, on June 17, 1907. It is not an uncommon species in Northern Ontario, but has not been recorded south of Go Home Bay in this province.

Its nymph is still unknown.

Leucorrhinia hudsonica (Selys) Hagen.

The adult of this northern species has not been found in this vicinity, but a number of nymphs were taken in a small marshy inlet, which we have good reason to ascribe to this form. These nymphs are identical with two exuviæ received from Prof. Needham and erroneously referred by him ('08) to *L. frigida*. Two nearly identical exuviæ were taken by the writer in June, 1913, at Nipigon, Ont., where *L. hudsonica* was flying in abundance, and where no other species was seen, except *L. glacialis*, whose nymph is known. These nymphs and exuviæ are too small for *proxima* and *hudsonica* is the only other regional species whose nymph is unknown. One of the Nipigon specimens has small dorsal hooks on segments 3, 5 and 6, the other has a single rudimentary hook on segment 4, while the Go Home Bay specimens have no trace of dorsal hooks. In spite of these somewhat marked variations it seems almost certain that all belong to one species and that this species is *L. hudsonica*.

Ten of these nymphs were collected at Go Home Bay, five of them being full-grown. They were collected prior to our first visit to the Station and neither date nor collector's name is known.

Leucorrhinia glacialis Hagen.

A single specimen of this species was taken at Go Home Bay by Mr. J. B. Williams, on July 14, 1909. It is more common farther north.

The nymph has been described by Needham ('01).

Leucorrhinia intacta (Hagen) Hagen.

This well-known species occurs but sparingly in the Go Home District, where it is occasionally seen in the open marshes bordering shallow bays. It is associated in such stations with *L. frigida* which is more generally distributed and far more numerous, but we have never taken it from the sphagnum bordered ponds, where *L. frigida* always occurs.

The nymph has been described by Needham ('01.) We have not found it in this district, but have taken it in abundance at Toronto and Lake Simcoe, where it is the only species of the genus.

A single dead specimen of *L. intacta* was found in a cobweb on the small island referred to under *Enallagma hageni* and *Libellula quadrimaculata* (vide pp. 67–90).

Sympetrum danae (Sulzer) Ris.

Syn. *S. scoticum* (Donovan) Newman.

A single male of this northern species was taken from the edge of a very shallow pond in the sand on the Giant's Tomb Island, July 14, 1912. It was a teneral and had evidently emerged on the day of its capture. It was kept alive until the colour pattern was fully developed.

This circumpolar species is very common in Ontario north of the Great Lakes. With the exception of a single individual taken at De Grassi Pt., Lake Simcoe, the present record is the most southerly for this species in the province.

Sympetrum costiferum (Hagen) Kirby.

Our earliest captures of the adult of this species in 1907 are from the Giant's Tomb Island, July 29, 1907. On this date a number of young individuals were flying about the shallow ponds in the sand and many exuviæ were found adhering to the reeds. In 1912, a few tenerals were taken at nearly the same spot on July 14, but they did not appear at Go Home Bay until about a week later. They soon became generally distributed in all the open reedy marshes bordering ponds and inlets and were often also seen away from the water. They became quite abundant in August and were still common when the Station was closed on Sept. 11. At this time many pairs were seen in copula.

As with most of the Sympetrums, we have neglected to rear the nymph though we are satisfied that the exuviæ referred to above and a number of full-grown nymphs of the same kind, taken at Go Home Bay and at Skerrevore, Ont., (by

Mr. Wodehouse) belong to this species.* They agree closely with Needham's ('01) description which was based on a single collapsed exuvia, except in the following particulars:—The dorsal hooks are somewhat shorter than the segments which bear them, the lateral spines of segs. 8 and 9 are also somewhat shorter than is indicated in the description, those of seg. 8 being about one-third as long as the segment, and those of 9 reaching only to the tips of the lateral appendages.

Besides these specimens, I have a number of similar but smaller nymphs, including two full-grown examples, from Fitzwilliam Island, Georgian Bay, collected by Mr. Wodehouse. Besides the smaller size these differ in the slightly shorter lateral spines of seg. 9. Specimens from Giant's Tomb Island are, however, intermediate in this character which appears to be a rather variable one. The number of mental and lateral setæ is slightly smaller in the smaller nymphs, there being 10-12 of the former and 9-10 of the latter, as compared with 13-15 mental and 10-11 lateral setæ in the larger specimens. The number of these setæ, however, seems to depend a good deal on size, and we doubt if in this case any other importance can be attached to the feature. It may be also noted in this connection that adults of *S. costiferum* vary in size with locality, specimens from Northern Ontario being distinctly smaller than those from farther south.

Sympetrum vicinum (Hagen) Kirby.

Full-grown nymphs of this species were collected towards the end of July and in early August and were found to be generally distributed along the marshy of boggy margins of still waters, their environment being similar to that of *Leucorrhinia frigida*. They were found, e.g., along the edges of sphagnum bogs as well as in shallow reed-grown waters.

The first imagos emerged on July 30 and by August 6 the pale yellow tenerals were quite common in the marshes. In the latter half of August they had for the most part acquired their bright red colour and were common everywhere. They were still numerous when the Station was closed on Sept. 11th. Many pairs were in copula at this time.

A description of the nymph is given by Needham ('01).

Sympetrum semicinctum (Say) Kirby.

This pretty species is not rare, but never appears in large numbers, as do most of the species of *Sympetrum*. Specimens were taken in open marshes adjoining shallow bays and creeks, but nothing distinctive was learned of their habits or haunts.

The nymph, which has been described by Needham ('01) was not obtained by us.

The dates of our specimens range from July 24 (1912) to Aug. 24 (1907).

*Since the above was written we have reared this species on Vancouver island and have verified the above determination.

Sympetrum obtrusum (Hagen) Kirby.

This common form appears considerably earlier than the other species of Sympetrum, specimens having been observed at least as early as July 1, 1912. At Lake Simcoe and southward, they appear before the end of June. The season for emergence is somewhat protracted and irregular, tenerals being seen as late as July 31. They fly until late in the season, several pairs in copula having been taken on Aug. 26th, 1912.

The adults are found in the same localities as *S. costiferum* and *vicinum*, but, as we have not found the nymph in this district we are unable to give anything distinctive as to the nature of its breeding-ground. Stray specimens of the imagos have occasionally appeared on the Station Island, where they certainly do not breed.

It is somewhat remarkable that the closely allied species *S. rubicundulum*, one of the commonest and most generally distributed of Odonata in Eastern North America, is wholly absent from the Go Home District so far as we are aware.

Sympetrum corruptum (Hagen) Kirby.

On July 14, 1912, this species appeared very unexpectedly on the low sandy eastern end of the Giant's Tomb Island. The island is divided here by a narrow channel, close to which, on the outer side, is a shallow pond or lagoon (Fig. 35). It was about the margins of the channel and lagoon, especially the former, that *Sympetrum corruptum* was observed. They were flying about from place to place, sometimes hovering over one spot, sometimes settling for a moment on the wet sand. They were so shy that it was almost impossible to get within striking distance, and more than an hour of patient effort was spent before one was secured. Two males and one female were all that were taken, all fully mature and in good condition.

This species was previously known from Ontario only by a single specimen taken at the Humber River (Walker '06). It is not known to occur east of this province, but it is common in the Prairie Provinces and also occurs in British Columbia.

The nymph has been described by Needham ('03).

Libellula quadrimaculata Linné.

This wide-spread circumpolar species is fairly common, but by no means abundant at Go Home Bay, where it frequents marshy bays and inlets. June 18 is the earliest date on which the adult was observed in 1907, while in 1912 it appeared somewhat earlier, but the exact date was not noted. It was more numerous during the latter than the former year.

A remarkable assemblage of this species was met with on June 27, 1912, on a small island in the open water of Georgian Bay, abut 3½ miles from the eastern coast. On this island, which has already been described (vide p. 67) there is a

small pond filling a depression in the almost bare rock and from this pond three species of Odonata were emerging in large numbers, viz., *Enallagma hageni*, *Ischnura verticalis* and *L. quadrimaculata*. Along one side of the pond was bare rock and in the few clumps of small reeds that were scattered along this shore, large numbers of exuviæ of the last-named species were found. One or two emerging imagos were also noted, while resting in the bushes of a dense thicket on the opposite side of the pond, which was only a few feet wide, were scores of teneral imagos.

The unusual abundance of this species here was probably due to the lack of competition with other large species, there being apparently no others present, although I found a single dead example of *Leucorrhinia intacta* in a cobweb, which had probably developed in the same pond.

It may be noted that the season for emergence was somewhat later here than at Go Home Bay.

Full-grown nymphs of this species were also collected by Mr. Wodehouse at the French River, June 19, 1912.

Libellula exusta julia (Uhler) Ris.

The scarcity of other species of Libellula in this region is fully compensated for by the multitudes of this form, which fly about almost every marshy bay or pond during June and July.

In the decaying organic matter at the bottom of such swamp waters, where other species of the genus are seldom found, *L. exusta julia* seems to find ideal conditions of environment, while in the ponds of agricultural districts, such as those in the environs of Toronto and Lake Simcoe, where *L. pulchella*, *lydia*, *quadrimaculata* and *luctuosa* are the prevailing species, *julia* is rare or wholly absent. It is not, however, quite uniformly distributed in the swamp waters of Go Home Bay, for in a small undrained pond on "Split Rock Island," just off the outer coast, we were unable to find the species. This pond (Plate VIII, Fig. 33) is surrounded by sphagnum bog and the aquatic vegetation is very scanty.

Full-grown nymphs were common in dredgings made on May 31, 1912, and during the week following. Imagos were first noticed on June 7 and had become abundant by the 13th. They continued so for about a month, their numbers dwindling during the last half of July until the 30th, when the last specimen was noted. A few specimens emerged in the laboratory during the latter half of June.

This dragonfly is not only common about its breeding-grounds, but also in the open rocky woods, where it takes short flights, frequently settling on the bare rocks after the manner of Gomphines. In fine still weather the males may be seen chasing each other swiftly and erratically over the water and are somewhat conspicuous objects on account of the white pruinosity of the thoracic dorsum and basal segments of the abdomen.

L. exusta julia ranges northward at least as far as Nipigon, Lake Superior.

Libellula pulchella Drury.

This well-known and conspicuous dragonfly is much less common in the region under discussion than in Southern Ontario, a fact which is probably due to differences in soil and drainage conditions, (vide p. 54). Specimens are, however, quite frequently seen in the vicinity of marshy bays and in openings in the woods nearby.

In size they are not inferior to specimens from more southern latitudes.

They have been taken in the vicinity of Go Home Bay between June 28 and Aug, 9, 1912, inclusive.

Libellula vibrans incesta (Hagen) Ris.

Go Home Bay is probably near the extreme northern limit of distribution of this Austral species. It is very rare here, only two examples having been obtained. Both of these were males, not yet pruinose, and were captured at the outlet of Galbraith Lake (Pl. VII, Fig. 30) on July 15, 1907. The only other known Canadian locality for this species is Point Pelee, Lake Erie, where it is common (Walker, '06, and F. M. Root, Can. Ent., XLIV, 1912, p. 209).

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EXPLANATION OF PLATES III–IX.

PLATE III.

Fig. 1. Nehalennia gracilis.—Lateral gill.
Fig. 2. Nehalennia gracilis.—Hind margin of head.
Fig. 3. Nehalennia irene.—Hind margin of head.
Fig. 4. Enallagma calverti.—Dorsal view of head.
Fig. 5. Enallagma calverti.—Lateral gill.
Fig. 6. Enallagma hageni.—Dorsal view of head.
Fig. 7. Enallagma signatum.—Dorsal view of head.

Fig. 8. Enallagma signatum.—Lateral gill.
Fig. 9. Enallagma pollutum.—Dorsal view of head.
Fig. 10. Enallagma pollutum.—Lateral gill.
Fig. 11. Boyeria grafiana.—Labium.
Fig. 12. Boyeria grafiana.—Abdominal appendages of female nymph.
Fig. 13. Boyeria vinosa.—Labium.
Fig. 14. Boyeria vinosa.—Abdominal appendages of female nymph.

PLATE IV.

Fig. 15. Neurocordulia yamaskanensis.—Nymph.
Fig. 16. Neurocordulia yamaskanensis.—Terminal abdominal segments of female nymph.
Fig. 17. Neurocordulia yamaskanensis.—Lateral view of abdomen.
Fig. 18. Neurocordulia obsoleta.—Terminal abdominal segments of female nymph.
Fig. 19. Neurocordulia obsoleta.—Lateral view of abdomen.
Fig. 20. Leucorrhinia intacta.—Dorsal view of head.
Fig. 21. Leucorrhinia intacta.—Terminal abdominal segments of female nymph.
Fig. 22. Leucorrhinia intacta.—Lateral view of abdomen.
Fig. 23. Leucorrhinia frigida.—Dorsal view of head.
Fig. 24. Leucorrhinia frigida.—Terminal abdominal segments of female nymph.
Fig. 25. Leucorrhinia frigida.—Lateral view of abdomen.

PLATE V.

Fig. 26. The outer coast and islands, looking westward. Habitat of Group 1a.
Fig. 27. Island off the outer coast, with precipitous shore. Habitat of Neurocordulia yamaskanensis and Argia moesta putrida (Group Ia).

PLATE VI.

Fig. 28. Rapids, Musquash River. Habitat of Gomphus brevis, Boyeria grafiana, Argia moesta putrida, etc. (Group Ia.)
Fig. 29. Small sandy beach with boulders, Station Island. Habitat of Gomphus lividus, G. exilis, Macromia illinoiensis, Didymops transversa, etc. (Groups Ia and Ib.)

PLATE VII.

Fig. 30. Outlet of Galbraith Lake. A composite of habitats of Group Ia (current), Ib and IIa (sublittoral zone).
Fig. 31. Outer end of Galbraith Lake. Typical habitat of Group IIa.

PLATE VIII.

Fig. 32. Shore of Burwash Pond, showing sphagnum-cassandra zone, with background of black spruce. Habitat of Group IIb.
Fig. 33. Pond on "Split-rock Island," showing sphagnum-cassandra zone. Habitat of Group IIb, especially Leucorrhinia frigida and Nehalennia gracilis.

PLATE IX.

Fig. 34. Mouth of a small creek. Habitat of Group IIa, passing into that of Group III in the distance.
Fig. 35. Shallow channel in the sand of Giant's Tomb Island. Habitat of Sympetrum corruptum.

PLATE III.

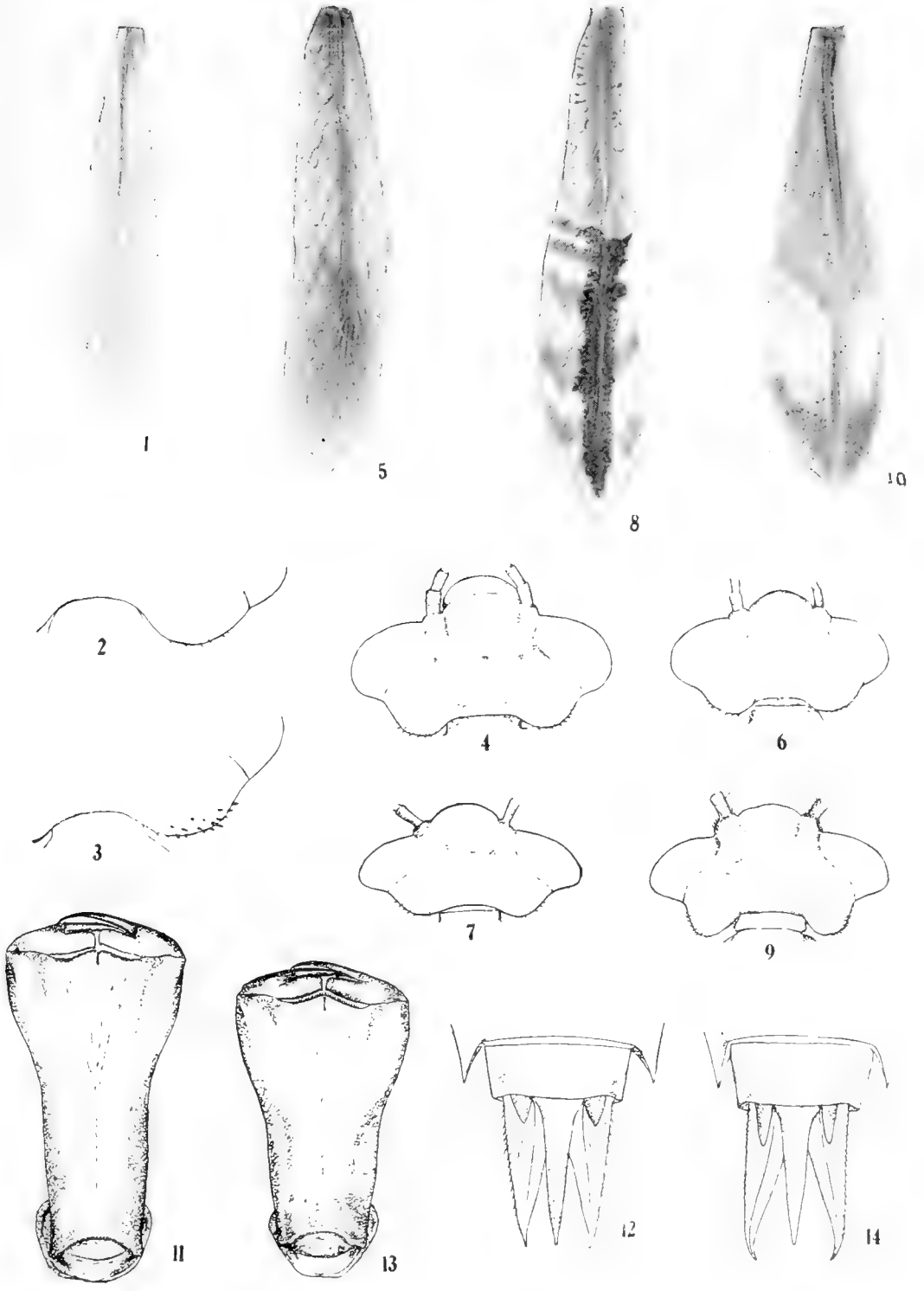
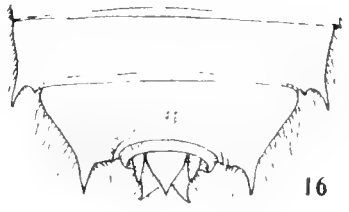


PLATE IV.



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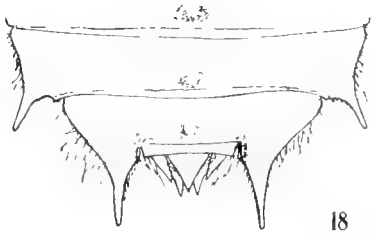

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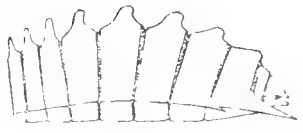

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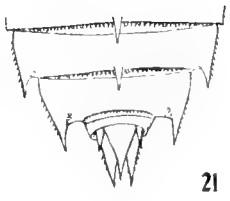

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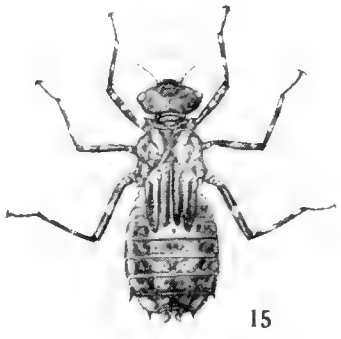

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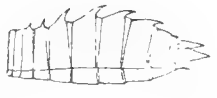

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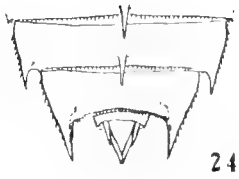

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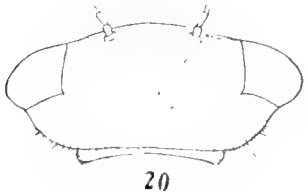

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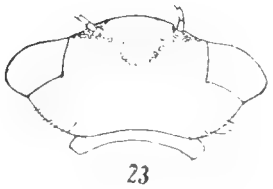

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Fig. 26. The outer coast and islands, looking westward, Habitat of Group Ia.

Fig. 27. Islands off the outer coast with precipitous shore. Habitat Neurocordulia yamaskamensis and Argia moesta putrida (Group Ia)

Fig. 28. Rapids, Musquash river. Habitat of Gomphus brevis, Boyeria grafiana Argia moesta putrida, etc. (Group Ia).

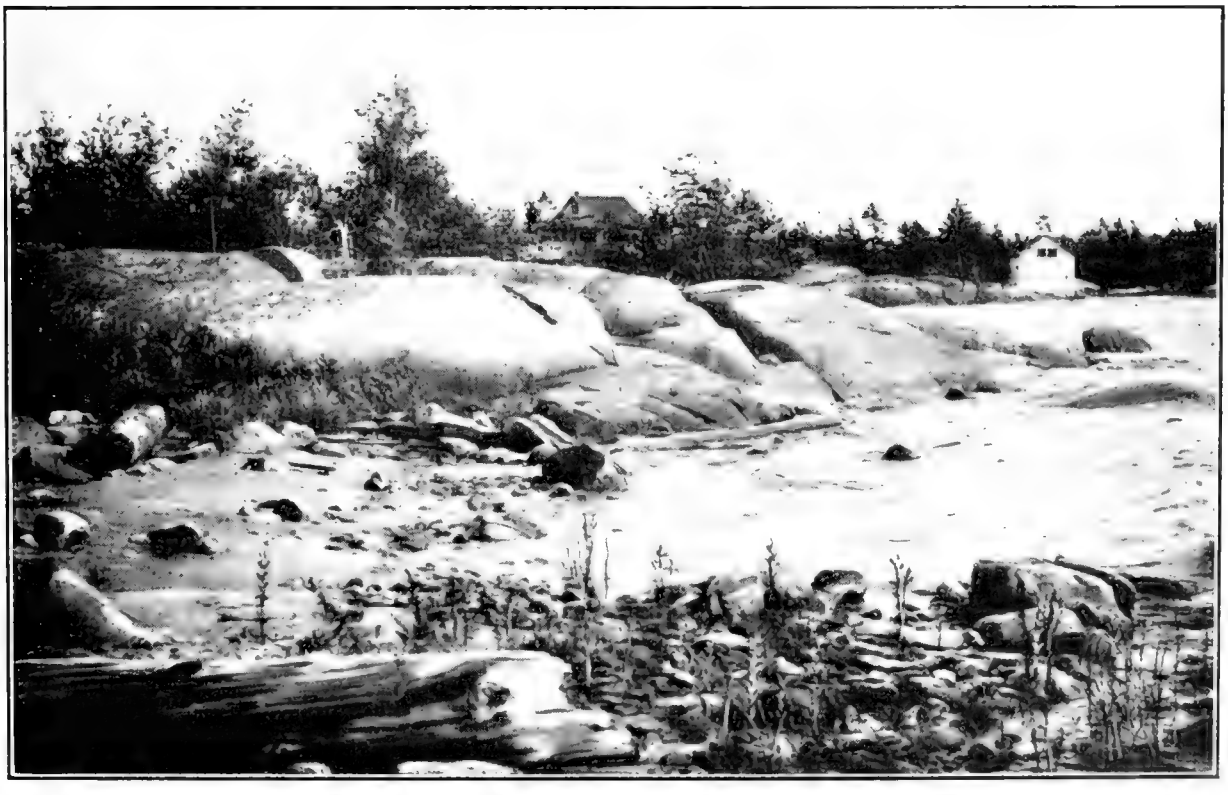

Fig. 29. Small sandy beach with boulders, Station island. Habitat of Gomphus lividus, G. exilis, Macromia illinoiensis, Didymops transversa, etc. (Groups Ia and Ib.

Fig. 30. Outlet of Galbraith lake. A composite of habitats of Group Ia (current) and IIa (sublittoral zone).

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Fig. 33. "Pond on Split-rock Island," showing Sphagnum-cassandra zone. Habitat of Group IIb, especially Leucorrhinia frigida and Nehalennia gracilis.

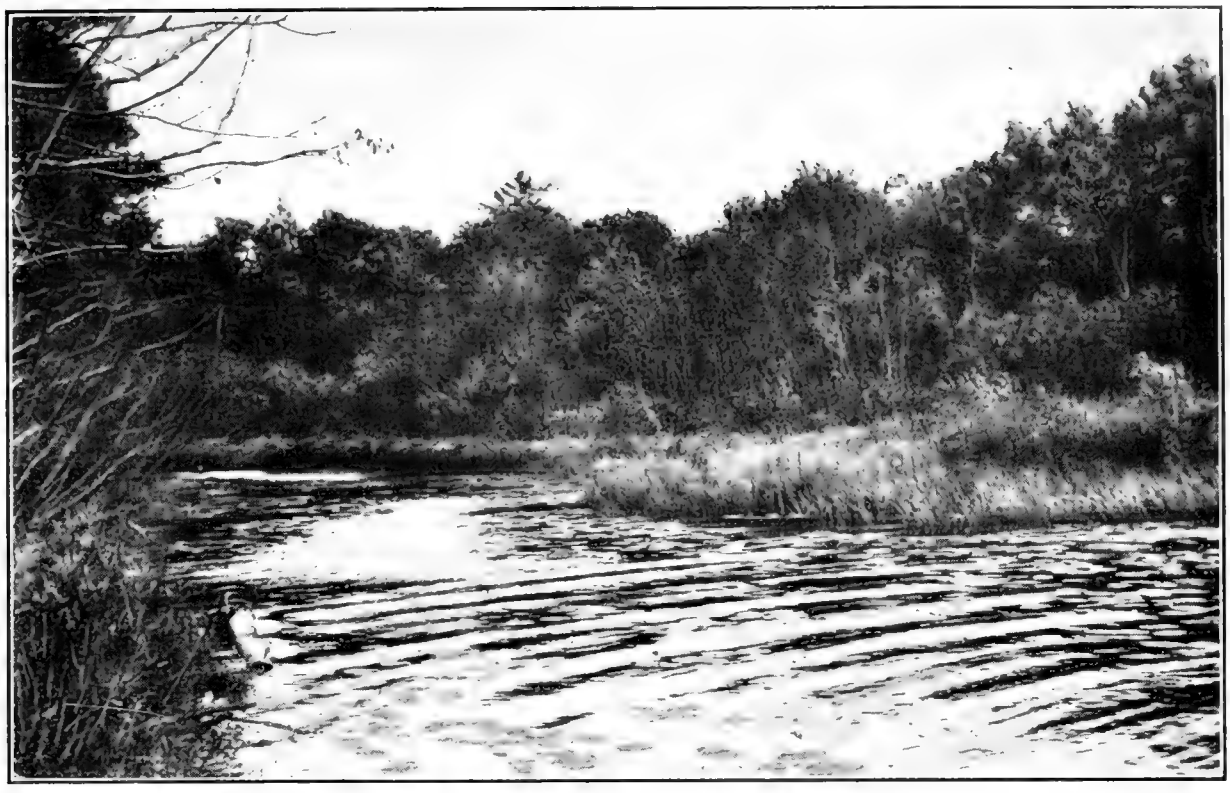

Fig. 34. Mouth of small creek. Habitat of Group IIa, passing into that of Group III in the distance.

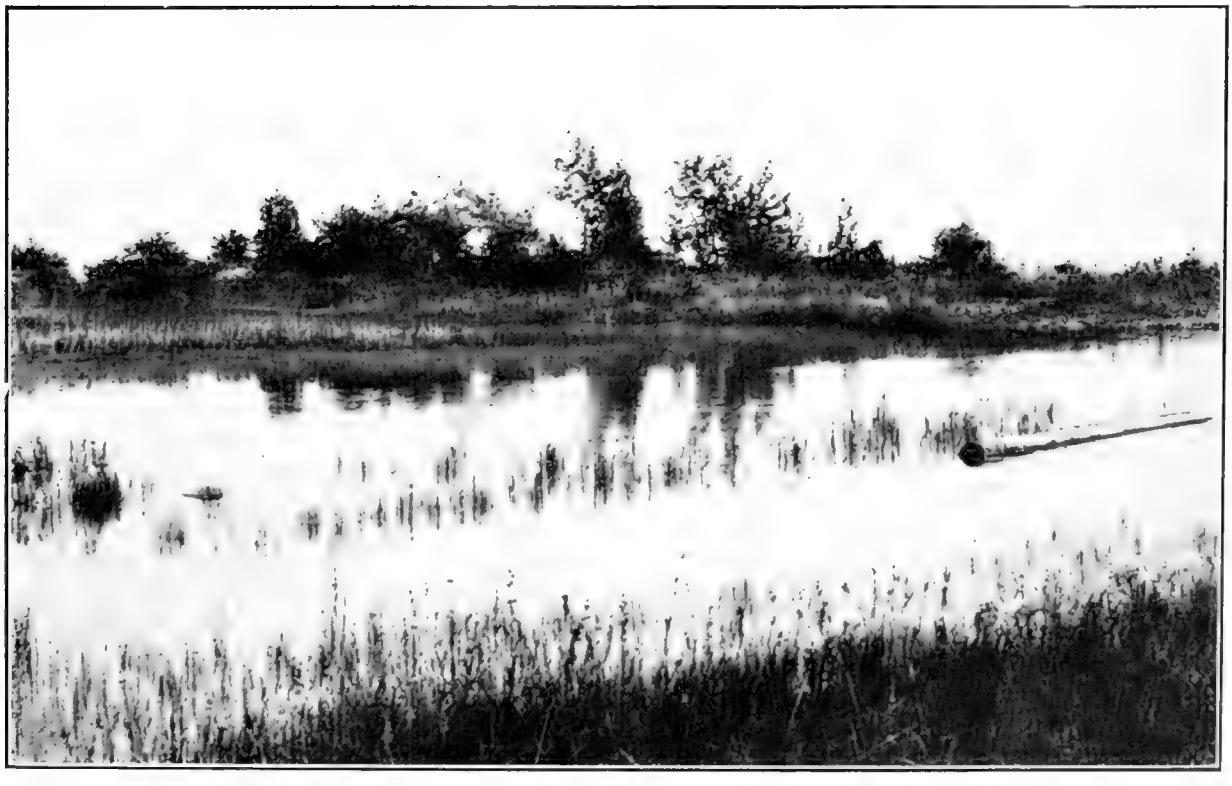

Fig. 35. Shallow channel in the sand of Giants Tomb island. Habitat of Sympetrum corruptum.

III.

THE MOLLUSCA OF GEORGIAN BAY.

By A. D. Robertson, B.A., University of Toronto.

(Plates X—XII)

In 1910 the writer undertook, in connection with the work of the Biological Station, an analysis of the local molluscan fauna of Go Home Bay. This study has since been extended to include various points around Georgian Bay, but because of the labour involved in working over the material, this paper deals only with the more limited area, leaving the general distribution for future discussion. The analysis of the species is believed to be fairly complete, and special care has been taken to observe critically the specific characters and the variations, whether due to environment, age or other cause. Notice has also been taken of the food of the various forms and of the extent to which they themselves serve as food for fishes and other animals.

The collections along-shore were made by hand and hand-dredges, while in the deeper water use was made of an iron dredge, provided with a fine inner screen supported by a course outer screen. The latter method entails much labour in sorting over the material but gives excellent results.

In the identification of species the writer is indebted to Mr. Bryant Walker of Detroit and to Dr. H. A. Pilsbry and Mr. E. G. Vanatta of the Philadelphia Academy of Natural Science, who determined a number of species and confirmed the determination of others. He is also under obligation to Professor B. A. Bensley, Dr. E. M. Walker and Dr. A. G. Huntsman of the University of Toronto for much kind assistance and advice.

The environmental features of this region are of interest because it falls within the Archean area. A general account of these features is given elsewhere by Bensley ('14), but reference may be made to those which are more important from the standpoint of this paper.

1. The glaciated surface of the rock is sparingly and unevenly occupied by soil and bottom deposits, accumulating in basins and consisting chiefly of disintegrated particles of gneiss, often with high organic content.

2. The indented shore-line leaves projecting headlands of fully exposed and bare character, while the protected smaller bays form isolated swamps with usually a deep deposit of mud and much organic material.

3 The main shore gives place outwards to larger, then to smaller islands and finally to reefs and submerged shoals, with clear rock or boulder bottom.

4. The deeper waters of the larger bays and open waters have flat bottoms, consisting of mud of fairly high organic content alternating with exposed patches of the underlying rock.

5. At places there are open or somewhat exposed channels with accumulations of clean sand, almost free from organic material.

6. In addition to the wave-action on the main shore and on the shoals, there is a constant flow of water in and out among the islands, giving conditions of exposure, temperature and oxygenation which are in marked contrast with those of the protected bays and especially with those of the inland ponds.

In general the species of mollusca exhibit great flexibility in their environmental relations. In many cases ecological selection is operative within broad limits, while in a few the environmental type is more or less specific. The chief factors in this selection appear to be (a) exposed or protected situation, (b) depth of water, (c) degree of aeration, (d) character of the bottom, and (e) food conditions. In the Genus *Lymnaea*, the long-spired forms occur in the stagnant bays, while the short-spired ones inhabit rocky shores. The species of *Planorbis* also occur in the swampy bays, though *P. deflectus* extends its range to the exposed rocky islands and the pools occurring on them. Most of the species of *Physa* are quite general in their distribution, but *P. integer* prefers the exposed shores. The genera *Ancylus*, *Amnicola* and *Campeloma* and the families *Unionidae* and *Sphaeriidae* occur in swampy bays and also, though much less abundantly, in inland ponds, with an extension of this range in *Amnicola*, the *Unionidae* and sometimes *Campeloma* to the sandy channels and of the *Sphaeriidae* to these channels and to sand or gravel banks in the deeper waters. *Goniobasis* is found abundantly where there are currents of clear, well-aerated water, in sand channels, on sandy beaches and on the exposed rocky shores. The genus *Valvata* is a sand-loving one, although of the two species, one, *tricarinata* is also found plentifully in weedy, muddy bays.

The inland ponds are exposed to extremes of summer and winter temperature. They are limited in the facilities they afford for migration to the deeper waters. They are poorly provided with means of aeration and are often surfeited with decaying vegetation and so afford an environment not highly favorable to molluscan life. Few forms occur and these not abundantly. Among them are *Ancylus parallelus*, *Campeloma decisum*, *Amnicola limosa* and the *Sphaeriidae*.

The protected muddy bays where these conditions are reversed afford a rich molluscan fauna with a wide range of species which includes the *Unionidae*, the *Sphaeriidae*, the genera *Valvata*, *Amnicola*, *Goniobasis*, *Planorbis*, *Ancylus*, *Physa* (with the exception of *P. integer niagarensis*) and the long-spired species of *Lymnaea* (*palustris*, *columella* and *haldemani*).

In the weedy sand-runs the same forms occur, with the exception of *Planorbis exacuous*, *P. dilatatus* and the *Lymnaea* mentioned above. In clean sand channels, free from weeds and exposed to currents, the *Unionidae*, the *Sphaeriidae* and the genera *Campeloma*, *Valvata* and *Goniobasis* occur.

The exposed rocky shores which seem to afford a scanty supply of food and an abundance of well-aerated water, yield *Lymnaea emarginata canadensis*, *L. decollata*, *L. stagnalis sanctamariae*, *Planorbis deflectus* and the various species of the *Physa*.

In the shallow island pools which are well-aerated and have a good supply of food, but which, on the other hand are subjected in some cases to destruction by drought and to severe winter conditions, *Planorbis deflectus* and *Lymnaea palustris* abound.

In deep dredging from sandy or gravelly bottoms, the *Sphaeriidae* and the genus *Valvata* are obtained.

The total number of species identified is 37, representing 14 genera in 8 families, as follows:—

I. Family LYMNAEIDAE.

A. Genus **Lymnaea.**

1. *Lymnaea stagnalis sanctamariae*, Walker.
2. *Lymnaea (Galba) decollata*, Mighels.
3. *Lymnaea (Galba) emarginata canadensis*, Sowb.
4. *Lymnaea (Galba) palustris*, Muller.
5. *Lymnaea (Pseudosuccinea) columella*, Say.
6. *Lymnaea (Acella) haldemani*, (Deshayes) Binney.

B. Genus **Planorbis.**

7. *Planorbis (Helisoma) bicarinatus*, Say.
8. *Planorbis (Pierosoma) trivolvis*, Say.
9. *Planorbis (Planorbella) campanulatus*, Say.
10. *Planorbis (Menetus) exacuous*, Say.
11. *Planorbis, (Menetus) dilatatus*, Gould.
12. *Planorbis (Gyraulus) hirsutus*, Gould.
13. *Planorbis (Gyraulus) deflectus*, Say.

II. Family PHYSIDAE.

C. Genus **Physa.**

14. *Physa heterostropha*, Say.
15. *Physa ancillaria*, Say.

15a. *Physa ancillaria magnalacustris*, Walker.

15b. *Physa ancillaria vinosa*, Gould.

16. *Physa gyrina*, Say.
17. *Physa integer niagarensis*, Lea.

D. Genus **Ancylus.**

18. *Ancylus parallelus*, Hald.

III. Family STREPTOMATIDAE.

E. Genus **Goniobasis.**

19. *Goniobasis livescens*, Menke.
20. *Goniobasis haldemani*, Tryon.

IV. Family AMNICOLIDAE.

F. Genus **Amnicola.**

21. *Amnicola limosa*, Say.
22. *Amnicola emarginata*, Küster.
23. *Amnicola lustrica*, Say.

V. Family VALVATIDAE.

G. Genus **Valvata.**

24. *Valvata tricarinata*, Say.
25. *Valvata sincera*, Say.

VI. Family VIVIPARIDAE.

H. Genus **Campeloma.**

26. *Campeloma decisum*, Say.

VII. Family UNIONIDAE.

I. Genus **Lampsilis.**

27. *Lampsilis ventricosus*, Barnes.

28. *Lampsilis luteolis*, Lamarck.

28a. *Lampsilis luteolis rosaceus* De Kay.

J. Genus **Anodonta.**

29. *Anodonta grandis*, Say.

29a. *Anodonta grandis footiana*, Lea.

K. Genus **Anodontoides.**

30. *Anodontoides ferussacianus*, Lea.

L. Geuns **Unio.**

31. *Unio complanatus*, Solander.

VIII. Family SPHAERIIDAE.

M. Genus **Sphaerium.**

32. *Shpaerium simile*, Say.

33. *Sphaerium striatinum*, Prime.

34. *Sphaerium rhomboideum*, Say.

35. *Sphaerium* (*Musculium*) *securis*, Prime.

36. *Sphaerium* (*Musculium*) *partumeium*, Say.

N. Genus **Pisidium.**

37. *Pisidium abditum*, Hald.

Family LYMNAEIDAE.

Represented by 13 species of *Lymnea* and *Planorbis*, together forming the third of the total number of Molluscan species.

Genus **Lymnaea.**

Of six species identified, two, *L. emarginata canadensis* and *L. Palustris* are the prevailing types. Both occur abundantly. L. *haldemani* was taken in only two situations, although it was present in numbers *L. decollata* was taken in several places, but nowhere abundantly. Of *L. stagnalis sanctaemariae* only six specimens in all were obtained. *L. columella* was frequently found, but not in numbers.

L. stagnalis sanctaemariae, Walker. The six specimens were identified as this species and variety by Mr. E. G. Vanatta. The shortened spire corresponds to the exposed situation in bare rocky channels. A light colored, transparent shell, 5 to 5½ rounded whorls with distinct suture. The aperture is broadly ovate, the edge of the lip thin, flared anteriorly; slit-like umbilicus widely open or nearly closed by the callus. (Pl. XI, Fig. 18).

L. (*Galba*) *decollata*, Mighels, occurs on rocky shores and in shallow rocky bays of outer islands. Stout, nicely formed little shell, rhomboidal in outline when viewed facing the aperture. Large body whorl, expanded aperture and short, sharp spire. Whorls 3. Color brownish horn, tinged with green, apical whorls darker, white varical thickenings on body whorl. In comparison with *L. emargi-*

nata canadensis the shell is smaller, shorter and smoother, the whorls fewer and more convex and the sutures are more impressed. (Pl. X, Fig. 7).

L. emarginata canadensis. Sowb.; very abundant on clean rocky shores, especially of the outer islands. Found also on sand and pebble bottom. Corresponding to its exposed position and in contrast to the other species, *L. palustris,* it is thick-shelled with shortened spire and is of light coloration. It is a medium-sized species (adult length 20-25mm.) and is usually recognized easily by its light horn colour and malleated surface. The spire is shorter than the aperture, the whorls well-rounded, 5-6 and the sutures distinct. The aperture is large and ovate with a somewhat flaring lip and with reddish varical thickenings usually prominent immediately behind it. A white callus spreads over the body-whorl and covers but does not close the deep slit-like umbilicus. Usually with several whitish or reddish varical thickenings. Identified as this variety by Mr. E. G. Vanatta. As it occurs at Go Home it is quite variable, especially in surface malleation, thickness of the shell, height of the whorls and length of the spire. Thinner shells show more definite malleations. Its food consists of algæ. It has been taken from the stomach of the whitefish, *Coregonus clupeiformis.* (Pl. X, Fig. 14).

L. (*Galba*) *palustris,* Muller, abundant in shallow bays on the bottom or on submerged vegetation, often on mud flats above the water's edge. It prefers moderately high temperatures. It is easily recognized by its narrow elongated form, dark colour and by the aperture which is usually shorter than the spire. Lip somewhat flared. Surface of shell variable, smoother in island pools, usually roughened by coarse lines of growth in muddy bays. Sometimes malleated. Color brown to almost black, darker in pools, often whitish due to erosion. In young, color darker and lip not flared. Distinguishable from *L. emarginata canadensis* in the more slender elongated form, narrower and shorter aperture, longer spire, darker color and distinct habitat. It feeds upon the filamentous green algæ, diatoms and desmids. Found in the stomachs of whitefish. (Pl. X, Fig. 8).

