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SELECTED STUDIES OF MICHIGAN LEECHES

By

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ABSTRACT

SELECTED STUDIES OF MICHIGAN LEECHES

By

Martin Leo Kopenski

This study is concerned with leeches present in Michigan, particularly in Marquette County waters. An attempt is made to correlate various chemical, physical and biological features of water with the abundance and distribution of leeches.

Leeches were taken from 50 locations in Marquette County in the Upper Peninsula of Michigan and from six each in Barry and Kalamazoo Counties in the Lower Peninsula. These leeches were collected over a period of six years (1961-1966) and were obtained from such habitats as lakes, ponds, bogs, rivers, and creeks. Tests to measure total alkalinity and pH were performed on waters from a representative number of the waters investigated. Several physical characteristics of the waters studied, such as depth, color, temperature, nature of the bottom, soil types, and whether lentic or lotic, were recorded. Certain biological factors, such as feeding habits, enemies, and reproductive habits, were noted.

Nineteen species of leeches were found in Michigan during this study. Nine species are recorded in addition to the listing of Miller (1937) bringing the total number known

for Michigan to 22. Most glossiphonids, piscolids, hirudids, and erpobdellids are abundant and widely distributed in the areas of the state which have been studied. *Helobdella stagnalis* was the most abundant leech found in Marquette County, 103 individuals having been taken, and *Erpobdella punctata* was encountered at 34% of the sites studied. The leech fauna of the Upper and Lower Peninsulas are similar and the species in Michigan compare closely to those in Ohio, Illinois, Minnesota, and Wisconsin.

The glossiphonids have been found to be more common in waters with a high total alkalinity. Most hirudids were found most commonly in waters with low total alkalinities, while erpobdellids vary. The abundance and distribution of most leeches are restricted by waters with low pH; however, leeches appear not to be restricted by waters with high pH readings.

Most leeches in Michigan prefer standing waters, with the glossiphonids being best adapted for living in running waters. Water temperature is a major limiting factor for the distributuion of only *Nephelopsis obscura* and *Philobdella gracilis*. Most leeches were found along a variety of bottom types with no preference shown. The presence or absence of submerged objects is a more important factor in their distribution than the nature of the bottom. The soils surrounding a body of water probably exert an indirect effect on the abundance and distribution of leeches by altering the chemical nature of the water which may affect the abundance and distribution of the leeches' food organisms.

The reproductive habits of leeches undoubtedly influence their abundance and distribution. The data indicate that the glossiphonids are the most prolific leeches in Michigan and consequently the most abundant and widely distributed. The erpobdellids are a less prolific group; however, their abundance and distribution are comparable to that of the glossiphonids. Predators probably exert some influence on the abundance of erpobdellids. The abundance and distribution of food organisms are undoubtedly the most important factors affecting the abundance and distribution of leeches.

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I wish to acknowledge the help of Dr. K. H. Mann for providing me with the English translation of Sandner's (1951) work and also his reprints and expert advice.

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

Introduction

Since no comprehensive study of the ecology of leeches has been performed in the United States, the present study was undertaken to determine what leeches are present in selected counties of Michigan and to describe their abundance and distribution. A comparison was made between the species inhabiting the waters of both peninsulas of Michigan. The species of leeches in Michigan were also compared with those of Ohio, Illinois, Minnesota, and Wisconsin since species listings have been compiled for these states.

Several chemical, physical, and biological features of the habitats studied were considered in an attempt to determine the most important factors regulating leech abundance and distribution. Since the relationship of these factors to leech abundance and distribution have been extensively studied only in Europe, a comparison was made between the results of this study and those of the European studies.

Literature Review

The major leech studies completed in the United States have been mainly concerned with species compilations for various states along with species descriptions and keys to their identification. Most of these works have been performed in the midwestern states. Nachtrieb, Hemingway, and J. P. Moore (1912) conducted an extensive survey of the leech fauna of Minnesota which has recently been extended by Keith (1954, 1960). J. P. Moore (1901) compiled a species listing for the state of Illinois. Bere (1931) studied Wisconsin leeches and compiled a species listing for that state. Sapkarev (1967) did a quantitative study of the leeches of Lake Mendota to determine their vertical and horizontal distribution and seasonal variations in population density. Miller (1929) studied the leeches of Ohio and in (1937) worked on Michigan leeches. The works of Mullen (1926) and Mather (1963) concern the leeches of Iowa.

The only significant study concerned with leeches of Michigan is that of Miller (1937). The leeches referred to in his study were secured from the Museum of Zoology of the University of Michigan, having been collected in Michigan in 1925, 1926, and 1927 by Dr. Y. Metzelaar and assistants of the University of Michigan. The majority of the collecting sites listed in this paper are in the Lower Peninsula of Michigan with a few from Luce County in the Upper Peninsula. Miller lists thirteen species of leeches found in Michigan and includes a key to their identification.

Only four major ecological studies have been completed on leeches. These have been performed by Pawlowski

(1936), Bennike (1943), Sandner (1951), and Mann (1955). According to Mann (1955), Pawlowski (1936) collected from 57 stations in the Polish Lake Wigryseen and in neighboring smaller bodies of water. First, he recorded information about the food habits of leeches; secondly, he related the leech fauna to the type of substratum; and thirdly, he classified his habitats as eutrophic, dystrophic, or oligotrophic, and considered which species of leeches occurred in each type.

Bennike (1943) collected from 215 habitats scattered over the whole of Denmark and investigated leech distribution mainly from the physical and chemical standpoints. He measured certain selected characteristics of the water and related these to the species present. He divided his habitats into lakes, ponds, bogs, and streams and described the leeches inhabiting each.

Sandner (1951) made an extensive survey in the county of Lodz in Poland, classifying his habitats into tarns, small ponds, fish-ponds, peat-pools, etc. He also made a number of physical and chemical observations on the water and attempted to relate these to the presence or absence of certain species of leeches.

Mann (1955) collected from 29 stations in Berkshire, and 29 in the lake district of Britain. He performed a number of physical and chemical tests on the water and classified his standing waters as oligotrophic, eutrophic, and dystrophic, and his running waters on the basis of current speed. He also used quantitative collecting methods by collecting at a given site for a certain period of time and he measured the area of his habitats. He presented data to show that the area of a given body of water has an effect on the species of leeches inhabiting such a body of water.

Mann (1962) states that only in Europe has the ecology of leeches been studied intensively. Information for the rest of the leech fauna of the world consists of brief notes about food organisms with which the leech is associated and perhaps some information about the habitats in which specimens have been found.

CHAPTER II

METHODS AND MATERIALS

Limnological Techniques

Chemical Methods: Chemical water analyses were performed at a representative number of the sites visited. The water tested was taken at the location of the leeches present. Two chemical characteristics of the water were measured, (1) pH and (2) total alkalinity.

1. pH: The pH of the water was measured in the laboratory by means of a Beckman pH meter calibrated to correct for temperature change. The pH was determined immediately after returning from the field not later than two hours after it had been obtained.
2. Total Alkalinity: The total alkalinity of the water was determined at the collecting site as soon as the water sample was obtained. The determination was made by adding four drops of phenolphthalein indicator plus two drops of methyl orange to a 100 milliliter sample and titrating with 0.2N H_2SO_4 until the solution turned salmon pink. The number of milliliters of 0.2N H_2SO_4 used times 10 represented the total alkalinity in mg./L. $CaCO_3$, Welch (1948).

Physical Methods: Several physical features of the habitats were recorded. The physical conditions described are those which existed at the exact location where specimens were obtained.

1. Bottom Composition: The bottom descriptions included are based on the bottom classifications system of Roelofs (1944).
2. Depth: The depth was measured by means of a yard stick.
3. Color: The water color descriptions included are based on gross observations as no color analyses were performed.
4. Temperature: The water temperature was measured by means of a Centigrade thermometer.
5. Lentic vs. Lotic: Leeches were collected from standing and running waters and the frequency of species inhabiting both types was compared.

Biological Data: The dominant floral and faunal inhabitants associated with the leeches collected at each site were recorded.

Leeches

Collecting Methods: The leeches referred to in this study were taken in the following ways:

1. Examination of the undersurfaces of submerged rocks, sticks, boards, logs, cans, and other submerged objects in the body of water.

2. Agitation of the water and netting free-swimming leeches which were disturbed by such agitation.

3. Examination of vertebrate hosts, such as, fish, frogs, and turtles which may harbor leeches.

4. Uprooting aquatic plants and examining their stems, roots, and leaves for adhering leeches.

5. Scooping up debris from the bottom, such as, submerged leaves, algae, and organic sediment. This material was sometimes examined by picking through it with forceps or placing it on dry land for a period of time. As the material dried, leeches were picked up as they left it.

Processing and Preserving: The leeches collected were taken to the laboratory in the living state. A label denoting the date and location of the collection site was inserted into each jar containing leeches. In the laboratory, the leeches were anesthetized by immersing them in a saturated solution of menthol. When the leeches would no longer respond to prodding, they were removed from the menthol solution. The mucus secreted by them during the preceding process was washed off. The erpbobdellid leeches were preserved internally by injecting 70% ethanol into the body cavity. This was done to insure preservation of the reproductive organs which might be necessary for positive identification. Next, the leeches were straightened and placed between two glass plates. A rubber band was wrapped around the glass plates with sufficient pressure to keep the leeches in an extended position without displacing or distorting the internal organs. This preparation was immersed in a 10% formalin solution to fix the leeches in this position. After the leeches were sufficiently hardened so as to remain in this extended position, they were removed from the formalin solution and placed in eight-dram vials containing 70% ethanol.

Identification: The identity of the leeches was determined by using one of several keys listed in the bibliography. One of the main characteristics used to identify these specimens was the number, shape, and position of the eyes. If the eyes were not clearly visible due to heavy pigmentation in the head region, the head portion of the leech was immersed in a 5% solution of potassium hydroxide to bleach out the pigments, thus rendering the eyes more apparent, Mann (1962). In the case of the erpobdellids, it was necessary to dissect out the reproductive organs in some cases in order to make positive identifications. In regard to *Haemopis* spp. the presence or absence of jaws plus the number of teeth on the jaws were used in determination of species. After the leeches were determined, the members of one species from a single collection were placed in a vial. A tag designating the date of collection, locality, locus, county, state, catalog number, and collector was inserted into each vial.

A taxonomic classification of Michigan leeches is given in Table A1, pages 135 and 136. A key to the identification of these leeches is included in Table A2, pages 137-140.

A listing of the station location, dates on which collecting was done, the species and number of each found, as well as the pH and total alkalinities of the waters studied is shown in Tables A3, A4, and A5, pages 143-152.

Cataloging: The cataloging system used for the preserved leeches is as follows: Roman numerals were used to designate the collecting sites beginning with the first collecting site visited and proceeding to the most recent. If a site was visited more than once, the same Roman numeral was used to designate the site. Capital letters were used to designate the family to which a certain species belonged, Arabic numbers the genus, and small letters the species. Thus Redberry Pond, the first site studied, would be indicated by IA_1a. A would represent the family Glossiphonidae, 1 the genus *Glossiphonia*, and a the species *complanata*. Leeches collected in Barry and Kalamazoo Counties were cataloged separately by county in the same manner as described.

Catalog Code to Leech Collection

Capital Letters = Family

A	Glossiphonidae	C	Hirudidae
B	Erpobdellidae	D	Piscicolidae

Arabic Numbers = Genera

1	Glossiphonia	7	Macrobdella
2	Helobdella	8	Haemopis
3	Placobdella	9	Theromyzon
4	Erpobdella	10	Illinobdella
5	Dina	11	Philobdella
6	Nephelopsis	12	Piscicola

Small Letters = Species

Genera		Species	Genera		Species
Glossiphonia	a	complanata	Nephelopsis	a	obscura
Helobdella	a	stagnalis	Macrobdella	a	decora
	b	fusca	Haemopis	a	marmorata
Placobdella	a	hollensis		b	grandis
	b	parasitica	Theromyzon	a	rude
	c	rugosa	Illinobdella	a	alba
	d	montifera		b	punctata
Erpobdella	a	punctata	Philobdella	a	gracilis
Dina	a	parva	Piscicola	a	milneri
	b	fervida			

CHAPTER III

THE STUDY AREAS

Introduction

Fifty collecting stations were selected representing such habitats as: lakes, ponds, bogs, rivers, and creeks located throughout Marquette County. Leeches were also collected from six sites in Barry County and six sites in Kalamazoo County in the Lower Peninsula of Michigan. These leeches were collected from habitats comparable to those in Marquette County.

The names used to designate collecting stations are those used on various maps of the areas. Where no known name could be found for a body of water, a name was derived in relation to a road or some permanent structure in the area.

Figure 1 depicts the three counties involved in this study. Figure 2, page 15, shows the location and soil relationships of the waters studied in Marquette County. Only the soil types immediately surrounding the waters studied are shown in Figure 2. Table 1, pages 37-39, lists several physical features of the waters investigated in Marquette County. Tables 2, pages 40-42 and 3, pages 43-45, denote the dominant floral and faunal inhabitants of the waters studied in Marquette County.

Fig. 1. Upper and Lower Peninsulas of Michigan showing the location of the three counties involved in this study.

Likewise, Tables 4, 5, and 6, pages 57-59, depict corresponding information for the waters of Barry and Kalamazoo Counties.

Marquette County

Geologic-Pedologic Description: The following geologic-pedologic description of Marquette County and the specific study areas is taken from Veatch (1953, pages 141-142).

> The Marquette area is a complex of rock knobs and deep-drift highland masses. Swamps and bogs in large and small basins are interspersed; and narrow swampy valleys form a network pattern. Other features of the landscape are: both large and small lakes, diverse in origin, shape, and kind of shore lines, beaver meadows; enclosed dry and wet valley plains and basins, floored with sand, gravel, and boulders. Streams are relatively numerous, have eccentric courses, and flow through swampy valleys and meadows.
>
> The dominant soils of the highland are reddish, loams or silts in texture, and overlie coarse glacial drift characterized by small fragments and boulders of basalts, gabbros, diorites, and a variety of other rocks, especially granites, schists, slates, and red sandstones. The soils on the dry plains are mainly Stambaugh and Rubicon types. Much of the present bare rock surface on crests of knobs and hills was originally covered by a blackish, spongy humous soil, and brown, silty loam which was lost through fire and rain-wash after lumbering. The swamp soils are mainly raw, highly acid, peats of the Greenwood and Spalding types, with less of the darker more decomposed Carbondale peat.

Figure 2 Legend

I. Red Drift. Bedrock basic igneous and granites. Podzol profiles, both weak and strong development of gray and brown horizons.

II. Largely gray drift, high proportion of slate rocks. Podzol profiles have buff and yellow orterde horizons. Brown podzols common.

III. Red Drift. Mostly granite rock, some sandstone and basic igneous rocks. Mostly normal podzol profiles including lithosols and brown podzols.

IV. Red Drift. Mostly igneous and metamorphic rocks in drift, fairly strong influence from sandstones; very slight or none from limestone. Podzol soil profiles; strongly developed brown horizons, except some dry sands which have only weak development and absence of a lower red clay.

V. Fluvio-glacial and outwash deposits. Little or no limestone influence. Podzol soil profiles, variably weak and very strong development of gray and brown horizons.

VI. Clayey Drift, red color; influence from sandstones, igneous and metamorphic rocks, little or no influence from limestone. Podzol profiles; variably weak, to strong development of gray and brown horizons.