L. (*Pseudosuccinea*) *columella,* Say. Common on lower surface of lily-leaves in stagnant, muddy bays. Easily recognized by its expanded and oblique body whorl, its long aperture, expanded anteriorly, rather sharp-pointed spire and its delicate shell-structure. Lines of growth prominent. Its elongated form and especially its delicate shell are adaptations to its protected habitat. Food consists of diatoms, desmids and other green algæ. (Pl. XI, Fig. 15).

L. (*Acella*) *haldemani* (Deshayes) Binney: Found on the lower surface of lily-leaves in well-sheltered muddy bays in late summer. Observed in but two situations, both of which were removed from open water and were especially well-protected. Several specimens secured in each situation. Diligent search failed to reveal any during the early summer and nothing was found to indicate their habitat during this period. These observations agree in their main features with Kirkland's account as given by Baker ('11). Those secured were, however, considerably removed from deep water; none were observed in the approaches to the bays, neither were any secured in dredging. This is the most striking *Lymnaea* of the region. Its extremely slender form, long spire, oblique, flattened whorls, long narrow aperture, sharply angular at the posterior end and its thin transparent

shell are unmistakable characters. The long spire and delicate shells are in conformity with its protected habitat. It varies in length of spire, conxevity of whorls and size and shape of the aperture and the axis is often considerably twisted. Its food consists of algæ. (Pl. X, Fig. 4).

Genus **Planorbis.**

Seven species were identified. Of these, three, *P. bicarinatus*, *P. trivolvis* and *P. campanulatus* belonging to a large-shelled group inhabiting muddy bays, possess comparatively high, sinistral shells and certain common characters in respect of the reproductive organs which will be dealt with in a subsequent paper. The others belonging to a small-shelled group with a more varied habitat possess low, flattened, dextral shells and, as far as examined, certain other characters in the reproductive organs. This group includes *P. hirsutus*, *deflectus*, *exacuous* and *dilatus*, the range of distribution of which varies with each species.

Planorbis bicarinatus, Say, occurs abundantly in weedy sand runs and weedy muddy bays; found also on rocks near the latter. Distinct and easily recognized by the two prominent angular carinae. Aperture slightly oblique, somewhat triangular, broadly rounded below, lip thin with varical thickening behind. Shell bi-concave, lower concavity with the sides interrupted by the carinae, upper smooth and funnel-like. Former apertures often evident on the body whorl as pronounced transverse ridges with darker periostracum. The possession of a broad high shell, which is carried on edge and has an aperture only slightly oblique, doubtless indicates for this form sheltered rather than exposed situations. In the young the carinae as pronounced but the aperture less oblique than in the adult. Food consists of green algæ. (Pl. X, Fig. 5).

Planorbis trivolvis, Say.; found plentifully in protected muddy bays and sometimes along the sheltered shores of the inner islands. Prefers shallow bays with comparatively high temperature. Found only in shore collections and water less than 2 feet in depth. The largest *Planorbis* of the region (Adult measurements,—width 20–30 mm, length 10–13 mm). Shell with shallow concavity above the smooth slopes of which are interrupted by the carina of about the last half of the body whorl. A deep umbilicus into which the rounded whorls disappear below. Aperture large, triangular or rhomboidal in outline, narrower above, lip thin, much flared with a varical thickening behind. One or more former apertures evident. Lines of growth coarse. Not fitted for exposed situations because of the size and shape of the shell and the vertical position in which it is carried. Varies with age. Young lighter in color, shells high and narrow, while adults are much broader than high. Recognized easily at all stages by the upper concavity of the shell. Series showing all stages readily secured. Eggs laid in flat brownish capsules on lily-leaves, sticks and even on other molluscs. Food, filamentous algæ, diatoms and desmids. (Pl. X, Fig. 6).

Planorbis campanulatus, Say.; occurs abundantly in weedy places, both muddy and sandy, up to the depth of at least three fathoms. Easily recognized by the campanulate expansion of the body whorl a short distance behind the aperture and

the narrowly constricted throat just behind this. Aperture rhomboidal, narrowed above. Narrowly rounded tops of the whorls all in the same plane. Lower surface like trivolvis but narrow lower edge of the whorls more rounded and less angular. Lines of growth coarse, regular and parallel. Adapted in the same manner as the two preceding species to protected rather than exposed situations. Often distorted so that the tops of the whorls are inclined at various angles. Varies considerably in length of campanulate expansion and also in thickness of shell. Feeds on filamentous green algæ, diatoms and desmids. (Pl. X, Fig. 1).

Planorbis exacuous, Say.; occurs in protected weedy places, never in large numbers. A well-marked species, having as distinguishing features a very sharp peripheral carina, a lens-shaped shell and small size. Whorls flattened above, broadly rounded below. Aperture triangular and very oblique. The greatly flattened shell and very oblique aperture which allow it to lie close to the surface over which it crawls would seem to adapt it to an exposed habitat, yet it was found only in protected places. Varies in color, light coloured in sandy, and brown in muddy places. (Pl. X, Fig. 3).

Planorbis dilatatus, Gould, occurs on sticks along muddy river banks and in muddy bays. Only a few obtained. Small brownish; top of shell flat; sharp peripheral keel almost level with top of shell; whorls broadly rounded below; aperture oblique; compared with *P. exacuous* it is smaller and higher in proportion, the whorls are flatter above and much more convex below and the carina is placed much higher.

Planorbis hirsutus, Gould, occurs plentifully in weedy, sandy channels and in muddy bays or in channels on smooth rocks covered with light deposit of sediment. Easily recognized by the rough hairy shell. Shell wide and flat, having a sharp, strongly deflected peripheral keel and a very oblique aperture. Surface covered by crowded rows of hairs. Last portion of body whorl often strongly deflected. Shell varies greatly with age. A shell of about three and a half whorls is concave above and below, the aperture is only slightly oblique, the centrally-placed peripheral keel is just appearing behind the aperture, the shell is high and all the whorls are on the same level. In older shells the aperture becomes oblique, the shell becomes wide and flat, and there is a pronounced peripheral keel deflected downwards. The last whorls also drop below the level of the preceding whorls and the shell becomes saucer-shaped. (Pl. X, Fig. 2).

Planorbis deflectus, Say, the most abundant *Planorbis* species of the region, possesses a wider range of habitat than any other species, plentiful in quiet weedy bays, in weedy sand channels and in shallow dark-colored pools on islands. Occurs also on exposed shores. Recognized by its small size and rounded periphery. Aperture only slightly oblique. Color varies from yellowish on lily-leaves in bays to dark brown in dark island pools. Whorls in one plane or with last part of body-whorl deflected downwards. Periphery sometimes flattened on its upper edge, giving a peculiar sloping aspect to last whorl. Some specimens banded alternate white and dark brown.

Family PHYSIDAE.

Represented by six species belonging to two genera, *Physa* and *Ancylus*.

Genus **Physa.**

Of this genus five species were obtained. Four of these are large and dark-colored, have short spires, thin shells and indistinct sutures and occur throughout a wide range of habitat. The fifth is small, light colored, with white varical thickenings of the whorls, has a more elongate spire and is found only on semi-exposed rocks. Although the two groups are quite distinct, the species within the first group are not so clearly differentiated. The characters upon which the species of this genus are based are exceedingly variable and the extremes of variation grade into one another so smoothly that an attempt to verify the present classification by breeding experiments and anatomical investigation seems desirable. The writer intends to undertake the task in the near future. In the meantime the distinctions here used will be those of the literature of the genus.

Physa heterostropha, Say, occurs usually in protected situations in weedy bays or quiet rocky channels, rare. Surface smooth and shiny, without sculpture, the spire elevated and the sutures distinct. Food, diatoms, desmids and other algæ.

Physa ancillaria, Say, very abundant, almost everywhere in sheltered bays and along partially exposed shores. In the spring it may be seen collecting in vast numbers to the breeding-grounds in rocky channels and in the bays of rocky islands. Within a few days after copulation the eggs are laid in elongated capsules. A single individual may lay as many as five capsules containing in all 150-300 eggs. Spire short, sutures not so distinct as in *P. heterostropha*. Shell more robust than in that species. Surface smooth and shining, sculptured. Varies much in surface sculpture, height of spire, size and shape of aperture and number of digitations on mantle. Such malformations as forked tentacles and lobes arising from upper surfaces of foot were found. Food consists of diatoms, desmids and other green algæ. A number were found in whitefish stomachs. (Pl. XI, Fig. 19).

A variety, *magnalacustris*, Walker, with white lines on body whorl also occurs.

The variety *vinosa* occurs in sheltered bays and on partially exposed shores. Shell robust, spire short but sharp; whorls rounded and suture distinct.

Physa gyrina, Say. Not very abundant, found in sheltered bays. Differs from *P. ancillaria* in larger size, more elevated spire, more slender form and coarser surface sculpture.

Physa integer niagarensis, Lea; found on somewhat exposed rocky shores. much smaller than any of previous forms, shell much like a small reversed *L. emarginata canadensis*. Shell light horn with many white bands transverse to whorls. Shell heavy, spire elevated, apex sharp, sutures distinct and whorls rounded. Identified by Dr. Pilsbry.

Genus **Ancylus.**

Ancylus is represented by a single species.

Ancylus parallelus, Hald.; very common in sheltered bays on under sides of lily leaves and on sticks. Shell flat, pyramidal; apex ⅓ length of shell from posterior end, directed backwards and to the left; sides nearly parallel, shell narrower in front. (Pl. XI, Fig. 17).

Family STREPTOMATIDAE.

Represented by two (?) species of the Genus *Goniobasis.*

Genus **Goniobasis.**

Goniobasis livescens, Menke. Obtained abundantly where there are currents, in sand runs or along rocky shores and on the rocky shoals near the outer islands. Occurs also but not plentifully in muddy bays. Spire long and tapering, apex usually eroded away, whorls 8-9, flattened, suture not deeply impressed, distinct carina at lower edge of whorl. Aperture small and rhomboidal; prolonged anteriorly into a slight groove, closed by an operculum borne on upper side of foot. Unlike the long spired species of *Lymnaea* which inhabit sheltered situations, this form which is also long spired is well-adapted to exposed places because of its strong heavy shell. In contrast with the *Lymnaea* also, it, when detached, does not float on the water, but sinks at once into deeper water. A quite variable species. Varies in length and stoutness of spire, usually high and slender, often quite short and stout, color dark brown, shaded with green, light green or white. In young, carina well-marked; in adults, no carina on body whorls; in younger, color much darker. Feeds on diatoms and desmids. (Pl. XI, Fig. 16).

Goniobasis haldemani, Tryon; (not positively identified.) Occurred on shady beach along exposed shore. Few obtained. More slender and elongated, whorls more rounded than in *livescens.* No carina and the color white tinged with green.

Family AMNICOLIDAE.

Represented by three species, all belonging to the genus *Amnicola.*

Genus **Amnicola.**

Of the three species obtained here, *A. limosa* is the most abundant. All occur in weedy places either with mud or sand bottom. *A. limosa* is secured also on the rocky shores of even the outer islands and *A. limosa* and *lustrica* were obtained in deep dredgings. Operculate.

Amnicola limosa, Say; obtained on weeds in sand channels or muddy bays, on rocky shores and in dredging at 20 fathoms or more. Very abundant, tentacles long and constantly in motion. The jet-black eyes placed at outer bases of ten-

tacles. Shell globose, whorls convex, apex usually rounded. Umbilicus small, aperture rounded. Shows considerable variation. Shell may be conic, spire elongated and apex sharp. The sutures vary in distinctness. Eggs laid in small triangular capsules on weeds, sticks, stones and even on the shells of other molluscs. (Pl. X, Fig. 9).

Amnicola emarginata, Say. Not numerous. Found with *A. limosa*. Distinguished from it by the truncated apex, the first whorl not rising above the second. Spire also more elongated than usual in *A. limosa*.

Amnicola lustrica, Say; not abundant. Occurs with other species of *Amnicola*; dredged in 20 fathoms or more of water. Compared with *A. limosa*, shell thinner, spire much more elevated, apex sharp, body whorl scarcely larger than the preceding one. (Pl. X, Fig. 10).

Family VALVATIDAE.

Two species belonging to one genus occur.

Genus **Valvata.**

Of the two species, one, *V. tricarinata* occurs abundantly. Operculate. The plume-like gills borne within the mantle-cavity.

Valvata tricarinata, Say., abundant in weedy places among islands on either sandy or muddy bottoms. Occurs on sandy bottoms even to depth of 20 fathoms. Prominent carinae, usually three. Umbilicus broad, open to apex. Whorls loosely appressed. Quite variable. One or all of the carinae may be lacking or indistinct. The order of their reduction appears to be peripheral, lower, upper. In sandy places malformations in which whorls do not touch preceding whorls occur, seen in early whorls, body whorl or intermediate ones. Found in whitefish stomachs. (Pl. XI, Fig. 21).

Valvata sincera, Say. Found only in dredgings in sandy places. Occurs at depths of up to 20 fathoms. Not abundant. Compared with *V. tricarinata* there are no carinae and whorls are more rounded. There are distinct, sharp, elevated ridges, parallel to lines of growth. In the young these ridges are finer and more closely placed. Subject in sandy places to malformations similar to those occurring in *V. tricarinata*. Abundant in stomachs of whitefish. (Pl. XI, Fig. 22).

Family VIVIPARIDAE.

Represented by one species belonging to Genus *Campeloma*.

Genus **Campeloma.**

Operculate. As family name indicates young are produced alive.

Campeloma decisum, Say; occurs abundantly in sheltered bays with soft mud bottoms and in sand channels with decaying vegetable content. Congre-

gates in decaying lily stems and on decaying logs. Recognized easily by large, heavy greenish shell, with short spire and eroded apex, its large, broad, brownish mottled foot and its long tapering tentacles. Color varied by narrow, irregularly placed dark bands crossing the whorls. In dark water it is often rusty brown. Young lighter in colour, lip of aperture thinner and shell has numerous fine lines parallel to whorls. All stages of development from young in the uterus to the adult form are easily obtained. Feeds on decaying vegetable matter. (Pl. XI, Fig. 20).

Family UNIONIDAE.

Represented by seven species belonging to four genera.

Genus **Lampsilis.**

Two species of this genus are reported.

Lampsilis ventricosus, Barnes. The single specimen obtained some years ago was identified by Bryant Walker as *L. ventricosus canadensis,* Lea, conforms to descriptions of *L. ventricosus* and since Simpson (1900) includes *canadensis* in synonymy of *ventricosus* it is here designated by the latter name. Shell, thick; color yellowish, darker in front. Few faint broad radiations behind, lines of growth coarse, beaks eroded, hinge line straight, nacre white, cardinal teeth double in both valves, lateral teeth single in right valve, double in left.

Lampsilis luteolis, Lamarck. Very abundant on the slopes of deep pools in sandy channels and along sloping muddy shores. Shell much higher behind the beaks. Beak sculpture consisting of about 13 fine wavy concentric ridges. Color light or dark brown, usually with numerous, sometimes brilliant narrow green rays. Two cardinal teeth in each valve, lateral teeth double in left valve and single in the right, long, curved and lamelliform. Nacre white. Hinge line curved. Varies in periostracum which may be smooth and shining or coarsely wrinkled, in outline of shell, in color in prominence and number of rays and in cardinal teeth which are pyramidal or lamelliform. Females inflated posteriorly. Young narrower than adults. A form is common here which is large and heavily shelled, has a dark brown periostracum often with a greenish sheen towards the umbones and is coarsely and closely wrinkled at the margin of the gape. The variety *rosaceus* which has smooth reddish-brown periostracum and rosy nacre also occurs. (Pl. XII, Figs. 23, 26, 30).

Genus **Anodonta.**

Of this genus one species occurs.

Anodonta grandis, Say, occurs plentifully on steep slopes of sand banks in sandy channels, and also, but less abundantly in the soft mud of sheltered bays. Shell thin, smooth, inflated, hinge-teeth lacking, usually dull in colour. Beak sculpture, four or five concentric ridges with anterior and posterior loops. Varies greatly in color, sometimes dull and almost rayless; at times brilliant, with many green rays. Varies also in inflation of shell and in outline. Forms were found typical of *footiana* as well as other typical of *grandis,* s.s., but there were also many intermediates. (Pl. XII, Figs. 25, 28).

Genus **Anodontoides.**

Represented by a single species.

Anodontoides ferussacianus, Lea. Plentiful in shallow sand channels and also in muddy places. Compared with *A. grandis* is smaller and much more elongated. Fine radiating sculpture at posterior of beak in addition to the five or six concentric doubly looped ridges. Color brown, tinged with green anteriorly and below and rusty brown posteriorly and above. (Pl. XII, Fig. 27).

Genus **Unio.**

Of this genus also only a single species occurs.

Unio complanatus, Solander. Very abundant in sand channels and along muddy or sandy shores of the inner islands or bays. Shells dark brown, no rays, beaks eroded, placed well forward, height behind beaks not greatly exceeding that in front, anterior end rounded, posterior tends to be angled. Ventral margin and hinge margin nearly straight, margin behind hinge curved. Teeth, both cardinal and lateral, single in right and double in left valve. Very variable, shells, narrow or broad, light or heavy; nacre white or purple. In old shells ventral margin tends to become emarginate. (Pl. XII, Fig. 29).

Family SPHAERIIDAE.

There are of this family, in this region, six species belonging to the two genera, *Sphaerium* and *Pisidium.*

Genera **Sphaerium.**

Five of the six species mentioned above belong to this genus.

Sphaerium simile, Say, occurs abundantly, buried in the sand on the slopes of deep pools in sandy channels; occurs also in the mud of sheltered bays. The largest of the family in this district. Beaks nearer anterior end of shell, inflated, closely approximated, beaks marked with coarse lines, lines of growth heavy, regular. Color brown or yellow, often brown with yellow border. Hinge line curved. Hinge slight. Varies in color. Young usually yellow, adult usually dark. Young thin, adult somewhat inflated. (Pl. I, Fig. 11).

Sphaerium striatinum, Lamarck. Abundant in sand banks in channels and in mud in sheltered bays. Shell somewhat inequilateral, beaks full, separated, lines of growth coarse with finer lines between. Beak sculpture not uniform, numerous regular coarse lines, few coarse lines irregularly placed or beak smooth. Shell thin, nacre bluish white with purple bands or patches.

Sphaerium rhomboideum, Say. Sand banks and muddy bays. Shell equilateral. Umbones depressed, approximated, marked by fine lines, lines of growth rather fine, regular; anterior slightly truncated, posterior somewhat angled below. Dark brown, narrow yellow border around margin; nacre bluish white. (Pl. X, Fig. 12).

Sphaerium (*Musculium*) *securis*, Prime. Abundant in sandy channels. Small, fragile, much higher in front of umbones which are centrally placed. Truncated behind, rounded in front, rhomboidal in outline, umbones calyculate and inflated, marked by fine concentric lines; lines of growth fine. Found in stomachs of white-fish. (Pl. X, Fig. 13).

Sphaerium (*Musculium*) *partumeium*, Say. Identified by Mr. E. G. Vanatta. Sand channels. Shell equilateral, oval in outline, large, truncated behind, color yellow, lines of growth fine.

Genus **Pisidium.**

One species of this genus occurs here.

Pisidium virginicum, Bourguignat. Abundant in sandy channels. Dark colored. Umbones elevated, placed posteriorly, shell heavy, brown or yellowish, truncated behind, triangular in front. Lines of growth coarse. Cardinal teeth single in right valve, inverted V-shaped; double in left; oblique, anterior narrow, posterior stout, inclined towards pyramidal. Laterals stout, double in right valve, single in left.

ARTIFICIAL KEY TO THE SPECIES IN THIS REPORT.

Since the recognition of these species is not an easy matter the following key based upon shell characters is given to facilitate their identification.

A. 1. Univalve, shell consisting of one valve.
  B. 1. Non-operculate, no operculum borne on upper surface of foot and closing the aperture of shell when animal is retraced.
    C. 1. Spire elevated and dextral, or flat.
      Family LYMNAEIDAE.
      D. 1. Spire elevated and dextral.
        Genus **Lymnaea.**
        E. 1. Spire elongated.
          F. 1. Much elongated and slender, whorls very oblique, shell thin.
            Lymnaea haldemani.
          F. 2. Elongated but stout; dark colored.
            Lymnaea palustris.
        E. 2. Spire short.
          F. 3. Thin-shelled, body whorl very large, whorls very oblique. Length of shell 15-18 mm.
            Lymnaea columella.
          F. 4. Shell large, smooth; whorls 5; length of shell 25-30 mm.
            Lymnaea stagnalis sanctaemariæ.
          F. 5. Shell medium sized, usually malleated; whorls 5; length of shell 20-25 mm.
            Lymnaea emarginata candensis.
          F. 6— Shell small, smooth; whorls 3; length of shell 10-12 mm.
            Lymnaea decollata.

D. 2. Spire flat.

Genus **Planorbis.**

E. 3. Shell large, high and sinistral.

F. 7. With wide shell concavity above.

Planorbis trivolvis.

F. 8. With narrow deep concavity above, two carinæ.

Planornis bicarinatus,

F. 9. With no concavity above. Expansion behind the aperture.

Planorbis campanulatus.

E. 4. Shell small, depressed and dextral.

F. 10. Shell covered with bristles.

Planorbis hirsutus.

F. 11. No bristles on shell.

G. 1. Peripheral keel level with the top of shell.

Planorbis dilatatus.

G. 2. Peripheral keel centrally placed. Shell lens-shaped.

Planorbis exacuous.

G. 3. No peripheral keel.

Planorbis deflectus.

C. 2. Spire elevated and sinistral or shell not spiral.

Family PHYSIDAE.

D. 2. Spire elevated and sinstral.

Genus **Physa.**

E. 5. Shell large.

F. 12. No sculpture on surface of shell.

Physa heterostropha.

F. 13. Surface sculptured, spire short, suture not impressed.

Physa ancillaria.

F. 14. Surface sculptured, spire more elevated, sutures impressed.

Physa gyrina.

E. 6. Shell small, usually whitish.

Physa integer niagarensis.

D. 4. Shell not spiral.

Genus **Ancylus.**

Ancylus parallelus.

B. 2. Operculate, operculum borne on the upper surface of foot and closing the aperture of the shell when the animal is retracted.

C. 3. Spire very high, shell large, length 25-30 mm.

Family STREPTOMATIDAE.

D. 5. Whorls towards apex not rounded.

Goniobasis livescens.

D. 6. Whorls towards apex more or less rounded.

Goniobasis haldemani.

C. 4. Spire low or only moderately high.

D. 7. Umbilicus narrow.

E. 7. Shell small, about 5 mm. in length.
Family AMNICOLIDAE.
F. 15. Shell globoid or low conic; apex rounded.
Amnicola limosa.
F. 16. Shell low, conic, apex emarginate.
Amnicola emarginata.
F. 17. Shell high conic, apex sharp.
Amnicola lustrica.
E. 8. Shell large and heavy. Apex usually eroded.
Family VIVIPARIDA.
Campeloma decisum.
D. 8. Umbilicus wide.
Family VALVATIDAE.
E. 9. Whorls bearing three carinae.
Valvata tricarinata.
F. 10. Whorls without carinae.
Valvata sincera.
A. 2. Bivalve shell consisting of two valves, united by a dorsal hinge.
B. 3. Shell large, one set of cardinal teeth in each valve.
Family UNIONIDAE.
C. 5. Shell heavy, bearing hinge teeth.
D. 9. Height behind beaks not greatly in excess of that in front.
Genus **Lampsilis.**
E. 11. Rays numerous and narrow.
Lampsilis luteolis.
E. 12. Rays few and broad.
Lampsilis ventricosus.
C. 6. Shell light, no hinge teeth.
Genus **Anodonta.**
D. 11. Shell high, no radiating sculpture on posterior part of beak.
Anodonta grandis.
D. 12. Shell low, elongated, radiating sculpture on posterior of beak.
Anodontoides ferussacianus.
B. 4. Shell small, two sets of cardinal teeth in each valve.
Family SPHAERIDAE
C. 7. Not trigonal in outline.
Genus **Sphaerium.**
D. 13. Beak not calyculate.
E. 13. Lines of growth regular, coarse.
F. 19. Shell usually with definite narrow yellow border and rhombic outline.
Sphaerium rhomboideum.
F. 20. Shell without definite yellow border and oval in outline.
Sphaerium simile.

E. 14. Lines of growth not regular, coarse, with numerous fine between.

Sphaerium striatinum.

D. 14. Beaks calyculate.

E. 15. Rhomboidal in outline.

Sphaerium (Musculium) partumeium.

C. 8. Shell trigonal in outline

Genus **Pisidium.**

Pisidium virginicum.

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1873. Tryon, G. W., Jr.—Land and Fresh-water Shells of North America, Pt. IV, Smithsonian Miscellaneous Collections (253) vol. 16; Washington 1873.

EXPLANATION OF PLATES.

PLATE X.

1. Planorbis campanulatus, Say, x2½.
2. Planorbis hirsutus, Gould, x3.
3. Planorbis exacuous, Say, x3.
4. Lymnæa haldemani, (Deshayes) Binney, x3.
5. Planorbis bicarinatus, Say, x2.
6. Planorbis trivolvis, Say, x1½.
7. Lymnæa decollata, Mighels, x3.
8. Lymnæa palustris, Muller, x2.
9. Amnicola limosa, Say, x1½.
10. Amnicola lustrica, Say, x1½.
11. Sphærium simile, Lamarck, x1½.
12. Sphærium rhomboideum, Say, x1½.
13. Sphærium (Musculium) securis, Prime, x3.

PLATE XI.

14. Lymnæa emarginata canadensis, Sowb, x2.
15. Lymnæa columella, Say, x3.
16. Goniobasis livescens, Menke, x2.
17. Ancylus parallelus, Hald, x3.
18. Lymnæa stagnalis sanctaemariae, Walker, x2.
19. Physa ancillaria, Say, x3½.
20. Campeloma decisum, Say, x1¼.
21. Valvata tricarinata, Say, 3½.
22. Valvata sincera, Say, 3½.

PLATE XII.

23. Lampsilis luteolis, Lamarck, x¾.
24. Series, lamellar to pyramidal teeth in Lampsilis luteolis, Lamarck, x¾.
25. Anodonta grandis, Say, x¾.
26. Lampsilis luteolis, Lamarck, x¾.
27. Anodontoides ferussacianus, Lea, x¾.
28. Anodonta grandis, Say, x¾.
29. Unio complanatus, Solander, x¾.
30. Lampsilis luteolis, Lamarck, x¾.


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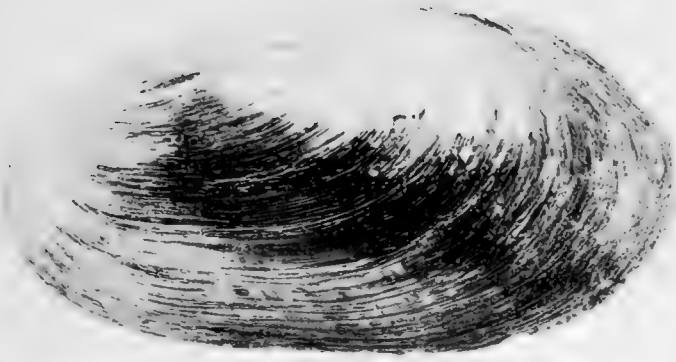

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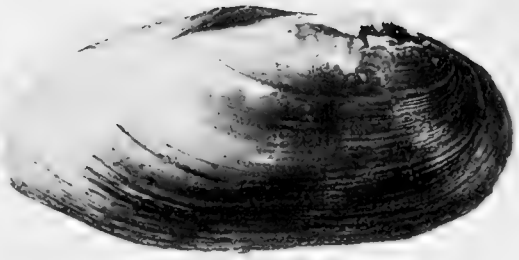

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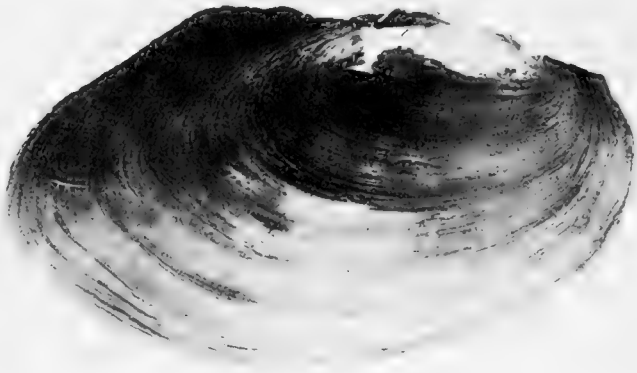

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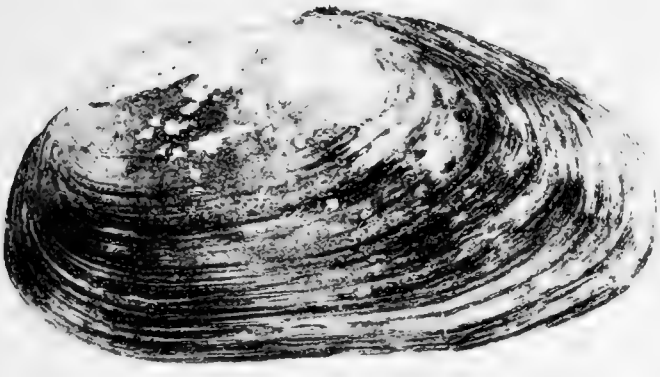

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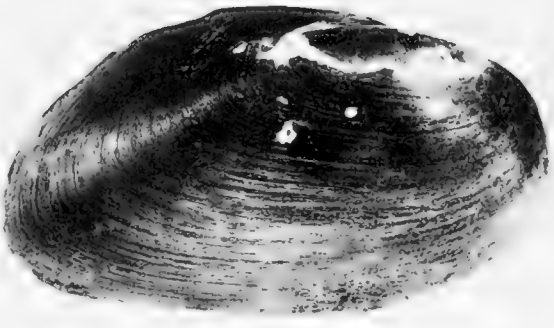

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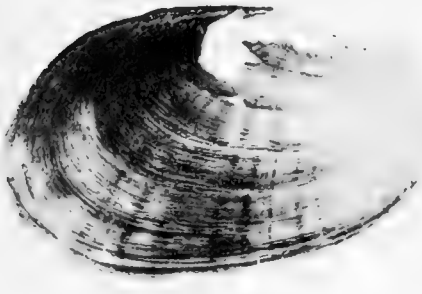

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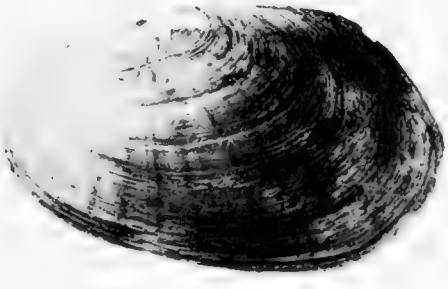

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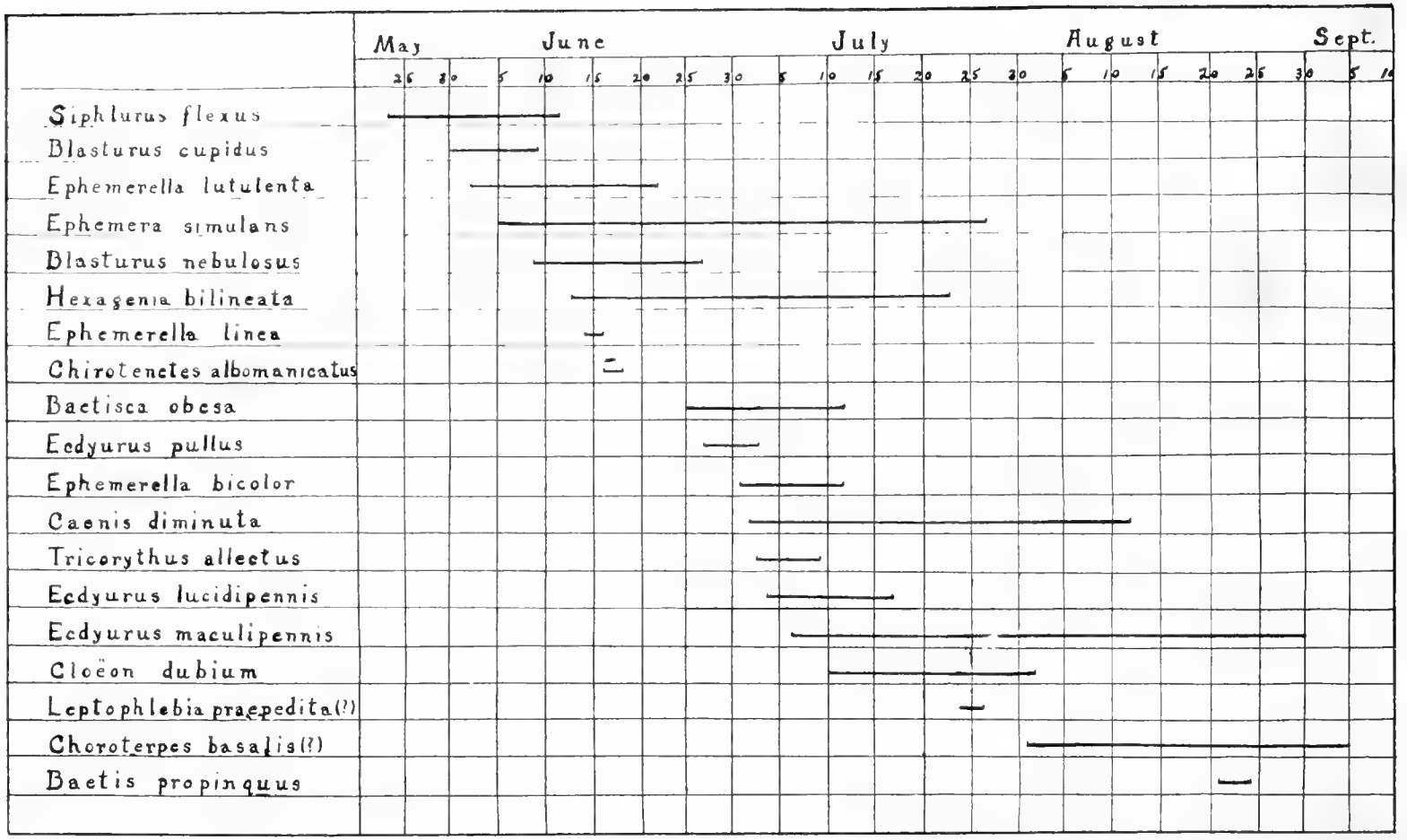

Fig. 1. Plan showing seasonal distribution of adults of Ephemeridæ.

IV.

REARING EXPERIMENTS AND ECOLOGY OF GEORGIAN BAY EPHEMERIDAE.

By W. A. Clemens, Department of Biology, University of Toronto.

(Plates XIII and XIV and 1 figure in the text)

The results given in the present paper are based upon a series of observations on the distribution and life histories of various species of this family, which were begun on the advice and under the supervision of Dr. E. M. Walker. Owing to the very imperfect knowledge of these species as they occur in Canadian localities, it was considered desirable to make collections of the local forms occurring in the vicinity of the Biological Station and to conduct breeding experiments to determine the identity of nymphs and imagos, and discover the time of emergence. These insects, as is well-known, are an important source of fish food. In view of the comparative abundance of the species of *Heptagenia* occurring in this region, however, and the exceptional facilities for their study, it was decided to deal with these species in a separate paper which appears elsewhere.

The life histories of comparatively few North American forms, comprising in all about 31, out of a total number of about 114, have been described. The first was that of *Baetisca obesa* Say, by Walsh in 1864. In 1901, Professor J. G. Needham reared and described six species; in 1904 he published the life histories of 11 more, and since then 2 others. In 1903, Mr. Edward Berry described the life histories of 3 forms and in 1911 Dr. Anna Morgan described 8.

The particular species are as follows: Needham (1901, 1904) *Heptagenia pulchella* Walsh; *Baetis pygmea* Hagen; *Siphlurus alternatus* Say; *Caenis diminuta* Walker; *Hexagenia variabilis* Eaton; *Ephemera varia* Eaton; *Chirotenetes albomanicatus* Needham; *Ameletus ludens* Needham; *Choroterpes basalis* Banks; *Callibaetis skokiana* Needham; *Ephemerella bispina* Needham; *Tricorythus allectus* Needham; *Leptophlebia praepedita* Eaton; *Heptagenia interpunctata* Say; *Ecdyurus maculipennis* Walsh; *Polymitarcys albus* Say; (By W. E. Howard); *Ephemerella dorothea* Needham; *Potamanthus diaphanus* Needham; Berry (1903); *Leptophlebia americana* Banks; *Blasturus cupidus* Say; *Callibaetis ferrugineus* Walsh.

Morgan (1911) *Ephemerella cornuta* Morgan; *Ephemerella rotunda* Morgan; *Ephemerella serrata* Morgan; *Ephemerella lata* Morgan; *Ephemerella tuberculata* Morgan; *Ephemerella deficiens* Morgan; *Ephemerella plumosa* Morgan; *Ephemerella spinosa* Morgan; *Iron fragilis* Morgan; *Epeorus humeralis* Morgan.

As for Canadian forms, L'Abbé L. Provancher, in 1877, recorded the following from Quebec; *Ephemera simulans* Walk.; *Hexagenia bilineata* Say.; *Heptagenia terminata* Walsh; *H. canadensis* Walker; *H. quebecensis* Provancher; *Siphlurus*

alternatus Say, *Baetis rubescens*, Hagen. In the Monograph of Eaton, 1888, are described the imagos of 21 taken in Canada. The following is a list of the species recorded and the localities from which they were taken. Those marked with an asterisk are recorded from Canada only:

Polymitarcys albus Say; Winnipeg River.
Emphemera guttalata Pict.; Quebec.
Ephemera simulans Walk.; St. Martin's Falls, Albany River.
Blasturus cupidus Say; Nova Scotia.
Blasturus nebulosus Walk.; St. Martin's Falls, Albany River.
**Ephemerella walkeri* Eaton; St. Martin's Falls, Albany River.
**Ephemerella invaria* Walker; St. Martin's Falls, Albany River.
**Baetis rubescens* Hag.; Quebec.
Baetis pygmeus Hag.; St. Lawrence River.
Centroptilum luteolum Müller; St. Martin's Falls, Albany River.
Callibaetis hageni Etn.; Puget Sound.
Callibaetis ferrugineus Walsh; Quesnel Lake, B.C., and Vancouver Island.
Siphlurus alternatus Say; North West Territory and Quebec.
**Siphlurus bicolor* Walker; St. Martin's Falls, Albany River.
**Rhithrogena vitrea* Walker; St. Martin's Falls, Albany River.
**Heptagenia canadensis* Walker; Canada.
Heptagenia verticis Say; St. Martin's Falls, Albany River.
**Heptagenia luridipennis* Burmeister; St. Martin's Falls, Albany River and St. Lawrence.
Heptagenia vicarius Walker; St. Lawrence River.
**Heptagenia quebecensis* Prov.; Quebec.
**Heptegenia basalis* Walker; Lake Winnipeg.

Specimens of many of these are in the British Museum, London, England. These were probably only casual captures and would seem to indicate a rich fauna in our northern inland waters.

I commenced collecting nymphs on May 25 and continued until September 6. The area covered was within a radius of about five miles of the Biological Station Island. Collections of nymphs were made in localities as varied as possible, such as along open shores, in quiet bays, quiet streams, rapids, above and below waterfalls, pools, ponds, lagoons, and in water from fifteen to forty-five feet deep.

The chief method of collecting was that of picking up stones along the shores from water three inches to two feet deep, and picking off the nymphs clinging to them with a pair of forceps, or lifting off the nymphs with the blade of a pocket knife. The dipnet was used in some localities and for deep water a dredge was dropped from the stern of a gasoline launch.

Each collection of nymphs, as it was brought in, was carefully examined under the binocular microscope and the species separated. A number of each species were then transferred to breeding jars and the remainder were killed and preserved in 70% alcohol. Glass battery jars were arranged on the centre table of the laboratory and each fitted up as nearly as possible to the conditions in which the

nymphs were found. For instance, for most of the nymphs of the genus *Heptagenia* which for the most part inhabit the swift water, a mixture of earth and sand was placed in the bottom of the jar and a couple of stones to which the nymphs could cling. Sticks were placed in the jars for the nymphs to crawl out upon when ready to emerge and a constant stream of fresh water supplied. For the *Hexagenia* nymphs, which were taken from deep water, the jar was partly filled with mud, which was dredged up in the locality from which the nymphs were taken. This was for the nymphs to burrow in. Only a trickling stream of water was necessary. *Blasturus* and *Caenis* nymphs did not require running water, as they were taken for the most part in ponds, pools and pot-holes in which the water was often almost stagnant. However the water in the jars was changed every day or so. Some dead leaves and twigs were placed in the bottom of the jar, to imitate the natural conditions.

Usually the stones placed in the jars were covered with algal forms upon which the nymphs could feed, but often algal material scraped from the stones was added.

Wire cages were placed over the jars to catch the subimagos as they emerged. It was impossible to set up breeding cages in the open on account of the changes of level of the water in Georgian Bay and because of waves produced by winds, or passing boats. Go Home River was too far from Station Island to be available.

When the subimagos appeared they were transferred to other vessels, where they were kept in an atmosphere very slightly humid and out of the direct sunlight, until their final moult. The imagos were killed with potassium cyanide and then preserved dry or in 70% alcohol. The final nymph slough and the subimago exuvia were both preserved for future reference.

In this way about 180 specimens were bred out. Altogether there were taken 29 species belonging to 16 genera.