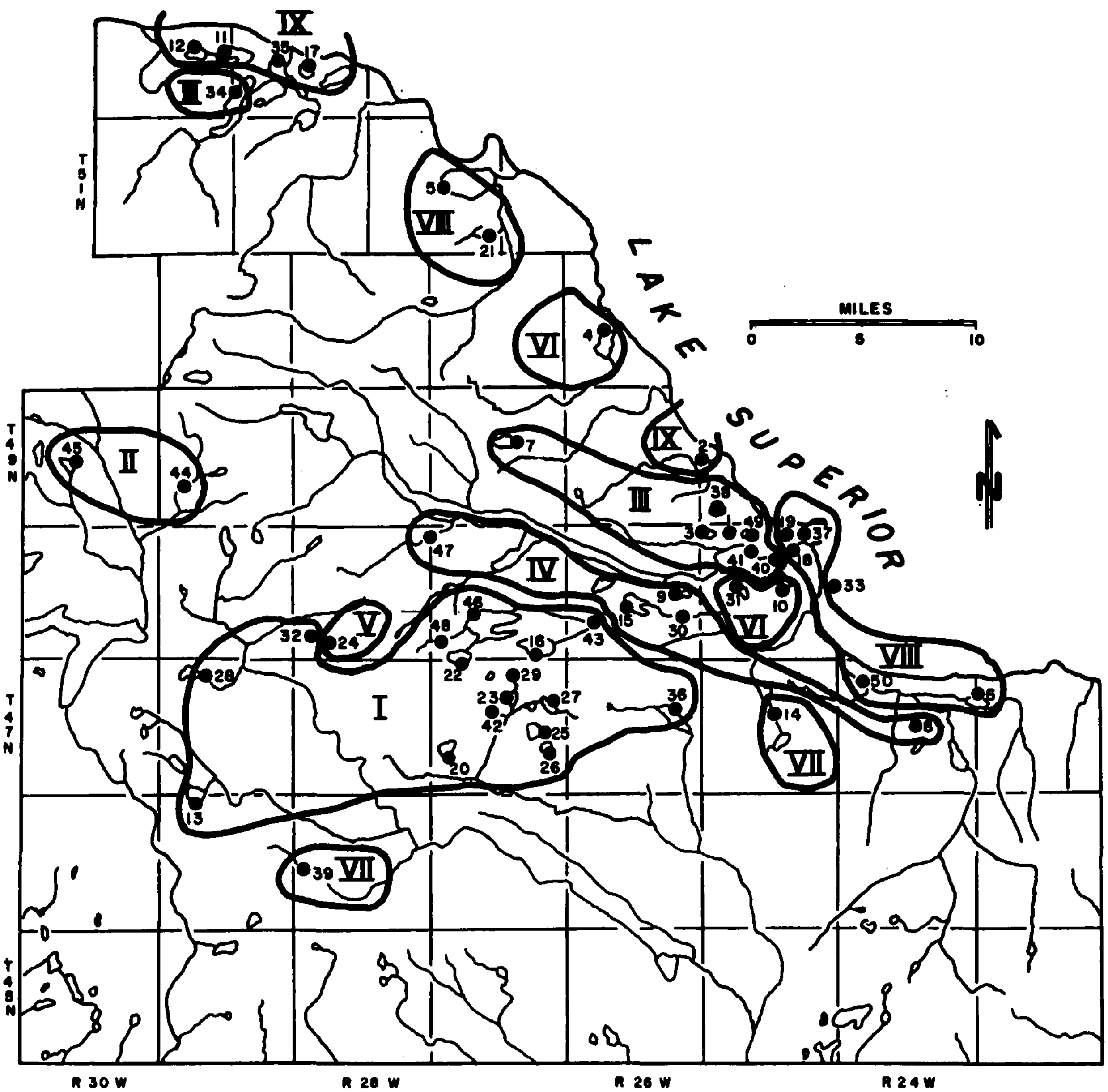
VII. Outwash, glacio-fluvial and lacustrine deposits, reddish color. No limestone influence, podzol profiles weakly or incompletely developed.

VIII. Mostly sand and gravel. Podzols either gray horizon or brown horizon separately strongly developed. Little or no limestone influence.

IX. Coarse red drift, hard compact sandy clay. Drift strongly influenced by local sandstone bedrock.

(from Veatch, Soils and Land of Michigan)

COLLECTING SITES
MARQUETTE COUNTY, MICHIGAN



1. REDBERRY POND
2. HARLOW LAKE
3. WALDO POND
4. SAUXHEAD LAKE
5. INDEPENDENCE LAKE
6. KAWBAWGAM LAKE
7. ROAD 510 POND
8. MANGUM ROAD DITCH
9. BAGDAD POND
10. CEMETERY POND
11. RUSH LAKE
12. HOWE LAKE
13. MINE SHAFT POND
14. ROAD 553 CREEK
15. HORSESHOE POND
16. TEAL LAKE
17. CRANBERRY BOG
18. DEAD RIVER
19. SMALL PONDS
20. VERNAL POND
21. SMALL CREEK
22. COOPER LAKE
23. BANCROFT LAKE
24. BOSTON LAKE
25. TILDEN LAKE
26. SCHOOLHOUSE LAKE
27. OGDEN LAKE
28. FISH LAKE
29. BACON LAKE
30. MORGAN CREEK
31. RAMSETH POND
32. HUMBOLDT POND
33. LAKE SUPERIOR
34. MOUNTAIN LAKE
35. PINE LAKE
36. GOOSE LAKE
37. ROD & GUN CLUB POND
38. WETMORE POND
39. WEST BRANCH CREEK
40. TOURIST PARK POND
41. DEAD RIVER
42. MINE SHAFT POND
43. CARP RIVER
44. DISHNO CREEK
45. ARFELIN LAKE
46. DEER LAKE
47. BARNHARDT CREEK
48. GOLDMINE CREEK
49. MIDDLE ISLE POINT BOG
50. CHOCOLAY RIVER

Fig. 2. Locations and soils of the waters studied.

Habitat Descriptions (Marquette County): Tables 1, 2, and 3 on pages 37-45 denote several physical and biological characteristics of the waters investigated.

The following habitat descriptions pertain mainly to the specific locations at which leeches were found with some information about the body of water as a whole. The criteria used to distinguish between lakes, ponds, rivers, bogs, creeks, and ditches are denoted.

LAKES

> "Bodies of water having an area of open, relatively deep water sufficiently large to produce somewhere on its periphery a barren, wave swept shore." (Welch, 1952, page 16)

Station 2. Harlow Lake derives its water supply from several small streams and occupies an area of 75 acres. It drains into Lake Superior by way of Harlow Creek. The bottom in the littoral zone consists of sand with small interspersed graveled patches. The bottom in the limnetic region is made up of fibrous and pulpy peat. An abundance and variety of aquatic plants are present consisting mainly of sedges (*Scirpus* spp.) in the littoral zone with pondweeds (*Potamogeton Richardsonii*) and (*P. Robbinsii*) mainly dominating the limnetic area. A wide variety of invertebrates are present with clams (*Anodonta* sp.) and snails (*Helisoma* sp.) predominating. Few crayfish (*Cambarus* sp.) are also present. Yellow perch (*Perca flavescens*) is the dominant species of fish with bluegills (_Lepomis macrochirus_) and northern pike (_Esox lucius_) also present. Frogs (_Rana_ spp.) occur in the littoral zone while snapping turtles (_Chelydra serpentina_) and painted turtles (_Chrysemys picta_) are present throughout the lake.

Station 4. Sauxhead Lake is fed by the Big Garlic River and drains into Lake Superior by way of this river. The bottom is mainly sand with pieces of submerged wood being abundant. Sedges (_Scirpus_ spp.) dominate the littoral zone with yellow water lilies (_Nuphar advena_) and pondweeds (_Potamogeton_ spp.) being prevalent in the limnetic waters. Clams (_Elliptio_ sp.), snails (_Campeloma_ sp.), and crayfish (_Orconectes_ sp.) are the dominant invertebrates with the vertebrates represented by yellow perch (_Perca flavescens_), northern pike (_Esox lucius_), and walleyes (_Stizostedion vitreum_).

Station 5. Independence Lake occupies an area of 1,860 acres, is fed mainly by the Yellow Dog River and drains into Lake Superior by way of the Iron River. The bottom consists of sand with patches of rubble and submerged wood. Pondweeds (_Potamogeton_ spp.) are the dominant plants while clams (_Pisidium_ sp.) and amphipods (_Hyalella azteca_) are abundant. Yellow perch (_Perca flavescens_), northern pike

(*Esox lucius*), and walleyes (*Stizostedion vitreum*) are the dominant vertebrates.

Station 6. Kawbawgam Lake occupies an area of 153 acres, possesses mainly a sand bottom, and drains into Lake Superior by way of the Chocolay River. Pondweeds (*Potamogeton* spp.) are the dominant plants while snails (*Physa* sp.) and isopods (*Asellus* sp.) are abundant. Yellow perch (*Perca flavescens*) and northern pike (*Esox lucius*) are present in sizeable numbers.

Station 11. Rush Lake is a clear deep oligotrophic lake with mainly a sand bottom with areas of overlying rubble and sticks. The littoral zone is occupied by rushes (*Juncus* sp.); no higher aquatic plants were visible in the limnetic area. Clams (*Pisidium* sp.) and crayfish (*Orconectes* sp.) are abundant with the dominant vertebrates being salmonids.

Station 12. Howe Lake, located near Rush Lake, resembles it in appearance and composition. The bottom is mainly sand covered with a 2-inch layer of silt, with an abundance of submerged sticks and intermittent accumulations of rubble. Rushes (*Juncus* sp.) dominate the littoral zone. The limnetic waters are deep with no higher aquatic plants evident. Clams (*Pisidium* sp.), crayfish (*Orconectes* sp.), and amphipods (*Hyalella* sp.) are present in small numbers with salmonids being the dominant vertebrates.

Station 16. Teal Lake occupies an area of 505 acres. The bottom is composed of bedrock with overlying sand in the deeper areas. Stonewort (Chara sp.) is the dominant plant in the littoral zone with pondweeds (Potamogeton spp.) dominating the limnetic waters. Planarians (Dugesia sp.) and crayfish (Orconectes sp.) are very abundant with chironomids (Chironomus sp.) present in smaller numbers. Yellow perch (Perca flavescens), pumpkinseeds (Lepomis gibbosus), and walleyes (Stizostedion vitreum) are the dominant fish.