The following are the genera represented:

Sub-family *Ephemerinae*
1. *Hexagenia.*
2. *Ephemera.*

Sub-family *Heptageninae*
1. *Heptagenia.*
2. *Ecdyurus.*

Sub-family *Baetinae.*
1. *Baetisca.*
2. *Leptophlebia.*
3. *Blasturus.*
4. *Choroterpes.*
5. *Ephemerella.*
6. *Drunella.*
7. *Caenis.*
8. *Tricorythus.*
9. *Chirotenetes.*
10. *Siphlurus.*
11. *Baetis.*
12. *Cloëon.*

Dr. Anna H. Morgan was kind enough to identify a number of species for me.

Hexagenia bilineata Say.

(Pl. XIII, Fig. 1).

Nymphs of this species were first taken on June 6, 1912, by dredging in water 15 to 45 feet deep. The bottom was very muddy. These were taken to the laboratory and about ten were placed in a breeding-jar, ¾ filled with soft muck. The nymphs immediately began to burrow, using their fore-legs to displace the mud. They were able to bury themselves in a remarkably short time. At first the gills were left partly exposed and the position of the creatures could be detected by the waving motion of these in the thin mud. They remained this way for a short time, but later on only the round openings of their burrows could be seen.

The first subimago to emerge from the breeding-jar was on July 3, and others followed during July and August. One nymph was still alive in the jar when I stopped my work on September 9th. On June 13th the first subimago was captured at large and from this on a few subimagos and imagos were taken at various times, but not until June 28th did they appear in large numbers. On this date about dusk, a large number of females were discovered flying up and down a long narrow channel between an island and the mainland. They dipped down frequently to deposit their eggs and many fell victims to hungry fish. For a couple of weeks after this, this species appeared in immense numbers. They commenced their flight about three-quarters to half an hour before dark and swarmed about the tree-tops, forty feet high. None were observed after July 23rd. On July 12 I caught a female just after copulation and held her over a jar of water, touching her abdomen to the water occasionally and she deposited a large number of eggs. The water was changed from time to time to keep it from becoming stagnant, and on August 17 a number of very small nymphs appeared. This was a period of thirty-six days.

Description of nymph. Length of body 30-35 mm.; setæ 13-15mm.; antennae 5-6mm. Head yellowish with the dorsal surface between ocelli and between eyes entirely brown, or in some cases lighter along median line and posterior margin. Antennae very hairy at joints of basal halves, while apical halves are entirely bare and become very slender. Margin and base of frontal piece hairy. Clumps of hairs between eyes and bases of antennae, in front of lateral ocelli and posterior to eyes. Mandibular tusks, ¾ length of antennae, upcurved, brown at tips, and with three longitudinal rows of hairs. Prothorax brown for the most part dorsally. Each abdominal segment has a large almost triangular brown area with two light areas within it. These light areas often reduced to mere stripes. Ventrally on segments 6 to 8 a faint median longitudinal dark streak, while on 9th segment there are two lateral streaks. Setæ of about equal length and very heavy at joints for entire length. Gills and legs of the usual Hexagenia type.

Ephemera simulans Walker.

For some inexplicable reason I was unable to find *Ephemera* nymphs at Go Home Bay, although the imagos were very abundant and the shore was strewn with the nymph sloughs. Dredging failed to bring them up, although *Hexagenia* nymphs were dredged up almost everywhere in Go Home Bay. However, Mr.

R. P. Wodehouse kindly gave me a number of specimens which he took at Shawanaga Bay, about fifteen miles north of Parry Sound on June 9 in 2 to 8 feet of water; some from the south east shore of Manitoulin Island, June 26th, in water two to five feet, and at Waubaushene on May 31 in 6 to 9 feet of water. Nymph sloughs were taken at Go-Home Bay from June 24 to July 9.

The first imago of this species was taken on June 5th at Giant's Tomb Island, 4 miles south west of Station Island, but none were taken at Station Island until June 21. After this date they became very abundant and remained so until July 27th. The males occurred in fairly large swarms all along the shore. They maintained their position in the air by a dancing motion, at a height of 10 to 35 feet. They appeared shortly before 8 'clock in the evening and continued until dark. When a female appeared among them quite a commotion was noticed. The successful male flying up beneath the female would grasp her around the prothorax with his fore-legs, and, bending up his abdomen, would put his forceps around her abdomen. His setæ usually aided him in securing and maintaining his hold, by being bent up over the female's body. The couple would then go off on a gradual downward slant toward the water, before reaching which the male would disengage himself and fly back to the swarm, while the female would fly out over the water close to the surface and soon begin depositing her eggs, by skimming the water with her abdomen. A peculiar thing was noticed, namely, that the male *Ephemera* frequently attempted copulation with the male *Hexagenia* evidently being deceived by the colour.

Heptagenia.

This proved to be a very abundant and interesting genus and is treated separately elsewhere. The nymphs of eight species were taken and the imagos of all of them reared, three of which proved to be new species. The life histories of none of these have been previously described. Besides these eight, Mr. R. P. Wodehouse gave me several nymphs of another species which he discovered along the east shore of Manitoulin Island, June 26th, 1912. These were not bred, so the species has not been determined.

Genus **Ecdyurus.**

Ecdyurus maculipennis Walsh.

(Pl. XIII, Fig. 2).

The nymphs were quite widely distributed, being common along open stony shores and in rapids. They were taken as follows:

(1) At Station Island, on July 2.

(2) At Giant's Tomb Island on July 14, in a large stony bay commonly called the "Gap," on the west side.

(3) On August 19th at the South Watcher Island, 6 miles from the mainland. This island is about 3 acres in extent and composed entirely of loose stones, with a clump of small poplar, willow and alder trees in the centre, and was the breeding-ground of hundreds of gulls.

(4) In the rapids above Sandy Gray Falls, on August 23rd.

The imagos of these collections emerged on July 6th, 17, August 23 and 30th respectively. Only a few imagos were taken at large.

Ecdyurus lucidipennis Clemens*

(Pl. XIII, Fig. 3).

Male imago:

Measurements: Body 6 mm.; wing 7 mm.; fore-leg 6·5 mm.

Face very slightly obfuscated. Dorsal surface of head dark brown or reddish. Notum dark brown; sides of thorax and ventral surface light yellow. Dorsum of abdomen a blackish brown and venter considerably lighter. Penis lobes and bases of forceps yellow. Forceps tinged with black. Setæ: basal half slightly tinged with black, minutely hairy. Fore femora dark, middle and hind yellowish. Wings hyaline; longitudinal veins slightly dusky, especially costa and subcosta; cross veins entirely colourless.

Female imago:

Measurements: Body 6 mm.; wing 7·5; fore-leg 4.

Thorax and abdomen lighter in colour than male.

Nymph:

Measurements: Body 7-8 mm.; setæ 3-4 mm.

Head brown with numerous light spots, chief of which are 6 along anterior margin; 2 lateral to each antenna, 4 elongated ones between antennæ and 2 small round spots anterior to these latter. Thorax lighter brown with numerous light areas. Anterior part of each abdominal segment brown. Four light spots along anterior margin, one large spot at each lateral margin and 3 along posterior margin. Setæ of about equal length and fringed with hairs; middle one slightly smaller in size than lateral ones. Femora flattened, fringed with spines along anterior margin and with hairs along the posterior; rather light in colour with two zigzag brown marks about middle and brown areas at distal and proximal ends. Tibiæ banded about the middle with brown. Tarsi with distal and proximal ends dark.

Nymphs of this species were collected at Station Island, July 1, and at Giant's Tomb Island, July 14th. Imagos were reared from these collections on July 4 and July 17 respectively.

Ecdyurus pullus Clemens†

(Pl. XIII, Fig. 4).

Male Imago:

Measurements: Body 10-11 mm.; wing 11 mm.; setæ 22 mm.; fore-leg 11-12 mm.

*Clemens, '13, p 329.

†Clemens, '13, p. 330.

Face pale, slightly tinged with brown along the carina. Dark brown on dorsal surface of head between eyes. Pronotum dark brown; mesonotum lighter; a dark brown line on each side of prothorax, extending forward from base of fore wing; other dark brown marks at bases of wings and legs. Dorsal surface of abdomen dark brown, somewhat lighter laterally toward anterior margin. Ventral surface light in colour. Genitalia of usual *Ecdyurus* type. Legs light in colour, dark at joints. Tarsi of fore legs in order of increasing lengths 1, 5, 4 (3 and 2) equal. Wings with longitudinal and cross veins brown, and very slightly darkened in apical costal region.

Nymph:

Measurements: Body 12 mm.; setæ 15.

Head brown with a colourless area on each side from eye to lateral margin of head and 3 light dots between eyes; slightly fringed with hairs along anterior margin. Pronotum somewhat lighter in colour than head, colourless areas along anterior and lateral margins and a light area about the middle of each half of pronotum. Mesonotum darker with numerous light spots. Each segment of abdomen brown; 1-8 have 6 light spots; on segments 4-8 the 2 near the median line are fused, forming a large, almost rectangular spot; segment 9 with only 4 light spots; segment 10 entirely brown. Gills comparatively small; lamellæ oval. Setæ of about equal size, with each 2 alternate segments brown; sparsely fringed at joints; outer margins of lateral ones not fringed. Femora stout and flattened, brown in colour; lighter at distal and proximal ends and 2 or 3 irregular light areas toward middle; covered with minute spines and fringed along posterior margin with hairs. Tibiæ alternately light and dark banded, fringed along both anterior and posterior margins. Tarsi brown with proximal tips colourless. Ungues double on each leg; the large one well curved; the other small and lateral to the large one.

The nymphs were collected along the very stony shores of islands three and four miles out in the open bay, from June 23 to July 6. Imagos were reared on July 2 and a few captured June 27th.

In the key to the genera of Mayflies of North America by Professor Needham in Bulletin 86, New York State Museum, there is a slight error in the separation of the genera *Ecdyurus* and *Heptagenia*. In *Ecdyurus* the basal segment of the male fore tarsus is shorter not longer than the fifth segment and the second and third segments of equal lengths. In *Heptagenia* the basal segment of male fore tarsus is longer than the fifth segment and the second and third segments may be equal or unequal.

Baetisca obesa Walsh.

This very interesting nymph was taken in only two localities. The one was along the north east shore of Giant's Tomb Island. This shore is quite sandy with numerous small stones and deepens very gradually. The nymphs were abundant here May 26, clinging to the stones in water from 3 to 15 inches deep. Some

of these were put in breeding jars, but did not emerge until July 13. On July 14 I visited this place again but could not find a single specimen, nor any sloughs along the shore. The other locality was the south east shore of Station Island, but the nymphs were not abundant. Only one imago, a female, was captured.

Leptophlebia (?) praepedita Eaton.

The only representative of this genus was a single almost mature nymph taken on July 21st in quiet water at the side of an old lumber chute. I was unsuccessful in breeding it and so am doubtful as to the species. It agrees with the description by Professor Needham, Bulletin 86, N.Y. State Museum, but this description is rather more generic than specific.

Genus **Blasturus.**

Blasturus cupidus Say.

This is an early species. Nymphs were first taken May 23. Subimagos appeared May 31 and transformed next day. The imagos were never very abundant and were captured around Station Island only. The last observed was June 9.

A small nymph collected May 31 was observed to be filled with small oval brownish bodies. These, upon dissection by Mr. A. R. Cooper, were found to be a trematode of the genus *Halicometra* and its eggs. Another nymph taken some time afterwards was also discovered to be parasitized.

Blasturus nebulosus Walker.

The nymph and imagos of this species were first taken June 9, on a small bare granite island, a short distance out in the open bay. On the top of this island were numerous pot holes of all sizes filled with water, and in these, under loose pieces of rock and some rubbish, the nymphs were very abundant, having tadpoles, chironomid larvæ and water beetles for associates. Many were covered with *Vorticella*. Several nymphs were seen to crawl out of the water and transform on the rock. Subimagos were clinging to the sides of the rocks in sheltered places while a few imagos were flying above the pools.

This species was again taken on June 27th on an island 5 miles from the mainland. This island had an area of about 3 acres and was almost smooth bare granite. On top was a pretty lagoon margined with water plants, shrubs and a few small trees. Imagos of *B. nebulosus* were dancing over this pond in the sunlight about 3 p.m., matings frequently occurring. A few nymphs were taken from the lagoon.

Up to the present time I have not been able to find any difference between the nymphs of these two species, but am adding a description of the nymph of *Blasturus nebulosus*.

Nymph:

Measurements: Body 9·5 to 10 mm.; setæ, 7-10 mm.

General colour blackish brown. Head with a dark area behind middle ocellus and between lateral ones; black, scroll-like markings between the eyes. Prothorax has a small light spot on each side, close to median line and near anterior margin; posterior to this and, farther from the median line is another larger oval light spot. Lateral to this is an elongated light area, beyond which is the light rounded lateral margin of the prothorax. Abdomen is blackish brown, with light brown markings. Segments 5 or 6 to 10 have a light median longitudinal stripe. On each segment is a slightly elongated incurved small light spot on each side of median line toward the anterior margin of the segment; posterior to this and more lateral is a larger round light area, which disappears usually on segments 8, 9 and 10. Ventral surface is light brown with three faint dark longitudinal lines, one median and two lateral. On each side of the median line in each segment is a very small, white oblique line near anterior margin and posterior to this is a small, white dot. Median seta shorter, slenderer and lighter in colour than the lateral ones. All fringed with hair at joints. Legs light brown. Posterior margin of tibia and tarsus fringed with hairs; anterior margin of femur fringed with spines, while anterior margin of tibia and tarsus have numerous serrated teeth. Inner margin of ungues with a row of teeth for its entire length.

Choroterpes (?) **basalis** Banks.

This is a late summer form. When I was beginning to think I had exhausted the collecting ground, I discovered this form in a small creek which formed the outlet of a chain of small lakes and which I had not visited for a month and a half. Large numbers of the nymphs were found here, July 30, clinging to stones in the quiet water. The next day several imagos emerged. As late as September 5th mature nymphs could be found. On July 31 a few nymphs were taken at Station Island and imagos on August 19th.

This later appearance of imagos at Station Island was noted also in the case of *Heptagenia tripunctata*. Mature nymphs of this species were taken in this creek May 31 and imagos emerged June 2, whereas no imagos appeared at Station Island until June 11th. This was probably due to the lower temperature of the water of Georgian Bay.

Genus **Ephemerella.**

Ephemerella lutulenta Clemens.*

Male imago:

Measurements: Body 8-9 mm.; wing 10 mm., setæ 12-14; fore-leg 8.

Face dark brown; a spotted reddish gray streak down carina and 2 similar

*Clemens, '13, p. 335.

lateral streaks from it to the base of antennae. Thorax dark reddish brown. Abdomen blackish brown; segments 9 and 10 slightly lighter in colour. Venter pale. Posterolateral margin of 9th segment produced into spines. Forceps pale with tips brown. Setæ reddish brown towards base but becoming pale toward tip; joinings brown. Legs greenish yellow, ungues brown. Segments of fore tarsi in order of increasing lengths 1, 5, 4, 3, 2; 1 very small; fore femur about 5/6 length of fore tibia. Wings entirely clear.

Female imago:

Measurements: Body 9-10 mm.; wings 10; setæ 10-12; fore-leg 5.

Quite similar to male. Posterolateral projection of 9th abdominal segment not as long as in male. Ninth segment ventrally produced posteriorly into a truncated triangular plate, with end emarginate.

Nymph:

Measurements: Body 10-11 mm.; setæ 6-7.

A large species, with colour varying from a dirty brown to a deep blackish brown, often of a granular appearance. Body and legs hairy. Head with a pair of occipital tubercles of varying size; in the male sometimes obscured by the developing eyes of the imago. Pronotum rectangular. Abdominal segments 2-9 produced laterally into flat spines; none on segment 1, minute on 2, increasing in size to the 9th; none on segment 10. A double row of spines on dorsal surface, very minute on segment 8-10, large on 1-7. On venter 6 small black dots on each segment, sometimes very faint. Rudimentary gills on segment 1; gill on segments 4-7; a large jointed elytroid gill cover 1·5 mm. in length. Femora stout, brown in colour with numerous round white dots and several irregular light areas. Tibiae with median brown band, distal ends light, proximal ends dark. Tarsi about same length as tibiae and with proximal half dark and distal half light. Claw with numerous pectinations. Setae well fringed with hairs along middle, almost bare at base and tip. Each 2 alternate segments brown.

The nymphs were taken almost everywhere about Go Home Bay from May 29th to June 19th. Mr. R. P. Wodehouse has also given me specimens from various places around Georgian Bay including Shawanaga Bay, Pentecost Island, French River, Sturgeon Bay.

Ephemerella lineata Clemens.*

(Pl. XIII, Fig. 5).

Female imago:

Measurements: Body 9 mm.; setæ 14; wing 10·5 mm.

Very similar to female of *E. lutulenta* but has a distinct rusty brown median longitudinal stripe on dorsal surface of abdomen. In a fresh specimen the stripe would probably extend over the thorax and thus correspond to the stripe of the nymph.

*Clemens '13, p. 336.

Nymph:

Measurements: Body 10 mm.; setæ 6 mm.

Slightly smaller than *E. lutulenta*, but very similar in colour, except that there is a dorsal median longitudinal white stripe from the interior margin of pronotum to the posterior margin of 10th abdominal segment. This stripe lies between the double row of spines on the abdomen. Occipital tubercles slightly longer than those of *E. lutulenta*.

The nymphs of this species were not very abundant and were found in about the same localities as *E. lutulenta* from June 3 to July 9. My bred specimens are dated June 14th and June 15th. I was unsuccessful in rearing a male.

Ephemerella bicolor Clemens.*

(Pl. XIV, Fig. 1).

Male imago:

Measurements: Body 5–6 mm.; wing 6mm.; setæ 8–9; fore-leg 6.

A small wholly brown species. It is very similar to *E. lutulenta*, in form and structure and apparently there are no satisfactory characters by which to distinguish it, except its size.

Female imago: slightly larger than male.

Nymph:

Measurements: Body 6–6·5mm; setæ 3mm.

These nymphs show a great variation in colour pattern. The light coloured specimens are of a dirty white colour with brown markings. Head for the most part brown, slightly paler towards posterior margin. Sides of pronotum brown; anterior margin of mesonotum brown and a brown area at posterior margin between the wing pads. Anterior halves of abdominal segments 2 and 3 brown and slight marks on 4th segment; brown areas on 6 and 7 about the median line, and on segment 9, there are 2 small brown dots at anterior margin and a rather semicircular brown band posteriorly. Some specimens are almost entirely brown and between these two extremes the amount of brown and white varies. A few specimens, especially females, show a slight indication of tubercles but they are never large as in the preceding species. A double row of spines on abdominal segments 1–7. Posterolateral margin of 3–9 produced into broad flat spines. Gills on segments 4–7, covered by a large jointed elytra. Setæ light brown basally, becoming paler distally; well-fringed with hairs; joints brown. Legs rather small; femora stout; colour for the most part brown, divided into 2 areas; the proximal one large and contains a rectangular white spot; the distal one smaller and contains a perfectly round white dot. Tibiae brown at proximal end and a brown band near distal end. Tarsi with a brown band toward proximal end; claws dark and pectinated.

The nymphs were everywhere abundant, especially along the open shore of Station Island. I have them also from Rattlesnake Harbour, Gray Island, Giant's Tomb Island, and Musquash River. The dates are from June 3 to July 9. Imagos were captured and reared from July 1 to July 12th.

*Clemens, '13, p. 336.

Genus **Drunella.**

I have two nymphs of this genus, identified for me by Dr. Morgan, but as I have not reared any imagos, I think it advisable not to describe the nymphs at the present time.

Caenis diminuta Walker.

This little nocturnal species came to the lamp in the reading room for the first time on July 2, and was taken as late as August 12th.

The nymphs are quite abundant in shallow, almost stagnant pools and lagoons from June 5 to July 30. I have them from various places around Georgian Bay.

Tricorythus allectus Needham.

The nymph was dredged up from a slightly sandy bottom in water 5 to 15 feet deep on Sept. 3. They were not reared, but imagos were taken July 3 and 9.

Chirotenetes albomanicatus Needham.

On June 16 I found a nymph slough at Sandy Gray Falls on the Go Home River but was unable to find either nymphs or imagos. I did not get up to the falls again until August 23 and then found the numerous small nymphs of the next generation.

Siphlurus flexus Clemens.*

Two beautiful *Siphlurus* nymphs were taken early in the season but both died before time of emergence. The first was found May 25th in the bottom of a canoe when some water was being emptied from it. The other was found June 3 beneath a stone in about one and a half feet of water along the open exposed shore of Station Island. Quite a number of imagos, apparently *Siphlurus,* were captured about this time and it seemed quite probable that they were the same species as the nymphs; and I think I have proved this quite conclusively by the wing venation. The wing of the imago has a very characteristic bend in Cubitus 2 at the base and the wing pad of the nymph shows this bend very distinctly. Again, the imago apparently has claws like an *Ameletus,* the two on one leg being unlike, and this can be made out in one nymph distinctly, due to the nymph dying just when about to emerge.

Male imago:

Measurements: Body 13–14 mm.; wing 12–13; setæ 23–24; fore-leg 12–13.

Head blackish brown except lower part of face, which is hyaline, tinged with brown; eyes large, meeting dorsally. Notum blackish brown. Sides of thorax marked irregularly with white. Abdominal segments 1, 8, 9 and 10 dark, segments 2–6 lighter in colour; these are light toward anterior margin and brown toward posterior; in the median line the brown is dark and forms a triangular area, the

*Clemens, '13, p. 338.

apex extending almost to the anterior margin; from the anterior margin in the median line, 2 bands arise, composed of black dots, which pass backwards curving outwards and ending near the base of the triangular brown area; between this line and the triangular area is a light brown oval area; segments 7–10 almost entirely blackish brown dorsally, but 7 and 8 have triangular white areas on sides, and 9 a slight indication only; segment 10 has sides of dorsum white, ventrally segment 1 dark brown; remainder white with brown markings; segment 2 has 2 brown spots, 3 with 2 smaller brown spots and a slightly reddish area at anterior margin in median line; on 4 and 5 the brown spots become smaller and the reddish area larger; segment 6 the reddish area is elongated to the posterior margin; segments 7 and 8 have a median longitudinal brown line, thickened about the middle, and 2 dots of unequal size on each side of it; segment 10 brown except for a lateral white streak on each side. Forceps white; 4 jointed; setæ white with brown joints, minutely pubescent. Fore-legs brown; femur with a light area near distal end, lateral to which is a dark brown band; tarsi with segments 1, 2 and 3 about equal in length, 4 slightly shorter, and 5 about half the length of 4. Hind legs lighter in colour than fore; a brown band on femur is distal half; tibia with a brown band about middle; tarsus light but brown at joints; joint between tibia and tarsus 1 not distinct. Claws unlike. Wings with brown neuration; costal cross-veins and others towards base of wing margined more or less with brown; slightly clouded in apical costal area; a heavy brown cloud at bulla; often a small cloud at bifurcation of median vein; cubitus 2 strongly bent at base. Hind wing with a large brown cloud at base.

Nymph:

Measurements: Body 15 mm.; setæ 5 mm.

I have two of these graceful nymphs, a male and a female, both mature, but unfortunately both died when just about to emerge. On this account it is difficult to describe the colour pattern as the body of the subimago shows through the nymph skin.

Head vertical; body curved. Posterior lateral margins of abdominal segments 1–9 produced into spines. Dorsal colour pattern distinct on segments 9 and 10 only; 9th segment pale with a short brown median longitudinal stripe, commencing at anterior margin; on each side of this is a short stripe of about the same length, but placed more posteriorly; lateral to this again is a large brown area, roughly triangular, apex at posterior margin, base at anterior; at lateral margin slightly below middle line is a small brown spot; on 10th segment is a median brown longitudinal stripe with 2 dots on each side of it. Ventral surface of abdomen white with 3 longitudinal brown stripes, one median and 2 lateral. Gills on segments 1–7; double on 1, 2 and 3. Three setæ of equal length; lateral ones fringed with hair on inner margins only except towards tips; in these specimens the lateral setæ are brown, lighter towards tips, while the median one is whitish; setæ banded toward distal end with brown. Legs pale; femur with proximal end brown and a brown band beyond middle; tibia with a brown band about the middle; tarsus with brown band towards proximal end; fore tarsus much longer

than fore tibiae; fore tarsus only slightly longer than hind tibiae; fore claw rather short, broad and bifid at tip; hind claws about twice length of the fore and very pointed.

Imagos were captured on the following dates; May 23, May 26 and June 12th. On the latter date a swarm or 12 or 15 individuals was observed flying off the west shore of Island Station from 12 to 20 feet from the surface of the water at 5.30 p.m. About 8 of these were taken.

Baetis propinquus Walsh.

The imago is described in Eaton, but my specimens do not show the subopaque area between the 2 nervures of the hind wing.

Nymph:

Measurements: Body 6 mm.; setæ 2.

Face vertical, mostly brown in colour; on dorsal surface of head on each side of median line is a row of irregularly shaped light spots. Notum brown with various light areas. Dorsum of abdomen for the most part brown; segments 2-4 brown with a light area in each half of segment and colourless margins; on segment 4 there is also a light area in median line; segment 5 quite light in colour; segment 6 brown with a light area along anterior margin and 2 faint ones posterior to it; segments 7 and 8, each with two rather large pale areas in posterior half; segment 9 almost entirely pale; segment 10 slightly brown, especially along posterior margin; on each side of the brown segments there are 2 small faint, pale, oblique, slightly curved streaks and a pale dot posterior to each. Ventrally the joinings of segments brown. Setæ slightly tinged with brown, with tips darker brown and a brown band beyond the middle; lateral setæ fringed on inner sides only. Legs pale; femora banded with brown about middle; tibiæ and tarsi darker toward distal ends; each claw with a lateral row of pectinations.

Nymphs of this species were taken at Go Home Bay from June 14 to July 22; on August 19 large numbers of them were discovered in a little bay of a small bare island about three miles out in the open. This rock was the home of numerous gulls and hence is commonly called "Rookery Island." The nymphs were mature and imagos emerged on August 21 and 22

Cloëon dubium Walsh.

The imagos I have agree with the description in Eaton, except that the intercalar veins are single, not in pairs. Probably the description is in error as the genus *Cloëon* typically has the intercalar veins single.

Nymph:

Measurements: Body 4-4·5 mm.; setæ 1·5.

Face vertical with 2 large pale areas above antennæ; between eyes a large pale area partly divided into 2 and containing 2 brown stripes. Notum brown

with irregular light areas. Dorsum of abdomen brown except lateral margins which are colourless; on each segment there are 2 small oblique pale streaks and 2 round dots posterior to the streaks. Setæ pale with brown band toward distal end; lateral setæ fringed on inner sides only. Gills double, apparently on segments 1 and 2 only; broader than gills of *Bætis;* a main trachea in each, slightly to outer side and branchlets on inner side only. Legs pale; femora banded with brown in distal half; tibiæ and tarsi brown toward proximal ends; claws comparatively long, sharp-pointed, and not pectinated.

The nymphs were not very abundant; my collections date from July 30 to Aug. 12.

Imagos were reared July 30 and August 2. Adults were quite numerous at Station Island about July 10, flying in small swarms along the shore, at a height of from 10 to 15 feet. They appeared about 7·45 in the evening.

This paper and the following one on the genus *Heptagenia* contain the results of but a few months collecting and rearing. The complete life histories of 9 new species were secured and the hitherto unknown nymphal stages of 9 other species determined by rearing. Besides a few observations on the habits of several species have been recorded. The results may be taken as an indication of the richness of our inland waters in aquatic insect life.

I am adding a diagram showing the length of time imagos of these species were seen, captured or bred. I find in a number of instances that the dates are somewhat later than those given for the same species at Fall Creek, Ithaca, New York.

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EXPLANATION OF PLATES.

PLATE XIII.

Fig. 1. *Hexagenia bilineata* Say.
Fig. 2. *Ecdyurus maculipennis* Walsh.
Fig. 3. *Ecdyurus lucidipennis* Clemens.
Fig. 4. *Ecdyurus pullus* Clemens.
Fig. 5. *Ephemerella lineata* Clemens.

PLATE XIV.

Fig. 1. *Ephemerella bicolor* Clemens.
Fig. 2. *Bœtis propinquus* Walsh.
Fig. 3. *Cloëon dubium* Walsh.
Fig. 4. Venation of wing pad of *Siphlurus flexus* Clemens.
Fig. 5. Wings of *Siphlurus flexus* Clemens.
Fig. 6. Fore-claw of nymph of *Siphlurus flexus* Clemens.
Fig. 7. Fore-claws of imago of *Siphlurus flexus* Clemens.

Fig. 1

Fig. 2

Fig.3

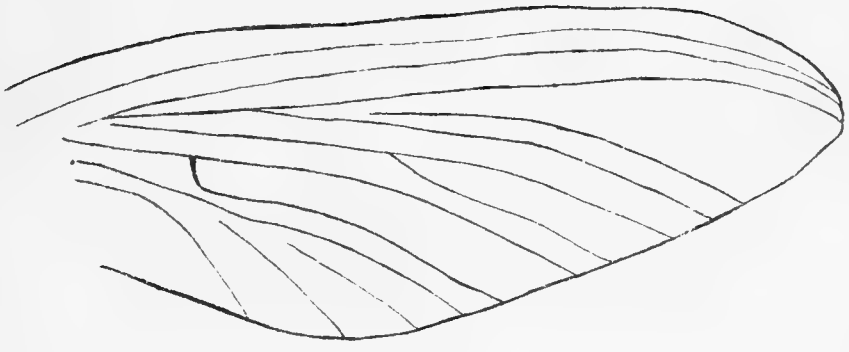
Fig.4

Fig.5

Fig. 2

Fig.3

Fig. 1



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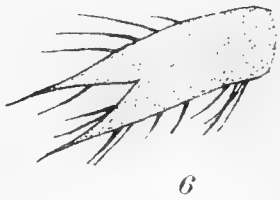

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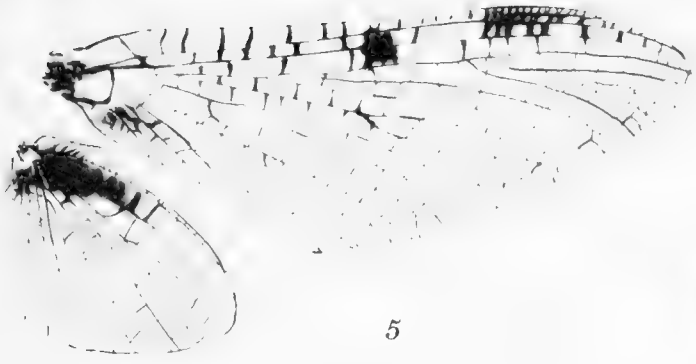

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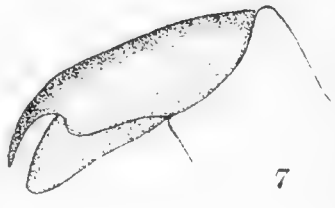

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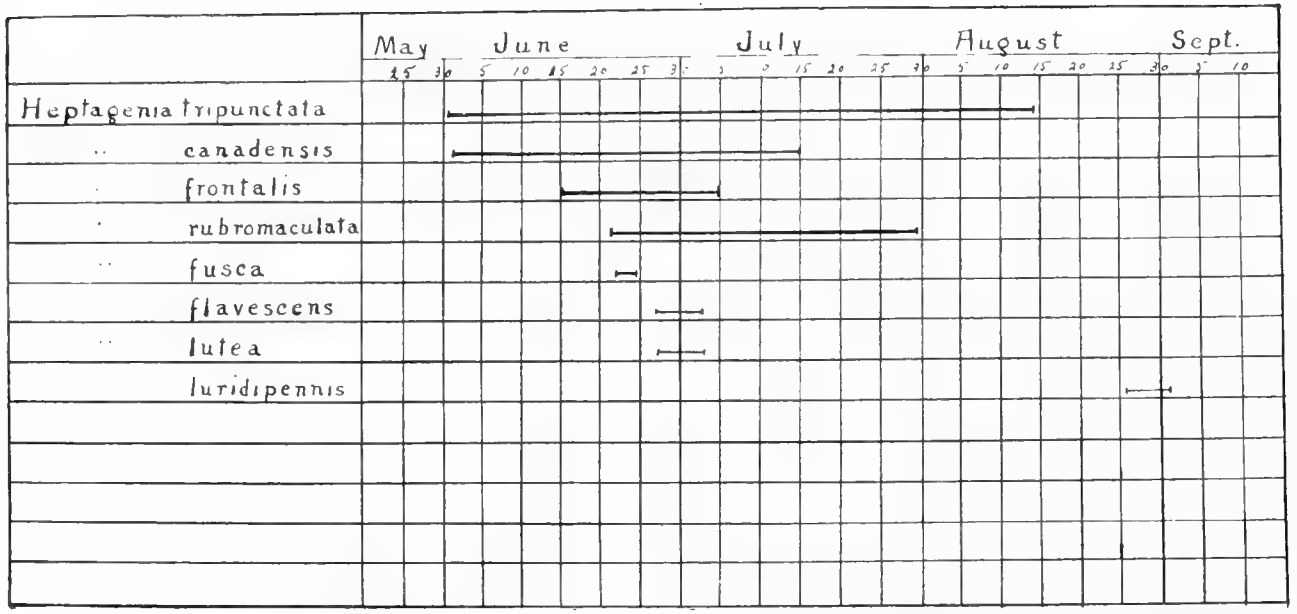

Fig. 1. Plan showing seasonal distribution of *Heptagenia*.

V.

LIFE-HISTORIES OF GEORGIAN BAY EPHEMERIDAE OF THE GENUS HEPTAGENIA.

By W. A. Clemens, B.A., University of Toronto.

(*Plates XV—XVIII, and 1 figure in the text*)

In the preceding paper on the mayflies or Ephemeridæ of Georgian Bay, the consideration of the genus *Heptagenia* was omitted for reasons there stated. The present paper is based on the results of observations and breeding experiments in connection with this genus covering a period of slightly over three months during the summer of 1912.

The genus *Heptagenia* is a comparatively large one as it occurs in America. Rev. A. E. Eaton in his Monograph of Recent *Ephemeridæ* made a summary of the then known North American species, amounting in all to at least 13, some of them, however, having been referred tentatively to the genus *Ecdyurus*. In 1910 Mr. Nathan Banks described 4 new species, making a total of 17 species recorded from America. Up to the present the nymphs of only 2 of these have been described namely. *Heptagenia pulchella* Walsh, and *H. interpunctata*, Say, both by Professor J. G. Needham in 1901 and 1904 respectively. In this paper are given the descriptions of the nymphs of five more as well as descriptions of the nymph and imagos of 3 new species.*

The nymphs of this genus inhabit swift water for the most part; clinging close to the sides and bottoms of stones. They are adapted to this life by reason of many interesting specializations, chief of which are, much-flattened bodies, flaring margins to head, spreading legs with flattened femora, pectinated claws, gills dorsally placed in an overlapping series and spreading setæ. A few species, however, are common in quiet water, notably *Heptagenia canadensis*, and *H. frontalis* while *H. tripunctata* was found to be everywhere abundant. The nymphs are quite active, for when a stone is lifted from the water they scurry over its surface usually seeking the lower side. The clinging habit was frequently demonstrated when quite a number were brought in and put in a vessel of water without a stone or stick for them to cling to; not having anything else, they would begin clinging to each other and soon would all be in a single mass. As for food, being herbivors, they usually find abundance of various algal forms on the stones to which they cling.

A *Heptagenia* completes its life-cycle in a year. The egg is deposited in the water and hatches in about 40 days. The remainder of the mayfly's life is spent in the water as a nymph with the exception of a short aerial life of from 2 to 4 days as a subimago and imago. As the time of emergence approaches, the nymphs probably migrate to the quieter water. I have not observed a *Heptagenia* emerge

*Since the above was written these new species have been described by the writer (Clemens) '13).

in the open, but in the laboratory they were observed to crawl up the sticks placed in the breeding-jar for the purpose and transform just above the water-level. The subimago stage generally lasted a day, but in the early part of the season it quite frequently lasted 3 days, and in a couple of instances 4 days. No doubt this time would have been shortened had the subimagos been out of doors. The imagos never appeared in large swarms as in the case of *Ephemera* and *Hexagenia*, but a swarm would consist of perhaps 50 to 100 individuals. They would begin their flight from three quarters to one half an hour before dusk, dancing up and down in their rhythmic manner at a height of from 12 to 20 feet. On calm evenings they could be found in numerous swarms all along the shore of the island, but on windy evenings would congregate on the lee side. The females of all the species observed at Station Island deposited their eggs by skimming the surface of the water and brushing off the eggs as they appeared from the openings of the oviducts. The earliest species was *H. luridipennis*, mature nymphs of which were taken on the afternoon of May 31, and one subimago emerged the same afternoon. The last was *H. luridipennis*, the imagos emerging Sept. 2, from nymphs collected August 23rd.

The following are the generic characteristics of the *Heptagenia* nymph:

Body flattened; head orbicularly rounded with flaring margins; eyes dorsally placed; postero-lateral angles of abdominal segments produced into spines; femora flattened; gills on segments 1 to 7, placed dorsally in an overlapping series and in life move in waving undulations; lamellae oblong or oval pointed, the 7th small and lanceolate. Branchial filaments bifid and united basally into a flat triangular plate. Setæ from one to one-and-one-half times length of body, spreading, fringed with hairs at the joints of the segments. **Mouth parts**—labrum with width nearly twice the length and a row of short spines along the ventral surface, just inside the anterior margin. Anterior margin densely fringed with hair. Mandibles rather triangular in shape; fangs two in number, the exterior one of the right mandible stouter than inner and separated along inner edge; the inner fang bifid at tip. Mandible fringed with hair along the exterior margin. Lacinia of first maxilla externally rounded, the anterior part being beset with spines and hairs. The internal margin beset with a very dense even row of hairs and fine bristles and several spines at upper corner. Palpus 3-jointed, basal one small, middle one stout, distal longer and more slender ending in a curved tip; a row of short spines near the apex. Palpus hairy along outer and inner margins.

Labium with two pairs of lobes. The outer oval and densely covered with hairs; the inner more slender, more pointed and incurved; also hairy. The anterior end of the distal segment of the palpus densely beset with long hairs and sharp pointed projections with teeth along inner sides, somewhat resembling a rake. Beneath this crown is a chitinized ridge. Hypopharyax with a triangular tongue; paraglossae extend outwards with ends curved slightly backwards.

Generic characters of the imago:

Fore leg of male as long or slightly longer than body. The lengths of male fore tarsi arranged in order of increasing lengths are 5, 1, 4, 3, 2; 3 and 2 equal

in some forms. Eyes simple; large, especially in male. Antennae short, 1 to 1·5 mm. Setæ 2½ to 3 times length of body; segments of basal half alternately darkened; minutely pubescent. Penis lobes extend backwards and outwards, almost L-shaped. In some forms the lateral extension lacking and hence rather oblong in shape. Stimuli adjacent between the lobes.

The species which I have taken fall into two distinct groups:—

In the first group, consisting of *H. tripunctata, H. luridipennis, H. flavescens, H. rubromaculata, H. fusca, H. Lutea,* the nymphs are characterized by having the lamellae of the gills oblong, claws usually pectinated, the distal segment of maxillary palpus thickest about its middle and with a small tuft of hair near its end. The body is much flattened and the colour more or less brown. The male imagos have the penis-lobes L-shaped and the 2nd and 3rd tarsal segments of fore leg are equal, while the fourth is about 4/5 the length of the 2nd.

In group 2, consisting of *H. canadensis, H. frontalis* and a third undetermined species represented by the nymph only, the nymphs have the lamellae of the gills oval and produced distally into a sharp point; claws are not pectinated, the distal segment of maxillary palpus thickest toward distal end and the tuft of hair is larger than in group 1; usually there are more teeth along anterior margin of lacinia. The body is less flattened and more reddish or yellowish. The male imagos have the penis lobes oblong, not L-shaped and the 2nd and 3rd tarsal segments not quite equal, while the 4th segment is about ½ the length of the second.

Key to Male Imagos

A. No black spots or bands on face below antennae, Group 1.
  B. Very pale species.
    C. Notum ferruginous, stigmal dots distinct ..... H. flavescens.
    C.C. Notum lighter; no stigmal dots ..... H. lutea.
  B.B. Dark species.
    D. Large, entirely brown species.
      E. Thorax with a broad dark median stripe or two narrow stripes close together ..... H. verticis.
      E.E. Thorax without dark median stripe ..... H. fusca.
    D.D. Not entirely brown
      F. Two very small dots on median carina between antennae ..... H. luridipennis.
      F.F No dots on median carina. Thorax and top of abdomen dark.
        G. Reddish area in pterostigmatic space of wing. ..... H. rubromaculata.
        GG. Without reddish area in wing ..... H. luridipennis.
AA. Two black spots or bands on face below antennae, Group II.
      H. A black band on face below antennae, a dark dash in wing. Abdomen dark ..... H. canadensis.
      HH. A black spot on face below antennae, no dash in wing, abdomen lighter ..... H. frontalis.

Key to Nymphs.

A. Gills oblong, Group I.

B. Nymphs entirely brown without a distinct dorsal colour pattern.

C. An inverted dark U-shaped mark on ventral surface of 9th segment and a dark spot on ventral surface of 8th. Dorsal surface of body has a smooth appearance.....H. flavescens.

CC. A row of dark mushroom-shaped marks along ventral surface and a rectangular dark mark on 9th. Dorsal surface has a rather granular appearance and lateral margins of body quite hairy. H. rubromaculata.

BB. Nymphs not entirely dark brown and have a distinct colour pattern.

D. Ventral surface of abdominal segments banded with dark bands along posterior margins.

E. Broad dark bands at posterior margin of each segment on dorsal surface.....H. fusca.

EE. Dark bands at posterior margins of segments 7, 8, 9, and 10, not as broad as preceding species and a more elaborate colour pattern.....H. lutea.

DD. Ventral surface not banded.

F. Two rows of black dots along ventral surface of abdomen. .....H. luridipennis.

FF. No dots .....H. luridipennis.

AA. Gills oval and pointed, Group II.

G. Two light longitudinal stripes on dorsal surface of abdomen close to median line.

H. Stripes fairly uniform for entire length. Reddish species..H. canadensis.

HH. The stripes not of uniform width, very wide on 8th segment, very narrow on 5, 6, and 7 so that darker intermediate parts have oval shapes. Lighter species.....H. frontalis.

GG. Dorsal surface of abdomen has appearance of 3 longitudinal dark stripes. Colour greenish yellow.....H. (undetermined species).

Mr. Nathan Banks kindly identified the imagos for me so far as possible.

Description of Species.

Heptagenia flavescens Walsh.

(Pl. XV, Figs. 4–5).

Male imago (Description taken from Monograph of Eaton, '88):

Measurements: Body 9+mm.; wings 11+mm.; setæ 27-38 mm.

Yellowish. Eyes bright greenish yellow during life. Notum ferruginous, sometimes verging upon piceous. Dorsum of abdomen ferruginous, darker at the tips of segments 2-7 and with a pair of subobsolete pale vittae at the base of each of them; venter pale greenish in segments 2-7 or 8. Setæ whitish; the joinngs fuscous. Fore leg pale ferruginous with a median and a terminal band on the femur, the tip of the tibia and the tarsal joinings and tips fuscous. Hinder legs

yellowish with the tips of the femora fuscous and the tarsal joinings and tips a little cloudy. Fore wing hyaline with a pale ferruginous cloud in the pterostigmatic region; neuration fuscous, excepting the basal ⅔ of the costa, subcosta and radius which are yellowish; the thickening at the bulla of the subcosta about 0·5 mm. long, is more or less obfuscated.

Female imago:

Measurements: Body 8 mm.; wing 10 mm.

Face clear; thorax yellow, slightly tinged with brown. Abdomen yellow; segments banded along posterior margin dorsally with black; stigmal dots marked. Femora with median and distal ferruginous bands. Most of the longitudinal veins of the fore-wing colourless; cross veins heavy and brown; very slightly clouded in the apical costal space; venation of hind wing almost colourless.

Nymph:

Measurements: Body 8–9 mm.; setæ 10–13 mm.

Head brown, very slightly covered with light dots; a light spot above each ocellus; a small light dot on each side of median ocellus; an irregular light area anterior and lateral to each eye. Pronotum brown with two light spots on each side; part of lateral margin. Mesothorax similar in colour to prothorax. Abdomen of a uniform brown colour dorsally, having a smooth appearance; lighter ventrally with a semicircular brown band on 9th segment and a median brown spot on 8th. Spines of lateral edge short. Setæ banded usually 3 dark and 1 light; sparsely fringed, usually only at base of light segment. Femora much flattened, brown and dotted with light spots, and having 3 irregular light bands; covered dorsally with small spines and posterior margin fringed with hairs and spines. Tibia with median and distal light bands. Tarsus tipped with white. Claws with two pectinations.

The nymphs of this species were taken up the Go Home River on June 16, 1912, immediately above Flat Rock Falls, where the water was flowing swiftly but smoothly. The nymphs were clinging to stones in water 1 to 1½ feet deep, not far from the shore. On this date they were also found just below Sandy Gray Falls in swift rough water, but close to shore. I was successful in rearing two specimens, but one escaped from the cage over the breeding-jar and could not be found. The remaining one was a female and hence to make the description as complete as possible, I have inserted the description of the male from Eaton. The dates of the two emergings were June 27 and July 3.

Heptagenia lutea Clemens.

(Pl. XV, Fig. 2).

Male imago:

Measurements: Body 9–10·5 mm.; wing 10·5 mm.; setæ 20 mm.; fore-leg 10 mm.

This is a light coloured species, slightly reddish on face below antennae; between ocelli and eyes, reddish brown. Thorax almost whitish yellow dorsally; light yellowish brown laterally; dark area on each side of pronotum; slight red and brown markings, beneath bases of fore and hind wings. Each of the abdominal

segments 1–8 banded dorsally at posterior margin, remaining parts of these segments being almost white; segments 9 and 10 entirely reddish brown; stigmal dots not marked; wings clouded in pterostigmatic space, a few cells reddish, femora with median and apical bands; tibia-tarsal and tarsal joints black; fifth tarsi and ungues dark.

Female imago:

Measurements: Body 11 mm.; wing 12 mm.; setæ 22 mm.

Abdomen more yellowish than male.

Nymph:

Measurements: Body 10 mm.; setæ 13–16 mm.

Head light brown in colour and dotted with light dots; light areas over ocelli; another at posterior margin of head in median line and a larger one lateral to each eye. Pronotum with a broad colourless lateral margin, remainder light brown numerous irregular light spots. Abdomen darker dorsally and with a rather complicated colour pattern. First segment light with 2 brown areas at side; 2nd, a narrow brown band along posterior margin and 5 brown areas and four light ones placed alternately; 3rd almost entirely dark with a few light dots; 4th with 2 dark spots in posterior lateral angles of segment; also a large dark area in centre of segment with a light area within it; 5th with a dark spot in each posterior lateral angle as in preceding segment; a dark band along posterior margin; 2 light areas surrounded with brown and a dark spot in centre of each; 6th almost entirely brown except for two light areas in anterior lateral angles; 7th with 2 large light areas with a brown dot in each toward inner side; 8th an irregularly light and dark coloured segment; 9th has a narrow brown band along posterior margin and a dark longitudinal stripe in median line; 10th almost entirely dark. Ventrally, the lateral and posterior margins of segments 2–8 dark; segment 9 with two large brown spots. Setae greenish; basal half well fringed at joints, distal half with each two segments alternately light and dark and few hairs at joints. Legs, femora with alternately light and dark irregular bands and covered with minute spines dorsally; posterior margin fringed with hairs; anterior margin also fringed but hairs shorter. Proximal end of tibia dark and has a dark band slightly beyond middle. Tarsi with a reddish brown band, very near proximal end. Claws with two pectinations.

The nymphs were quite abundant along the open shore of Station Island and west of it, my collections dating from June 3 to July 2. Besides I have a few from a small waterfall on the Musquash River, 3 miles south of Go Home Bay, taken June 30, and 3 small nymphs from Sandy Gray Falls, Aug. 23. Imagos emerged from June 27 to July 3.

Heptagenia fusca Clemens.

(Pl. XVI, Fig. 1).

Male imago:

Measurements: Body 10 mm.; wing 13; setæ 26.

No marks on face; ocelli almost in a straight line, middle one the smallest. Pronotum brown, slightly darker along the median line. Mesothorax uniformly brown. Abdomen with posterior $\frac{1}{3}$ of each segment of same brown colour as thorax

and projections from this band anteriorly in the median line, almost forming a continuous longitudinal stripe on the abdomen; the band widens slightly laterally also; remaining portions of each segment somewhat light brown; ventrally very slightly banded. Forceps and penis lobes of usual form. Femora banded in middle and at distal end. Wings large; costa, subcosta and radius light in colour while remainder of longitudinal and the cross veins brown. No cloud in pterostigmatic space.

Female imago:

Measurements: Body 10–12 mm.; wing 14 mm.; setæ 18 mm.

Quite similar to male, except that abdomen is considerably darker.

Nymph:

Measurements: Body 12–14 mm.; setæ 15–20; antennae 3 mm.

Head brown, dotted with light spots; usually 3 light areas at posterior margin between eyes and 2 lateral to each eye; anterior margin well fringed with hairs. A light longitudinal median line on pronotum; 2 light areas on each side and lateral margin colourless; remainder of pronotum brown with small light dots. Posterior $\frac{1}{3}$ of each abdominal segment 6–10 almost black; segments 1–6 brown; the remainder of each segment varying from light brown to greenish yellow; ventrally posterior $\frac{1}{4}$ of each of the segments 2–8 brown; 9th segment has 2 dark areas laterally. Femora light brown on upper surface with a few lighter areas and covered with minute spines dorsally; posterior margins fringed with hairs; proximal end of tibia dark brown and its third $\frac{1}{4}$ dark; proximal half of tarsus dark. Setæ well fringed with hairs at the joints.

While on a canoe trip up the Go Home River, June 16th, I collected a number of the nymphs of this species just below Sandy Gray Falls. The only imagos I have are the ones reared from this collection. The dates of emergence are June 23rd and 24th.

This species is close to *H. verticis* but lacks the dark median stripe on the thorax, and does not show the slightest trace of a dash in the wing under the bulla.

Heptagenia tripunctata Banks.

(Pl. XV, Fig. 1).

Male imago:

Measurements: Body 9-11 mm.; wings 12-13 mm.; setæ 25-35 mm.; forelegs 12-14 mm.

Two small dots on median carina, slightly below level of antennæ. Thorax brown; on pronotum a dark spot at anterior margin in median line, sometimes divided into two by a fine light line; two small dark spots just posterior to these; an oblique dark streak on each side of pronotum; a brown stripe on coxa of foreleg and extending up on side of prothorax.

Short dark stripes at bases of fore and hind wings. Abdominal segments 1 to 7 paler than rest of body; segments 8-10 dark, similar to thorax; three dots on dorsum of each abdominal segment at posterior margin; stigmal dots well marked. Setæ with alternate joints of basal half dark. Femur of fore-leg darkened at both ends and with a median band. Tibia-tarsus joint dark. Yellowish in apical costal space of wing and a reddish area in pterostigmatic space.

Female imago:

Measurements: Body 10-12; wings 14-16; setæ 22-25.

Nymph:

Measurements: Body 11-14 mm.; setæ 12-16.

Head deep brown, occasionally almost black dotted with light spots; three light areas along anterior margin of head and one at posterior margin between eyes. Pronotum similar in colour to head with light dots and about 5 larger light areas on each side; lateral margin with a light area which extends in some distance. A light area in antero-lateral angle of mesothorax. Femora stout with 5 irregular light areas; small spines very numerous; posterior margins fringed with hairs. Tibiæ with 2 dark and 2 light areas, arranged alternately. Abdomen similar in colour to head and thorax; a light area on segments 4 and 5 containing a small triangular dark area at anterior margin of segment 5, lateral to which are 2 dark dots; another light area on segments 7, 8, 9 and 10 containing 2 dark dots on 8 and 2 on segment 9; usually the 3 dark spots at posterior margin of the segments of the abdomen of the imago can be distinguished; ventrally two longitudinal rows of dark dots, increasing slightly in size toward posterior end; segment 9 usually with 2 pairs, the anterior pair small, posterior pair larger. Setæ with alternate dark and light areas. Gills have the lamellæ slightly rounded at distal end.

This species was by far the most abundant at Go Home Bay. The nymphs were found in almost every locality where there was a stone to cling to, except, of course, in stagnant water, and could be taken at any time during the three months. The first specimens bred emerged May 31, but the first capture was not made until June 11. On this date a small swarm of about 20 individuals was discovered about 8.15 p.m., flying from 10 to 20 feet high, facing north. One female and several males were taken. Soon after this they became very abundant and remained so until about July 5th. The last specimen bred is dated Aug. 13.

Heptagenia rubromaculata Clemens.

(Pl. XVI, Fig. 2).

Male imago:

Measurements: Body 8 mm.; wing 8 mm.; setæ 17 mm.; fore-leg 7 mm.

No marks on face; darker spot at posterior margin of head between eyes. Thorax dark; median longitudinal dark stripe on pronotum; dark brown stripe on coxa of fore-leg and extending up the side of prothorax. Abdominal segments 1-7 lighter; 8-10 dark, similar to thorax; each segment banded at posterior margin; stigmal dots distinct; wing has a reddish area in pterostigmatic space.

Female imago:

Measurements: Body 9-9·5 mm.; wings 13-14 mm.; setæ 15-22 mm.

Often slightly reddish on face beneath antennæ. Dark brown on dorsal surface of head behind ocelli. Abdomen varies from a reddish to a yellowish colour in dried specimens.

Nymph:

Measurements: Body 9-10 mm.; setæ 10 mm.

Head dark brown, dotted with minute light spots. Pronotum similar in colour to head; two light areas on each side, the outer one sometimes joined to the light margin. Abdomen dark brown with a granular appearance; sometimes a faint broad, dark longitudinal streak can be made out with 2 dots on each side of it on each segment excepting 9 and 10; ventral surface lighter with a median row of irregular dark spots and lateral rows of small dots or lines, the median dots sometimes broken up so that only 4 or 5 small dots remain in their place. On segment 9 the markings are usually jointed, forming roughly three sides of a square. Femora with 4 irregular dark bands; both posterior and anterior margins very hairy. Claws pectinated. A very hairy species, having anterior margin of head, sides of thorax and abdomen very hairy.

This nymph was first taken on June 15 in what is commonly called the Narrows, near the mouth of the Go Home River. The water here had a well-marked current, but scarcely swift. On June 30 I found them very numerous in the very swift water of a rapid near the mouth of the Musquash River. Nearly a month after this on July 20 and 22 I discovered mature nymphs at an old lumber chute on the Go Home River in fairly swift water.

Imagos were bred from the nymphs taken at the Narrows on June 22nd and 25th; at the Musquash rapids from July 3 to 5th; at the chutes July 24-29th. No imagos were captured.

Heptagenia luridipennis Burm.

(Pl. XV. Fig. 3).

Male imago:

Measurements: Body 7-8 mm.; wings 8 mm.; setæ 2 -22 mm.; fore-leg 8 mm.

Face clear; slight dark marks at posterior margin of head between eyes. Median longitudinal stripe on pronotum; sides brown; mesonotum dark brown; brown area in front of base of middle leg. Segments 1-7 of abdomen light coloured segments 8·9 and 10 dark, similar to thorax, narrow black bands along posterior margins of the segments; stigmal dots distinct. Apical costal area of wing not distinctly darkened and no reddish coloured area.

Female imago:

Measurements: Body 9 mm.; wings 10 mm.

Nymph:

Measurements: Body 7-8·5 mm.; setæ 10-14 mm.

Head brown with light dots; anterior margin fringed with hairs. Prothorax similar in colour to head; on pronotum a light spot on each side of median line; lateral to this another larger one and lateral to this again another which extends to the lateral margin. Abdomen similar in colour to prothorax; a row of black dots on each side corresponding to the stigmal dots of imago; segment 3 for the most part light with a round brown spot in median line and with two short projections laterally; segment 4 with a small triangular brown spot in median line

with base to anterior margin while the apex meets a large brown area leaving a small light area on each side of the triangle; lateral to the brown area is a light one and lateral to this is a triangular dark spot in the posterior angle of the segment; segment 5 much like the 4th; segment 6 entirely dark except for two small spots at anterior margin and 2 toward lateral margin; segment 7 with a triangular dark spot in median line with base to anterior margin and apex reaching about middle of segment; on each side of triangle 2 dark spots; segment 8 similar to the 6th; segment 9 irregularly marked; roughly, it is dark with a darker median longitudinal stripe, 2 light spots on each side and another at lateral margin; segment 10 entirely dark; ventrally 2 dark spots at lateral margins of 9th segment just beside the lateral spines of that segment; sometimes a triangular spot in the median line. Setæ with basal half fringed with hairs at joints.

The nymphs of this species were the last to be taken. On August 23rd I found them in a rapid just above Sandy Gray Falls, about 5 miles from Station Island. I was successful in rearing quite a number of these dating from August 28th to Sept. 1.

Heptagenia canadensis Walker.

(Pl. XVI, Fig. 4).

Male imago:

Measurements: Body 8–9 mm.; wings 9 mm.; setæ 20–22 mm.; foreleg 9 mm.

A dark species; a black band on face below each antenna; dark reddish brown between lateral ocelli; a small black dot close to inner margin of each eye; posterior margin of head with a narrow black line thickened at median line. Prothorax brown; short dark band along posterior margin of pronotum, the ends of which turn obliquely across the side of pronotum. Mesothorax rich brown dorsally, sides lighter, oblique dark stripes at base of fore and hind limbs; dorsum of abdomen black; slightly darker in median line; and a lighter area in each segment on either side of it. Posterior margins of segment 1–9 margined with black; 10th segment lighter; stigmal dots obscured by the black colour of the abdomen; penis lobes rather oblong in shape; setæ almost white, tinged with black; joints darker. Femur of fore-leg almost yellowish tinged with black and having median and distal black bands. Tibia lighter; tibiotarsal joint black; tarsi tinged with black; lengths of segments arranged in increasing order 5, 1, 4, 3, 2; the 2nd slightly longer than the 3rd. Wings with a dark dash and numerous cross-veins margined with black between the dash and base of wing; terminal margin of hind wing slightly tinged with black.

Female imago:

Measurements: Body 9–10 mm.; wing 12 mm.; setae 15 mm.

Abdomen very reddish, often blackish red.

Nymph:

Measurements: Body 11 mm.; setæ 15 mm.; antennae 3·5 mm.

Head reddish brown in colour; a small dark area immediately in front of each antenna; and another about the same size in front of each eye; a black dot behind each lateral ocellus; a light area in front of median ocellus, and a larger light area

between each lateral ocellus and eye. Another lateral to each eye along margin of head; mouth parts of the type belonging to group 2.

Pronotum reddish brown with a dark and an approximate light area in each lateral half; margin colourless.

Abdomen darker than thorax; each segment with four light longitudinal streaks, 2 near median line and the other two near lateral margin ; black dots, corresponding to the stigmal dots just inside of lateral light streaks. Ventrally the abdomen is almost white, each segment has two light brown lateral streaks, while 9th has its lateral and posterior margins margined with light brown. Short lateral spines at posterior lateral angles of segments 8 and 9. Setæ of equal length; light brown; joints fringed with hair. Gills oval and pointed, femur of fore-leg light brown with 4 light areas. Two small ones towards anterior margin and two large towards posterior. Distal end light coloured. Femora of hind legs with fewer pale-markings. Tibae alternately banded with brown and white. Tarsi have very broad median bands, legs slightly hairy along posterior margin.

This species was the second most abundant at Go Home Bay. The nymphs were taken from May 25th to June 31st in various localities, but never in swift water, the usual place being quiet bays. On Sept, 5th some small nymphs were found in a small creek which were evidently the next generation.

Almost mature nymphs were taken in this creek on May 31. The first bred specimen is dated June 1, and the last July 4th. Imagos were very abundant at Station Island from June 25th to July 15th.

Heptagenia frontalis Banks.

(Pl. XVI, Fig. 3).

Male imago:

Measurements: Body 7–8 mm.; wings 9 mm.; setæ 18–20 mm.; forelegs 7 mm.

Much like *H. canadensis* but lighter in colour, face yellowish a black dot on face below each antenna; a smaller black dot near inner margin of eye; pronotum light brown with a black streak on each side. Mesonotum rich brown; sides of thorax whitish yellow, segments 1–7 of abdomen very light, with posterior margin black; 8–10 reddish dorsally; stigmal dots distinct; setæ white. No dash in wing and cross veins not margined. Femora yellowish with black median and apical bands.

Female imago:

Measurements: Body 8–9 mm.; wings 10 mm.; setæ 15 mm.

Head and thorax light yellow ; dots on face beneath antennae almost forming bands; sometimes a black dot at lateral margin of each side of pronotum, usually a few cross-veins margined with black on the wing.

Nymph:

Measurements: Body 9–10 mm.; setæ 9–10 mm.

Head yellowish brown in colour; three almost round light spots along anterior margin of head; a light area in front of each ocellus; usually a light area along median line between eyes and 2 smaller ones lateral to this along posterior margin

of head. A black dot below each antenna, in front of each eye and near inner margin of each eye.

Thorax lighter in colour than head; on each side of pronotum, near median line is a small light spot; just lateral to this is a triangular dark spot and lateral to this again is another light area. In anterior angle of pronotun is an oval light spot. Along posterior margin extending some distance on either side of median line is a broad light band, which is connected by a light longitudinal stripe along median line of mesonotum, to a large irregular light area on the mesonotum.

Abdomen usually light yellowish brown; the colour pattern, roughly, has the appearance of a broad light band along median line in which, on segments, 5, 6, and 7 are oval dark areas, in 8 a narrow stripe and in 9 a round dark area in each segment, on either side of this broad light band is a short light stripe; ventral surface almost white with 2 lateral light brown longitudinal stripes on segments 1–9; a broad band across 9th along posterior margin, joining the 2 lateral stripes. Segments of setæ alternately light and brown. Legs pale, colour pattern similar to *H. canadensis.*

This species was not nearly so abundant or wide-spread as *H. canadensis.* Nymphs were taken in quite similar localities and at about the same time. They were taken from June 15 to July 2, and imagos reared from June 26 to July 4.

Heptagenia sp. indet.

(Pl. XVI, Fig. 5).

Nymph:

Measurements: Body 10–11mm.; setæ 12–13 mm.

Head light brown; sometimes 3 light areas along entire margin but frequently middle one is lacking and the 2 lateral ones are connected with the light margins lateral to eyes. An almost black spot in centre of each half of pronotum; around this is an irregular light area, exterior to which is a brown area. Abdomen whitish yellow with 5 longitudinal yellowish brown stripes in each segment 1-8. Setæ light greenish yellow; joints abundantly fringed with hairs. Legs yellowish brown in colour; pattern similar to the 2 preceding species.

Mr. R. P. Wodehouse kindly gave me these nymphs which he collected along the east shore of Manitoulin Island on June 26th, 1912. As they were not reared the species cannot be ascertained at present.

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EXPLANATION OF PLATES.

PLATE XV.

HEPTAGENIA NYMPHS.

Fig. 1. *Heptagenia tripunctata* Banks.
Fig. 2. *Heptagenia lutea* Clemens.
Fig. 3. *Heptagenia luridipennis* Burm.
Fig. 4. *Heptagenia flavescens* Walsh.
Fig. 5. *Heptagenia flavescens*, ventral view.

PLATE XVI.

HEPTAGENIA NYMPHS.

Fig. 1. *Heptagenia fusca*, Clemens.
Fig. 2. *Heptagenia rubromaculata* Clemens.
Fig. 3. *Heptagenia frontalis* Banks.
Fig. 4. *Heptagenia canadensis* Walker.
Fig. 5. *Heptagenia*, undetermined.

PLATE XVII.

MOUTH-PARTS AND GILL OF NYMPH OF *H. LUTEA* CLEMENS, AND GENITALIA OF *H. TRIPUNCTATA* BANKS.

Fig. 1. Left maxilla.
Fig. 2. Labium.
Fig. 3. Labrum.
Fig. 4. Hypopharynx.
Fig. 5. Left mandible.
Fig. 6. Gill.
Fig. 7. Genitalia.

PLATE XVIII.

MOUTH PARTS AND GILL OF NYMPH OF *H. CANADENSIS* WALKER, AND GENITALIA OF IMAGO.

Fig. 1. Left maxilla.
Fig. 2. Hypopharynx.
Fig. 3. Labrum.
Fig. 4. Labium.
Fig. 5. Left mandible.
Fig. 6. Gill.
Fig. 7. Genitalia.

Fig. 1

Fig. 2

Fig. 3

Fig 4

Fig. 5

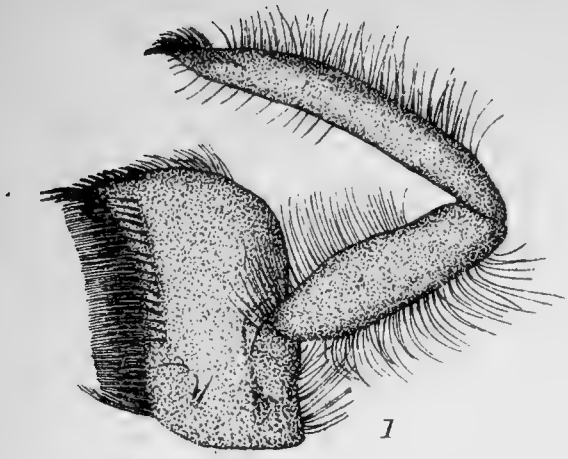
Fig. 1

Fig 2

Fig.3

Fig.4

Fig.5



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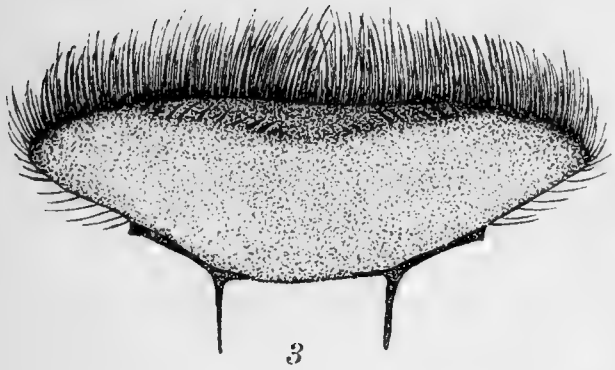

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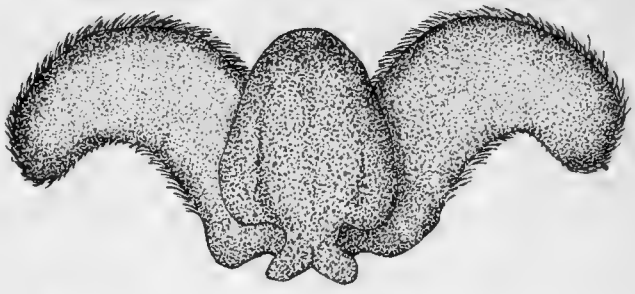

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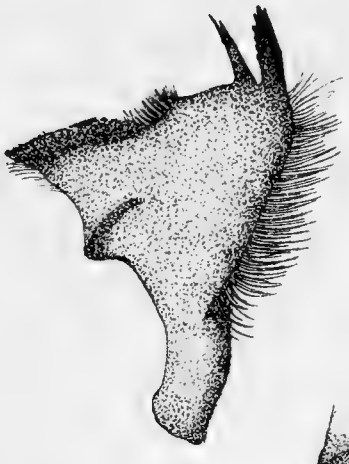

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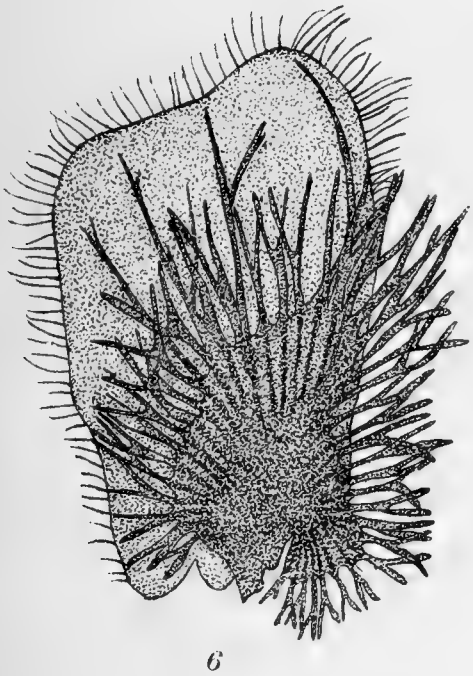

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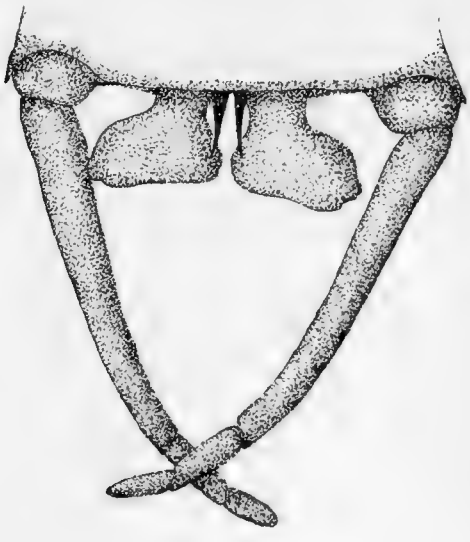

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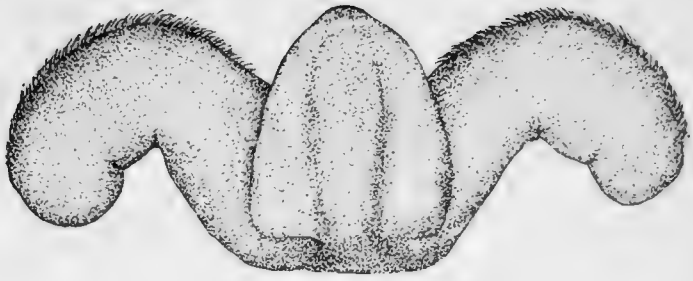

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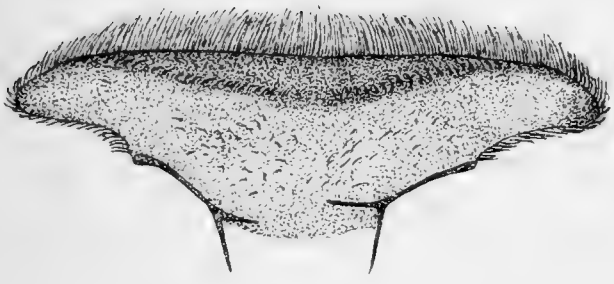

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VI.

THE FRESH-WATER MALACOSTRACA OF ONTARIO.

By A. G. Huntsman, B.A., M.B., University of Toronto.

(*13 figures in the text*)

The greater part of the material upon which this paper is based was collected at the Georgian Bay Biological Station. As it seemed desirable to bring together records of all the species known to occur in the region of the Great Lakes, the scope of the paper was extended beyond the Georgian Bay region and material from other localities in Ontario was studied.

The scope of the paper may be considered as the Canadian part of the region of the Great Lakes, which is practically limited to the Province of Ontario. Only a small part of our waters has as yet been examined, and the following list of species cannot be considered as exhaustive, but it may be noted that few species have been added to the list of Malacostraca reported from the Great Lakes in "The Fresh-water Crustacea of the United States" published by S. I. Smith in 1874, and probably very few remain to be added.

As the literature necessary for the identification of species is more or less scattered and inaccessible, it has been deemed advisable to include keys for the determination of the species, together with figures of the principal parts useful in diagnosis so that this account may serve as a basis for future work.

Much work remains to be done to determine the distribution of the various species. The localities from which specimens have been obtained, are given, but no systematic collecting has been done in any part of the Province with the exception of Georgian Bay. Doubtless the majority of the species occur throughout the entire region, wherever suitable habitats are to be found.

The importance of the Malacostraca in connection with our fresh-water fisheries can scarcely be overestimated. They form the chief element in the food of many of our food-fishes. Their large numbers, their free-living habits and their general edibility render them particularly suitable as fish food. It is very desirable to learn more of their life-histories, habits, food, etc., so that their numbers may be increased or extralimital species that are desirable may be introduced. The practical value of such work would be very great, as the lake area of the Dominion is exceedingly large and able to support an immense number of fish. The probability of a successful issue of such researches is greater in the case of fresh-water than in that of marine forms, owing to the fact that the various conditions can be much more readily controlled in closed-in bodies of water.

Some of our Malacostraca are large enough to serve as food for man. The crayfishes and shrimps are marketed in many of the American states, but in Canada little use has been made of them. Our crayfishes are quite large, but our shrimps are small. A species of shrimp that occurs in Ohio could doubtless be introduced here very readily.

The Malacostraca are also of importance as serving as intermediate hosts for many parasites which occur in fishes.

The greater part of the material that I have examined was collected in the summer of 1912 by Mr. R. P. Wodehouse at various points in the Georgian Bay. To Dr. E. M. Walker, Mr. A. R. Cooper and Mr. A. D. Robertson I am indebted for material from the Georgian Bay and from other points in Ontario. I have indicated the sources of my material in the following way,—from Mr. R. P. Wodehouse—(Wo), from Dr. E. M. Walker—(Wa), from Mr. A. R. Cooper—(C), and from Mr. A. D. Robertson—(R).

Key to the Orders.

A_1. Eyes sessile (Fig. 1). First thoracic segment fused with head. Remainder (seven in number) free, with large appendages.

B_1. Body compressed dorso-ventrally. Branchiae on abdominal appendages..... **Isopoda.**

B_2. Body laterally compressed. Branchiae on thoracic appendages (Fig. 3, br)..... **Amphipoda.**

A_2. Eyes pedunculated. The majority of the thoracic segments fused with the head to form dorsally a carapace (Fig. 5).

C_1. Thoracic legs similar and biramous (Fig. 6). Several of the posterior thoracic segments not fused with the carapace..... **Mysidacea.**

C_2. Posterior five pairs of thoracic legs uniramous and large, anterior three biramous and small. Not more than one thoracic segment free from carapace. ..... **Decapoda.**

Order ISOPODA.

For North America, this group has been monographed by Miss Harriet Richardson (see Bibliography). Only two fresh-water species have been reported from the region of the Great Lakes. They belong to the family Asellidae. For Canada no records have been published. The Isopods are to be found crawling about in shallow water in a variety of situations (among weeds, under stones, etc.).

Key to the Genera.

A_1. Mandible with palp (Fig. 1, d)..... *Asellus.*

A_2. " without palp (Fig. 1, b)..... *Mancasellus.*

Asellus communis Say. Fig. 1, c, d.

Harger in Smith, 1874, p. 657; Richardson, 1905, p. 420.

Abundant nearly everywhere in shallow water among weeds and frequently found in stagnant pools. Richardson records it from Massachusetts to Michigan on the north.

Localities.—GEORGIAN BAY: Go Home, Fitzwilliam Id. (R); Waubaushene, Go Home, Shawanaga, French River, Fitzwilliam Id. (Wo). LAKE ONTARIO: Toronto.

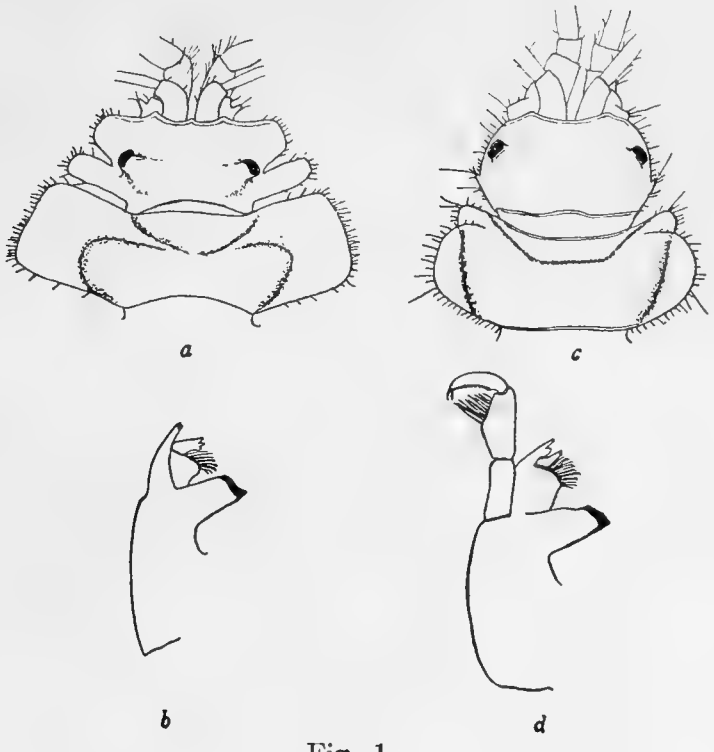

Fig. 1.

This species differs from other members of the genus in having the head broadest about its middle, the uropods about as long as the last segment, distinct epimera on all the thoracic segments and the palmar margin of propodus of first gnathopod with one or two teeth. Length up to 11 mm. (15 mm. Harger).

The specimens that I have examined do not agree perfectly with the description of *Asellus communis* given by Richardson. They are in many respects intermediate between her descriptions of that species and of *Asellus intermedius*. With the latter my specimens agree in having a distinct lobe at the posterolateral angle of the head, and the antennule extending to the middle of the last segment of the peduncle of antenna. According to Richardson, the flagellum of the antennule is composed of fourteen articles in *communis* and of nine articles in *intermedius*. In my specimens they vary in number from nine to twelve. The inner branch of the uropods is sometimes of the same width as the outer as described for *intermedius* and sometimes twice as wide as the outer as described for *communis*. It is to be doubted whether these are distinct species. Richardson copied Smith's figure of *Asellus communis*, which does not agree with her description of that species but agrees more nearly with her description of the other species. Until the matter is settled by further study, I consider it best to use Say's name, which is the older.

Mancasellus tenax (Smith). Figs. 1, a, b; 2.

Asellus tenax Smith, 1871, p. 453.

Asellopsis tenax Harger in Smith, 1874, p. 601.

Mancesellus tenax Underwood, 1890, p. 359; Richardson, 1905, p. 415

This species is less abundant than the preceding one and is more restricted to open and pure water, although one record is from a small inland lake. It has been reported as ranging from Lake Superior to the Detroit River. This range must be extended to Lake Ontario. It is probably found throughout the entire region of the Great Lakes. It has been found in as deep water as 30 fathoms (Smith).

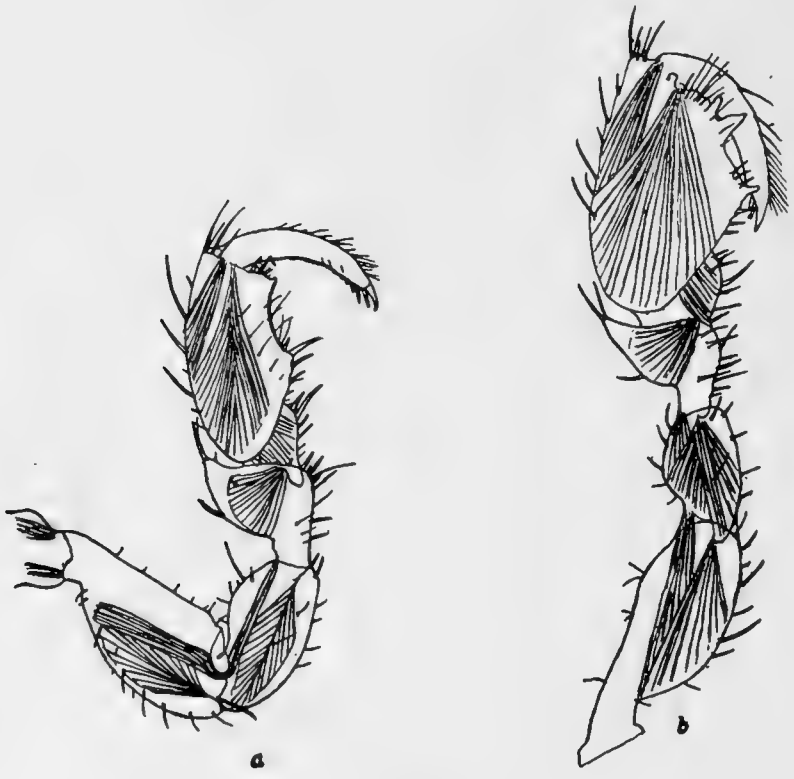

Fig. 2.

Localities.—Lakes Superior and Huron (Smith).

Georgian Bay: Sydney Bay (Wiarton), Go Home (R); Sturgeon Bay, Shawanaga, Tamarac Bay (Manitoulin Id.), Fitzwilliam Id. (Wo).

Lake Ontario: Toronto Island.

Stomachs of *Coregonus clupeaformis* (R), *Perca flavescens* (Forbes).

In addition to the generic difference given in the key, this species is readily distinguished from the preceding by the extended truncate epimera (not separate from the segments) and by the head being much broader than long and with a deep incision on each side (Fig. 1, a). Length up to 11·5 mm. (13 mm., Harger).

From other species of the genus this differs in having deep lateral incisions in the head, antennae about half the length of the body and the uropods about two-thirds the length of the last segment.

Two subspecies or varieties are distinguished, *M. tenax tenax*, the typical and

commoner variety and *M. tenax dilata* (Smith) 1874, p. 661. The latter differs from the former in being broader, in having more joints in the flagellum of the antennule, and in having three teeth (the middle one largest) on the palmar margin of the propodus of the first gnathopod of the adult male (see Fig. 2). I am unable to definitely separate these, either as to the width of the body, number of joints in flagellum of the antennule or in the shape of the first gnathopoda of the male. The extremes in the conditions of the gnathopoda are shown in Fig. 2. In some lots of specimens, one or other form appears to predominate and in others all gradations between the two extremes are to be seen. The typical *dilata* I have seen only from the north end of the Georgian Bay (Fitzwilliam Id.). Smith's specimens came from the Detroit River.

Order AMPHIPODA.

Miss Weckel (see bibliography) has recently given an account of the fresh-water species of this group occurring in North America. Six species have been reported from the region of the Great Lakes, although only three have actually been recorded from Canada. The Amphipods occur at practically all depths, either crawling about among debris or swimming freely near the bottom. Only rarely do they venture out into the open water.

Key to the Genera.

A_1 Last thoracic leg shorter than preceding one and with basal joint large and leaf like. (Fig. 3)..... *Pontoporeia.*

A_2 Last thoracic leg longer than preceding one and with basal joint little larger than that of preceding one.

B_1 Telson cleft to base. Third uropod biramous, rami nearly equal (Fig. 4, b). ..... *Gammarus.*

B_2 Telson notched. Third uropod biramous but inner ramus rudimentary (Fig. 4, c)..... *Eucrangonyx.*

B_3 Telson entire. Third uropod uniramous (Fig. 4, d)..... *Hyalella.*

Pontoporeia hoyi (Stimpson Mss.) Fig. 3.