Station 22. Cooper Lake occupies an area of 34 acres and is surrounded mostly by woodland with a small area of pasture land on the south shore. The bottom in the littoral zone is composed of sand with an abundance of submerged sticks and a few boulders. The bottom in the limnetic area is composed of fibrous and pulpy peat. Rushes (Juncus spp.) are abundant in the littoral zone with pondweeds (Potamogeton spp.), yellow water lilies (Nuphar advena), and bushy pondweed (Najas flexilis) dominating the limnetic waters. Amphipods (Hyalella sp.) and aquatic insects mainly gyrinids (Gyrinus sp.) are abundant. Yellow perch (Perca flavescens) and bullheads (Ictalurus sp.) are the representative fish.

Station 23. Bancroft Lake occupies an area of 28.5 acres. The bottom consists of pulpy peat covered with pieces of submerged concrete at the site of collection. Aquatic plants are sparse being represented by patches of pondweeds (Potamogeton spp.). Snails (Physa sp.) are very abundant with amphipods (Hyalella sp.) and crayfish (Orconectes sp.) being present in fewer numbers. Bullheads (Ictalurus sp.) are the dominant fish along with a few cyprinids.

Station 24. Boston Lake is a spring fed lake occupying an area of 50.5 acres. The bottom in the littoral zone consists of sand with intermittent accumulations of rubble. The bottom in the limnetic zone consists of pulpy peat. Yellow water lilies (Nuphar advena) and pondweeds (Potamogeton spp.) are abundant. Clams (Sphaerium sp.), snails (Helisoma sp.), and crayfish (Cambarus sp.) are the dominant invertebrates. White suckers (Catostomus commersonnii) are present in large numbers, while black crappies (Pomoxis nigromaculatus) are present in fewer numbers.

Station 25. Tilden Lake occupies an area of 53 acres and reaches a maximum depth of 37 feet. The bottom consists of sand, rubble, and numerous submerged logs. The entire shoreline of the lake is heavily wooded. Arrowhead (Sagittaria latifolia) and sedges (Scirpus spp.) are present but not abundant. Crayfish (Cambarus sp.) is the dominant invertebrate.

Salmonids are the dominant fish along with a wide variety of cyprinids.

Station 26. Schoolhouse Lake is a shallow lake surrounded by wooded hills. The bottom consists of muck with a 6-inch layer of hemlock (*Tsuga canadensis*) bark overlying it in the littoral zone. Bur reed (*Sparganium androcladum*) and arrowhead (*Sagittaria latifolia*) are abundant in the littoral zone with yellow water lilies (*Nuphar advena*) dominating the limnetic waters. Planarians (*Dugesia* sp.), amphipods (*Hyalella* sp.), and snails (*Physa* sp.) are very abundant. No representative vertebrates were observed.

Station 27. Ogden Lake is an elongated, shallow lake. The bottom consists of pulpy peat overlain with numerous sticks and chips of wood. Eel grass (*Vallisneria americana*), pondweeds (*Potamogeton* spp.), and yellow water lilies (*Nuphar advena*) are the dominant plants although they are not abundant. Planarians (*Dugesia* sp.), snails (*Physa* sp.), and crayfish (*Orconectes* sp.) are numerous. No vertebrates were observed.

Station 28. Fish Lake occupies an area of 156 acres and possesses a sand bottom with numerous patches of overlying gravel. Arrowhead (*Sagittaria latifolia*) and horsetails (*Equisetum* sp.) crowd the littoral zone of the lake. Yellow water lily (*Nuphar advena*) is the dominant plant present in the limnetic water, although it is not abundant. Snails (*Campeloma* sp.), clams (*Sphaerium* sp.), and amphipods (*Hyalella* sp.) are abundant. The fish present in order of abundance are yellow perch (*Perca flavescens*), black crappies (*Pomoxis nigromaculatus*), bluegills (*Lepomis macrochirus*), and northern pike (*Esox lucius*).

Station 29. Bacon Lake fits in the category between lake and pond. It is a shallow lake reaching a maximum depth of 15 feet. The bottom consists of sand overlain with a 3-4 inch layer of fibrous peat. Bur reed (*Sparganium androcladum*) and bushy pondweed (*Najas flexilis*) are abundant. Snails (*Physa* sp.) and culicine larvae (*Chaoborus* sp.) occur in small numbers. Cyprinids are the dominant vertebrates.

Station 33. The portion of Lake Superior examined is a bayou altered considerably by man for the purpose of boat storage and launching. The bottom is composed of sand with pieces of overlain concrete, also bricks, rubble, and boulders. Waterweed (*Anacharis canadensis*) is the only aquatic plant in this area and is not abundant. Snails (*Campeloma* sp.) and (*Physa* sp.) are abundant along with isopods (*Asellus* sp.). Fish are scarce in this area although fish from the lake proper sometimes enter into this bayou.

Station 34. Mountain Lake is a clear, deep, oligotrophic lake with a sand bottom overlain with gravel and intermittent pieces of wood. Sedges (Scirpus spp.) dominate the littoral zone of the lake. The limnetic waters are devoid of visible aquatic plants due to the great depth. Snails (Physa sp.) and amphipods (Hyalella sp.), as well as salmonids, are abundant.

Station 35. Pine Lake is a deep oligotrophic lake with a sand bottom overlain with intermittent sticks. The littoral zone is crowded with sedges (Scirpus spp.) while pondweeds (Potamogeton spp.) dominate the limnetic zone. Snails (Physa sp.), clams (Pisidium sp.), and amphipods (Hyalella sp.) are the predominant invertebrates. This lake, along with Howe, Rush, and Mountain Lakes previously described, is located on the property of the Huron Mountain Club and is not accessible to the general public. Consequently, these four lakes have not been subjected to the ravages of man and are possibly the least modified and in the author's estimation the most beautiful lakes in the State of Michigan.

Station 36. Goose Lake occupies an area of 446 acres and possesses a sand bottom covered with a thin layer of silt. This lake in past years was a receptacle for the sewage wastes of the City of Negaunee. This practice was discontinued ten years ago; however, extensive algal blooms still occur during the summer. Yellow water lilies (Nuphar advena) and pondweeds

(*Potamogeton* spp.) are present in large numbers. Copepods (*Cyclops* sp.) and cladocerans (*Daphnia* sp.) are exceedingly numerous. Yellow perch (*Perca flavescens*) and northern pike (*Esox lucius*) are the dominant vertebrates.

Station 45. Arfelin Lake occupies an area of 66.5 acres, reaches a maximum depth of 35 feet, and drains into the Peshekee River. The bottom in the littoral zone consists of sand covered with gravel and submerged sticks. Pondweeds (*Potamogeton* spp.) are present in small numbers. Sponges (*Spongilla* spp.) are abundant adhering to submerged sticks. Planarians (*Dugesia* sp.), snails (*Ferrisia* sp.), and the chironomid (*Chironomus* sp.) are also numerous. The dominant fish are catostomids, salmonids, and cyprinids.

Station 46. Deer Lake is a body of water containing many islands, bayous, inlets, and outlets. The bottom consists of sand with few submerged rocks. Blue green algal blooms of *Anabaena* sp. and *Microcystis* sp. occur frequently and there is a lush growth of pondweeds (*Potamogeton* spp.) and duckweed (*Lemna minor*). Oligochaetes and chironomids (*Chironomus* sp.) are extremely numerous while snails (*Physa* sp.) and amphipods (*Hyalella* sp.) are present in lesser numbers. Yellow perch (*Perca flavescens*) are the dominant fish.

PONDS

> "Very small, very shallow bodies of standing water in which quiet water and extensive occupancy by higher aquatic plants are common characteristics." (Welch, 1952, page 16)

Station 1. Redberry Pond is spring fed and reaches a maximum depth of ten feet. The bottom consists of fibrous peat overlain with numerous submerged logs. Yellow water lilies (Nuphar advena) are abundant and occupy the greater portion of the pond during the summer months. Snails (Physa sp.), amphipods (Hyalella sp.), and aquatic insects mainly dragon fly and damsel fly naiads are abundant. Yellow perch (Perca flavescens) are present in small numbers. Painted turtles (Chrysemys picta belli) are the predominant vertebrates with small populations of red-spotted newts (Notopthalmus viridescens) and green frogs (Rana clamitans) also present.

Station 3. Waldo Pond reaches a maximum depth of eight feet and possesses a bottom composed of pulpy peat with submerged wood. Yellow water lilies (Nuphar advena) are abundant in the limnetic waters, while sedges (Scirpus sp.) dominate the littoral zone. The invertebrates are represented by amphipods (Hyalella sp.), and aquatic insects mainly the dytiscid (Dytiscus sp.). Yellow perch (Perca flavescens) and bluegills (Lepomis macrochirus) are the dominant fish. Painted turtles (*Chrysemys picta*) are abundant throughout the pond.

Station 7. A small, un-named pond along County Road 510 which is supplied by several small un-named creeks. The bottom consists of muck covered with leaves, sticks, and logs. Sedges (*Scirpus* sp.) and cattails (*Typha latifolia*) are present in small numbers. Snails (*Lymnaea* sp.) are abundant along with a few isopods (*Asellus* sp.). Cyprinids are the dominant fish; other vertebrates are rare or absent.

Station 9. Bagdad Pond possesses a bottom of muck with intermittent submerged logs. A portion of the pond has a bog margin of *Sphagnum* spp., leatherleaf (*Chamaedaphne calyculata*), pitcher plants (*Sarracenia purpurea*), and cranberries (*Oxycoccus* sp.). Most of the pond, however, is surrounded by red maple (*Acer rubrum*), white birch (*Betula papyrifera*), and white cedar (*Thuja occidentalis*). Yellow water lilies (*Nuphar advena*) dominate the open waters along with sedges (*Scirpus* sp.). Snails (*Amnicola* sp.), copepods (*Diaptomus* sp.), and crayfish (*Orconectes* sp.) are abundant. Frogs (*Rana* spp.), red-spotted newts (*Notopthalmus viridescens*), and painted turtles (*Chrysemys picta*) are also abundant.

Station 10. The Park Cemetery Pond is a small pond reaching a diameter of about 30 feet. It is surrounded by a mowed lawn. It is completely crowded with white water lilies (*Nymphaea odorata*). Amphipods (*Hyalella* sp.), isopods (*Asellus* sp.), and painted turtles (*Chrysemys picta*) are abundant.

Station 13. This is an un-named pond formed by the flooding of an old iron mine shaft. Water is supplied by underground springs. The bottom consists of clay and submerged logs. Yellow water lilies (*Nuphar advena*) are present in small numbers. Invertebrates are sparse with snails (*Physa* sp.) being present in small numbers. No vertebrates were observed.

Station 15. Horseshoe Pond is an out-pocketing of Horseshoe Lake. The bottom consists of sand with submerged boulders. It reaches a depth of 15 feet. Most of its shoreline is surrounded by *Sphagnum* sp., leatherleaf (*Chamaedaphne calyculata*), sundews (*Drosera* spp.), and pitcher plants (*Sarracenia purpurea*). The northern shore borders U. S. Highway 41 and has been filled in with boulders. The open water contains small growths of pondweeds (*Potamogeton* spp.) and bladderwort (*Utricularia vulgaris*). Snails (*Physa* sp.), copepods (*Cyclops* sp.), and cladocerans (*Bosmina* sp.) are abundant. Bullheads (*Ictalurus* sp.) and cyprinids are the dominant fish with a few painted turtles (*Chrysemys picta*) present.

Station 19. This study area consists of several interconnected ponds formed by the overflow of the Dead

River. The bottom consists of sand with submerged wood and boulders. Sedges (*Scirpus* spp.) are the dominant plants. Crayfish (*Orconectes* sp.) and isopods (*Asellus* sp.) are present, but not abundant. Some cyprinids are present; however, frogs (*Rana* spp.) and toads (*Bufo americanus*) are the dominant vertebrates.

Station 20. This is a small vernal pond formed from melted snow. The bottom consists of muck with submergent and emergent logs scattered throughout. Portions of the pond are surrounded by a sphagnum mat with white cedar (*Thuja occidentalis*) growing in it. Another portion is bordered by fill from a railroad grade. Eel grass (*Vallisneria americana*) and spike rush (*Eleocharis* sp.) are abundant. Copepods (*Cyclops* sp.), cladocerans (*Daphnia* sp.), and fairy shrimp (*Eubranchipus* sp.) are abundant. Frogs (*Rana* spp.) and salamander larvae (*Ambystoma* spp.) are the dominant vertebrates.

Station 31. Ramseth Pond is fed by a small un-named stream. The bottom consists of muck overlain with submerged sticks and leaves. Stonewort (*Chara* sp.) is very abundant throughout the pond, as well as a smaller population of pondweeds (*Potamogeton* spp.). Amphipods (*Gammarus* sp.) and water boatmen (*Sigara* sp.) occur in sizeable numbers, as well as frogs (*Rana* spp.), red-spotted newts (*Notopthalmus viridescens*), and painted turtles (*Chrysemys picta*).

Station 32. Humboldt Pond was formed by the excavation of land and filled by surface water. The bottom consists of sand with submerged boulders and sticks. Cattails (*Typha latifolia*) and horsetails (*Equisetum* sp.) are dominant in the shallows; no plants are evident in the deeper waters. Amphipods (*Hyalella* sp.) are present but not numerous. Vertebrates are seemingly absent.

Station 37. This un-named pond is located on the Marquette Rod and Gun Club property and is formed by the back flow of the Dead River. The bottom consists of muck and submerged wood. Yellow water lilies (*Nuphar advena*) are abundant and dominate the open waters; sedges (*Scirpus* sp.) are abundant in the shallows. Very few invertebrates are present with the exception of some aquatic insects mainly whirligig beetles (*Gyrinus* sp.). Frogs (*Rana* spp.) and toads (*Bufo americanus*) are abundant.

Station 38. Wetmore Pond is fed by several small un-named streams. The bottom is composed of pulpy peat with overlain logs. Yellow water lilies (*Nuphar advena*) are the dominant plants. Backswimmers (*Notonecta* sp.), as well as painted turtles (*Chrysemys picta*), are abundant.

Station 40. The Tourist Park Pond is formed by the backwaters of the Dead River due to a dam. The bottom is mainly sand with a few boulders. This area is used as a swimming area; consequently, other than some eel grass (Vallisneria americana), aquatic plants are sparse. Clams (Pisidium sp.) and snails (Physa sp.) are present in small numbers, while vertebrates are absent in this area.

Station 42. The Mine Shaft Pond resulted from the flooding of an abandoned mine shaft by spring waters. The bottom consists of clay. No higher aquatic plants or vertebrates are evident. Water scavenger beetles (Hydrophilus sp.) occur in small numbers.

BOGS

Bodies of standing water completely surrounded by a sphagnum mat containing such plants as leatherleaf (Chamaedaphne calyculata), sundews (Drosera sp.), pitcher plants (Sarracenia purpurea), and cranberries (Oxycoccus sp.).

Station 17. This is a shallow body of water not exceeding four feet in depth. The bottom consists of fibrous and pulpy peat with little submerged wood. Surface run-off is the main source of water. It is surrounded by a sphagnum mat which contains sundews (Drosera spp.), pitcher plants (Sarracenia purpurea), leatherleaf (Chamaedaphne calyculata), and cranberries (Oxycoccus sp.). The open water is dominated by rushes (Juncus sp.). Water boatmen (Sigara sp.) are the dominant invertebrates with some snails (*Stagnicola* sp.) also present. No vertebrates were evident.

Station 49. This bog receives its water from a small unnamed stream and also from springs. The bottom consists of fibrous peat with numerous submergent and emergent logs. The emergent logs are a favorite stand for painted turtles (*Chrysemys picta*) which are abundant and also mallards (*Anas platyrhynchos*) and black ducks (*Anas rubripes*) which frequent this body of water. The sphagnum mat surrounding this body of water contains the same plants listed for the previous habitat. The open water is heavily populated with yellow water lilies (*Nuphar advena*). Amphipods (*Hyalella* sp.) and isopods (*Asellus* sp.) are the dominant invertebrates but are not abundant.

RIVERS

Bodies of running water whose width exceeds twenty feet along most of its course.

Stations 18 and 41. The Dead River is a long river which traverses most of Marquette County from West to East and empties into Lake Superior. Several hydroelectric dams located along this river cause water backup into large basins. This river is approximately 30 feet wide along most of its course and the depth varies from four feet along most of its course to twenty feet behind the dams. The bottom is sand with overlying gravel, boulders, and submerged wood. Waterweed (Anacharis canadensis) is common in the eddies while stonewort (Chara sp.) occurs in patches in the faster moving waters. Caddis cases (Leucotrichia sp.), chironomids (Chironomus sp.), and mayfly larvae (Hexagenia sp.) are abundant, as well as sponges (Spongilla sp.), snails (Physa sp.), planarians (Dugesia sp.), clams (Pisidium sp.), and crayfish (Cambarus sp.). This river is primarily a trout stream and also contains a wide variety and abundance of cyprinids.

Station 43. The Carp River is also an extensive body of water which flows throughout most of the county, possesses many tributaries, and empties into Lake Superior. The bottom consists mainly of sand with intermittent graveled areas. The vegetation along its banks varies from one section of the stream to another but generally consists of tag alder (Ulnus incana), red-osier dogwood (Cornus stolonifera), and white cedar (Thuja occidentalis). The soil along this river contains an unusually large number of earthworms (Lumbricus sp.) which are washed into the stream during heavy rains. Aquatic plants are sparse, being represented by patches of waterweed (Anacharis canadensis) and eel grass (Vallisneria americana). Isopods (Asellus sp.), amphipods

(*Hyalella* sp.), crayfish (*Orconectes* sp.), and caddis larvae (*Limnephilus* sp.) are abundant. Salmonids, cyprinids, and catostomids are the most abundant fish present.