P. affinis Smith, 1871, p. 452.
" " Nicholson, 1872, p. 501.
" *hoyi* Smith, 1874, p. 647.
" " Weckel, 1907, p. 26.

This species occurs in abundance on muddy or gravelly bottoms at various depths down to 169 fathoms (Smith). In Lake Superior, according to Smith, it is found in as shallow water as 4 fathoms. It is the same at the north end of Georgian Bay, where it was dredged last summer (1912) by Messrs. Robertson and Wodehouse in Rattlesnake Harbour, Fitzwilliam Id. In this harbour many whitefish are caught in pound nets, and they doubtless feed upon this species in

the harbour. In the southern end of Georgian Bay, I do not know of it being taken in shallower water than about 20 fathoms and, in Lake Ontario, Nicholson did not obtain it in shallower water than about 30 fathoms.

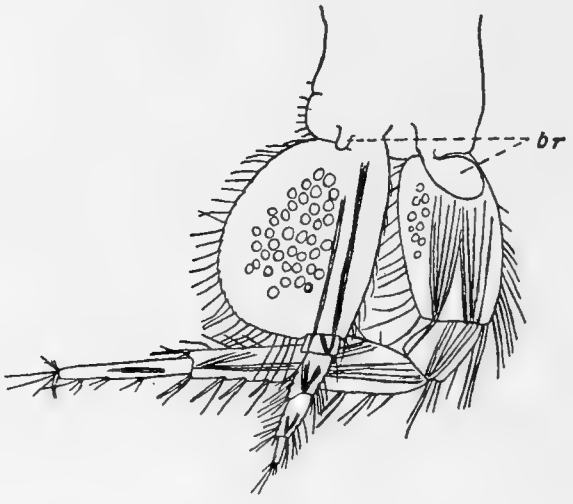

Fig. 3.

Localities.—Lakes Superior and Michigan (Smith).

Georgian Bay: Near Pine Ids., 20 fathoms (Wa); East of South Watcher Id., 20 to 25 fathoms; Rattlesnake Harbour, Fitzwilliam Id., 4½ fathoms (R and Wo).

Lake Ontario, near Toronto, 30 to 40 fathoms (Nicholson).

Stomachs of whitefish from Lakes Superior and Michigan (Smith), from Georgian Bay (Wa, C, R); *Uranidea formosa* (C) from Port Credit, Lake Ontario.

In addition to the differences given in the key, this species can readily be distinguished from our other Amphipods by the rudimentary condition of the 'hands' of the second gnathopods. Length up to 8 mm.

Pontoporeia filicornis (Stimpson Mss.)

Smith, 1874, p. 649; Weckel, 1907, p. 28.

A single specimen was dredged by Stimpson in Lake Michigan near Racine in 40 to 60 fathoms. It has not since been found. It is distinguished from the preceding species chiefly by the very long antennæ and antennulæ, which are as long or longer than the body.

Genus Gammarus.

Key to the Species.

A_1 Terminal joint of outer ramus of last uropod without long plumose hairs on outer margin..... *G. fasciatus.*

A_2 Terminal joint of outer ramus of last uropod with long plumose hairs on outer margin..... *G. limnaeus.*

Gammarus fasciatus Say. Fig. 4, b.

(?) *Gammarus* sp. Nicholson, 1873, p. 500.

Gammarus fasciatus Smith, 1874, p. 653, Weckel, 1907, p. 40.

Generally distributed in shallow water, under stones and among weeds, etc. It is probably our commonest Amphipod, although not found in as large numbers as is *Hyalella*. It is found from Maine to Wisconsin on the north according to Smith.

Localities.—Lakes Superior and Michigan (Weckel).

Georgian Bay: Waubaushene, Rattlesnake Harbour (Fitzwilliam Id.) (Wo); McGregor Bay (Wiarton) (R).

Lake Ontario: Toronto; Coburg (Wa).

Niagara Falls (Weckel).

Stomachs of Black Bass (Forbes).

The characters of this species have been sufficiently indicated in the keys. Length up to 15 mm.

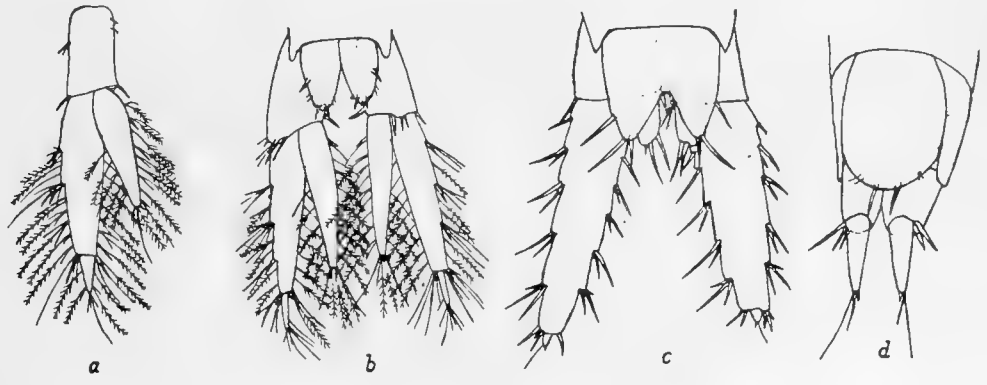

Fig. 4.

Gammarus limnaeus Smith. Fig. 4, a.

G. lacustris Smith, 1871, p. 453.

G. limnaeus Smith, 1874, p. 651; Weckel, 1907, p. 42.

This species is much less abundant than the preceding and occurs with it. According to Weckel, it ranges from Maine to Utah.

Localities.—Lakes Superior and Michigan (Smith and Weckel).

Georgian Bay: Rattlesnake Harbour (Fitzwilliam Id.) (Wo).

Stomachs of Trout (Smith).

I have been unable to separate this species from the preceding, except in regard to the presence or absence of bristles on the sides of the terminal segment of the outer ramus of the last uropods. The number of joints in the secondary flagellum of the antennule varies from 2 to 4 in *G. limnæus* and from 3 to 6 in *G. fasciatus*. The other differences given by Weckel are only differences of degree and not easily applied. Length up to 20 mm.

Eucrangonyx gracilis (Smith). Fig. 4, c.

Crangonyx gracilis Smith, 1871, p. 453; 1874, p. 654.

(?) *Crangonyx* (?) sp. Nicholson, 1873, p. 501.

Eucrangonyx gracilis Weckel, 1907, p. 32.

This species does not appear to be very common. It is found in shallow water among weeds and down to 13 fathoms (Smith). According to Weckel it ranges from Rhode Island to Wisconsin.

Localities.—Lakes Superior, Michigan and Huron (Smith and Weckel).

Georgian Bay: Go Home (R); Shawanaga (Wo).

Bond Lake (near Toronto).

Stomach of Mud-minnow (*Umbra limi*) (Forbes).

This species is well characterized by the features mentioned in the keys and by the figure. Among other things it can be distinguished from the two species of *Gammarus*, which it very much resembles, by the absence of stout bristles on the dorsal surface of the abdomen and by the structure of the secondary flagellum of the antennule, which consists of two joints, the last one very short.

Length up to 18 mm.

Hyalella knickerbockeri (Bate). Fig. 4, d.

H. dentata Smith, 1874, p. 645.

H. knickerbockeri Weckel, 1907, p. 54; Jackson, 1912.

This species is extremely abundant among weeds in shallow water, both in the Georgian Bay and in Lake Ontario. Smith reports it from Maine to Wisconsin on the north.

Localities.—Lakes Superior and Michigan (Smith and Weckel).

Georgian Bay: Go Home (C and R); Matchedash Bay (R); Waubaushene, Shawanaga, French River, Killarney, Tamarac Bay (Manitoulin Id.), Fitzwilliam Id. (Wo).

Lake Ontario: Toronto.

Stomachs of the following fishes according to Forbes (1888),—*Perca flavescens, Percina caprodes, Micropterus dolomieu, Eupomotis gibbosus, Lepomis pallidus, Ambloplites rupestris, Aphredoderus sayanus, Fundulus diaphanus, Notropis cornutus, N. heterodon, Ictalurus punctatus, Ameiurus natalis, A. nebulosus, Amia calva* and *Polyodon spathula.*

This species is easily recognized by the exceedingly broad and clumsy hands of the second gnathopods of the male, by the absence of a secondary flagellum on the antennule and also by the spines projecting backward from the middle of the posterior margin of each of the first two abdominal segments. Weckel includes in this species forms without these spines. In my material I have not seen any individuals without them. Length up to 7 mm.

Order MYSIDACEA.

Of this group only a single species occurs within our limits.

Mysis relicta Loven. Figs. 5 and 6.

Mysis oculata var. *relicta* Sars, 1867, p. 14.
" *relicta* Smith, 1874, p. 642.

This species swims about in shoals near the bottom in rather deep water (from 4 to 148 fathoms, Smith) in probably all our lakes. It forms a large part of the

Fig. 5.

food of many of our fishes. It has been reported by Smith from Lakes Superior and Michigan. To these I can add the Georgian Bay and Lake Ontario. It also occurs in the Scandinavian Lakes and in Ireland.

Localities.—Lakes Superior and Michigan (Smith).
Georgian Bay: Near South Watcher Id., 20 f., sand (Wa).
Lake Ontario: Near Port Credit (C).

Fig. 6.

Stomachs of whitefish, Lake Superior (Smith), and of herring, *Clupea aestivalis*, in Lake Ontario (C).

The identification of the *Mysis* of our lakes with that occurring in the Scandinavian lakes seems at first sight very surprising. It is impossible for it to have been transported from one place to the other. This makes it practically certain that they have both been derived independently from one of the marine species, probably *Mysis oculata*. Smith, after comparing the American with European specimens, states that he is unable to find any differences. I have had no European specimens for comparison, but a comparison with Sars' account (1867), has shown me no differences, with the possible exception of the third and fourth pleopods of the male. But as these appendages differ in different individuals from our lakes and as the figures of Sars are evidently from a somewhat immature male, I hesitate to ascribe any importance to the differences noticed. A careful study of an abundance of material may yet show that our species is distinct from the European. Length about 16 mm.

Order DECAPODA.

The forms belonging to this group are larger than those of the other groups. There are a single shrimp and eight species of crayfishes from the region of the great lakes.

Key to the Genera.

A_1 Third from last pair of thoracic limbs not chelate (provided with pincers). ..... *Palaemonetes.*

A_2 Third from last pair of thoracic limbs chelate..... *Cambarus.*

Palaemonetes paludosa (Gibbes). Fig. 7.

Hippolyte paludosa Gibbes, 1851, p. 197.

Palaemonetes exilipes Stimpson, 1871, p. 130; Smith, 1874, p. 641.

Palaemonetes paludosa Kingsley$_1$ 1878, p. 97; Underwood, 1890, p. 374.

This is our only large shrimp. It is found swimming about in the bays and rivers of the Lake Erie drainage area. It has not previously been recorded from Canada.

Fig. 7.

Localities.—Detroit River and Sandusky Bay (Lake Erie) (Smith).

Welland River (Wa).

Stomachs of *Perca flavescens*, *Apomotis cyanellus*, and *Ameiurus natalis* (Forbes, 1888).

This species is readily distinguished from our other Crustacea by its laterally compressed, dentate rostrum (see figure), by the sharp bending of the abdomen at the third abdominal segment and by the enlarged lateral plates of the second abdominal segment. There are from 7 to 9 teeth on the dorsal edge of the rostrum and from 1 to 3 on the ventral edge. Length up to 38 mm.

Genus *Cambarus*.

All our crayfishes belong to the genus *Cambarus*. One species of the allied genus *Astacus* or *Potamobius* occurs on the coastal slope of British Columbia.

We have two monographs of the crayfishes of North America, one by Hagen (1870), and another by Faxon (1885). Ortmann (1905) has given the most recent revision of the group.

The crayfishes are bottom forms, living altogether in shallow water, not descending deeper than a few fathoms. For the most part they shelter themselves during the day under stones, plants, etc. or in holes excavated in the mud.

Eight species are properly referable to our region. Four of these have already been reported from Ontario and to these I can add two. The other two I have not seen.

Outside of Ontario, *C. bartonii* has been reported from New Brunswick and Quebec, and *C. virilis* from several points in the middle west (Lake Winnipeg, Saskatchewan River, Red River).

Key to the Species.

A_1 First abdominal appendages of male hooked (Fig. 8, e–f). Rostrum without lateral teeth (Fig. 9, d, e—f).

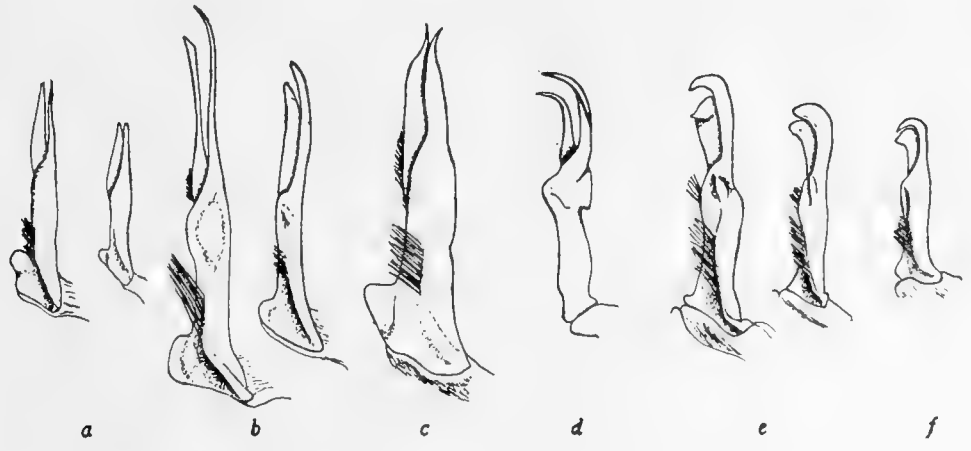

Fig. 8.

B_1 Areola of moderate width (Fig. 9, e).....*C. bartonii.*

B_2 Areola nearly or quite obliterated in the middle (Fig. 9, d).

C_1 Dactyl of first legs excavate at base on outer side (Fig. 11, a).*C. fodiens.*

C_2 Dactyl of first legs not excavate at base (Fig. 11, b).....*C. diogenes.*

A_2 First abdominal appendages of male styliform and curved (Fig. 8, d). Rostrum without lateral teeth or occasionally with..... *C. immunis.*

A_3 First abdominal appendages of male styliform and straight (Fig. 8, a, b, c Rostrum with lateral teeth (Fig. 9, a, b, c).

D_1 Sides of carapace with many teeth (Fig. 9, c)..... *C. limosus.*

D_2 Sides of carapace with only one distinct tooth on each side (Fig. 9, a, b).

E_1 Areola of moderate width (Fig. 9, a). First abdominal appendages of male with short tips (Fig. 8, a)..... *C. propinquus.*

E_2 Areola rather narrow (Fig. 9, b). First abdominal appendages of male with long, tapering tips (Fig. 8, b).

F_1 Sides of rostrum straight..... *C. virilis.*

F_2 Sides of rostrum concave..... *C. rusticus.*

Having examined only five of the eight species, I have not been able to devise a key for all the species, that would be applicable to both sexes. The five species can be readily distinguished from each other by characters of the carapace or chelipeds, as shown in figures 9 and 10. The following keys may be found useful and include all the species* that have been found within our borders but not all that will probably be found to occur.

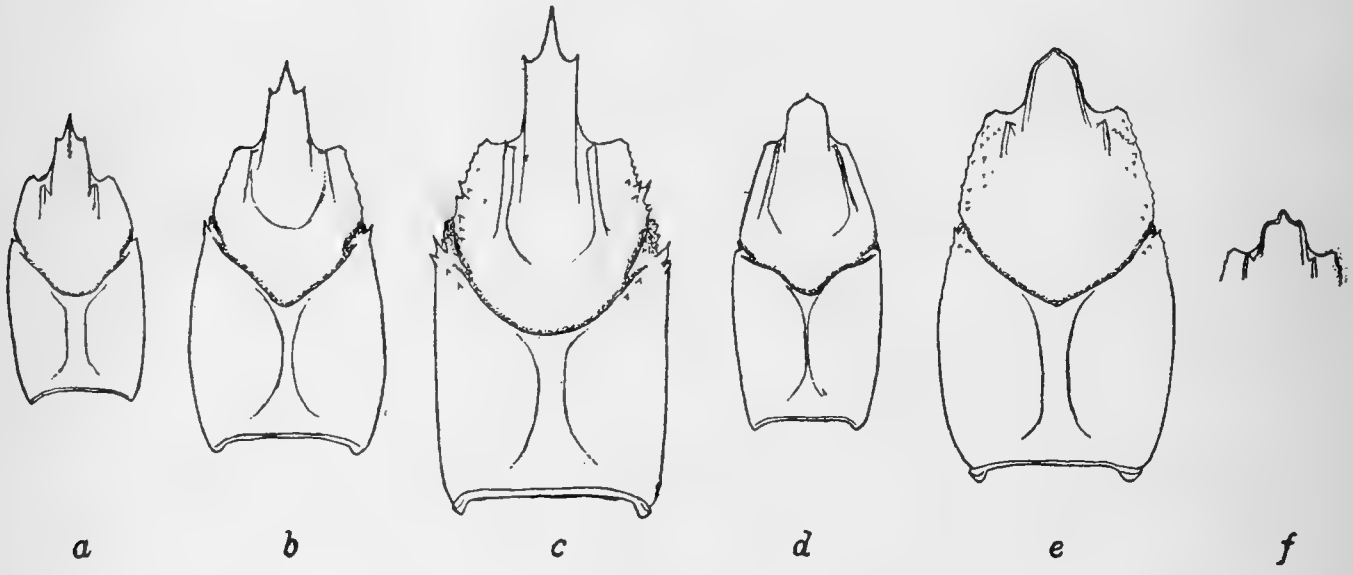

Fig. 9.

Key based upon the characters of the **carapace.** (Fig. 9).

A_1 Rostrum with lateral teeth.

B_1 Numerous spines on sides of carapace..... *C. limosus.*

B_2 Only one pair of spines on sides of carapace.

C_1 Areola broad (about 2 mm)..... *C. propinquus.*

C_2 Areola narrow (about 1 mm)..... *C. virilis.*

A_2 Rostrum without lateral teeth.

*Except *C. immunis.*

D_1 Areola nearly or quite obliterated. ..... *C. fodiens* and *diogenes.*
D_2 Areola broad.
E_1 Rostrum nearly square..... *C. bartonii bartonii.*
E_2 Rostrum oblong..... *C. bartonii robustus.*

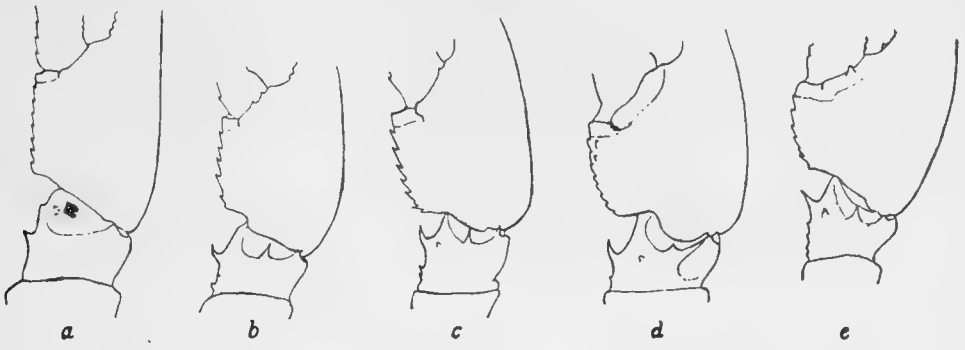

Fig. 10.

Key based upon the characters of the large **chelipeds.** (Fig. 10).

A_1 Carpus without ventral median anterior tooth. Inner border of hand or propodus straight..... *C. propinquus.*
A_2 Carpus with ventral median anterior tooth. Inner border of propodus curved.
B_1 Two teeth on ventral margin of joint between dactyl and propodus. *C. virilis.*
B_2 No teeth on ventral margin of that joint ..... *C. bartonii.*
B_3 One distal tooth on ventral margin of that joint. Dactyl not excavated at base..... *C. limosus.*
B_4 One median tooth on ventral margin of that joint. Dactyl excavated on outer side near base..... *C. fodiens.*

Cambarus bartonii (Fabr.) Figs. 8, e; 9, e, f; 10, d; 12, c.

Hagen, p. 75; Faxon, p. 59; Ortmann, p. 120.

This is perhaps our commonest crayfish. It is found under stones, etc. in running or open water, often at considerable depths. According to Abbott (see Faxon) it sometimes burrows in muddy banks. It has been reported from St. John, N.B., to Lake Superior on the north.

Localities. — Lake Superior (Hagen). Searchmont (Algoma District), (Williamson).

Georgian Bay: Giant's Tomb, Go Home, Shawanaga, Bustard Ids., French River (Wo); Go Home from fish nets (Wa); Copperhead Id.

Grant River (Brant Co.), Welland River.

Niagara (Hagen).

Humber and Don Rivers near Toronto (Hagen).

Iroquois (C).

Length up to 100 mm. Antennae frequently longer than body. Rostrum without lateral teeth, in shape from nearly square to rather long rectangular. Areola from 1/7 to 1/10 the width of the carapace. Only one distinct spine on each side

of carapace, although there are numerous tubercles on each side, particularly anteriorly. In large specimens, the fingers of the large chelipeds are relatively very long, narrow and curved. The propodus or hand may be even more than two-thirds as long as the body. The annulus ventralis of the female (Fig. 12, c) has a very small excavation which is almost in the middle line. It is sometimes on the right side (lower figure) and sometimes on the left (upper figure). This recalls the dimorphism that has long been known to exist in the males and that was first described by Hagen and that affects the first pair of abdominal legs. Whether this dimorphism in the female is strictly comparable with that in the male may be doubted. It is more like the *inversio viscerum* that occasionally occurs in many animals. I have observed it in other species of *Cambarus* although not in as well marked a state as in this species.* The specimens show roughly about equal numbers of the two kinds. The dimorphism shown in the first abdominal appendages of the males of this species is represented in Fig. 8, e.

This species has a number of varieties. From western Ontario I have seen only the form known as *robustus* (Fig. 9, e). From Iroquois in eastern Ontario, I have received specimens both of *robustus* and of the tpyical *bartonii*, with a square rostrum. The latter appears to mature at a much smaller size. A male, 23 mm. long, has the first abdominal appendages well developed and extending forward between the fourth pair of thoracic legs. In a male *robustus*, 33 mm. long, the first abdominal appendages are small and rudimentary, not extending in front of the fifth thoracic legs. Hagen considered these two forms as distinct species but Faxon subsequently united them into one. It is probable that further study will show that they are distinct.**

Cambarus fodiens (Cottle). Figs. 8, f; 9,d; 10,e; 11,a; 12,e.

Astacus fodiens Cottle, 1863, p. 216.

Cambarus argillicola Faxon, 1885, p. 76.

This appears to be the common burrowing crayfish in Ontario. It is found in swamps, etc. which become dry in the summer. At this time it retreats to its burrows, the mouths of which are surmounted by the so-called 'chimneys' which are formed by pellets of mud.

Cottle records it from Ontario, but does not give the locality. A few years previous to the time of publication of his article, he was residing at Woodstock. Faxon records it from Toronto and Detroit. The only adult specimens I have seen were given to me by Dr. E. M. Walker, who had received them from a student but without any record of the locality. Strathroy (H. B. Sifton).

Length from 60 to 70 mm. (76 mm. according to Faxon). Rostrum without lateral teeth, similar to that of *Cambarus bartonii robustus* but without thickened margins and with the tip well bent down. Carapace practically without lateral spines or tubercles. Depth of carapace (except in young individuals) equal to or

*Andrews (Proc. Bost. Soc. Nat. Hist., vol. 32, 1906, p. 477) found it in four out of five species examined, and thinks it may be general in *Cambarus*.

**Ortmann in Williamson (1907) reports the typical *bartonii* from near Lake St. John, Quebec, as well as from Searchmont, Algoma District.

greater than breadth (in *C. bartonii* it is only two-thirds of breadth). Areola not entirely obliterated at any point, but nearly so. The excavation at the base of the movable finger of the large chelae enables one to readily recognize this species.

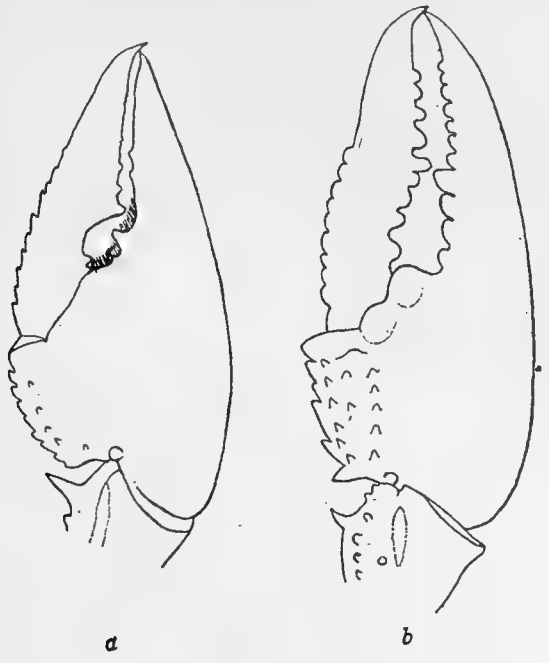

Fig. 11.

Faxon apparently had no knowledge of Cottle's article. The description of Cottle leaves no doubt as to the identity of his species with that of Faxon. Cottle gives an account of the burrowing habit and of the duration of the spawning period.

Cambarus diogenes Girard. Fig. 11, b.

C. obesus Hagen, p. 81.

C. diogenes Faxon, p. 71. Ortmann, p. 120.

This is the common burrowing form of the eastern United States. Hagen records it from Lakes Erie and Ontario and Faxon from Detroit. It has not yet been found within our borders but probably occurs.

Length up to 111 mm. (Faxon).* Rostrum without lateral spines, areola obliterated in the middle, first abdominal appendages of male hooked, movable finger of large chelae without excavation at base.

Cambarus immunis Hagen. Fig. 8, d.

Hagen, p. 71; Faxon, p. 99. Ortmann, p. 113.

This species is reported by Faxon as being found concealed among weeds in muddy pools and ditches connected with the Detroit River. Localities:—Twenty-mile creek near Tintern, Lincoln County.

Length up to 3·2 inches. Rostrum usually without lateral spines. Areola narrow. Movable finger of large chelae usually excised near base on outer side. First abdominal appendages of male styliform and curved.

*124 mm. (Williamson).

Cambarus limosus (Raf.) Figs. 8,c; 9,c; 10,c; 12,d.

C. affinis. Hagen, p. 60; Faxen, p. 86.

C. limosus Ortmann, p. 107.

This appears to be one of the commonest and largest species of the eastern United States and is the one usually sold in the markets, according to Faxon. According to Abbott it is mostly found in the rivers under flat stones in deep water.

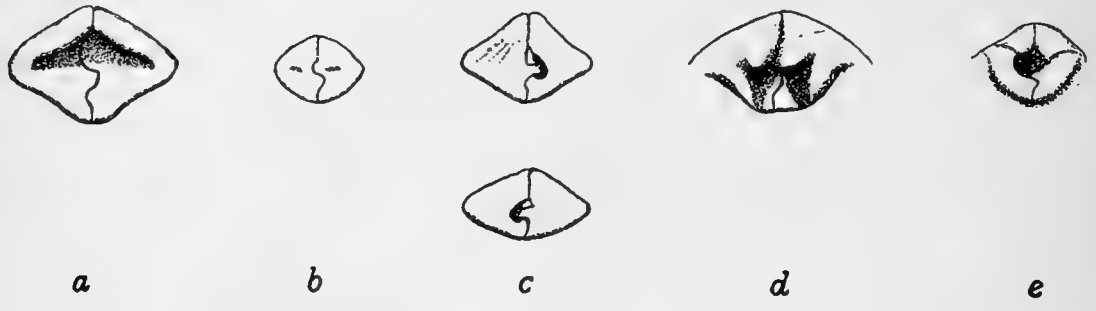

Fig. 12.

Localities.*—Lake Superior (Faxon).

Lake Superior and Niagara (Hagen).

Iroquois, Ontario (C).

Length up to 120 mm. Areola of moderate width, about 1/12 width of body. Rostrum with well developed lateral spines and a rather long narrow tip. Numerous spines on sides of carapace, chiefly in front of cervical groove and along its posterior margin. First abdominal appendages of the first form of male with tapering tips, the extremities being bent away from each other. Annulus ventralis of female with a transverse sinus behind and two projections in front, one on either side of a median depression.

Cambarus propinquus Girard. Figs. 8,a; 9,a; 10,a; 12,b; 13,a.

Hagen, p. 67; Faxon, p. 91; Ortmann, p. 112.

This is our smallest species. It is generally distributed over the whole region. On the whole it keeps nearer to the shore than the other open water species and is at times found in quite stagnant water (small inland lakes along shore of Georgian Bay).

Localities.—Lake Superior (Hagen): St. Mary's River, Heyden, Searchmont (Williamson).

Georgian Bay: Sturgeon Bay, McCoy Id., Shawanaga, Bustard Ids., French River, Killarney, Tamarac Bay (Manitoulin Id.), Fitzwilliam Id. (Wo); Go Home, Santa Gre, Shawanaga, Tamarac Bay (R); Collingwood, Go Home (Wa).

Walkerton (I. A. Sinclair), Grant River (Brant Co.), Welland River (C. O. E. Kister).

* Ortmann considers that the records of Faxon and Hagen are incorrect, and that this spe cies does not occur in the lake region. I did not myself collect the Iroquois specimens.

Detroit River, St. Clair River, (Faxon).
Strathroy (H. B. Sifton).
Niagara (Hagen).
Lake Ontario (Girard).
Toronto (Faxon), Iroquois (C).

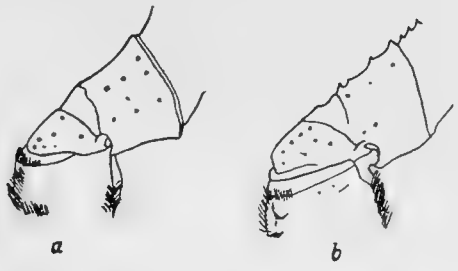

Fig. 13.

Stomachs of *Micropterus dolomieu* (C), *Lota maculosa, Micropterus dolomieu* (Forbes).

Length up to 65 mm. Usual length of adult individuals, from 40 to 50 mm.

Rostrum with lateral spines. A single spine on each side of carapace. Areola broad, from $\frac{1}{3}$ to $\frac{1}{4}$ of width of body. No teeth on anterior border of third joint of large legs (Fig. 13,a). No middle anterior spine on ventral side of carpus ol large legs. Inner border of hand or propodus quite straight. First abdominaf appendages of male with short straight tips. Annulus ventralis of female without sulcus or processes.

Cambarus virilis Hagen. Figs. 8,b; 9,b; 10,b; 12,a; 13,b.

Hagen, p. 63; Faxon, p. 96; Ortmann, p. 113.

This species appears to be quite abundant in the Georgian Bay but not in Lake Ontario. Like the last species it occurs in open water and also in rather stagnant pools, and in depth down to 8 fathoms.

Localities.—Lake Superior (Hagen).

Georgian Bay: Waubaushene, Giant's Tomb, Go Home, McCoy Id., Shawanaga, Bustard Ids., Killarney, Tamarac Bay, (Wo); Go Home, (Wa); Wiarton Collingwood, Bustard Ids., Killarney, (R).

Lake Rosseau.

Toronto (Hagen); Sandy Lake (Ortmann).

Stomachs of *Micropterus dolomieu* (C), *Perca flavescens, Anguilla chrysypa* and *Amia calva* (Forbes).

Length up to 90 mm. (as much as $6\frac{3}{4}$ in. according to Bundy). Usual length of mature specimens, from 60 to 75 mm.

Rostrum with lateral spines. A single spine on each side of the carapace. Areola narrow (1/21 to 1/15 of the width of the body). Several teeth along anterior border of third joint of large legs (Fig. 13, b). A middle anterior spine on ventral side of carpus of large legs and occasionally a small accessory one between this spine and the inner spine of the carpus (Fig. 10, b). First abdominal appendages of male with long somewhat curved tips. Annulus ventralis of female with a deep and broad transverse sinus.

Cambarus rusticus Girard.

Hagen, p. 71; Faxon, p. 108.

This species has been reported by Hagen from Lake Superior and by Faxon from Lake Erie. It will doubtless be found within our limits.

Length up to 73 mm. Rostrum with lateral spines, its margins concave. Areola narrow. First abdominal appendages of male with long, straight or somewhat curved tips.

LIST OF REFERENCES.

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VII.

NOTES ON THE HIRUDINEA OF GEORGIAN BAY.

By Miss C. G. S. Ryerson, B.A., University of Toronto.

Some time ago Dr. E. M. Walker placed in my hands, for the purpose of identification and morphological study, the entire collection of Hirudinea belonging to the Georgian Bay Biological Station. This collection contained numerous specimens obtained in different seasons and particularly the special collection made by Mr. R. C. Coatsworth in 1910. This collection was accompanied by extensive field notes which were kindly placed at my disposal by Mr. Coatsworth, and which have been freely used. Useful information has also been supplied by Mr. A. D. Robertson. In several cases it has been difficult to make satisfactory determination on account of lack of information on anatomical features, a study of which is now in progress.

Hitherto, collections of leeches have been made chiefly in the lakes and rivers of the United States and little work has been done in Canadian waters. Bristol (1899) in his paper on the Metamerism of *Nephelis*, mentions having received several specimens from Toronto. Verrill (1872) found *Ichthyobdella punctata* in Lake Superior. Nicholson (1872) in his "Contributions to Fauna Canadensis" describes four species from Lake Ontario. Moore (1905) in his paper on "Hirudinea and Oligochæta of the Great Lakes," describes species which, except for two parasitic forms are common around Toronto.

There appear to be four families represented in the Georgian Bay region, namely, the *Glossiphonidæ*, *Hirudinidæ*, *Erpobdellidæ*, and *Ichthyobdellidæ*. Judging from the field notes, there is a great uniformity in the environmental conditions of the various species. Whether free-swimming forms such as the *Hirudinidæ* and *Erpobdellidæ* or less active creeping forms such as the *Glossiphonidæ*, leeches, as a rule, choose sheltered places where their movements will not be hampered by the motion of the water. Further in such places are found snails, oligochætes and other invertebrates which form the food of the majority of species. Semi-permanent parasites such as *Placobdella parasitica* or the *Ichthyobdellidæ* accommodate themselves to the environment of the host, but during the breeding season retire to the shelter of plants or stones.

The following is a list of the species herein described:

I. Family Glossiphonidæ.

A. Genus **Glossiphonia**, Johnston.

1. *G. stagnalis*, Linn.
2. *G. fusca*, Castle.
3. *G. nepheloidea*, Graf.
4. *G. heteroclita*, Linn.
5. *G. complanata*, Linn.

B. Genus **Placobdella,** Blanchard.
6. *P. parasitica,* Say.
7. *P. rugosa,* Verrill.
8. *P. montifera,* Moore.
9. *P. phalera,* Graf.
10. *P. picta,* Verrill.

II. Family HIRUDINIDÆ.
C. Genus **Macrobdella,** Verrill.
11. *M. decora,* Say.
D. Genus **Haemopis,** Savigny.
12. *H. marmoratis,* Say.
13. *H. grandis,* Verrill.

III. Family ERPOPDELLIDÆ.
E. Genus **Erpobdella,** Blainville.
14. *E. punctata,* Leidy.
F. Genus **Nephelopsis,** Verrill.
15. *N. obscura,* Verrill.

IV. Family ICHTHYOBDELLIDÆ.
G. Genus **Piscicola,** Blainville.
16. *P. milneri,* Verrill.
17. *P. punctata,* Verrill.

Family GLOSSIPHONIDÆ.

Leeches of small to medium size, rather short and broad; caudal sucker usually broad and flat; the somites of the middle region of the body usually of three annuli and in most species sensillæ and cutaneous papillæ, in some species several series. Eyes 1–4 pairs, situated close to the median line. The first may be compound, the others simple. From the mouth situated in the oral sucker the pharynx passes backwards and forms a sheath for the protrusible proboscis. This is succeeded by the œsophagus and the crop. The crop possesses from one to ten pairs of lateral cæca and the stomach four pairs. In the literature of the group this family is characterized by the possession of salivary glands, but five species possess in addition to these a pair of œsophageal glands (Hemingway, 1908). The eggs and young of these forms are carried on the ventral surface of the body of the parent. The adult individuals are usually found clinging to fish or frogs, sticks or stones.

Genus **Glossiphonia,** Johnston.

Moderately depressed or elongated, tapering more or less toward the anterior end. Eyes 1-3 pairs, simple; cutaneous papillæ present in some species but usually not conspicuous. Pharyngeal glands diffuse; gastric cæca 1-7 pairs, not greatly branched. Sperm ducts forming long open loops. Chiefly free-living forms.

Glossiphonia stagnalis, (Linn.) Johnston.

Hirudo bioculata, Bergmann (1757).
Hirudo stagnalis, Linnæus (1758).
Clepsine modesta, Verrill (1872).
Helobdella stagnalis, Blanchard (1896).

In the collection there are fifty-seven adult specimens, together with a number of young which appear to belong to this species. Size small, usually not exceeding an inch in length when extended. The crop, when empty, shows one pair of long posterior cæca, which lie alongside the stomach. When the crop is full, five or six pairs of cæca may be visible, but usually only three or four pairs can be seen. At the twelfth annulus there is a small brown chitinous plate on the dorsum, which marks the position of the nuchal gland; this plate is usually visible to the naked eye and furnishes a means of distinguishing the species. The simple eyes in the fourth somite of this leech correspond to those of *G. nepheloidea.* The color is generally white to semi-transparent, but some specimens are flecked with grey.

In specimens collected in the vicinity of Toronto last autumn a pair of conspicuous white spots, close to the dorsal median line were observed. These, on closer examination, proved to be the atria showing through the transparent body-wall. These spots were not observed in the Georgian Bay specimens, but since they become less conspicuous after preservation, it is probable that their absence is due to the effects of the preserving fluids, or possibly there is a difference in respect of the season of the year.

In one instance a leech of this species was found attached to a tadpole in a pool where tadpoles were numerous. In other instances, specimens were taken in dredgings from swampy bays or from under stones or again on aquatic plants.

Glossiphonia fusca, Castle.

Clepsine papillifera, var. *lineata,* Verrill (1874).
[Not *Hirudo lineata,* O. F. Müller (1874)].
Glossiphonia lineata, Moore (1898).
Glossiphonia fusca, Castle (1900).

Twenty-one specimens have been identified as belonging to this species. Size from 5 to 13 mm. in length and from 1·5 to 3·5 mm. in breadth; crop of five or six pairs of caeca, not greatly branched. Shape very similar to that of *G. stagnalis* but not so capable of extension. The color varies from yellowish grey to almost white. On the dorsal surface there are usually three to five series of rather prominent papillae. Along the line of the papillae there is a more or less complete longitudinal white band and the papillae are frequently tipped with black. The simple pair of eyes are located on the fourth annulus or in the furrow between the third and fourth. Several specimens were taken from the lower sides of sticks.

Glossiphonia nepheloidea, Graf.

Clepsine nepheloidea, Graf (1899).
Glossiphonia elongata, Castle (1900).

The collection contains but three specimens identified as this species. They are rather elongated and worm-like in form with weak suckers. In size similar to *G. stagnalis,* but capable of greater extension. The single pair of crop diverticula are shorter than those of *G. stagnalis.* The single pair of eyes are large and widely separated. Color light brownish to white.

These specimens were obtained from dredgings at a depth of from one to six feet in a soft muddy bottom.

Glossiphonia heteroclita, Linn.

Hirudo heteroclita, Linn. (1761).
Hirudo hyalina, O. F. Müller (1774).
Clepsine hyalina, Moquin Tandon (1826).

Four specimens identified as this species were from 5 to 11 mm. in length and from 1·5 to 3·5 in breadth. In shape they are similar to *G. stagnalis,* but not so extensible. In color they are white to semi-transparent, which enables one to distinguish the six pairs of gastric caeca when filled with blood. The three pairs of eyes, arranged in two parallel lines, close to the median line, show clearly against the white background.

The specimens were taken from the lower sides of stones along the shore of a small bay and in a pool.

Glossiphonia complanata, (Linn.) Johnston.

Hirudo complanata, Linn. (1758).
Clepsine elegans, Verrill (1874).
Clepsine patelliformis, Nich. (1872).

Thirty-six specimens have been referred to this species. In size, they vary from 10–16mm. in length and from 2 to 6·5 mm. in breadth, though larger specimens have been found. Individuals of this species are larger than those of the species already described. The margins are thick and the head is not distinctly widened. The three pairs of eyes are usually situated on annuli 2, 3, and 4. The second pair, largest and farthest apart, is said by Castle (1900) to correspond to the single pair of eyes in *G. stagnalis.* Seven pairs of gastric caeca. The ground color varies from brown to bright green dorsally, paler ventrally. On the dorsal surface are two brownish lines running from just behind the eyes backward. These lines are usually more or less interrupted by whitish spots metamerically arranged. Elsewhere on the dorsal surface appear series of white or yellow flecks. On the ventral surface there is also a pair of longitudinal brown lines but rather paler. Dorsal cutaneous papillae are present but are not conspicuous.

An examination of serial sections revealed a pair or tubes which come into

view several microns posterior to the female genital pore. These tubes appear to bend on themselves, the outer arm ending blindly at about the point where the first pair of gastric caeca appear. The other arm passes backward and appears to connect posteriorly with the seminal duct. This blind end may be merely the anterior end of the outer arm of the seminal loop. Also between the genital pores, appears the end of a loop, similar in structure to the oviducts, which passes backward and connects with the oviducts posterior to the female pore. The point of attachment is approximately that of the caecum attached to the oviduct of *P. montifera* (Moore 1912).