Station 50. The Chocolay River spreads over 20-25 miles and possesses many tributaries. It is approximately 25 feet in width and varies in depth from 1-6 feet along its course. The bottom is mostly sand with intermittent stretches of gravel, rubble, and boulders. Pondweeds (*Potamogeton* spp.) and water-weed (*Anacharis canadensis*) are present but not abundant. Planaria (*Dugesia* sp.), snails (*Ferrissia* sp.), amphipods (*Hyalella* sp.), and isopods (*Asellus* sp.) are abundant. Salmonids are the dominant fish with cyprinids and catostomids also present.

CREEKS

Bodies of running water whose width does not exceed 15 feet along most of its course.

Station 14. This is a spring fed, un-named creek located along County Road 553 which varies within 2-3 feet in width. The bottom consists of sand with numerous submerged sticks and leaf litter. Stonewort (*Chara* sp.) is abundant and is the only higher aquatic plant in the area. Clams (*Sphaerium* sp.) and amphipods (*Hyalella* sp.) are present but not abundant. No vertebrates were evident.

Station 21. This creek is a small branch of the Yellow Dog River which meanders through a low marshy area. The bottom consists of muck with numerous submerged logs and tree stumps which project above the water. Sedges (Scirpus spp.) dominate the shoreline of the creek, whereas no higher aquatic plants are present in the open water. Snails (Physa spp.) and isopods (Asellus sp.) are abundant along with some red-spotted salamanders (Notopthalmus viridescens) and frogs (Rana spp.).

Station 30. Morgan Creek originates at Morgan Pond and empties into the Carp River. Alternate slow and fast moving water occur along its course. The bottom consists of sand covered with rubble and a few submerged sticks. The width varies within 3-10 feet while the depth varies from 1-3 feet. The slower waters are crowded with yellow water lilies (Nuphar advena) and pondweeds (Potamogeton spp.). Bur reed (Sparganium androcladum) and spike rush (Eleocharis sp.) are abundant along the shoreline. Planaria (Dugesia sp.), snails (Helisoma sp.), and blackfly larvae (Simulium sp.) are abundant. Cyprinids are the dominant fish with some salmonids also present.

Station 39. West Branch Creek is spring fed and empties into the Escanaba River. It varies within 5-8 feet in width with a depth of 1-3 feet. The bottom is sand with overlying rubble. Sparse growths of pondweeds (Potamogeton spp.) and bur reed (Sparganium androcladum) occur along its shoreline. Planaria (Dugesia sp.) are present in small numbers. Cyprinids are abundant and some salmonids also occur.

Station 44. Dishno Creek originates from two small unnamed lakes and after traversing about six miles empties into the Peshekee River. The bottom is composed of sand almost completely covered with rubble. This creek is approximately 12 feet wide and varies in depth within 1-3 feet. No higher aquatic plants were present at the collecting site. Sponges (Spongilla sp.), snails (Physa sp.), and blackfly larvae (Simulium sp.) are abundant. Cyprinids are the dominant fish present.

Station 47. Barnhardt Creek is a spring fed and ground water seepage creek which is 10-12 miles long and empties into the Dead River basin. It possesses mainly a sand bottom with patches of rubble. No higher plants are present in the faster waters; yellow water lilies (Nuphar advena) are very abundant in the slower reaches of the creek. Aquatic insects are exceedingly numerous, particularly caddis larvae (Limnephilus sp.) and dobsonfly larvae (Corydalus cornutus). Planaria (Dugesia sp.) are also present in large numbers. This is primarily a trout stream with a wide variety of cyprinids also present.

Station 48. Goldmine Creek is a shallow, fast-moving creek. It is about six feet wide and two feet deep. The bottom consists of sand and rubble. No higher aquatic plants were observed in the collecting area. Snails (*Physa* sp.) and planaria (*Dugesia* sp.) are the predominant faunal inhabitants.

DITCH

A depression along a road which is fed by surface run-off and the overflow from a nearby stream.

Station 8. The Mangum Road Ditch extends along the Mangum Road and is only 2-6 inches deep. The bottom is composed of muck. It is crowded with cattails (*Typha latifolia*) and sedges (*Scirpus* sp.). Snails (*Stagnicola* sp.) and dragonfly naiads (*Helocordulia* sp.) are present but not abundant. Frogs (*Rana* spp.) are the only vertebrates present.

Table 1. Physical Features of the Waters Investigated in Marquette County.

Station	Bottom	Depth (Ft.)	Color	Temp. °C	Date
1	Fibrous Peat, Detritus	2	Brown	10	9/16/65
2	Sand, Gravel, Detritus	3	Clear	14	9/22/63
3	Pulpy Peat, Detritus	2	Brown	10	9/16/65
4	Sand, Detritus	4	Clear	10	10/10/65
5	Sand, Rubble, Detritus	2	Clear	15	10/10/65
6	Sand, Detritus	1	Clear	12	10/13/61
7	Muck, Detritus	3	Yellow	7	10/14/61
8	Muck	.5	Brown	9	10/16/61
9	Muck, Detritus	1	Yellow	18	8/28/65
10	Muck, Detritus	2	Brown	11	11/ 5/61
11	Sand, Rubble, Detritus	3	Clear	8	5/ 6/62
12	Sand, Rubble, Detritus	2	Clear	10	5/ 6/62
13	Clay, Detritus	3	Clear	8	5/13/62
14	Clay, Detritus	1	Clear	12	5/19/62
15	Sand, Detritus	3	Clear	8	8/25/62
16	Sand, Bedrock	3	Clear	8	8/26/62
17	Fibrous and Pulpy Peat	3	Brown	12	10/29/62
18	Sand, Gravel, Boulders	1	Clear	10	4/26/63
19	Sand, Detritus	2	Clear	12	4/27/63
20	Muck	.5	Yellow	10	5/ 4/63
21	Muck, Detritus	2	Brown	12	4/26/63
22	Sand, Rubble, Detritus	1	Clear	14	8/28/63
23	Pulpy Peat, Detritus	2	Clear	9	8/28/63

Table 1 (cont'd.)

Station	Bottom	Depth (Ft.)	Color	Temp. °C	Date
24	Sand, Rubble	1	Clear	18	9/ 1/63
25	Sand, Rubble, Detritus	2	Clear	17	9/ 5/63
26	Muck, Detritus	3	Clear	18	9/ 5/63
27	Pulpy Peat, Detritus	2	Clear	20	9/ 5/63
28	Sand, Gravel, Detritus	2	Clear	23	9/18/63
29	Sand, Detritus	2	Clear	24	9/18/63
30	Sand, Rubble	3	Clear	14	9/14/63
31	Muck, Detritus	1	Brown	16	5/ 8/64
32	Sand, Detritus	1	Clear	12	9/15/63
33	Sand, Rubble, Boulders	.5	Clear	17	5/ 5/66
34	Sand, Rubble, Detritus	1	Clear	12	9/28/63
35	Sand, Detritus	2	Clear	11	9/28/63
36	Sand	12	Clear	10	8/25/63
37	Muck, Detritus	2	Brown	16	5/ 6/64
38	Pulpy Peat, Detritus	2	Brown	14	5/16/64
39	Sand, Rubble	1	Clear	13	6/28/64
40	Sand, Rubble	3	Clear	18	6/29/64
41	Sand, Rubble	.3	Clear	8	9/16/65
42	Clay	2	Clear	12	7/ 5/64
43	Sand, Rubble	3	Clear	19	7/ 8/64
44	Sand, Rubble	1	Clear	10	8/ 2/64
45	Sand, Gravel, Detritus	2	Clear	22	8/ 2/64
46	Sand, Rubble	1	Green	10	8/ 4/64
47	Sand, Rubble	1	Clear	10	8/ 4/64

Table 1 (cont'd.)

Station	Bottom	Depth (Ft.)	Color	Temp. °C	Date
48	Sand, Rubble	2	Clear	10	8/ 4/64
49	Fibrous Peat, Detritus	.4	Yellow	15	9/ 5/65
50	Sand, Detritus	1	Clear	9	11/ 4/65

Table 2. Floral Inhabitants of the Waters Studied in Marquette County.