These specimens were obtained from dredgings in a channel from 3 to 5 fathoms deep, from under shells, stones and logs in small inlets or in pools.

Genus **Placobdella,** Blanchard.

The collection affords five species belonging to this genus. Form more or less broad and flattened, crop with seven pairs of caeca which are usually more or less branched. As commonly described, the species of this genus possess compact salivary glands, but in three of the five species these glands were found to be diffuse. In all the species, however, there was observed a pair of glands opening into the oesophagus similar to those mentioned by Hemingway (1908) as occurring in *Placobdella pediculata.* These glands are lined with columnar epithelium, whereas the salivary glands are unicellular. Another generic feature is the absence of a seminal loop, but, in one species, viz., *P. picta,* the seminal duct was observed to form a distinct loop.

Placobdella parasitica, (Say) Moore.

Hirudo parasitica, Say (1824).
Glossiphonia parasitica, var. *plana,* Castle (1900).
Placobdella parasitica, Moore (1901).

Sixty-five specimens of the collection have been assigned to this species. In size they vary from 8 to 60 mm., in length and from 1·5 to 18 mm. in breadth. The color varies from dark or light brown to deep green with a series of yellow markings along the margins and a yellow vitta in the dorsal median line. This vitta may reach the length of the body, expanding at intervals of about three somites or it may be confined to a few somites at the anterior end of the body. Some specimens have an intermediate series of yellow spots. The ventral surface is striped longitudinally with light and dark. Dorsally there are three series of more prominent cutaneous papillae and several series of smaller ones. These papillae are always smooth, though inconspicuous in some specimens. The oesophagus is long and looped and at the anterior end of the first loop are the long oesophageal glands.

The greater number of specimens were found attached to turtles of various kinds, *Clemmys guttatus, Aromochelys odoratus, Chelydra serpentina* and *Chrysemys picta.* One was found on a perch, another on a *Macrobdella decora* and numbers were taken from the lower sides of stones, sticks, etc., in small bays or lakes.

Placobdella rugosa, (Verrill) Moore.

Clepsine ornata, var. *rugosa,* Verrill (1874).
Glossiphonia parasitica, var. *rugosa,* Castle (1900).
Placobdella rugosa, Moore (1901).

Thirty-five specimens possess the general form and coloration characteristic of this species. Sizes from 10 to 59 mm. in length and from 3 to 17 mm. in greatest diameter; in shape similar to *P. parsitica,* broad, flat and blunt at the anterior end. In color also these two species are alike except that in *P. rugosa* the contrasts are rather less striking. In *P. rugosa* there is usually an interrupted, dark, dorsal median band. The cutaneous papillae on the dorsal surface are arranged as in *P. parasitica* but the surface of these is especially rough, hence the specific name *rugosa.* The oesophageal glands are in this species also, long, blind tubes.

The collections were made from dredgings, in small lakes and bays, from under sticks and stones in pools or ponds or from the turtles *Chelydra serpentina* and *Chrysemys picta.*

Placobdella montifera, Moore.

Not *Clepsine carinata,* Diesing (1858).
Clepsine papillifera var. *carinata,* Verrill (1874).
Hemiclepsis carinata, Moore (1901).

Among the leeches collected at Georgian Bay, there are twenty-six specimens with the discoidal head and three prominent series of papillae characteristic of this species. Shape more slender and less flattened than most of the species of this genus. In size varying from 5 to 21 mm. in length and from 1·5 to 5 mm. in breadth. The ground color is greenish or brown. A darker band is frequently to be seen in the dorsal median line. Along the margin a yellowish band may be seen and the papillae may be tipped with yellow.

Moore (1912) describes compact salivary glands for this species but the dissection of the specimens showed that these glands are diffuse rather than compact.

An interesting similarity has been observed between the position and the structure of the oesophageal glands in *P. montifera* and *P. pediculata.* In one specimen, a tube-like body is attached at the male pore, but it has not been found possible to explain its presence.

The majority of the specimens were collected from the lower sides of logs, stones, or shells of molluscs. Several were obtained by dredging at a depth of six fathoms. One specimen was found clinging to a garpike (*Lepisosteus osseus*) and another to a sunfish (*Eupomotis gibbosus*).

Placobdella phalera, Graf.

Seven specimens showing the markings characteristic of this species were collected. In size varying from 10 to 18 mm. and from 2 to 6 mm. in breadth. Body broad and flattened, tapering to a rather slender anterior end. Colour brown with a striking greenish tinge. From the anterior end backward to about the

seventh annulus, the dorsal surface is yellow and a yellow band passes around the body in the region of the eleventh or twelfth annuli. Along the margin of the body are yellow spots on the tips of the first and third annuli of the somite. In some specimens there is a median dark brown line interrupted in some cases by yellow patches. There are, usually, three series of papillae, but, in one specimen, five were observed.

As shown by dissection, there is a long looped oesophagus with a short pair of oesophageal glands connected with it. The diffuse salivary glands attached at the base of the proboscis, are of large size and stretch outward and backward, not forward as in other species. In one specimen the stalk of the posterior sucker was found to be quite long. In another specimen small bodies which appeared to be spermatophores were found attached to the body.

The specimens collected were taken from dredgings at a depth of from one to six feet and from the lower sides of stones or clam-shells on a sandy shore.

Placobdella picta, (Verrill) Moore.

Clepsine picta, Verrill (1872).

In the collection there is only one specimen answering to the description of this species. This specimen measures 29 × 5 mm. and is broad and flat in shape. The dorsum is marked with numerous longitudinal lines of deep green. Verrill describes this species as having a marginal series of yellow spots on the tips of the first and third annuli of the somite. In the preserved specimen the presence of these spots cannot be observed with certainty and the notes give no information on this point. The colour of the ventral surface is a flecked green. In the living specimen numerous papillae were observed on the dorsum.

There are diffuse salivary glands present and the oesophageal glands are long and similar in form to those of *P. rugosa* or *P. parasitica.* The oesophagus is almost straight, not looped as in the other species of this genus. The seminal duct forms a long loop connecting with the testicles anteriorly, much as in the species of *Glossiphonia.*

The single specimen of this species collected was found on the lower side of a clam shell on a sandy bottom.

Family Hirudinidae.

Distinguished by the presence in most species of five pairs of eyes, a five-ringed somite, three toothed jaws and a large mouth occupying the entire oral sucker. There is no protrusible proboscis.

These leeches are free swimmers and subsist upon the blood of animals or upon weaker invertebrates.

Genus **Macrobdella,** Verrill.

Characterized by large size and the presence of metamerically arranged black and red spots on the dorsum.

Macrobdella decora, (Say) Verrill.

Hirudo decora, Say (1824).
Hirudo decora, Leidy (1868).
Macrobdella decora, Verrill (1872).

Thirty-six adults and several young specimens in the collection possess the markings and general form peculiar to this species. In size, there is considerable variation, the largest specimen being 120x18 mm. The body is rather long and narrow, soft and limp. Dorsally the ground color is some shade of olive green, with conspicuous red and black dots metamerically arranged. The male and female genital pores are separated by five annuli and posterior to the female pore appear four openings which are arranged in a quadrate figure. These are the openings of the copulatory glands.

This form was usually found free in channels, ponds or bays and also clinging to sticks or stones.

Genus **Haemopis,** Savigny.

Among the *Hirudinidae* examined there are two species of leeches with the mottled or sooty gray colour characteristic of this genus. There is no appearance of metameric arrangement in the blotches. Especially in the contracted specimens, there is a noticeable angle in the posterior half of each annulus.

Haemopis marmoratis, (Say) Moore.

Hirudo marmorata, Say (1824).
Aulastomum lacustri, Leidy (1868).
Haemopis marmoratis, Moore (1901).

Twenty-one specimens have been assigned to this species. Size 40 to 90 mm. in length and 8 to 11 mm. in breadth. The colour in a majority of cases is dark and mottled or almost black, but in a few instances the ground color tends toward light grey. The angle in the posterior half of each annulus is quite prominent in this species and the body is more rounded at the margins than in *H. grandis,* the other species collected in this district.

These specimens were taken from the lower sides of stones in small bays or channels or from water plants.

Haemopis grandis, Verrill.

Semiscolex grandis, Verrill (1874).

Six specimens were identified as belonging to this species. Size large, 100 to 160 mm. long and 20 to 30 mm. wide, in the contracted condition. Colour dorsally slightly mottled, greenish-grey, ventrally plain. Lateral angle sharp; the male genital pore, twenty-four rings posterior to the mouth.

Dissection showed eleven pairs of testes, though ten pairs appears to be the more usual number (Moore, 1912). The gastric caeca in the specimen dissected were much larger in both dimensions than in the small *H. marmoratis.*

One specimen was obtained by dredging in the French River at a depth of twenty-five or thirty feet. The others were found in small lakes and among the islands. This leech is reported to have been seen feeding upon dead fish, but I have not been able to obtain positive information on this point.

Family Erpobdellidae.

The medium size, long, slender form and firm muscular body distinguish this family from others. The presence in the collection of one hundred and eighty specimens in the two species of this family shows that the group is well represented in the Georgian Bay region.

Genus **Erpobdella,** Blainville.

The representatives of this genus are slightly depressed in the posterior region of the body and rounded anteriorly. The five annuli of the complete somite are approximately equal in length. In some specimens the fifth annulus was slightly enlarged and showed signs of division, but dissection revealed the form of sperm duct characteristic of this genus.

Erpobdella punctata, (Leidy) Moore.

Nephelis punctata, Leidy (1870).
Erpobdella punctata, Moore (1901).

Of all the leeches in the collection, this species appears to have been the one most commonly taken. Specimens were obtained by dredgings in sandy channels or muddy bays and, along every sheltered pebbly shore either the leech itself or its cocoons were to be found on the lower sides of sticks and stones. The variati ons in color are considerable. Some specimens are light or dark brown with practically no markings while others show a series of dark flecks or dots on either side of the median line.

While examining these specimens I noticed that a considerable number possess four pairs of eyes, two pairs in somite II and also two pairs in somite IV. The usual number is three pairs (Moore 1901).

Genus **Nephelopsis,** Verrill.

Size large, body much depressed posteriorly. All annuli of complete somites more or less distinctly subdivided.

Nephelopsis obscura, Verrill.

Seventy-four specimens, large and small, have been thus identified. In size, these vary from 13 to 42mm. in length and from 3 to 5 mm. in breadth. The leech is evidently of the *Herpobdellidae,* but the greater depression of the body posteriorly and the greater diameter at that point mark it as distinct from *E. punctata.* The margin of the body is sharp and may tend upward in the preserved specimen.

The color is usually light, mottled grey but in some the dorsum is blotched with dark pigment.

Cocoons similar to those described by Verrill (1872) were found on the lower sides of stones in a pool beyond the reach of the waves.

Family Ichthyobdellidae.

This family is represented in the collection by forty-two specimens apparently belonging to at least two species. In the one type there is a slender, rounded body and large explanate suckers; in the other the suckers scarcely exceed the body in diameter while the rounded, slender body tapers toward the anterior end. Both forms possess a protusible proboscis and are parasitic on fishes.

Genus **Piscicola**, Blainville.

For the determination of these forms Verrill's paper (1872) was used and two species have been identified with his genus *Ichthyobdella*.

An examination of the external features of the one species would lead one to suppose that it belongs to this genus. The form is slender and rounded, the suckers large and explanate. So far as can be ascertained, fourteen annuli constitute a complete somite. No papillae or sensillae are in evidence. There are two pairs of eyes widely separated on the base of the head.

Where information is given the specimens obtained at the Biological Station were found clinging to lake trout (*Cristivomer namaycush*), but the same form has been found free in the waters of Lake Ontario.

Piscicola milneri, Verrill.

Ichthyobdella milneri, Verrill (1872)

In size this leech varies from 12 to 35 mm. in greatest diameter. The body slender and rounded, tapering toward the anterior end. There are two pairs of eyes plainly visible. The anterior pair are larger and farther apart than the posterior pair. The suckers are two or three times as wide as the body and are deeply cupped and excentrically attached. In the lateral region of the body seventeen pairs of vesicles were observed. The color is deep yellow with a symmetrical pattern in brown. There are four longitudinal yellow bands, dorsal median, lateral and ventral median. The brown color in the form of irregular pigment cells, is laid down in twelve longitudinal lines which are arranged in four groups of three, each group alternating with the yellow bands.

In each group of brown lines the uppermost line is more or less broken, showing a tendency to a series of heavy brown metameric bars. On the posterior sucker twelve dark brown eye-spots were observed. Verrill speaks of a tinge of green, but this was not observed in any of the specimens in the collection. The absence of this color, however, may be due to the effect of the preserving fluids.

These specimens were taken on lake trout (*Cristivomer namaycush*).

Piscicola punctata, Verrill.

In size these specimens vary from 15 to 30 mm. in length and from 2 to 3mm. in greatest diameter. The form is rounded and slender, and the division of the body into anterior and posterior portions is evident. The suckers are slightly explanate but do not exceed the body in diameter nor are they so deeply cupped as in *P. milneri*. The separation of the suckers from the body is not so well defined as in most Piscicolas.

In these specimens one pair of eyes has been observed but the number of annuli in a complete somite has not been determined.

At about the anterior end of the middle third of the body is an area covering apparently seven annuli. This area has a more or less swollen, porous appearance and contains the genital pores. This region evidently answers to the description of a clitellum, although a distinct clitellum is described as absent in this family (Moore, 1912).

An examination of a dissected specimen reveals the presence of a protrusible proboscis, an oesophagus and a moniliform crop. Attached at the base of the proboscis are a number of whitish bodies irregular in shape and provided with long white "ducts". These are, in all probability, the diffuse salivary glands. Attached to the oesophagus about midway is a pair of bodies which resemble the oesophageal glands of *Placobdella montifera*.

The ovaries appear in the form of two elongated sacs. There are five pairs of testes. Attached in the region of the "clitellum" are four thick layers of tissue just beneath the layer of longitudinal muscle. These bodies, probably the clitellar glands, pass backward toward the posterior end of the body.

These specimens were found clinging to rock bass (*Ambloplites rupestris*).

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VIII.

CONTRIBUTIONS TO THE LIFE HISTORY OF PROTEOCEPHALUS AMBLOPLITIS LEIDY.

A Parasite of the Black Bass.

By A. R. Cooper, M.A., University of Toronto.

(Plates XIX—XXI)

During the summer of 1909 the writer began a systematic study of the parasites infecting fresh-water fishes of the Georgian Bay region. In the course of this work it was noticed that the visceral organs of the small-mouthed black bass were greatly infected with the plerocercoids of some species of Proteocephalus. Up to that time Leidy's description of *Tænia micropteri* was the only reference to plerocercoids found in the bass, so that it was thought that these were individuals of that species. Furthermore, there appeared to be a close resemblance between the scolex of this form and that of *P. ambloplitis* Leidy, which was found in the intestinal tract of the same host, consequently a comparative study was undertaken to find out whether the resemblance was sufficient to warrant the view that the former was a larval stage of the latter. In order to ascertain the local distribution of the infection, adult hosts ranging in length from 22-23 cm., were taken in different localities around the Lake Biological Station on Georgian Bay, from the outlying islands and reefs some miles from shore inwards to the inland lakes and the Go Home River. The present paper is devoted chiefly to a description of certain stages of these plerocercoids and their identification with *P. ambloplitis*, but a number of observations on the life-history of this species have also been appended.

As a rule, bass of small size caught inshore are not greatly parasitized by *P. ambloplitis*, only occasionally is a young one found to contain a number of individuals of this species. Large bass, on the other hand, are invariably much infected. It is probable that the harboring of even a dozen or more adult specimens of this worm would have no noticeable effect on the fish in view of the presence of scores and even a hundred or more of echinorhynchi which are found in the pyloric cœca and intestines of every adult bass one examines. Of a small lot of bass caught near a group of islands lying about three miles from the mainshore, three, averaging 26 cm. in length, were examined for parasities, and in only one of these were adult specimens of *P. ambloplitis*, to the number of nine, found in the stomach. On the other hand the plerocercoid above-mentioned, which will be called *P. micropteri* Leidy (LaRue, '11) was well represented. In ten bass from twenty-one to to twenty-nine centimetres in length, only three harbored adults (*P. ambloplitis*) namely, two, each ten centimetres long when extended, in the first bass; two, thirty-three and ten centimetres, respectively, in the second; and three much smaller

in the third. As for the bass taken up the river, no adult tape-worms were found, yet the whole aspect of the parasitic fauna of these fish otherwise presents practically no differences from that of the hosts procured farther out among the islands off the shore.

So far as the influence of seasonal changes on the presence of adult individuals of this parasite is concerned, everything seems to depend on the food-supply and its alteration. In the late spring and early summer, when the bass are inshore spawning, the food appears to consist almost entirely of minnows which are then very plentiful; later the diet is restricted to crayfish. There is, however, a variation in the proportions of these two kinds of food from season to season, a variation which obviously depends on the numbers to be found by bass on the feeding-grounds, but which has a distinct influence on the presence of cestodes in the host. Again, the earliest fish to come in for spawning in June harbor comparatively few adult tapeworms, while later, about the middle of July, more are met with. This points to a rapid growth from the oncosphere stage, as has been noted by different authors for other species.

The Occurrence of the Plerocercoid in the Host.

In 1887 Leidy described under the name of *Tænia micropteri* a plerocercoid which he found in the body-cavity of the black bass, *Micropterus nigricans*, (the green or bayou bass, now called *M. salmoides* Lacépède, but since his description was based on external features only, it is now of comparatively little value. However, it is evident that this worm is the larval stage of some species of Proteocephalus (LaRue, '11). Furthermore, Leidy's description of the scolex: "head large compressed spheroidal, with four subterminal, spherical bothria and a papillaform, unarmed summit; neck none.....," is so suggestive of the plerocercoids here shown in Figs. 4 and 6, that in spite of the fact that no specimens were found in the few adults of *M. salmoides* examined, and that, to my knowledge, Leidy's original specimens have not been studied in serial sections, I feel justified in concluding that, in all probability, *P. micropteri* and the plerocercoid described below belong to the same species.

A number of hosts were dissected, and all the visceral organs excepting the air-bladder and the heart were found to be infected. The following table shows to what extent this occurs taking into consideration only those plerocercoids which could be seen with the unaided eye in nine specimens of the host species:

Number.	Length in cms.	Stomach.	Intestine.	Liver.	Ovaries.	Testes.	Mesenteries and cœlomic cavity.	Spleen.	Cœca.	Kidneys.
1	23.7	.....	2	.....	10	.....	.....	.....	.....	.....
2	32.8	1	.....	.....	.....	.....	.....	.....	.....	.....
3	26.2	1	6	.....	17	.....	2	1	2	9
4	?	.....	2	7	.....	9	14	.....	5	.....
5	29.6	.....	1	5	10	.....	.....	1	.....	.....
6	21.8	.....	.....	1	.....	1	2	.....	.....	.....
7	25.9	.....	.....	.....	.....	.....	.....	2	.....	.....
8	22.5	.....	.....	.....	.....	.....	.....	2	.....	11
9	25.0	.....	.....	5	11	.....	.....	.....	.....	.....

Above Table shows the occurrence of the plerocercoid in visceral organs of nine specimens of *M. dolomieu.*

From this it is seen that there is considerable variation in the numbers of the plerocercoid infecting the different organs: there is also a variation in their size. Those found in the *stomach* are very few in number and quite small. The *intestine,* on the other hand, harbors most of the plerocercoids found in the alimentary tract, their size ranging from 0·5 cm. to the adult condition (vide infra). Most of those found in the *liver* (Pl. XIX, Figs. 2, 3, 4 and 5) which, like the livers of most fishes harboring larval cestodes is much infested, average about 1 cm., the limits being from less than 1 mm. to 2 or 3 cms. as dissected out without the use of a lens or dissecting microscope. The smaller specimens are more cylindrical and compact in their structure than are the larger ones, the latter being, as Leidy describes them, "soft and white." The plerocercoids found in the *ovaries* and *testes* are somewhat flattened behind the constriction between the scolex and the body, soft and distended as if well provided with nutriment, that is, the constriction itself is deeper and the apex of the scolex is also better developed than in those found in the other of the visceral organs (Pl. XIX, Fig. 6). The scolex is attached to the outer wall or stroma of the gonad, while the body lies free away among the eggs or sperms, as the case may be, thus surrounded with a rich nutritive medium. The presence of such a food supply doubtless accounts for the greater diameter, the length remaining more nearly the same for similar stages of development. Furthermore the plerocercoids found in the gonads are on the average much larger than those found in the other viscera, another point which illustrates the influence of the surrounding tissue on the growth

of the worm. The few plerocercoids which are found on the mesenteries and in the cœlomic cavity average about 1 cm. in length and resemble those found in the ovaries and testes in that they are more distended than specimens from the alimentary tract. The presence of these will be discussed below in connection with the transference of the oncosphere and its further development. A number of cases were met with in which plerocercoids about 1·5 cm. in length were protruding into the coelomic cavity through apertures in the intestinal wall. Similar apertures are often caused by the probosces of echinorhynchi, and in one case a plerocercoid was found protruding from one of them together with one of these parasites. Again, in a small number of cases larvæ were found with their scolices imbedded in the stroma of the ovaries while their bodies were lying in the cœlomic cavity. Fish No. 2, in the table, harbored only one larva whose scolex was imbedded in the wall of the stomach, the body, about twice as long as the diameter of the scolex, remaining suspended in the lumen of the tract. The scolex was surrounded by a cavity, a little larger than itself, whose diameter was that of the thickness of the wall of the stomach less a thin outer membrane separating the cavity from the cœlome of the host; and in this space were the remains of the stomach wall in a comminuted state much resembling digestive débris. In the wall of the duodenum near the pylorus of fish No. 5, there was a similar cavity containing a plerocercoid about 2 or 3 mm. in length, with its suckers invaginated, which condition will be seen below to be normal for specimens of that size. These two cases could be explained by the development of the oncosphere which had not burrowed far into the wall of the alimentary tract, and perhaps the others could be dealt with in a similar way, but the evidence, though quite meagre, seems to point to an active boring by the larva. In this connection, several authors have recorded the wandering of larvæ in the tissues of the host and in the cœlomic cavity. Those found in the *spleen* are quite like specimens taken from the liver of the host. The *kidney*, on the other hand, is infested with small spherical forms with their scolices invaginated as shown in Figs. 1b and 1c.

External Features of the Plerocercoid.

The larvae are found with or without the scolex or sucker-bearing portion evaginated. In the very young forms, (Pl. XIX, Figs. 1a, b and c) the suckers are constantly invaginated, but when a length of about 1 mm. has been reached the suckers are found evaginated. From that time until a length of 6 or 7 mm. is attained (Pl. XIX, Fig. 5) they may be found in either condition depending on the location in the host and the manner of preserving or fixing. From observations of a number of plerocercoids of all sizes from different visceral organs it may be concluded that the sucker region remains permanently evaginated after a length of about 10 mm. has been reached. However, there are exceptions, as many specimens much longer are found with the scolex in the former condition. For example, the scolices of those found in the gonads of the host are protruded where the length of the body ranges from 4-40 mm., the latter being the length of the largest specimen I have yet found. When a fixing fluid is applied to small speci-

mens whose suckers are temporarily evaginated, there is often a sudden invagination of the scolex, while the converse is the case with somewhat older specimens. Both actions are apparently due to the instability of the conditions.

In young specimens where the scolex is only temporarily protruded, the anterior end bearing the organs of adhesion is somewhat cone-shaped with the base resting squarely on the anterior end of the body proper, as shown in Figs. 3 and 4. This structure is also to be seen in the large plerocercoids found in the gonads of the host, but from the size and greater development of the end-organ, which occupies a large space in the apex of the scolex, together with the well-nourished condition of the body, it is obvious that the neck, if the term may be used, is almost obliterated (Pl. XIX, Fig. 6). In larvae with the scolices permanently extended (Pl. XIX, Fig. 5) there is a well-defined neck, while the scolex is shaped like two truncated pyramids placed base to base, thus very closely resembling the scolex of the adults of *P. amblopli**t**is* as described by Benedict ('00). The body of the worm varies from the oval shape seen in Figs. 1, a, b, and c, Pl. XIX, through the elongated oval or elliptical outline of the older invaginated specimens, (Pl. XIX, Fig. 2) to the cylindrical form as shown in Figs. 4 and 5, Pl. XIX. Later when segmentation commences, the body is quite torulous. The flattening is well marked in those found in the gonads of the host some time before the development of the rudiments of the male reproductive organs shows that segmentation has commenced.

After the suckers have become permanently everted they are seen to undergo movements which may be observed at will when the animals are placed in tepid normal saline solution. These movements are rather indefinite and spontaneous at first, but as the plerocercoid develops they become more apparently purposive, and still later they are identical with those observed in adult specimens of *P. amblopli**t**is*. When the worm is not attached to the bottom of the receptacle, the suckers grope around here and there through the solution, being alternately protruded and withdrawn in diagonal pairs, while the whole scolex moves slowly to the right or left or occasionally rises from the bottom. The apex does not take part in these movements. Sometimes two adjacent suckers attach themselves firmly to the bottom of the vessel while the two free ones protrude and retract alternately. Again the worm may move along slowly, by alternately freeing and reattaching the two lower suckers while the other two continue with the groping movements. When this takes place the body is drawn along the distance travelled, generally not more than the width of the scolex or the distance between the centres of the adjacent suckers, by a bead-like contraction commencing near the scolex and travelling slowly towards the posterior end of the body. Occasionally all four suckers are used for attachment, and then the only movements to be seen are the contractions which follow one another slowly backwards. After a few seconds of attachment in this manner, the two anterior suckers are raised and the motions are resumed as described above.*

* A similar movement observed first by Batsch and later by Kraemer for *Taenia* (*Proteocephalus*) *torulosa* Batsch was described as "paarweise."

In the smaller forms, e.g., those shown in Fig. 1c, the movements are confined to irregular contractions of small amplitude of the whole body in a longitudinal direction.

Anatomy of Larvae of Different Sizes.

The smallest specimen investigated by means of serial paraffin sections measured 0·29 mm. in diameter by about 0·25 mm. in length. The suckers show narrow spindle fibres, two zones of nuclei and circular muscle-fibres on the inside and outside of the spindles, all characteristic of the adult *P. ambloplitis* as described by Benedict. The invagination chamber is large and contains mucus. The measurements are considerably less than those given below for an older larva, the end-organ being 0·058 mm. in diameter and the suckers 0·084 mm. The former is essentially similar in structure to that of the older plerocercoids. A few nuclei are found lying within the basement membrane, and there is found a cross of large muscle-fibres in the parenchyma behind the organ. This parenchyma is very loose and open, especially immediately behind the end-organ (here situated more posteriorly than the suckers, since the scolex is invaginated). Longitudinal muscle-fibres are few, but there are many nucleated anlagen in that area. The cuticula is thin and the cuticular muscles are poorly differentiated. The caudal vesicle gives off two main branches. Parenchyma cells surround these branches, as described below and extend for some distance out on secondary branches, thus suggesting the origin of the excretory vascular system (cf. Braun, '94-'00). Only a few parenchymatous spaces are to be observed, and the connections between them and the branchlets of the caudal vesicle are not evident.

Later the parenchymatous cells grow and take on a more definite stellate appearance showing their fine processes distinctly while the muscle-fibres become more strongly developed from the anlagen in the parenchyma.

Larva, 0.7 mm. in length, Pl. XIX, Fig. 1c.

At this stage of the development the cuticula measures 8μ in thickness, just 1μ less than that given by Benedict for the adult *P. ambloplitis*. The tube leading from the invagination chamber to the exterior has a diameter of 48μ including the cuticula itself, which is here deeply incised. Around this tube the circular muscles are well developed while the longitudinal fibres are very numerous and quite large. The suckers are 110μ in diameter and show at their centres spindle fibres 32μ long, the rest of the musculature being well-developed in plerocercoids of this size. The crenulated cuticle lining the cavities of the suckers is 3μ in thickness. The end-organ, which, so far as structure is concerned, seems to be as well-developed as that of the plerocercoid described below, has a diameter of 0·150 mm. and a length of 0·135 mm., which measurements show that it is proportionately much larger than in an older plerocercoid (vide infra). The caudal vesicle, 60μ in length, is forked for a distance of 15μ, and this forked portion is lined with a continuation of the cuticula applied to the inside of the vesicle itself. Small absorptive cells are grouped around the vesicle in the typical manner, but the cuti-

cular muscles are here poorly developed. Proceeding from the forked portion of the vesicle are two main longitudinal excretory vessels, each 10μ in diameter, with very thin but distinct walls. These vessels course slightly backwards before passing forward where they connect with a meshwork of vessels of the same size situated in the scolex region; but on account of the invagination of the scolex the latter are directed posteriorly again. Some distance in front of the caudal vesicle the beginnings of the second excretory vessels may be seen in the parenchyma as a very small tube running along the larger vessel on each side and gradually diverging from it as far anteriorly as the latter can be traced. That part of the anterior anastomosis of the excretory vessel mentioned above, which is closely associated with the organ-end and invaginated suckers, is circularly disposed as are the parenchyma cells, owing to the compression due to invagination; at a later stage when the scolex is permanently everted, they are more loosely arranged.

Plerocercoid, 2.9 mm. in length, Pl. XIX, Fig. 4.

The plerocercoid of th s size shows practically all of the structures found in the older specimens, so that it will be described somewhat at length.

Masculature of Scolex.—At a depth of about 15μ from the apex of the scolex general oblique muscle fibres are found coursing from the lateral walls to the dorsal and ventral surfaces, thus forming a rhomboid whose diagonal axes lie in the coronal and sagittal planes of the animal. These also surround the end-organ and its opening quite like similar fibres described by LaRue ('09). As seen in Pl. XX, Fig. 7, most of them are attached to the wall of the scolex near the edges of the suckers but some end in the parenchyma before the sucker is reached. They can be traced backward from the tip to a distance of about 150μ beyond which they remain as vestiges only, attached to the indentations between the suckers, Pl. XX, Fig. 8; and, furthermore, the farther back one traces them the fewer are those fibres which run between the suckers and the end-organ. This shows that from their points of attachment on the wall of the scolex the fibres curve forward towards the apex, which is well shown in longitudinal sections.

No "muscle-cross" due to the crossing of rhomboid fibres, with fibres running dorso-ventrally and laterally, connecting opposite structures, as described by La-Rue for *P. filaroides*, can be made out in this region of the scolex, for here is situated the very large end-organ (Pl. XX, Fig. 8). It is surrounded by a thick mat of circularly arranged fibres which do not appear to run transversely or dorso-ventrally in any part of their course.

At a depth of 140μ transverse sections of the flared ends of the "diagonal muscle cross" may be seen between the inner walls of the suckers and the wall of the end-organ. Farther on these ends are cut more obliquely and converge towards the end-organ fast diminishing in size as the sections go farther back, until at a level of 230μ the end-organ is just passed and the muscle cross itself is seen very distinctly (Pl. XX, Fig. 10). In this section the flared ends of the two crossing bundles and their narrowed centres are quite characteristic (LaRue); the fibres are, however, more numerous than those of *P. filaroides*, according to LaRue's figure and each

bundle is about 35μ at its widest. This muscle-cross can be traced for 20μ farther. Just before it disappears its fibres become closely arranged in the centre of the section, but the flared ends may pass a little farther back if any part of a sucker remains past the decussation. From this and the appearances in longitudinal sections passing through diagonally opposite suckers it is seen that the relation between the end-organ and the muscle star is that of a body suspended in a sling; contraction of the fibres would obviously protract the apex of the scolex both by the retraction of the suckers and the protrusion of the end-organ.

Just before the posterior end of the end-organ is reached straggling fibres coursing dorso-ventrally and laterally appear in four groups in the areas bounded by adjacent suckers and the walls of the end-organ. Farther back these elongate centrally and mingle with the descussation of the diagonal fibres before the latter disappear (Pl. XX, Fig. 10) the double crossing forming Riggenbach's "Muskelsterne". They are rather loosely arranged, are quite narrow as compared with those of the diagonal group, and continue posteriorly to the caudal vesicle, around which a few may be found; they are the dorso-ventral and lateral muscles of the adult strobila (Fig. 12). Benedict in his paper on *P. ambloplitis* describes them as originating from cells which may be situated anywhere within the longitudinal muscles of the plerocercoid. The cell itself is spindle-shaped, has a large nucleus which fills up most of the body of the cell and sends off fibres at least in two opposite directions. Other fibres crossing these muscle-cells near the centre give the appearance of as many as four originating from one cell. The fibres themselves run out into the cortical parenchyma well towards the absorptive cells.

Longitudinal Muscles.—The longitudinal body-muscles are quite prominent and situated about three-eighths of the length of the shorter radius from the cuticula, (Pl. XXI, Fig. 12); towards the ends of the major axis of the more or less elliptical cross-section they lie relatively nearer the latter. The fibres themselves cannot be said to be regularly arranged in groups as described by Benedict for the adult, yet here and there two to four and sometimes more are somewhat isolated from their fellows. Towards the posterior end of the plerocercoid they approach the centre, but at about the anterior end of the caudal vesicle they fall off considerably in number. Anteriorly most of them after passing the neck constriction break up into four groups each of which is attached to the posterior half of a sucker. A very few fibres, however, pass by the suckers and become lost in the parenchyma around the equatorial region of the end-organ.

Parenchyma.—In the area enclosed by the longitudinal muscles the parenchyma is in the form of an open mesh-work of very fine fibres and cell-processes. The nuclei of these cells are scattered irregularly throughout the area and are easily confused with nuclei of dorso-ventral and lateral muscle fibres. The cortical parenchyma, on the other hand, is more compact, the cells being arranged roughly in a radial manner. Throughout the parenchyma, more especially in the medullary portion, very many comparatively large spheroidal spaces are to be seen. These may reach a diameter of 15μ. While the fixing of fresh material with glacial acetic acid demonstrates the presence of much calcareous matter in the parenchyma by effervescence and the passing out of gas-bubbles through the cuticula, it cannot

be concluded that these spaces are filled with chalk bodies; it is quite probable that they accommodate oil-globules (LaRue). Furthermore, in plerocercoids from the ovaries or testes of the black bass where they are richly supplied with food, these spaces are very numerous, quite large and crowded closely together. It is doubtless their distension with fat which causes the well-nourished appearance of these larvæ as mentioned above.

Subcuticula or Absorptive Cells.—The subcuticular cells are quite granular in consistency and possess comparatively large nuclei which stain deeply with Heidenhain's iron-haematoxylin stain (Pl. XXI, Figs. 12 and 13). Centrally they are more or less abruptly attenuated, thus not proceeding far into the cortical parenchyma with processes of whose cells they mingle and anastomose. Including these attenuations as far as they may be distinctly traced with a magnification of 450 diameters, the cells average 20μ in length. Their peripheral ends are truncated, slightly expanded and apparently closely applied to the outer circular layer of muscles, while the longitudinal cuticular muscle fibres penetrate their broad bases some little distance from the latter. However, in gaps in the layer of circular muscles the absorptive cells are seen to proceed farther out as fine processes which can be distinctly traced as such into the cuticula for at least one-third of its thickness. Furthermore, it is quite likely that these processes proceed farther out, perhaps as far as the boundary between the two layers of the cuticula, as described below, but the highest powers used did not show this positively. A study of better sections with various kinds of fixations would doubtless much elucidate this problem which has occupied the attention of so many workers during the past.

Cuticular Muscles.—The cuticular muscles are quite typical in their structure and arrangement and closely resemble those figured by Benedict for the adult *P. ambloplitis* They are shown in various figures, especially in Pl. XXI, Fig. 13.

Cuticula.—By the use of the iron-haematoxylin stain the cuticula is resolved into two distinct layers, the outer of which takes no stain as compared with the inner. The latter (Pl. XXI, Fig. 13 cu″) is about four times as quick as the former, and takes the stain better in its outer parts. But in deeply stained series the inner portions show the structure described above under the subcuticula. In the middle third of the cuticula, which takes the stain well, what appear to be fine processes from the absorptive cells become arranged in a more or less parallel manner and extend to the boundary between the two layers where a layer of comparatively large granules, quite regularly arranged, is plainly to be seen. Beyond this the cuticula appears to be quite homogenous with the highest powers of magnification available. The parallel processes, however, are identified more by small spindle-shaped granules placed along their courses than by the parts of what must be canals between these enlargements. Thus it seems that the outer homogeneous layer of the cuticula is something quite different from the inner layer although it takes a transparent counter-stain like Orange G. to the same extent as the latter. Concerning the significance of these layers, the extent of the present work will not permit the making of any definite statements. It seems, however, that the external layer of the cuticula is a definite structure and not something added from the outside since it is of uniform thickness, excepting where broken by injury, and has a

definite outer boundary which is at least optically different from the rest of the layer.

Nervous System.—In plerocercoids of this size the nervous system is quite well developed and essentially the same as that described for the adult by Benedict. The nerve ring is found at a depth of about 120μ from the apex, but it is quite thin especially where it passes between the large end-organ and the suckers which are quite close together at this level (Pl. XX, Fig. 8). At the points where the large nerves supplying the suckers are given off the nerve ring is swollen to form ganglia. From the ring two somewhat flattened cords course posteriorly to supply the body of the plerocercoid. In the anterior part of the body they are situated in the cortical parenchyma, while in the posterior region they approach the centre somewhat and lie in the band of longitudinal body-muscles just outside the excretory vessels.

Excretory System.—The excretory system at this stage is characterized by the presence of a large number of flame cells and two longitudinal vessels, connecting anteriorly with a meshwork of fine tubes surrounding the suckers and end-organ. These two vessels are unequal in size, nor are their courses and connections similar. The larger, averaging between 5 and 8μ in diameter, has thin walls and gives off a large number of branches whose diameters are quite as great as that of the main vessel. These branches are distinguishable as vessels with walls for very short distances only, since they soon fuse with parenchymatous spaces in a complicated manner. Here and there branches can be seen running from this vessel to the periphery, narrowing as they approach the cuticle and eventually piercing it by apertures much smaller than the diameter of the main vessel. These, however, are not as numerous as might be expected from the development of the main tube itself. The other vessel is from one-quarter to one-third the size of the larger and pursues a straight course; on the other hand, it has thicker walls in which prominent nuclei are to be seen. While its origin in the region of the suckers is more easily made out than that of the larger vessel, posteriorly it becomes so constricted at different levels that it all but disappears from view; near the caudal vesicle, and just before joining the latter, it bends forward and inward behind the anterior end of the vesicle and opens by an aperture quite separate from its fellow of the opposite side.

On each side of the plerocercoid the two excretory vessels are situated just within the longitudinal body muscles, about 35μ apart and on a line inclined at various angles to the perpendicular to the longitudinal axis of the transverse section, the smaller vessel constantly lying nearer the centre of the section.

The caudal vesicle is 70μ long and 10μ in diameter, including the cuticular lining. The lumen itself is somewhat stellate in shape owing to deep incisions and folds in the cuticula. The absorptive cells follow the cuticula from the outer wall of the worm throughout its whole length, while the cuticular muscles are well developed as far as the apertures of the excretory vessels. As this place is approached the longitudinal fibres diverge and become lost in the parenchyma; likewise the absorptive layer suddenly disappears.

Flame-cells are very numerous and comparatively large at this stage. They are found to be confined to an area around the excretory vessels as described by

LaRue for the species *P. filaroides;* Pl. XXI, Fig. 14, shows a typical group of flame-cells connected to the smaller excretory vessel (vide supra). While it was rather difficult to make out the exact point where the common duct emptied into the longitudinal excretory vessel, it could be seen that more flame-cells poured their excretions into the smaller vessel than into the larger and more irregular of the two. The stellate appearance at the ends of the flame-cells in this figure seems to be due to contraction of the cell-body and the staining of numerous radiating strands in its protoplasm, which do not appear in sections stained lighter. The parts of the flame-cells itself are seen in Pl. XXI, Fig. 15. The outlines of the cell-body are difficult to discern, but they are quite irregular, as shown, the protoplasm being prolonged into many processes of different lengths. Very little structure can be detected in the protoplasm, but it is evident that vacuoles observed bv various authors are present. The nucleus is comparatively large and stains deeply. The ciliary flame is rather large and attached at its proximal end to a very deeply staining body situated close to the nucleus, doubtless the basal granules of the individual cilia massed together, which, by the way, are difficult to separate optically. The conical cavity in the cell which accommodates the ciliary flame is easily seen and has peculiar elongated thickenings in its walls, much resembling elongated nuclei but which show practically no structure. The cavity itself is directly continous with the very thin-walled, homogenous canaliculus which connects it with those of its neighbours to the longitudinal excretory vessels.

End Organ.—In his description of the scolex of *P. ambloplitis* Benedict makes the following statement: "Directly beneath the apex of the scolex is a sac of cuticular structure enclosing a small number of circular masses, closely packed together. The masses seem to be of a calcareous nature and are penetrated by numerous fine canals. No connection whatever could be traced between this sac and any outside system, although the excretory ducts form a thick network around it." Longitudinal sections of the two scolices of sexually mature specimens showed two conditions of this end-organ (Pl. XXI, Figs. 16 and 17) which are very suggestive. In both cases the organ, although not separated from the surrounding parenchyma by a clear zone as in LaRue's account of *P. filaroides,* is quite distinct from the latter. Evidently Fig. 16 represents a younger stage than does Fig. 17. In the latter it is to be noted that the whole of the central tissue has lost its structure, remaining as so much connective tissue, irregular muscle-fibres and other deeply-staining bodies; the granular nature of the organ is more evident and the material seems to be arranging itself into definite areas, doubtless to form the calcareous bodies above mentioned. The connection between the cuticula and the organ is much less evident; the muscular bounding fibres, which are continuations of the longitudinal muscular layer of the body of the worm, are losing their connections with the musculature beneath the cuticula; in fact the whole organ and its surroundings seems to be in a degenerated state. On the other hand, Pl. XXI, Fig. 16, presents what one might consider a more functional structure. Although there is no direct aperture through the cuticula of the scolex connecting the organ with the exterior, it is quite evident that at a slightly earlier stage such might be found. The muscular boundary is more definite, and the contents of the organ,

namely, peculiar basal cells whose free parts project into a fibrous meshwork in the spaces of which there is to be found a fluid with very fine granules, more nearly approach the condition about to be described.

In the plerocercoid described above (Pl. XIX, Fig. 4) the end-organ extends 220μ from the apex. Its cross section throughout the series is somewhat elliptical, the major axis measuring at its greatest 290μ and the minor 196μ, diameters 229 and 230μ, thus presenting a more nearly spherical outline. The organ has a thick wall composed of two layers. The outer and thicker is made up of comparatively large muscle-fibres running in a general circular direction and intermingled with longitudinal fibres which constitute the inner layer. These fibres fuse with the cuticular musculature at the anterior end of the end-organ. Next towards the centre of the organ comes a very thin basal membrane much resembling the cuticula on the exterior of the plerocercoid and continuous with that lining the invagination chamber of the apex of the larva (Pl. XX, Fig. 9). The organ opens to the exterior by an aperture 29μ in diameter and circular in shape. It is lined with the cuticula from the surface of the worm, which continues down into the lumen of the organ for about half its diameter as a thin-walled tube, perforated freely, more especially as it nears the centre of the organ, by wide irregular openings. This tube is supported by numerous radiating strands of tissue attached to short, conial and wedge-shaped processes from the cells situated on the basement membrane. In most series of plerocercoids of this age these radiating filaments disappear at the posterior end of the organ as distinct connections between the basal cells and the central tube, leaving only scattered pieces lying in radial directions from the latter. The general arrangement is best seen in transparent preparations of whole plerocercoids; in these the strands all appear to emanate from the aperture of the organ. The basal cells are very irregular, granular, highly-stainable and have large nuclei, themselves readily taking the stain. The processes both free and attached to the central tube are bathed in a fluid filling the organ, which is very fine and granular in consistency and stains very deeply with Heidenhain's iron-haematoxylin. In some series a clear area surrounding the inner end of the central tube shows where some of the material has been expelled from the organ, since in longitudinal sections a band of material is often found protruding through the aperture to the exterior.

LaRue discusses this end-organ at some length in *P. filaroides*, among other things mentioning its occurrence in the plerocercoid found in *M. dolomieu*, in all probability that being dealt with in this paper. Apart from this species the end-organ has been described only in Riggenbach's P. sp.?, *P. Lonnbergii* Fuhrmann, and in *P. ambloplitis* Leidy, the latter by Benedict.

As to the function of the organ, if it has any definite function, the extent of my studies will not permit me to give anything further than suggestions. From its early disappearance in *P. filaroides* and its great development in this plerocercoid, one would be inclined to conclude that it functions only in the larval stages, since obviously the organ as found in the adult is functionless at least so far as the external surroundings of the plerocercoid are concerned. Unfortunately I have not at hand a complete series from the plerocercoid to the adult stage, the oldest

specimen of the former condition which shows signs of segmentation being only 39 mm. long. In this specimen (Pl. XIX, Fig. 6) the apex of the scolex is very prominent and is occupied almost wholly by the end-organ which is somewhat flattened dorso-ventrally as is the scolex itself and measures 426 by 360μ in the cross-section by 380μ in length. Furthermore, the basal cells are represented by only small remains with here and there short processes, and widely-separated radiating pieces represent the strands connecting them with the central tube of the organ. The aperture is relatively quite large. The contents show larger granules, while only that part at the posterior end of the tube seems to be very fluid. When fresh material is fixed it is a common occurrence to see a short, thick, viscid stream of liquid oozing from the apex of the scolex. As soon as this material comes in contact with the fixing-fluid, it coagulates, thus demonstrating its protein nature. Microchemical tests show that it contains lime-salts, while the basal cells are likewise rich in calcium. From this it would appear that the basal cells secrete the material found in the cavity of the organ, but whether the material is for digestion in connection with the boring action which some authors attribute to the plerocercoids, for adhesion or merely represents the remains of a much-altered rostellum, perhaps in connection with excretion, must remain conjectural until further study throws more light on the subject.

The study of plerocercoids intermediate in length between that just described and the 39 mm. specimen mentioned above, showed that besides the general growth and differentation of all of the tissues there is particular development in the cuticula, end-organ and excretory vessels.

The cuticula as a whole gets much thicker while its external layer becomes relatively thinner. The end-organ grows comparatively rapidly until it occupies almost the whole of the apex of the plerocercoid (Plate XIX, Fig. 6). Its degeneration into the calcareous bodies of the adult scolex must take place very quickly, as has been demonstrated for *P. filaroides* by LaRue. Unfortunately I have not yet procured specimens showing this degeneration.

In the 39 mm. plerocercoid the excretory vessels are three or four on each side in the neck region. One pair lying in a "median frontal plane" (Benedict) are the largest and most regular of them all; few branches are given off from them in the scolex where they gradually diminish in size and disappear near the apex. Another pair giving off many branches, a large number of which go to the exterior, lies in a sagittal plane on each side of the body just outside the first vessel but within the longitudinal body-muscles, thus forming the base of a triangle whose apex is the largest vessel. Other large vessels in the region of the scolex are merely branches, but some run parallel to the main vessels for considerable distances, and one may develop into a fourth vessel. This latter statement refers especially to one seen outside the longitudinal muscle zone, about half-way between it and the cuticula. This arrangement of vessels is also found in specimens only 10 mm. long, where even a fifth vessel may be seen running parallel to the others for a short distance. However, when these vessels are traced backward, they all, excepting the smaller pair in the median frontal pair unite to form the single pair of large vessels, evidently ventral in position, which course irregularly backwards

and unite with the caudal vesicle. The smaller, median frontal pair are the smaller vessels described above for a shorter plerocercoid which becomes lost in the parenchyma around the end-organ forward and the caudal vesicle posteriorly, thus exactly coinciding with Benedict's median frontal pair, excepting that this writer did not see the posterior connections. The large size of this pair as described above for the 39 mm. larva must be due to some physiological condition or individual variation since they are not thus distended in the 25 mm. specimens. An important point to be noticed in connection with the development of the excretory vessels is that the posterior end of the plerocercoid remains in a primitive condition while the anterior end specializes; and the development of the other parts bears out this statement.

The evidence given above appears to establish the idea of the identity of this plerocercoid and *P. ambloplitis*, more especially with regard to the following points:

(1) The excretory vessels of advanced stages of the former are identical with those of the latter;

(2) Measurements of the cuticular structures and the parts of the suckers are the same in both forms, relatively speaking;

(3) The movements of the suckers during life are identical;

(4) The nervous system of *P. microperi* is essentially the same as *P. ambloplitis;*

(5) The stages in the development of the end-organ, although not complete, suggest a continuity between the two forms.

The Intermediate Hosts.

Our knowledge of the development of the genus Proteocephalus (Ichthyotaenia) dates as far back as 1878 (Gruber). Since then data have been added from time to time, so that only now are we getting a general idea of the whole process. Gruber found several stages of a plerocercoid in *Cyclops brevicaudatus*, which he believed to be those of *Proteocephalus* (*Taenia*) *torulosa* Batsch. Zschokke ('84) found the unsegmented larva of *P. longicollis* Rud. in the liver of *Salmo umbla* in which the adults were found, and what he called the larva of *P. torulosa* in *Coregonus fera* in the month of January, in the intestine of *Lota vulgaris* in the month of February, and in *Alburnus lucidus* in March. These observations in the light of present knowledge suggest a comparatively simple life-history in that the larvæ may develop from the oncospheres in the final host and in a short period, as found by LaRue ('09). The former was also observed for *P. longicollis* by von Linstow ('91). Riggenbach ('96) describes the plerocercoid found in the parenchyma of the scolex of *Corallobothrium lobosum* Rigg., which closely resembles that of *P. ambloplitis* found in the black bass and other fresh-water fishes, but he gives no suggestions as to its adult existence. In the section, rntitled, "Development," he merely mentions work contained in some of the above eeferences, after saying that "on the development of the uterine eggs, as well as

the early stages of the Ichthyotaeniae almost nothing has yet been published." Schwarz ('08), in speaking of the development of the reptilian Ichthyotaeniae, takes Gruber's observations as his basis and proceeds to elucidate the infection of reptiles through Cyclops and the aquatic habits of the hosts concerned. Fuhrmann ('03) considers the larvæ found in the livers of Salmonids and Percids by von Linstow, von Siebold and Zschokke as strayed larvæ having mistaken hosts and having then taken a particular aspect. This view would explain the fate of numbers of the plerocercoids of *P. ambloplitis* found encysted in young and old bass. Unless the bass were eaten by larger fish such as *Amia*, *Lepisosteus*, *Esox* or *Salvelinus* in which they could develop as in a second final host they would surely disintegrate eventually. Fuhrmann showed by his infection experiments that the intermediate hosts of the Ichthyotæniæ were the one or the other of the copepods found in the plankton used as food. LaRue's infection experiments with *Chironomus* larvæ, *Daphnia*, *Cyclops*, *Notonecta*, some larvæ of the *Dytiscidae*, tadpoles of *Rana catesbiana*, besides the Salamander (*Amblystoma tigrinum*) itself proved failures as did those of Schneider ('04). However, he furnishes conclusive evidence, "first, that the encysted plerocercoid (of *P. filaroides*) is the larval form of the cestode found in the same host; second, that the period of development from the plerocercoid after ingestion is short."

In connection with the present study only a few infection experiments were tried, but they gave no results; it was found very difficult to keep the young of *M. dolomieu* alive and unmolested,—they are very sensitive to change of environment—whereas the young of *M. salmoides* are easily kept in captivity. However, a thorough series of dissections was carried out with bass of all sizes from those taking their first food after hatching, about 8 mm. in length, to adults. This resulted in a very fair acquaintance with the great variety of food-forms of *M. dolomieu* as found on the eastern shore of Georgian Bay, but the points elucidating the life-history of *P. ambloplitis* were rather few in number.

Plerocercoids were first found in hosts about 40 mm. in length and between that and 50 mm. the infection was not considerable. The organs infected were, first the liver, then the alimentary tract and coelome. Observations on methods of infection pointed, first, to the direct development of the oncospheres accidentally introduced (autoinfection), their subsequent transference by means of the blood stream (Braun), and the boring of the oncospheres themselves; second, to infection from invertebrate food-forms such as *Sida*, *Daphnia*, *Chironomus* larvæ and *Coriza*; and thirdly, to infection from minnows and young perch which constitute a part of the food and from which large numbers of very small plerocercoids closely resembling the youngest stages described above are freed in the stomachs of the bass. This latter method is borne out by the fact that no tape-worms were found in those fish examined in the early fall of 1910 when the food taken was composed wholly of crayfish, whereas a comparatively heavy infection was found with those taken on the outlying reefs and islands where minnows constitute the bulk of the food. Thus the evidence points to *P. ambloplitis* having at least two intermediate hosts, the first, some unknown species of aquatic arthropod, and the second, either different species of minnows, small perch or the final host itself.

Our knowledge of the identity of the first intermediate host of the genus Proteocephalus is confined to Barbieri's paper on *P. agonis* Barb. Although he did not absolutely prove his hypothesis, he collected sufficient evidence to lead one to feel justified in concluding that *Bythotrephes* and *Leptodora* are the forms in which the oncosphere of that species develops into the very young plerocercoids.

The Egg.

Up to the present the egg of the genus Proteocephalus has been described for only a few species, but the descriptions all show that it consists of a six-hooked embryo or oncosphere surrounded by three membranes. The outer or first membrane is very variable in shape and size while the other two are constant in mature eggs, that is, in eggs showing three pairs of hooks. The third or innermost membrane is difficult to differentiate in whole specimens since it is so thin and so closely applied to the embryo.

The egg of *P. ambloplitis* is shown in Pl. XX, Fig. 11. It is to be seen that the first membrane varies from a nearly spherical shape to that seen in e, which is rarely found. These extreme variations appear in eggs all procured from a single ripe proglottis, but those shown in Figs. 11 a, c and d are commonest. In fact, apparently all the eggs in most ripe proglottides possess these peculiar dumb-bell shaped outer membranes, thus leading one to consider their structure as characteristic of the species. At any rate, such appendages do not appear in the eggs of any other of the several species of Proteocephalus I have examined. On the other hand the rest of the egg is quite typical. As suggested in Fig. 11d and shown in the extreme in e, these characteristic swellings of the outer membrane are not quite in line with the longitudinal axis of the egg. In such eggs as shown in Figs. 11 a, c and d, from which living oncospheres can be expressed, the outer membrane varies in length from 55μ to 75μ. The second membrane, however, is more constant in diameter, varying only from 24μ to 27μ. The third membrane is not easily seen in the intact egg, but parts of it appear after the oncosphere has been pressed out. The granular layer between the second and third membranes as seen in optical sections is quite uniform in thickness, about one tenth of the diameter of the second membrane, and is composed of fine granules and spherical yellowish globules scattered about so as to leave irregular, often circular, clear areas through which one can see the oncosphere. The largest of these small granules are, however, apparently identical with the smallest globules, so that the whole suggests fat droplets of various sizes.

The oncosphere may be easily pressed out under a glass-cover from the central parts of the egg to either of the expansions of the outer envelope, that is, to the space between the outer and second membranes. There it is seen to move vigorously, the hooks acting in a manner very similar to that described by LaRue for *P. filaroides*. A pressure which is not quite sufficient to cause the oncosphere to escape from the second membrane almost invariably stimulates it to begin its movements *in situ*. These take place outside of the egg-membranes at the rate of about fifteen per minute. From the 10μ sections of ripe proglottides stained

in Heidenhain's iron-haematoxylin the oncosphere was seen to be made up of a number of cells packed closely together, whose boundaries were obscure while their nuclei were deeply stained. In living oncospheres each hook was observed to be imbedded in a cone of homogenous material, the apex of which surrounded the proximal end, slightly swollen in this species, while the base at the surface of the oncosphere was about three times the diameter of the distal end of the main shaft of the hook. The tips of the hooks appeared to protrude from the surface of the onocsphere, especially during the phase of separation of the former.

All of these observations and measurements were made from fresh material in normal physiological saline solution, so that the various stages in the swelling of the outer envelope were not due to osmotic action; this takes place apparently within the uterus as a stage in the development of the egg.

March 3, 1913.

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EXPLANATION OF FIGURES.

All drawings, unless otherwise mentioned, were drawn to the scale indicated with the aid of an Abbé camera lucida.

Abbreviations.

ac.	Absorptive cell.	lcm.	Longit. cuticular muscles.
bac.	Basal cells.	m.	"Muskelsterne".
bm.	Basal membrane.	mw.	Muscular wall of end-organ.
cu.	Cuticula.	n.	Neck.
cu'.	Outer layer of cuticula.	ng.	Nerve ganglion.
cu".	Inner layer of cuticula.	nac.	Nuclei of absorptive cells.
ccm.	Circular cuticular muscles.	om.	Outer membrane.
ct.	Central tube.	on.	Oncosphere.
eo.	End-organ.	pac.	Parenchyma cells.
eeo.	Entrance to end-organ.	par.	Parenchyma.
exv.	Excretory vessels.	sm.	Second membrane.
gr.	Granular material.	weo.	Wall of end-organ.
lbm.	Longitudinal body muscles.	ym.	Yolk mass.

PLATE XIX.

Figs. 1, a, b.—Plerocercoids from kidney of host, × 33.

Fig. 1 c.—Small plerocercoid from liver of host, × 33.

Figs. 2, 3, 4, 5.—Plerocercoids from liver and intestine of host, × 33.

Fig. 6.—Plerocercoid from gonad of host, × 33.

PLATE XX.

Fig. 7.—Transverse section through a 2·9 mm. plerocercoid, 30μ from the apex, × 105.

Fig. 8.—Transverse section of same, 130μ from apex, showing end-organ and suckers, × 130.

Fig. 9.—Longitudinal section through end-organ of another specimen, showing structure × 130.

Fig. 10.—Transverse section through the 2·9 mm, plerocercoid 240μ from apex, showing "Muskelsterne", × 130.

Fig. 11.—Egg, showing structure and various forms of the outer membrane, *a* × 700; others × 350.

PLATE XXI.

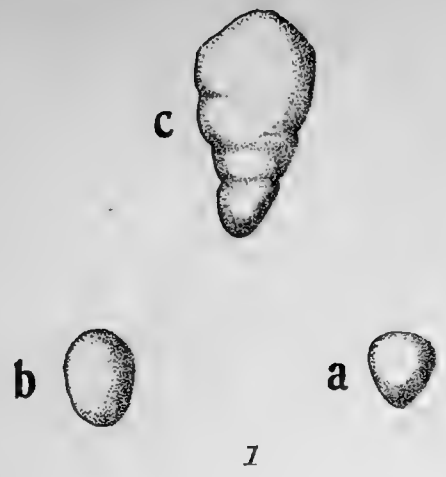
Fig. 12.—Transverse section through body of plerocercoid, showing general structure; semi-diagrammatic, × 130.

Fig. 13.—Part of a transverse section through the body of a plerocercoid, showing details of cuticular structures, × 600.

Fig. 14.—A group of flame-cells in connection with one of the excretory vessels of the median frontal pair, × 1,000.

Fig. 15.—A flame-cell greatly magnified, showing structure, × 2,000.

Fig. 16, 17.—Longitudinal sections of different conditions of the end-organ in adult specimens of P. ambloplitis, × 330.



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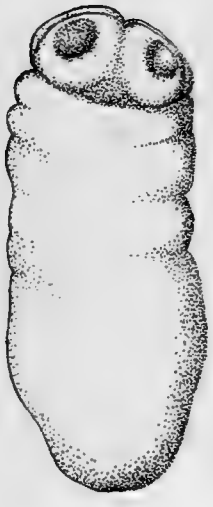

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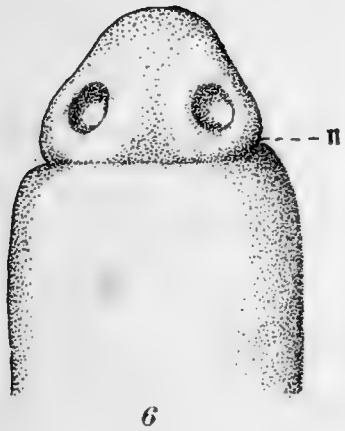

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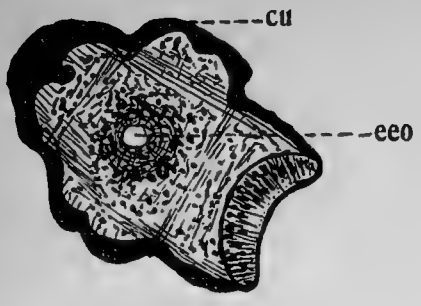

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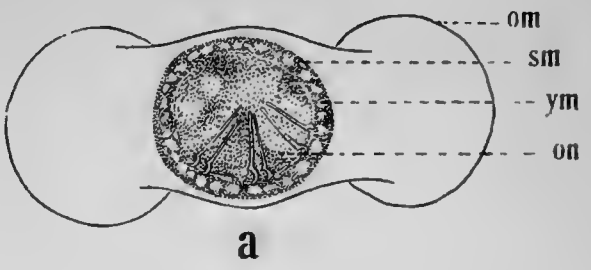

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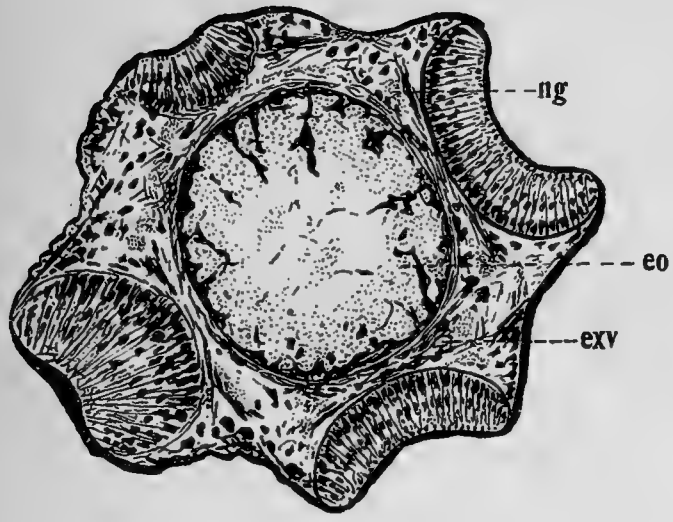

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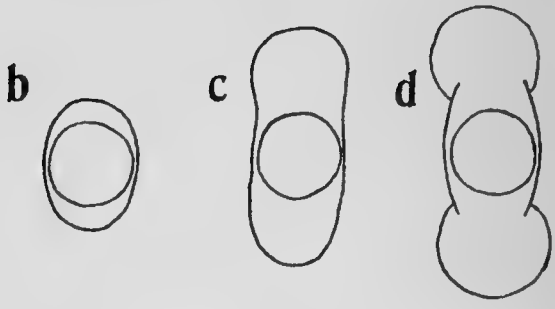

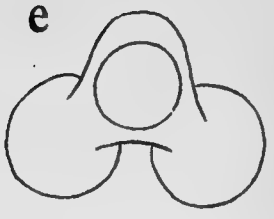

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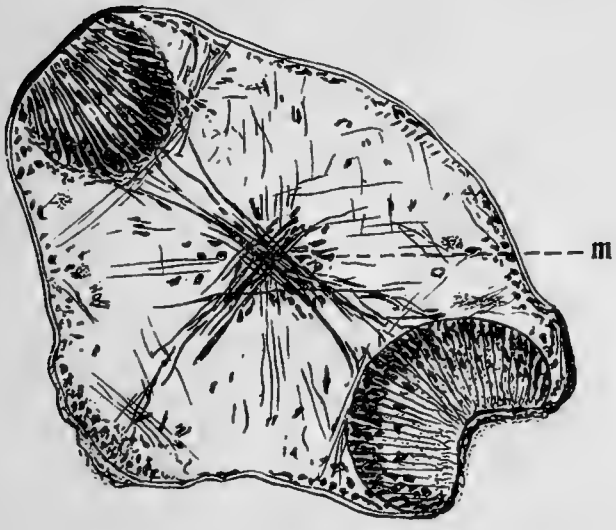

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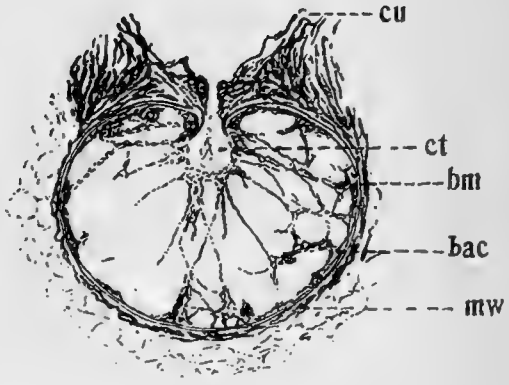

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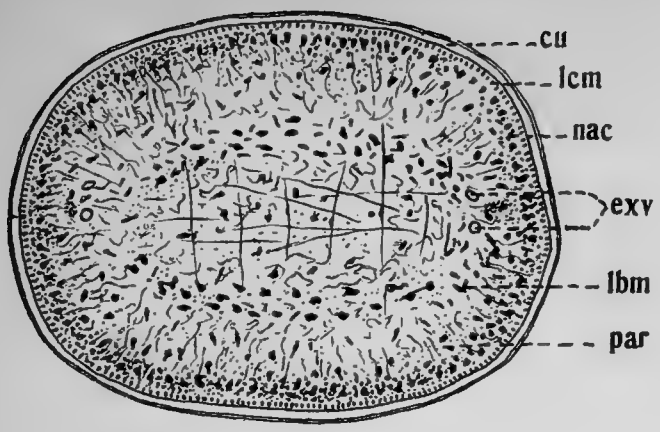

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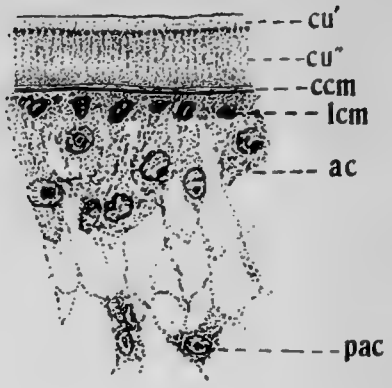

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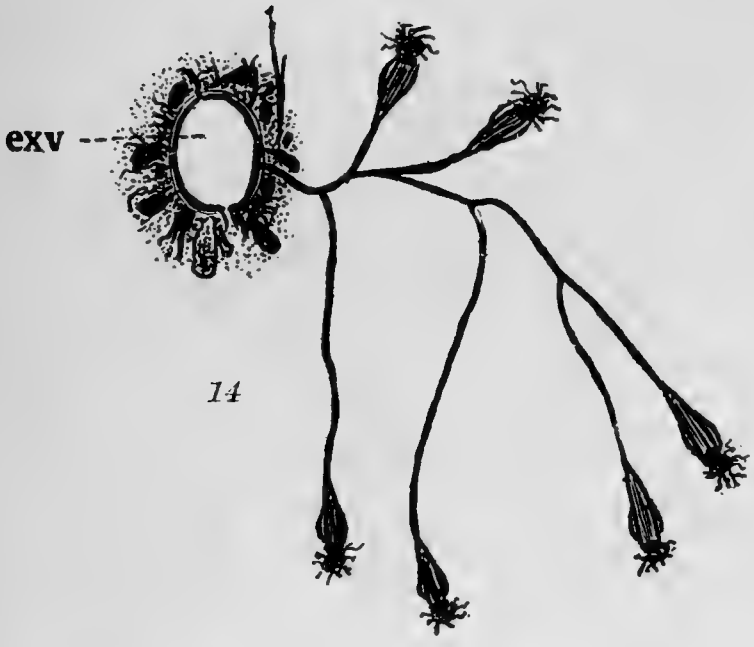

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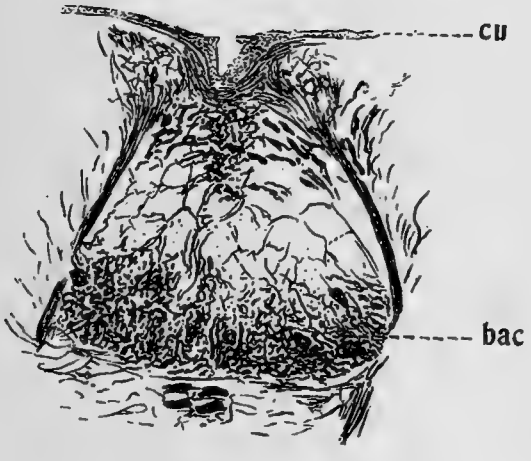

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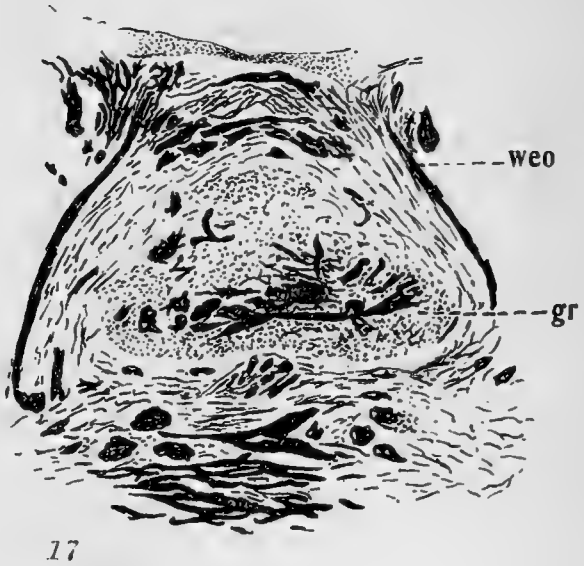

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IX.

BRYOZOA OF THE GEORGIAN BAY REGION.

By H. T. White M.A., High School, Sudbury, Ont.

The work upon which this paper is based was carried out at the Georgian Bay Biological Station during the summers of 1911 and 1912, under the direction of Dr. B. A. Bensley and Dr. E. M. Walker. I have been concerned chiefly with collecting and identifying the species and with noting the habitats and variations shown.

At Go Home Bay, nine species and one variety were identified. This is double the number reported from any other locality in North America. The Bryozoa are pretty well distributed around the Georgian Bay, and most of the species are found wherever suitable places occur. The relative abundance varies with the season

It was found necessary to introduce certain changes in the classification of the Plumatellas, as given by Kraepelin (1887) and Davenport (1904). Otherwise the classification of those authors has been followed. The nomenclature has been changed from that of the authors quoted, in accordance with the law of priority.

The changes in the genus *Plumatella* were deemed necessary, because there were as great differences between varieties of a species as between different species. For that reason, *Plumatella polymorpha* Kraepelin has been divided into *P. repens*, *P. fungosa*, and *P. appressa*. New variations in some of the characters of the species have been noted.

Comparatively little has been published concerning the Bryozoa of Canada. In 1855, Goadby and Bovell published notes concerning a 'Plumatella' from Rice Lake, Ontario. It evidently was *Pectinatella*. In 1880, Thomas Hincks published some notes made by his father on 'a supposed Pterobranchiate Polyzoan' collected in the Humber River near Toronto. According to Osler, this may have been *Pectinatella*. In 1883, Prof. William Osler, then at McGill University, gave an account of a number of Bryozoa from Canada. He records *Cristatella* from several points in Quebec, *Pectinatella* from Quebec and Ontario, and *Plumatella arethusa*, *P. vitrea* and *P. diffusa* (probably = *P. repens*, *P. punctata* and *P. emarginata*, respectively) from various localities.

Paludicella articulata (Ehrenberg). (= *ehrenbergii* auct.)

This is quite inconspicuous and may easily be overlooked. It occurs at Go Home, Skerryvore, French River, Killarney and Waubaushene.

Habitat very varied; under stones in rapid streams or fairly exposed shores, or more protected places, e.g. bays and ponds. In the latter it is found under water-lily leaves, or sticks. June to September. Common both in 1911 and 1912.

Fredericella sultana (Blumenbach).

The colonies are all small and the statoblasts few. The colonies present about the same appearance throughout the season, as in the case of *P. articulata*. They

do not appear till about June and remain throughout the summer. It occurs at Go Home, Parry Sound, Skerryvore, French River, Killarney, Manitoulin Island, and Waubaushene. It has also been found at Brantford and Sudbury.

Habitat.—Found in the same places as *P. articulata*, on the under sides of stones in streams or along exposed shores, or under sticks, water-lily leaves, etc., in bays and ponds. The abundance was about the same in 1911 and 1912.

Genus *Plumatella*.

Key to species.

A_1 Colony with vertical as well as horizontal branches.

B_1 Cuticula thick and brown, with a keel that broadens at the aperture. Free statoblasts elongated; proportions 1: 1·53 to 1: 2·8. *P. emarginata.*

B_2 Cuticula thick and colorless; colony robust; zooecia in groups; keel absent; free statoblasts nearly circular. *P. repens.*

B_3 Cuticula colorless to brown; tubes elongated, often pendant; may be keeled and emarginate; free statoblasts nearly circular. *P. fungosa.*

A_2 Colony with horizontal branches only (rarely vertical).

C_1 Cuticula colorless to brown; tubes usually with a clear, longitudinal band; depressed and closely adherent to the substratum (usually). Free statoblasts nearly circular. *P. appressa.*

C_2 Cuticula delicate, colorless to white; mouth cone elevated, often wrinkled and speckled with white. Free statoblasts nearly circular. *P. punctata.*

Plumatella emarginata Allman. (=*princeps* Kraepelin). var. *emarginata.*

Tubes openly branched, repent, with short lateral branches, antler-like. Statoblasts always few, but more abundant in older colonies. Although rather well distributed about Georgian Bay, this form is nowhere very abundant, and the colonies are rather small. It is found at Go Home, Parry Sound, Skerryvore, French River, Killarney, Manitoulin Island, Fitzwilliam Island, Tobermory, and McGregor Harbor. Specimens have been collected also at Brantford.

Habitat varied; frequently under stones along rather exposed shores, but also under stones or sticks in bays or in running water. Appears June to September, more abundant in July than earlier. Colonies become darker with incrustations, but modifications with the season not great. More abundant in 1912 than in 1911 at Go Home.

Plumatella repens (Linn.) (=*P. polymorpha*, var. *caespitosa* and *repens* Kraepelin).

This is the most variable of all the species found in Georgian Bay. The colony starts from an embryo of usually two individuals, and single tubes develop, branching somewhat openly. At this stage it is much like *P. punctata*, var. *prostrata.* Later the zooecia are found in groups, and the colony is caespitose. If the area of the substratum is very limited, a dense mass, half or three-fourths of an inch thick is formed with only the apertures rising free. In some cases the tubes remain scattered, or are intertwined rather than bunched. It is very probable that this last variation is the *P. polymorpha*, var. *repens* of Kraepelin. Intermediate stages may readily be found. It is, of course, found in the same places as the more usual

variety. The statoblasts of this species are very abundant in well developed colonies. It has been found at Go Home, Skerryvore, French River, Killarney, Fitzwilliam Island, and Tobermory.

Habitat.—This species is found chiefly under the leaves of water-lilies and other plants, on sticks, stones, and old iron, in ponds and sheltered bays, sometimes exposed to the direct sunlight. The colonies appear first from the middle to the end of May. The first colonies are found chiefly on twigs and bark, since the leaves are not yet developed. They do not seem to avoid the light and the twigs offer almost no shade. About a month later the colonies are fully developed, and soon afterwards disappear. At this stage the statoblasts are exceedingly abundant, and numerous embryos may be seen swimming about. These soon develop into small colonies, and during the latter half of July and in August these are in many places found in great abundance under water-lily leaves.

Brown bodies are very abundant in older colonies, especially of the first generation, shortly before it disappears. The branches of the colony usually contain *Chironomus* larvæ, which devour the cuticula. In some cases swarms of unicellular organisms may be seen in the zooecia. This species was common at Go Home, both in 1911 and 1912.

Plumatella fungosa (Pallas), (=*P. polymorpha*, var. *fungosa* Kraepelin).

The statoblasts of this species are more elongated than those of *P. repens*. Davenport gives the limit of the varieties of *P. repens* as 1 : 1·5; but specimens from Georgian Bay are often more elongated, the proportions being as high as 1: 1·65. The lower limit of the statoblasts of *P. emarginata* is given as 1 : 1·53, thus overlapping with this species; but this does not prevent the identification of the species by means of the statoblasts, since many of those of *P. fungosa* are quite round, specimens with the proportions of 1 : 1·2 being found.

This species occurs at Waubaushene, Go Home, Skerryvore, French River, Killarney, Club Island, Tobermory, and McGregor Harbor.

The habitat of this species is on leaves of pond weeds, water-lilies and sticks. It coats leaves of pondweeds (*Pontederia*) and is thus somewhat exposed to sunlight. It is found in still water or only moderately exposed to waves. Brown bodies and statoblasts very abundant in older colonies. Like *P. repens*, this species is sometimes found in dense masses, with strings of tubes extending out two and a half inches, or more. They are found in almost incredible numbers during the latter part of July in Matchedash Bay, near Waubaushene, coating the pondweeds which clog the bay. From July to September. Not rare in 1911 or 1912, but found in a number of places in 1912, where they were absent in 1911. The form is rather constant throughout the season, except for the changes due to crowding.

Plumatella appressa Kraepelin. (=*P. polymorpha* var. *appressa* Kraepelin).

Cuticula transparent to brown, coriaceous; tubes flattened, closely adherent to the substratum, and seldom rising from it. There is usually a clear longitudinal band, or a low keel. The branching is angular. The fixed statoblasts are abundant in this species, and may be seen adhering to the under sides of the flat

stones, which are the favorite resort, long after the colony has disappeared. The free statoblasts are nearly circular. Statoblasts and brown bodies very abundant in mature colonies.

This species is the most abundant and widespread of the Bryozoa of Georgian Bay, being found all around the bay along exposed shores.

The habitat is chiefly under flat stones along rather exposed shores and in rapid streams, but sometimes in more protected places, and then it may rise from the substratum, the tubes become more rounded and intertwining, and the longitudinal clear band often be absent. From the end of May till September. The form is rather constant throughout the season.

Plumatella punctata Hancock.

Var., *prostrata.* Stock repent and open, forming long hyaline tubes that give rise to only a few, likewise repent, lateral tubes. This was found at Go Home, Skerryvore, French River and Killarney. Outside of Georgian Bay it has been found in several places, Brantford, Aurora, and Sudbury.

The habitat is under stones or sticks in running water, or along more or less exposed shores. At the chute in the Go Home River it occurs associated, or even intertwined with *Paludicella articulata* and *Fredericella sultana.* Brown bodies and statoblasts are not abundant. The colonies vary but little with the season. Common in both 1911 and 1912.

Pectinatella magnifica Leidy.

The colonies are conspicuously marked with white bodies, situated at the outer ends of the mouth cones and near the ends of the lophophores. The latter is due to the habit of the animals of flexing the lophophores so that they touch the white body on the mouth cone. Part of the substance adheres to them.

This species was found at Go Home Bay and French River. It was not abundant.

The habitat is chiefly under sticks, stones, logs, etc., sometimes under water-lily leaves. It mostly lives in sheltered bays, ponds, or slow streams. July to September. More abundant and widespread in 1912 than in 1911.

Cristatella mucedo Cuvier.

This species found above the chute Go Home River and sparingly at Tobermory.

Its habitat is on or under logs, sticks, or sometimes water plants in slow-flowing water. It does not always avoid the light. The statoblasts are abundant. The colonies do not change greatly with the season, but may disappear very quickly. Abundant for a short time in 1911 and 1912.

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X.

PRELIMINARY REPORT ON THE PLANTS OF GEORGIAN BAY.

A Contribution to the Biology of the Georgian Bay Waters.

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With an added List of Algæ collected and determined by A. B. Klugh, M.A., Lecturer on Botany, Queen's University, Kingston.

During my stay in 1911 at the Dominion Biological Station, Go Home Bay, Georgian Bay, I hoped to begin a study of the fungus attacking fish-eggs in the vicinity of the Station. I was unable to reach the Station until June 19th, the first summer trip of the passenger steamer from Penetang. I found that by that date all the Black Bass had left their eggs, which had either hatched, decayed, or been in some other way hidden or destroyed. Rock Bass,—*Ambloplites rupestris* —were still protecting their eggs. I collected and preserved all I could find of these, as in every case they were attacked by a fungus. This I was able to identify as a '*Saprolegnia*,' probably '*mixta*.' On most of the lots of these eggs the fungus had reached the zoopore stage, but I have been unable to discover any *Saprolegnia* oospores on them. I gathered a good many facts regarding this fungus and its distribution and its attacks on fish and fish eggs, but this should accompany an account of its conditions and effects in our waters, such as I hope to be able to prepare at some future time after a study of these waters earlier in the summer.

Disappointed in my hope of studying water-moulds I turned my attention to the green water-plants of Georgian Bay. So far as I can learn little work has been done in this field, and no report upon them published. Dr. Bensley who was Curator of the Station, informed me of the desirability of gathering materials for a complete biological survey of Georgian Bay, on account of the close relation of these facts to the fishing industry.

Accordingly I gave my time to the collecting and determining of the littoral and plankton flora, of the waters within convenient reach of the Station. Incidentally I collected and classified all the fleshy fungi I found—some thirty-five species in 1910 and 1911. My list of plants must be considered as preliminary, as many common genera were not in fruit at the time I collected them and could not be identified. Also in such a group as the Diatoms my identifications are only of the well marked species.

My assistant, Mr. Klugh, spent May and June on the west side of Georgian Bay in the vicinity of Colpoy's Bay, and at my suggestion studied the algæ found there. I am inserting his list to supplement my own.

I believe we shall find the flora of Georgian Bay quite as luxuriant as that of Lake Michigan, or Lake Erie, and possibly approaching that of Lake St. Clair, although the conditions are quite dissimilar from those reported by Thompson, Snow, and Pieters. This work is valuable from the purely scientific, as well as from its economic side, because of our lack of knowledge of the distribution of the fresh-water algæ of Canada.

The list of water plants now presented is the result therefore of a few weeks' work at the Biological Station at Go Home Bay on the south east shore of Georgian Bay, during August and September, 1911.

A study of algæ is especially important in connection with those waters which are the spawning ground and nurseries of the food fish, of which Lake Huron furnishes so large a supply. The innumerable islands, points and inlets along the east shore of Georgian Bay seem to furnish almost ideal conditions for the development of fish life. If we can show that the microscopic creatures are present which form the first food of the fry, and that for these minute animals there is an adequate quantity of the still more minute plants on which they feed, —we shall have gone far toward furnishing a basis for the expectation that scientific methods of conservation and propagation will renew the copious supply of fish for which these waters were once famous.

The chain of life which begins with the unicellular algæ and ends with man, has been often demonstrated. The one-celled plants convert the non-living substances—atmospheric gases and water with its dissolved salts—into the lowest form of living matter. Mingled with these are many forms, so lacking in definite characters that so far it has been found impossible to decide their affinities. They constitute the *Protista*, possibly neither plant nor animal, but of the common structure from which both branches of life have developed. The quantity of unicellular plants per unit volume of water decides the quantity of the Protozoa, Rotifera and Crustacea which may inhabit the waters. These latter are known to serve as the chief if not the only food of the young and small fish. Favorable conditions of shelter and food are indispensable to the growth and rapid development of the young food fish. We are therefore quite safe in deciding that a prime biological condition for a plentiful fish fauna is the presence of an abundant growth of microscopic plants.