Station	Ceratophyllum	Myriophyllum	Nymphaea	Nuphar	Typha	Scirpus	Eleocharis	Potamogeton	Najas	Anacharis	Sagittaria	Vallisneria	Sparganium	Utricularia	Juncus	Equisetum	Chara
1		X		X													
2		X				X		X	X	X							X
3				X		X		X									
4				X		X		X		X							
5	X	X		X		X	X	X		X							X
6	X			X				X									
7					X	X											
8					X	X											
9				X		X		X						X			
10			X														X
11						X									X		
12															X		
13				X													
14																	X
15			X		X			X			X			X			
16								X									X
17															X		
18											X						X

Table 2 (cont'd.)

Station	Ceratophyllum	Myriophyllum	Nymphaea	Nuphar	Typha	Scirpus	Eleocharis	Potamogeton	Najas	Anacharis	Sagittaria	Vallisneria	Sparganium	Utricularia	Juncus	Equisetum	Chara
19						X											
20							X						X				
21						X											
22				X				X	X						X		
23								X									
24				X				X									
25						X					X						
26				X							X		X				
27				X				X				X					
28				X							X					X	
29									X				X				
30				X			X	X					X				
31								X									X
32					X											X	
33								X		X							
34						X											
35						X		X									
36				X				X									
37				X		X											

Table 2 (cont'd.)

Station	Ceratophyllum	Myriophyllum	Nymphaea	Nuphar	Typha	Scirpus	Eleocharis	Potamogeton	Najas	Anacharis	Sagittaria	Vallisneria	Sparganium	Utricularia	Juncus	Equisetum	Chara
38				X													
39								X					X				
40								X					X				
41										X							X
42																	
43										X		X					
44																	
45	X							X									
46								X		X							
47				X													
48																	
49				X				X									
50								X		X							

Table 3. Faunal Inhabitants of the Waters Studied in Marquette County.

Fauna / Station	Planaria	Oligochaetes	Clams	Snails	Copepoda	Cladocera	Amphipoda	Isopoda	Crayfish	Insect Larvae	Percidae	Centrarchidae	Cyprinidae	Salmonidae	Salamanders	Frogs	Turtles
1		X		X		X	X			X	X				X	X	X
2	X	X	X	X	X	X			X	X	X	X				X	X
3				X			X			X	X	X				X	X
4			X	X	X		X		X	X	X					X	X
5			X	X			X		X	X	X					X	X
6		X		X				X		X	X						
7				X				X		X			X				
8				X						X						X	
9				X	X		X		X	X					X	X	X
10				X			X	X		X							X
11			X						X	X				X			
12			X				X		X	X				X			
13				X						X							
14			X				X			X							
15				X	X	X				X			X			X	X
16	X	X		X	X				X	X	X	X				X	X
17		X		X						X							
18	X	X	X	X		X		X	X	X			X	X			

Table 3 (cont'd.)

Station	Planaria	Oligochaetes	Clams	Snails	Copepoda	Cladocera	Amphipoda	Isopoda	Crayfish	Insect Larvae	Percidae	Centrarchidae	Cyprinidae	Salmonidae	Salamanders	Frogs	Turtles
19							X	X	X	X						X	
20					X	X				X					X	X	
21				X			X			X					X	X	
22							X			X	X					X	
23				X			X		X	X			X				
24			X	X					X	X		X					
25					X				X	X			X	X			
26	X			X			X		X	X							
27	X			X				X		X							
28			X	X	X		X			X	X	X					
29				X						X							
30	X	X		X						X			X	X			
31				X		X	X			X					X	X	X
32							X			X							
33		X	X	X	X	X				X			X	X			X
34				X			X			X				X			
35			X	X			X			X				X			
36					X	X				X	X						

Table 3 (cont'd.)

Station	Planaria	Oligochaetes	Clams	Snails	Copepoda	Cladocera	Amphiboda	Isopoda	Crayfish	Insect Larvae	Percidae	Centrarchidae	Cyprinidae	Salmonidae	Salamanders	Frogs	Turtles
37		X								X						X	
38			X							X							X
39	X				X					X			X	X			
40			X	X						X							
41	X	X	X	X		X	X		X	X			X	X			
42										X							
43		X			X	X	X	X	X	X			X	X			
44				X						X							
45	X			X					X	X			X	X			
46		X		X			X			X	X						
47	X									X			X	X		X	
48	X			X						X							
49							X	X		X							X
50	X			X			X	X		X			X	X			

Barry and Kalamazoo Counties

Geologic-Pedologic Description: The following geologic-pedologic description of Barry and Kalamazoo Counties and the specific study areas in these two counties is taken from Veatch (1953, "Soil Map of Michigan"). The land features of these two counties fit mainly into three categories as follows:

1. Broken or hilly landscape caused by basin depressions and other inequalities which are constructional features of glacial deposition, rather than because of dissection by streams. Lakes, lake basins, and valley swamps are characteristic, there are very few streams, although short drainage hollows confluent to basin and valley are numerous.

   The principal soil types are Bellefontaine, Hillsdale, and Coloma; there are numerous variants of these types related to the lithological variability of the underlying glacial drift, which in many places is a confused dump-like deposit of sands, silts, clays, gravel, and boulders.

2. The land surface, in part, is flat and dry or merely diversified by very shallow sags; in other places the surface is indented by numerous small potholes, and broken by larger basin depressions and valleys containing lakes, swamps, and marshes.

   The soils are mainly sandy loams, but also, in part, loams of the Fox and closely related soil types. Surface boulders are common, but gravelly and cobbly soils are local in occurrence throughout the areas.

3. Flat valley plains; mixed swampy, semi-wet and dry. Locally high proportion of muck; some recent alluvial soil. Textures mainly sandy loams and loams; included sands and clays. Gravelly substrata common and locally gravelly at the surface.

Figure 3 shows the locations and the soil relationships of the collecting sites in Barry and Kalamazoo Counties. These soils fit into three categories which correspond to the previous three generalized land descriptions of the two counties. Table 4, page 57, shows several physical features of the waters investigated in Barry and Kalamazoo Counties. Tables 5, page 58, and 6, page 59, denote the dominant floral and faunal inhabitants of the waters studied in Barry and Kalamazoo Counties.

Figure 3 Legend

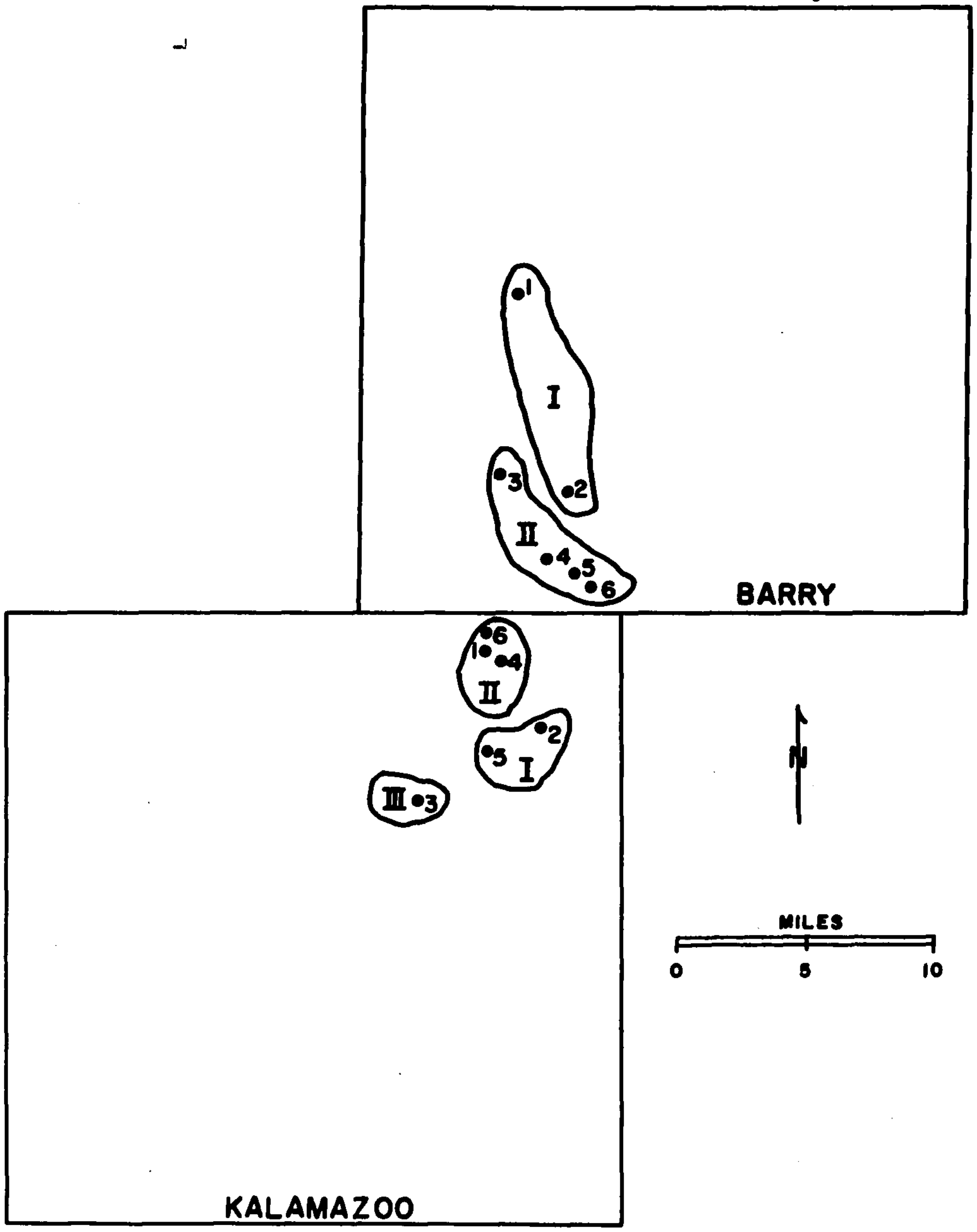
I. Mostly moraines; some included outwash and glacio-fluvial valley deposits. Diverse kinds or rocks, with a variable weak to strong influence from local sandstones, limestones and shales. Soil profiles mostly belong in the gray-brown podzolic group.