The surroundings most favourable for the growth of the more minute algæ are quiet waters, sunlight, and a plentiful growth of larger plants such as Chara, Potamogeton, Elodea, Utricularia, and Myriophyllum, as bottom and shore growths. These larger plants serve as shelters and homes for the minute forms, and wherever the former are absent, we cannot expect the latter to be abundant.

The prevailing westerly winds give such an eroding power to the water washing the islands and eastern shore of Georgian Bay that only in the deeper inlets and sheltered bays and river mouths can we find conditions suitable for shore growths of the larger plants. The steepness of the gradient at which the crystalline rocks forming the shore enter the water, seldom permits of an extended submerged terrace of proper depth for the anchored society of plants. Hence only in a few places, and those more or less remote from the open bay, can we find littoral zones characteristic of such quiet shallow waters as Lake St. Clair.

Beds of Chara—that most important breeding ground for minute algæ,—were seldom found. The following lists are far from being exhaustive even of the small district investigated.

Not expecting to undertake a study of the green plants, my supply of reference authorities was far from complete, and necessitated much drawing and recording of measurements for future reference. Only such specimens as lent themselves by good condition, reasonable size, and characteristic marks, were determined. Many non-fruiting forms of the higher algæ were passed over unidentified. Subsequent observation at a different season may add very considerably to every group.

SHORE AND BOTTOM FLOWERING PLANTS.

From the moist border outward about the following order may be found but never all at one place:

Gratiola aurea Muhl.
Utricularia cornuta Michx.
Gerardia purpurea L.
Isoetes echinospora var. muricata. Engelm.
Ranunculus flammula L. var. reptans L (Meyr).
Lobelia Dortmanna L.

The above are usually, but not always, in the water.

Juncus Balticus Willd. var. littoralis Engelm.
Typha latifolia L.
Eriocaulon articulatum (Huds) Morong.
Sparganium eurycarpum. Engelm.
Sagittaria latifolia. Willd, forma diversifolia Engelm.
S. graminea Michx.

These are found usually in water less than one foot deep.

Pontederia cordata L.
Scirpus hudsonianus (Michx) Fernald.
Nymphaea advena Ait. var. variegata (Engelm).
Nymphoides lacunosum (Vent) Fernald.
Brasenia Schreberi Gmel.

The above are found in water up to three feet in depth.

Utricularia vulgaris L. var. americana.
U. minor L.
Ceratophyllum demersum L.
Myriophyllum spicatum L.
Elodea canadensis Michx.
Valisneria spiralis L.
Potamogeton heterophyllus Schreb; forma myriophyllus (Robbins) Morong.

Potamogeton pectinatus L.
No doubt other Potamogetons are to be found.

Chara and Nitella were found only in water less than one foot in depth, but may occur at greater depths.

CYANOPHYCEAE.

Chroococcus turgidus (Kutz) Naeg.
C. turicensis (Naeg) Hansg.
Both of the above are frequent in washings from submerged plants collected in muddy bays.
Gleocapsa sp. In washings from submerged moss from Go Home River at Chute.
Aphanocapsa Grevillei (Hass) Rab.
Aphanothece pallida (Rab).
On Chara from Louden's Bay.
A. stagnina (Spring) A. Br.
Gonphosphaeria aponina Kuetz.
Clathrocystis aeruginosa. (Kuetz) Henfrey. In floating plankton.
Coelosphaerium Kuetzingeanum Nag.
In all surface collections made with plankton net in quiet waters.
Merismopedium glaucum (Ehren) Nag.
In shallow bays of warm water.
Eucapsis alpina Cl. & Sh.
Oscillatoria limosa Agardh.
In surface plankton in steamer channel.
Lynbya sp. in scrapings from submerged stones in Gap, Giant's Tomb.
Scytonema Naegelii Kg. (Tolypothrix penicillata) (Agardh) Thuret.
In scrapings from rocks. Fraser's Channel.
S. crispum Bornet.
Plentiful, in scrapings from submerged rocks.
Nostoc comminutum Kutz.
Common in surface collections with the next.
Anaboena flos aquae. Kutz.
Dichothrix horsfordii Barnet.
Rivularia dura, Roth.
In scrapings from rocks, Fraser's Channel.
R. echinulata (Smith) Barnet.
On culms of Scirpus. Go Home River near the Chute.
Stigonema mamillosum Agardh.

CHLOROPHYCEAE

Volvocales.

Chlamydomonas pulvisculus Ehrb
Common in surface plankton with the two following.

Botryococcus Braunii Kutz.
Tetraspora lubrica (Roth) Agardh.
Pandorina morum (Mull) Bory.
In washings from a submerged moss from Go Home River near the chute.

Protococcales.

Pleurococcus vulgaris. Meneg.
In scrapings from back of a large Snapping Turtle.
Selenastrum acuminatum Lagerh (Conn & Webster's Fresh Water Algæ of Conn). In washings of Nitella from Louden's Bay.
Palmodictyon viride, Kutz—with above.
Scenedesmus quadricauda (Turp) Breb.
S. obliquus (Turp) Kutz.
S. bijuga (Turp) Wittr.
With the next in surface plankton.
Rhaphidium convolutum (Corda) Rabenh.
Schizochlamys gelatinosa A Br.
Tetracoccus botryoides West, as described in West.
Coelastrum cambricum Archer.
C. sphaericum Nag.
These are frequent in collections.
Dimorphococcus cordatus Wolle.
Plentiful.
Pediastrum Boryanum (Turp) Meneg.
P. tetras. Ehrenb.
P. Ehrenbergii A. Br. An unsymmetric specimen noted.
P. sp.
A symmetrical non-clathrate form of 64 cells, bearing on the outer margin slender projections, each with a well-marked capitellate termination. Very similar to the portion of P. glanduliferum Benn. as figured by West. Found in washings from Limnea and other crustacea.

Confervales.

Confervaceae.
Ophiocytium capitatum Wolle
In surface plankton but infrequent.
Characium heteromorphum (Reinsh) Wolle.
Attached to Œdogonium.
Chlorobotrys regularis (West) Bohlin.
In washings from Nitella.
Dictyosphaerium Ehrenbergianum, Nag.
D. reniformis, Bulnh.
Both of these frequent in collections.

Chaetophoraecae and *Oedogoniaceae.*

Chaetosphaeridium globosum (Nordst) Klebahn.
In scrapings from rocks in Fraser's Channel.
Œdogonium fragile Wittr.
Œ. crispum Wittr.
Bulbochaete monile Wittr. & Lund.
With Œdogonium from near the chute in Go Home River.
Bulbochaete sp. In washings from Utricularia purpurea.

Coleochaetaceae.
Coleochaete soluta. (Breb) Pringsh.
On submerged culms of Scirpus in Go Home River below the chute, and plentiful, in scrapings of submerged rocks in Fraser's Channel, August 23rd, bearing oogonia many of which were brownish at that date.

Conjugales.

Mougeotia calcarea (Cleve) Wittr. On Island 218, two miles north of Go Home Bay. M. genuflexa, Agardh.
Desmidaceae.—
Penium oblongum D. By.
P. rupestre Kg. Common in washings of submerged moss.
Closterium striolatum Ehrb.
var. intermedium.
Cl. parvulum, Naeg.
Cl. Dianae Ehrb. Frequently found.
Cl. pronum, Breb.
Several other species undetermined.
Cosmarium moniliforme, Ralfs.
Cos. sexangulare, Lund.
Cos. orbiculatum, Ralfs.
Cos. perforatum, Lund.
Cos. pyramidatum, Breb.
Cos. Meneghinii Breb—plentiful in washings from Fontinalis.
Cos. Nordstedtii Delfs.
Cosmarium sp. agreeing with description and figure of Cos. Eloiseanum Wolle, but lacking the granular tumors.
Docidium Baculum Breb.
Pleurotaenia Trabecula (Ehrb) Nag.
P. crenulatum (Ehrb) Rab.
Xanthidium cristatum (Breb) Ralfs.
X. antilopeum (Breb) Kg.
var. Minneapoliense Wolle.
X. fasciculatum (Ehrb) Ralfs.
Staurastrum dejectum Breb.

St. ophiura Lund. var. tetracerum Wolle.
St. " " " pentacerum "
St. odonatum, Wolle.
Euastrum elegans Kg.
E. magnificum Wolle.
E. ventricosum Lund.
Micrasterias furcate (Ag) Ralfs.
M. pseudo-furcata, var. Minor(?) Wolle.
M. lanticeps, Nord. common.
M. crux Melitensis (Ehrb) Hass.

Diatomaceae

Acnanthes exilis Kg.
Asterionella formosa var. gracillima, V.H.
In surface plankton in steamer channel at entrance to the Bay.
Amphora ovalis Kg.
Cocconema lanceolatum Ehrb.
Cosinodiscus lanceolatum Ehrb.
Cosinodiscus plentiful in, and characteristic of dredged material from east edge of sand beach Giant's Tomb.
C. lacustris, from inner bay.
Craspedodiscus microdiscus Ehrb. (?)
Denticula lauta Bail.
Encyonema gracile Rab.
Epithemia turgida Kg.
E. argus Kg.
Fragilaria—Ribbons of acute-pointed individuals frequent in scrapings from submerged rocks and in floating plankton in steamer channel.
Gonphonema geminata Ag.
Melosira granulata Bail.
Navicula viridis. Kg.
In ribbons of 100 individuals among decaying Zygnema.
Stauroneis Phoenocenteron Ehrb.
Surirella elegans Ehrb.
Synedra ulna var. splendens.
Tabellaria fenestrata (Lyng) Kg.
T. flocculosa (Roth) Kg.
Terpsinoe Musica Ehrb.

Through the kindness of Mr. C. S. Boyer, of Philadelphia, one of the authorities on Diatoms, I am able to add the following, identified from the material I collected in the immediate vicinity of Go Home Bay:—

Amphora ovalis (Bréb) Kütz.
Anomœoneis serians Bréb.
Cyclotella striata Kütz.
Cymbella cuspidata Kütz.

C. gastroides Kütz.
C. cistula (Hempr.) Kirchn.
C. lanceolata (Ehr.) Kirchn.
Cymatopleura elliptica Itm. Sm. Rare form.
Diploneis elliptica (Kütz.) Cl.
Eunontia gracilis (Ehr.) Rab.
E. major. (Itm. Sm.) Rab.
var. impressa.
E. formica (Ehr.)
Frustulia vulgaris Thw.
Gonphonema constrictum Ehr.
G. capitatum Ehr.
G. acuminiatum. f. coronatum (Ehr.) Rab.
Melosira granulata.
Meridion intermedium var constrictum H. L.S.
Nitzchia amphioxys (Ehr.) Itm. Sm.
Navicula pseudo-bacillum. Grun.
Neidium iridir (Ehr.) Cl.
Pinnularia divergens. Ralfs.
P. nobilis Ehr. Also varieties.
P. tabellaria Ehr.
Stauroneis gracilis. Itm. Sm.
Surirella splendida Itm. Sm. Also varieties.
Synedra danica Kütz.

Batrachospermum moniliforme. Roht.—though not a green alga.—should be mentioned. It was found attached to timbers of a rude wharf.

The following named algæ were collected and identified by my colleague, Mr. A. B. Klugh, during May and June, 1911. The collections were made at various points as indicated in the notes, but all along the Georgian Bay shore or in the waters immediately tributary to the Bay.

Chroococcus turgidus, Naegeli. Bog, Mud Lake, near Colpoy's Bay, June 7, Marsh Oliphant, June 14.

Microcystis marginata, Kuetzing. Floating among other algæ at windward shore of Sky Lake, near Oliphant, May 28; Bog, Mud Lake, Near Colpoy's Bay, June 26.

Merismopedium glaucum, Naegeli, Plankton, Pool on the Commons, Colpoy's Bay, May 8, 1911; Swale, Colpoy's Bay, May 20; Pool, McGregor's Harbour, Cape Croker, May 30; Shore of Lake Huron at Oliphant, June 14; Sky Lake May 28.

Oscillatoria tenuis, Agardh. Damp places on rock. Colpoy's Bay, May 11.

Oscillatoria subtilissima, Kuetzing. Damp places on rock, Colpoy's Bay, May 11.

Oscillatoria formosa, Bory. On timber in a small stream near Colpoy's Bay, May 27.

Nodularia paludosa, Wolle. Swale near Colpoy's Bay, May 20: Swamp, Golden Valley, June 1.

Anabaena torulosa, Lagerheim, Swale, Colpoy's Bay, May 20; Swamp, Golden Valley, June 1.

Stigonema mamillosum, Agardh. Bog, Mud Lake, near Colpoy's Bay, June 7.

Calothrix parietina, Thuet. Damp place on limestone rock, Colpoy's Bay, May 11.

Ophiocytium cochleare, A. Braun. Swale, Colpoy's Bay, May 20; Swamp, Golden Valley, June 1; Swamp near Boat Lake, June 16; Ditch, Oliphant, June 14.

Ophiocytium parvulum, A. Braun. Swale, Colpoy's Bay, May 20; Swamp Golden Valley, June 1; Bog, Mud Lake, June 7; Swamp near Boat Lake, June 16; Ditch, Oliphant, June 14; Pool, Hope Bay, June 8.

Ophiocytium gracilipes, Rab. Scarce, in a collection from a marsh on the Cape Croker road, May 30.

Conferva bombycina, Agardh. Swamp, Golden Valley, June 1; Swamp, Mar road, June 5. Diteh, near Boat Lake, June 16; Stream in sandy shore, Oliphant, June 14.

Zygnema leiospermum, De Bary, common near mill at Lake Isaac, June 5.

Spirogyra catenaeformis, Kuetzing, Bog, Mud Lake, June 26.

Spirogyra varians, Kuetzing. Common with abundant zygospores, in ditch near Wiarton, May 5. By May 26 it had completely disappeared though the ditch still contained plenty of water. Scarce in a swamp near Boat Lake, June 16, zygospores present.

Spirogyra orthospira, Naegeli. Small stream from spring, Oliphant, June 14, in all stages of conjugation; Ditch, Colypoy's Bay, June 23.

Spirogyra weberi, Kuetzing. Common in pools in sand of shore of Lake Huron at Golden Valley, in all stages of conjugation, June 1; Ditch, Lion's Head, June 8, just beginning conjugation; in small stream in sandy shore at Oliphant, June 14, spores mature; Swamp, Adamsville, June 8.

Spirogyra insignis, Kuetzing. Ditch, near Wiarton, June 4, spores nearly mature.

Mougeotia genuflexa, Agardh. Common in a small marsh near Purple Valley, May 30, very sparingly fruited; Swamp, Golden Valley, June 1.

Mougeotia scalaris, Hassall. Near mill, Lake Issac, June 5; Pool in swamp at Mud Lake, June 6.

Mougeotia viridis, Wittrock. Common in swale, Colpoy's Bay, May 20.

Chlamydomonas communis, Snow. Abundant in a collection from a swamp on Mar road, June 5.

Chlamydomonas globosa, Snow. Common in pools and swamps throughout the Peninsula.

Pandorina morum, Bory. In small marsh at Sky Lake, May 28; in marsh on Cape Croker road, May 30; Swamp, Golden Valley, June 1; abundant in a collection from a swamp on Mar road, June 5.

Tetraspora lubrica, Agardh. Common in a stream in a pasture, Colpoy's Bay, April 30th; in pools along a bush road, near Mar, May 10. In a stream between Colpoy's Bay and Purple Valley, May 27.

Chlorococcum humicola, Rabenhorst. Common under dripping water.

Characium naegelii A. Braun. Common on other algæ, particularly on Conferva bombycina throughout the peninsula.

Characium ambiguum, Hermann. On Conferva bombycina in swale near Colpoy's Bay, June 20th.

Rhaphidium falcatum, Cooke. Swamp, Mar road, June 5; Ditch, near Boat Lake, June 16; Pool, Hope Bay, June 8; Shore of Lake Huron at Oliphant, June 14.

Rhaphidium falcatum aciculare, Hansgirg. Swale, Colpoy's Bay, May 20; Pool near Colpoy's Bay, May 30; common in swamp near Golden Valley, June 1.

Nephrocytium agardhianum, Naegeli. Swamp on Mar road, June 5.

Tetraedron minimum, Hansgirg. Pool, Hope, June 8; small stream, Oliphant, June 14.

Scenedesmus bijuga, Wittrock. Pool, Hope Bay, June 8; Pond on Commons, Colpoy's Bay, May 11

Scenedesmus obliquus, Kuetzing. A common plankton form throughout the Peninsula.

Scenedesmus quadricauda, Brebisson. A common plankton form throughout the region.

Scenedesmus quadricauda abundans, Kirchener. Pool, McGregor's Harbour, Cape Crocker, May 30; Ditch, near Boat Lake, June 16.

Coleastrum proboscideum, Bohlin. Swale, near Colpoy's Bay, June 5; Marsh, Oliphant, June 14.

Sorastrum spinulosum, Naegeli. Scarce, in collection from a pool at Hope Bay, June 8.

Hydrodictyon reticultaum, Lagerheim. Forming a sheet over the surface of a large pool at edge of swale near Colpoy's Bay, June 5.

Pediastrum boryanum, Meneghini. A very common plankton form throughout the Peninsula.

Pediastrum tetras, Ralfs. Scarce, in collection from a marsh at Oliphant, June 14; Pool, Hope Bay, June 8.

Ulothrix aequalis, Kuetzing. This species and Ulothrix zonata are the commonest filamentous forms on the rocks of the shores of Georgian Bay. They occur in patches consisting of one species only. Gametes were mature on April 30.

Ulothrix zonata, Kuetzing. Common, on rocks along shores of Georgian Bay; fruiting on May 7.

Oedogonium capilliforme, Kuetzing. Swale, Colpoy's Bay, June 5.

Chaetosphaeridium globosum, Klebahn. On Oedogonium capilliforme in swale, Colpoy's Bay, June 5.

Chaetophora elegans, Agardh. Forming globular gelatinous masses about 5 mm. diameter on stones in a pool on the Cape Croker road, May 30; forming light green spheres from extremely minute size up to 1 mm. diameter on sticks at edge of a willow swale near Colpoy's Bay, June 5.

Chaetophora incrassata, Hazen. Attached to a log in a ditch, near Wiarton, May 12; common on stones at bridge over Patanelly River, near Mar, June 1.

Stigeoclonium lubricum, Kuetzing. Common in a little stream from a spring near Wiarton, May 5.

Draparnaldia acuta, Kuetzing. In pools with Tetraspora lubrica on a bush road near Mar, May 10; Stream near Wiarton May 19; Stream near Golden Valley, June 1.

Draparnaldia glomerata, Agardh. Swale, Colpoy's Bay, May 20: Swamp, Golden Valley, June 1.

Pleurococcus vulgaris, Meneghini. Common on trees, walls, etc.

Tretepohlia aurea, Martius. Scarce on limestone rocks in Populus-Thuja scrub along Mar road, June 20: forming bright orange velvety cushions from 1 to 2 dm. in extent; forming light orange-colored patches on rocks along the shore road at Colpoy's Bay.

Cladophora callicoma, Kuetzing. Scarce in stream at Colpoy's Bay.

Vaucheria sessilis, D. C. Common in swale along Wiarton road, oospores not yet mature, June 23.

Vaucheria geminata racemosa, Walz. Swamp near Boat Lake, June 15.

XI.

LIST OF GEORGIAN BAY FLESHY FUNGI AND MYXOMYCETES.

By T. H. Bissonnette, M.A., Queen's University, Kingston.

The following is a preliminary list of fleshy fungi which I collected and classified August and September, 1912. In the work of collecting and classifying Miss Penson and Mr. Woodhouse preceded me at the Biological Station, and this report combines the work of the three of us.

N.B.—Only where the species were classified are any entered. Almost all the genera found are included, but only those species are included which were determined and duly classified.

Agarics.

1. Amanita phalloides No. 35 Aug. 3/12 Wishart's Bay.
   A. muscaria " 77 Aug. 7/12 Long Bay.
   A. Frostiana " 176 & 192. Aug. 25/12 Galbraith's Creek.
   Aug. 27/12 Loudon's Bays.
   A. mappa " 130 Aug. 25/12 Galbraith's Creek.
2. Ananitopsis strangulata No. 44. Aug. 3/12 Wishart's Bay.
   A. vaginata fulva No. 2, Aug. 2/12 Creek near Chute.
   A. vaginata livida No. 196 Aug. 30/12 Meuller's Bay.
3. Lepiota acutesquamosa No. 143 Aug. 21/12 Creek near Chute.
   L. asperula " 218 Sept. 3/12 Laforge's Wood.
   L. granulosa " 227 Sept. 4/12 Long Bay.
4. Armillaria mellea No. 121 & 14 Aug. 19/12 Laforge's Wood & Aug. 2/12 Creek near Chute.
5. Tricholoma No. 134 Aug. 20/12 Fenton's Bay.
   T. sejunctum " 149 Aug. 21/12 Creek near Chute.
   T. album " 166 Aug. 23/12 Skidway above Sandy Gray.
   ..... " 9 Aug. 2/12 Creek near Chute.
6. Clitocybe No. 24 July 20/12 & Aug. 3/12 Creek near Chute.
   " " 60 Aug. 4/12 Sandy Gray Falls.
   " " 118 Aug. 16/12 Giant's Tomb.
   C. infundibuliformis No. 122 Aug. 19/12 Laforge's Wood.
   C. phyllophila " 127 Aug. 19/12 Laforge's Wood.
   C. clavipes (media?) " 131 Aug. 19/12 Laforge's Wood.
   C. subditopoda " 197 Aug. 30/12 Meuller's Bay.
   C. media " 240 Sept. 6/12 Galbraith Lake.
7. Cantharellus, cinnabarinus No. 57 Aug. 4/12 Sandy Gray Falls.
   C. infundibuliformis " 58 Aug. 4/12 Sandy Gray Falls.
   C. aurantiacus " 59 " " " "

C. brevipes No. 106 Aug. 12/12 Giant's Tomb.
C. cibarius " 150 Aug. 21/12 Creek near Chute.

8. Myctalis,—
9. Lactarius indigo No. 20 Aug. 2/12 Creek near chute.
L. piperatus No. 68 Aug. 4/12 Sandy Gray Falls.
L. resimus " 164 Aug. 23/12 Skidway above Sandy Gray Falls.
L. cinereus " 175 Aug. 25/12 Galbraith's Creek.
L. regalis " 194 Aug. 28/12 Sandy Gray Falls.
10. Russula virescens " 39 & 142 Aug. 3/12 Wishart's Bay.
R. alutacea " 169 Aug. 23/12 Skidway above Sandy Gray Falls.
R. emetica " 188 July & Aug. Everywhere.
R. rubra " 189 Aug. 22/12 Loudon's Bay.
11. Hygrophorus miniatus No. 94, Aug. 7/12 Long Bay Aug. 27, Loudon's Bay No. 187.
12. Pleurotus sapidus No. 112 Giant's Tomb, Aug. 12/12.
P. ostreatus No. 161 Aug. 23/12 Skidway above Sandy Gray.
P. petaloides No. 205 Sept. 1/12 Giant's Tomb.
13 Collybia radicata No 3, Aug 2/12 Creek near chute.
C. familia (Marshall) No. 53, Aug. 4/12 Sandy Gray Falls.
C. velutina No. 79 Aug. 7/12 Long Bay.
C. zonata, No. 141 Aug. 21/12 Creek near chute.
C. myriadophila No. 89 Aug. 7, Long Bay.
C. confluens, No. 178, Aug. 25/12 Galbraith's Creek.
14. Mycena galericulata No. 177 Aug. 25/12 Galbraith's Creek.
M. Leaiana No. 180 Aug. 25/12 Galbraith's Creek.
15. Omphalia companella No. 10 & 140 Aug. 2/12 Creek near chute.
Aug. 21/12.
16. Marasmius rotula, No. 55, Aug. 4/12 Sandy Gray Falls.
velutipes No. 12/12 Laforge's Wood.
siccus No. 160 Aug. 23/12 Skidway above Sandy Gray.
17. Xarotus.
18. Heliomyces.
19. Lentinus.
20. Panus—strigosus (?) No. 183 Aug. 19/12 Giant's Tomb.
21. Trogia crispa No. 199 Sept. 1/12 Giant's Tomb.
22. Schizophyllum commune No. 206, Sept. 3/12 Station Island and elsewhere.
23. Lenzites separia No. 193 Aug. 28/12 Portage from Sandy Gray to Flat Rock Rock Lake, in Woods.
24. Volvaria.
25. Annularia.
26. Pluteus cervinus No. 113, Aug. 12/12 Giant's Tomb.
27. Entoloma rhodopolium, No. 146, Aug. 21/12 Creek near chute.
28. Clitopilus prunulus No. 167 Aug. 21/12 Creek near chute.
C. Noveboracensis No. 204 Sept. 1/12 Giant's Tomb.
C. abortivus No. 152 Aug. 21/12 Creek near chute.
C. orcellus (?) No. 67, Aug. 4/12 Sandy Gray Falls.

29. Claudopus nidulans (?) No. 182 Aug. 25/12 Galbraith's Creek, Aug. 19 Giant's Tomb.
30. Eccilia.
31. Leptonia.
32. Nolanea.
33. Pholiota dura (dwarf) No. 212, Sept. 1/12 Giant's Tomb.
    P. squarosa No. 253 Sept. 8/12 Laforge's Wood.
34. Cortinarius alboviolaceous No. 167 Aug. 23/12 Old skidway above Sandy Gray Falls.
    C. armillatus No. 213 Sept. 3/12 Laforge's Wood.
    C. cinnamoneus No. 243, Sept. 7/12 Burwash Lake.
35. Flammula.
36. Inocybe.
37. Hebeloma glutinosum No. 148 Aug. 21/12 Creek near chute.
38. Paxillus.
39. Crepidotus versutus No. 165 Aug. 23/12 Skidway above Sandy Gray.
    C. mollis " 219 Sept. 3/12 Giant's Tomb.
40. Tubaria.
41. Naucoria hamodryas No. 128, Aug. 19/12 Laforge's Wood.
42. Pluteolus.
43. Galera crispa or laterita No. 181 Aug. 25/12 Galbraith's Creek.
44. Bolbitius.
45. Chitonia.
46. Pilosace.
47. Agaricus sylvaticus No. 97, Aug. 12/12 Giant's Tomb.
48. Stropharia.
49. Hypholoma perplexum, No. 99, Aug. 12/12 Giant's Tomb.
50. Deconica.
51. Psilocybe, spadica, No. 168, Aug. 23/12 Skidway above Sandy Gray Falls.
52. Psathyra—No. 4, Aug. 2/12 Creek near chute.
53. Coprinus atramentarius. No. 12 Aug. 2/12 Creek near chute.
    C. ovatus No. 173 Aug. 25/12 Galbraith's creek.
54. Gomphidius.
55. Psathyrella.
56. Panaeolus.
57. Chalymatta.
58. Anellaria.

Polyporaceae—Pored Fungi.

59. Boletus scaber No. 64, Aug. 4/12 Sandy Gray Falls.
    subtomentosus No. 65, Aug. 4/12 Sandy Gray Falls.
    felleus No. 66 Aug. 4/12 Sandy Gray Falls.
    versipellis No. 132 Aug. 20/12 Fenton's Bay.
    edulis No. 144 Aug. 21/12 Creek near chute.
    americanus No. 186, Aug. 27/12 Loudon's Bay.

Boletus edulis clavipes No. 145 Aug. 21/12 Creek near chute.
chrysenteron No. 162, Aug. 23/12 Skidway above Sandy Gray Falls.

60. Strobilamyces strobilaceous No. 114, Aug. 16/12 Giant's Tomb.
61. Boletinus pictus, No. 242, Sept. 7/12 Burwash Lake.
62. Fistulina.
63. Polyporus velutinus, No. 34, Aug. 2/12 Creek near chute.
fomentarius No. 75, Aug. 4/12 Sandy Gray Falls.
picipes (or elegans), No. 88, Aug. 7/12, Long Bay.
frondosa No. 110, Aug. 12/12 Giant's Tomb.
applanatus No. 129, Aug. 19/12, Laforge's Wood.
pubescens No. 163, Aug. 23/12 Skidway above Sandy Gray.
cinnabarinus No. 179, Aug. 25/12 Galbraith's Creek.
resinosus, No. 182, Aug. 25/12 " "

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64. Polystictus biformis No. 42, Aug. 3/12, Wishart's Bay.
versicolor No. 133, Aug. 20/12, Fenton's Bay.
perennis, No. 216, Sept. 3/12, Laforge's Wood.
pergameus, No. 136, Aug. 19/12 " "
hirsutus, No. 209, Sept. 1/12, Giant's Tomb.
65. Fomes leucophaeus, No. 129, Aug. 19/12, Laforge's Wood.
66. Trametes.
67. Merulius.
68. Daedalea quercina No. 37, Aug. 3/12, Wishart's Bay.
confragosa No. 185 Aug. 27/12, Loudon's Bay.
ambigua No. 195, Aug. 29/12, Meuller's Bay.
unicolor, No. 248 Sept. 8/12, Laforge's Farm.
69. Favolus canadensis, No. 137, Aug. 19/12, Laforge's Wood.
alveolatus, No. 40, Aug. 3/12, Wishart's Bay.
70. Cyclomyces.
71. Glaeoporus.

Hydnaceae—Fungi with Teeth.

72. Hydnum coralloides No. 100, Aug. 12/12, Giant's Tomb.
caput-ursi No. 101, Aug. 12/12 "
caput medusae No. 102, Aug. 12/12 "
spongiosipes, No. 125, Aug, 19/12, Laforge's Wood.
septentrionale, No. 126, Aug. 19/12 " "
adustum, No. 135, Aug. 19/12 " "
pulcherrimum No. 251, Sept. 8/12 " "
73. Irpex.
74. Phlebia.
75. Grandinia.

Thelephoraceae—Smooth hymenium or wrinkled.

76. Craterellus.
77. Corticium sambucum No. 191, Aug. 27/12, Loudon's Bay.
78. Thelophera.

79. Stereum.
80. Hymenochaete.

Clavariaceae, Coral Fungi.

81. Sparassis.
82. Clavaria flava No. 11, Aug. 2/12, near chute Aug. 4, Sandy Gray Falls.
stricta No. 156, Aug. 21/12, Creek, near chute.
pistillaris, No. 157, Aug. 23/12, Sandy Gray point—small form.
cristatum No. 159, Aug. 23/12, Skidway above Sandy Gray Falls.
aurea, No. 203, Sept. 1/12, Giant's Tomb.
mucida, No. 174, Aug. 25/12, Galbraith's Creek.
pistillaris, No. 201, Sept. 2/12, Giant's Tomb, large form.
83. Calocera.
84. Typhula.
85. Lachnocladium.

Tremellini.

86. Tremella.
87. Tremellodon gelatinosum Sept. 8/12, Laforge's Wood.

Ascomycetes—Sac Fungi.

88. Morchella.
89. Verpa.
90. Gyromitra.
91. Helvella.
92. Hypomyces.
93. Leptoglossum luteum No. 70, Aug. 4 and Aug. 23/12, Sandy Gray Falls.
94. Spathularia.
95. Leotia-lubrica No. 115, Aug. 15/12, Wishart's Bay.
No. 184, Aug. 27/12, Loudon's Bay.
96. Peziza nebulosa No. 74, Aug. 4/12 Sandy Gray.
badia, No. 87, Aug. 7/12, Long Bay.
scutellata, No. 138, Aug. 19/12, Laforge's Wood.
semitosta, No. 139, Aug. 19/12, " "
hemispherica, No. 155, Aug. 21/12, Creek near Chute.
repanda, No. 249, Sept. 8/12, Laforge's Wood.
aurantea, No. 252, Sept. 8/12, " "
97. Urnula.
98. Helotium.
99. Bulgaria inquinans, not preserved.

Nidulariaecae—Bird's nest Fungi.

100. Cyathus.
101. Crucibulum.
102. Nidularia pisiformis 116, Aug. 16/12, Giant's Tomb.

Basidiomycetes.

103. Phallus duplicatus, No. 98, Aug. 12/12, Giant's Tomb.

104. Lysurus.
105. Mutinus.
106. Calvatia maxama No. 1, Aug. 2/12, Creek near Chute.
107. Lycoperdon gemmatum No. 120, Aug. 19/12, Laforge's Wood.
pyriforme (log form), No. 120, Sept. 1/12 Giant's Tomb.
pyriforme ground form 211, Sept. 1/12 " " larger.
108. Bovista pila—No. 119, Aug. 19/12, Laforge's Farm.
109. Bovistella.
110. Scleroderma aurantium, No. 158, Aug. 23/12, Old Skidway above Sandy Gray.
111. Catastoma.
112. Secotium.
113. Polysaccum.
114. Mitremyces.
115. Geaster triplex No. 90, Aug. 23/12, old skidway above Sandy Gray.

Sphaeriaeceae.

116. Cordyceps.
117. Claviceps.
118. Xylaria polymorpha No. 15, Aug. 2/12, Creek near chute and elsewhere.
polymorpha spatularia, No. 73, Aug. 4/12, Sandy Gray Falls.

Myxomycetes.

119. Stemnotis fusca No. 29, Aug. 12/12, Creek near chute.
120. Calcareous Myxomycete, on sticks. Not identified.
Creamy one, also Tycogala, small red, Aug. 2, No. 30. Creek near chute.

I may add that the method pursued in this mycological research was as follows:—

Each afternoon, when possible, baskets and bottles for small specimens were taken, and we visited the hardwood bushes of the neighborhood and collected specimens till dark or nearly so. On our return to the Laboratory, we arranged our collections upon white paper in such a manner that spores would be shed over night and this means of identification utilized. The following morning we identified as many as possible and took description of those we could not identify, after which we preserved all but the Boleti and the Bracket fungi in 4% formalin in jars, tagged with numbers corresponding to our list, which contained either the species or the description and date and place where the species was found. Bracket fungi we preserved dry in cigar boxes or, when large, in large boxes. Boleti, we preserved in a mixture of 4% formalin and 30% alcohol, as they broke down in 4% formalin. In many cases one day's collecting furnished material for two or more days' work in classification. Where trips were longer, a whole day was required for collecting. The collecting covered the area around the station near the shores, within a radius of 7 miles among the islands and about 7 miles up the Go Home river. In no cases were we able to take long trips inland because of the roughness of the country and the difficulty of finding our boat on our return to the shore.

XII.

NOTES ON THE AQUATIC PLANTS OF GEORGIAN BAY.

By A. B. Klugh, M.A., Queen's University, Kingston.

During the latter part of August and the first three weeks of September, 1912, I was engaged in a study of the Hydrophytes of Georgian Bay in connection with the Biological Station at Go Home Bay, Muskoka. In company with Mr. A. D. Robertson, M.A., I made a trip round the Bay, collecting along the shore at numerous points. A full report upon the Algæ collected on this trip is given in my paper in "*Rhodora.*," Vol. 15, No. 173 (May, 1913), in which a new species of *Rivularia* is described, and twelve species of Algæ new to Canada are recorded.

The following are the records of the Pteridophytic and Spermatophytic Hydrophytes observed on the trip referred to.

PTERIDOPHYTA.

Isoetes macrospora. Dur. Growing on muddy bottom in eight feet of water near the mouth of the Shawanaga River Aug. 26.

Isoetes echinospora braunii Engelm. Growing submerged near shore in the Shawanaga River Aug. 27. Submerged in a foot of water at Killarney Sept. 4. Submerged, in Collins' Inlet Sept. 3.

SPERMATOPHYTA.

MONOCOTYLEDONEÆ.

Sparganium simplex, Huds. In lake off Shawanaga River, Aug. 27.

Potamogeton natans, L. Severn River, Aug. 21. At mouth of Shawanaga River, Aug. 27.

Potamogeton heterophyllus, Schreb. Waubaushene, Aug. 27. In lake off Shawanaga River, Aug. 27.

Potamogeton epihydrus cayugensis, Benn. In the French River at foot of the last rapids, Sept. 1.

Potamogeton lucens, L. At mouth of Shawanaga River, Aug. 26.

Potamogeton perfoliatus, L. Severn River and covering large areas of water in Georgian Bay at mouth of Severn River, Aug. 21. Near mouth of Shawanaga River, Aug. 26. French River, Sept 1. Killarney, Sept 4.

Potamogeton zosterifolius, Schw. Near the mouth of the Shawanaga River, Aug. 26. Waubaushene, Aug. 21.

Potamogeton pusillus tenuissimum, Mertens and Koch. In a very small almost cut-off inlet in one of the Bustard Islands off French River. Aug. 30.

Potamogeton dimorphus, Raf. In lake off Shawanaga River, Aug. 27. In little almost cut-off inlet in one of the Bustard Islands off French River, Aug. 30. In pool at the foot of the last rapids on the French River, Sept. 1.

Potamogeton pectinatus, L. Matchedash Marsh, Waubaushene, Aug. 24. Killarney, Sept. 4.

Najas flexilis, Rostk & Schmidt. Waubaushene, Aug. 21. In lake off Shawanaga River, Aug. 27. In the Shawanaga River, Aug. 26. In pool at foot of the last rapids on the French River, Sept. 1.

Elodea canadensis, Michx. Waubaushene, Aug. 21. In pool at foot of last rapids on the French River, Sept. 1.

Vallisneria spiralis L. Waubaushene, Aug. 21. In pool at foot of last rapids on the French River, Sept. 1.

DICOTYLEDONEÆ.

Ceratophyllum demersum, L. Waubaushene, near Canary Island, Aug. 21.

Nymphæa advena, Ait. Severn River Aug. 21, In the Shawanaga River, Aug. 26. In lake off the Shawanaga River, Aug. 27. In pool at foot of last rapids on the French River, Sept. 1. In Collin's Inlet, Sept. 3.

Castalia odorata, Woodville & Wood. In lake off the Shawanaga River, Aug. 27. In pool at foot of last rapids on the French River, Sept. 1. In Collin's Inlet, Sept. 3.

Brasenia schreberi, Gmel. In lake off the Shawanaga River, Aug. 27.

Callitriche autumnalis, L. In little almost cut-off inlet in one of the Bustard Islands off French River, Aug. 30.

Hypericum boreale, Bicknell. Submerged form; in the Shawanaga River, Aug. 27.

Myriophyllum spicatum, L. In the Severn River, Aug. 21. At the mouth of the Shawanaga River, Aug. 26. In little almost cut-off inlet in one of the Bustard Islands off French River, Aug. 30. In pool at the foot of the last rapids on the French River, Sept. 1.

Myriophyllum heterophyllum, Michx. In pool at foot of the last rapids on the French River, Sept. 1.

Nymphoides lacunosum, Fernald. In lake off the Shawanaga River, Aug. 27.

XIII.

ENTOMOSTRACA OF GEORGIAN BAY.

By G. O. Sars. Professor of Zoology, Christiana University, Norway.

The following is a list of Entomostraca occurring in a series of surface tow-nettings made by Dr. E. M. Walker in the summer of 1907, at the Georgian Bay Biological Station, Go Home, Georgian Bay, Lake Huron.

CLADOCERA.

1. *Holopedium gibberum*, Zaddach.
   Very common in all the samples.
2. *Sida crystallina*, Müll.
   Occasionally from the bottom.
3. *Daphniella brachyura*, Lievin.
   Not infrequent in some of the samples.
4. *Daphnia hyalina*, var. *oxycephala*, G. O. Sars.

This form was recorded by the present author in 1890 as a variety of *D. galeata*, G. O. Sars. I now, however, regard it as more properly belonging to the species D. *hyalina*, Leydig, with which also Herrick has identified it.

Occasionally in most of the samples.

5. *Hyalodaphnia retrocurva*, var. *intexta*, Forbes.

This form has erroneously been identified by Herrick with *H. kahlbergensis*, Schœdler, which is a variety of a quite different species, viz., *H. cucullata*, G. O. Sars. The present variety exhibits in its general appearance and particularly in the shape of the head, a strong resemblance to *H. cederstrœmii*, Schœdler, which is a variety of *H. cristata*, G. O. Sars. It differs, however, among other things, in the more obtuse rostrum and in the presence of a well-devel oped natatory seta on the first joint of the lower or inner ramus of the antenna, this seta being wholly absent in *H. cederstrœmii*.

Rather common in all the samples.

6. *Ceriodaphnia scitula*, Forbes.

The most conspicuous character distinguishing this species is the peculiar shape of the fornix, which is produced above the bases of the antennæ on each side to a rather large gibboiform prominence.

Not infrequent in some of the samples.

7. *Bosmina longirostris* (Müll.) var.

This is a very small variety, especially distinguished from the type by the somewhat longer shell-spines, which, moreover, exhibit each one or two well-marked serrations not found in the usual form.

Not infrequent in some of the samples.

8. *Polyphemus pediculus*, Müll.
   Rather abundant in most of the samples.
9. *Leptodora hyalina*, Lilljeb.
   Likewise rather common.

COPEPODA

10. *Epischura lacustris*, Forbes.
    Very abundant in all the samples.
11. *Diaptomus oregonensis*, Lilljeb.
    Likewise abundant in most of the samples.
12. *Diaptomus minutus*, Lilljeb.
    Together with the preceding species, but less abundant.
13. *Cyclops brevispinosus*, Herrick.

This form is closely related to *C. robustus*, G. O. Sars, and is perhaps the same species.

Only a few specimens observed, apparently dredged from the bottom.

14. *Cyclops thomasi*, Forbes.

This form has been identified by Dr. Schmeil and some other authors with *C. pulchellus*, Koch (=C. *bicuspidatus*, Claus). It is however, as I have convinced myself, a well-defined species.

Not infrequent in some of the samples.

15. *Cyclops edax*, Forbes.

Nor in the case of this species has its validity been admitted by Dr.Schmeil, who regards it as only a variety of *C. leuckarti*, Claus. I find it, however, to be quite certainly specifically distinct though nearly allied to that species.

Common in most of the samples.

OSTRACODA.

16. *Cyclocypris serena*, Koch.
    Occasionally from the bottom.