II. Outwash plains, partly glacio-fluvial valleys and delta plains. Gray drift, diverse rocks, but medium to strong influence from limestone, and variable to medium to strong influence from local sandstone and shale formations. Soils mostly in gray-brown podzolic group.

III. Glacio-fluvial valley deposits and wet outwash plains. Coarser deposits have a medium to high content of limestone, floor of clay till generally at shallow depths. Profiles in part transitional toward gray-brown podzolic.

(from Veatch, *Soils and Land of Michigan*)

COLLECTING SITES
BARRY AND KALAMAZOO COUNTIES, MICHIGAN



KALAMAZOO COUNTY

1. GULL LAKE (T.1S.–R.9W., SEC.7)
2. AUGUSTA CREEK (T.1S.–R.9W., SEC.27)
3. KALAMAZOO RIVER (T.2S.–R.10W., SEC.23)
4. WINTERGREEN LAKE (T.1S.–R.9W., SEC.8)
5. GULL CREEK (T.2S.–R.9W., SEC.7)
6. MARL POND (T.1S.–R.9W., SEC.6)

BARRY COUNTY

1. OTIS LAKE (T.3N.–R.10W., SEC.30)
2. PLEASANT LAKE (T.1N.–R.9W., SEC.8)
3. CROOKED LAKE (T.1N.–R.10W., SEC.1)
4. LAWRENCE LAKE (T.1N.–R.9W., SEC.27)
5. PURDY LAKE (T.1N.–R.9W., SEC.36)
6. STREWINS LAKE (T.1N.–R.9W., SEC.36)

Fig. 3. Locations and soils of the waters studied.

Habitat Descriptions (Barry and Kalamazoo Counties): The criteria used to designate lakes, ponds, bogs, rivers, creeks, and ditches are the same as those used in describing the habitats in Marquette County.

Barry County

LAKES

Station 1. Otis Lake is in a dystrophic state characterized by its shallowness, brownish-colored water, and unproductivity. The bottom consists of pulpy peat with a few submerged logs. Lush growths of yellow water lilies (Nuphar advena), white water lilies (Nymphaea odorata), pondweeds (Potamogeton spp.), and bladderwort (Utricularia vulgaris) are present. The predominant invertebrate inhabitants are snails (Physa sp.) and dragonfly naiads (Macromia sp.). The vertebrate representatives are mudminnows (Umbra limi), bullheads (Ictalurus spp.), frogs (Rana spp.), and painted turtles (Chrysemys picta).

Station 2. Pleasant Lake is a seepage lake surrounded partially by an inhabited beach area, partially by such trees as red maple (Acer rubrum), elm (Ulmus americana), white oak (Quercus alba), and tamarack (Larix laricina), and partially by a sphagnum mat. The bottom consists of sand in certain sections and muck in others. Pondweeds (Potamogeton spp.) are the dominant limnetic plants with white water lilies

(Nymphaea odorata) and yellow water lilies (Nuphar advena) also present, while the littoral zone is dominated by sedges (Scirpus spp.), rushes (Juncus spp.), water shield (Brasenia Schreberi), and pipewort (Eriocaulon septangulare). Copepods (Cyclops sp.) and (Diaptomus sp.) are present, as well as numerous frogs (Rana spp.) and musk turtles (Sternothaerus odoratus). Bluegills (Lepomis macrochirus) are the dominant fish.

Station 3. Crooked Lake possesses a marl bottom with few submerged sticks. The water is bluish-green in color due to the abundance of blue-green algae, mainly Anabaena sp. and Microcystis sp. The littoral zone is crowded with sedges (Scirpus spp.) and waterweed (Anacharis canadensis), whereas the limnetic waters contain mainly pondweeds (Potamogeton spp.). Planarians (Dugesia sp.) and snails (Helisoma sp.) occur in sizeable numbers. Yellow perch (Perca flavescens) and bluegills (Lepomis macrochirus) are the dominant fish present.

Station 4. Lawrence Lake possesses a marl bottom and its depth has been increased exceedingly by the removal of marl for agricultural purposes. Extensive growths of pondweeds (Potamogeton spp.) are present, as well as bushy pondweed (Najas flexilis), sedges (Scirpus spp.), and stonewort (Chara sp.). Some white water lilies (Nymphaea odorata) and yellow water lilies (Nuphar advena) occur in the littoral zone. The invertebrate fauna is sparse being represented mainly by snails (Physa sp.), copepods (Cyclops sp.), and cladocerans (Daphnia sp.). Bluegills (Lepomis macrochirus) are present in small numbers, as well as northern pike (Esox lucius). Frogs (Rana spp.) and musk turtles (Sternothaerus odoratus) are relatively abundant.

Station 5. Purdy Lake is a dystrophic lake which could also be classified as a bog. It is surrounded by a sphagnum mat containing sundews (Drosera spp.), pitcher plants (Sarracenia purpurea), leatherleaf, (Chamaedaphne calyculata), bog rosemary (Andromeda glaucophylla), and poison sumac (Rhus vernix). The bottom is composed of fibrous and pulpy peat with some submerged wood. The depth of this body of water probably does not exceed five feet. The open waters are crowded almost exclusively with yellow water lilies (Nuphar advena). The littoral zone contains a large population of bladderwort (Utricularia vulgaris). Few invertebrates are present being represented only by a few hydracarina and snails (Physa sp.). Bluegills (Lepomis macrochirus) are the dominant fish, while some frogs (Rana spp.) and painted turtles (Chrysemys picta) are also present.

Station 6. Strewins Lake is a dystrophic lake with a bottom consisting of sand and pulpy peat. Yellow water lilies (*Nuphar advena*), pondweeds (*Potamogeton* spp.), and arrowhead (*Sagittaria latifolia*) are abundant. The invertebrates are represented mainly by dragonfly naiads (*Neurocordulia* sp.). Frogs (*Rana* spp.) and painted turtles (*Chrysemys picta*) are also present.

Kalamazoo County

LAKES

Station 1. Gull Lake is a drainage lake supplied by several creeks and drained by way of Gull Creek. It is one mile wide by five miles in length and reaches a depth of 105 feet. The water is deep blue in color due to the reflection of the sun from the marl which has accumulated over the sand bottom. Numerous boulders are present in the littoral zone. The dominant emergent plants are rushes (*Juncus* spp.), while pondweeds (*Potamogeton* spp.), coontail (*Ceratophyllum demersum*), water milfoil (*Myriophyllum* sp.), and stonewort (*Chara* sp.) are fairly abundant. A wide variety of invertebrates, such as planaria (*Dugesia* sp.), snails (*Physa* sp.), clams (*Pisidium* sp.), copepods (*Cyclops* sp.), and cladocerans (*Daphnia* sp.) and (*Leptodora kindtii*) are present. Likewise, a large variety of fish are present dominated by centrarchids, percids, with some salmonids and osmerids along with other fish. Frogs (Rana spp.), painted turtles (Chrysemys picta), soft shell (Trionyx spinifer), and snapping (Chelydra serpentina) are also present.

Station 4. Wintergreen Lake is a highly productive lake whose eutrophication has been enhanced by the addition of nutrients from the excreta of waterfowl. The maximum depth of the waters of this lake is 20 feet; however, a thick layer of fibrous and pulpy peat overlies the true bottom. The dominant plants are yellow water lilies (Nuphar advena), coontail (Ceratophyllum demersum), water milfoil (Myriophyllum sp.), white water lilies (Nymphaea odorata), sedges (Scirpus spp.), and pondweeds (Potamogeton spp.). The dominant invertebrates are copepods (Cyclops sp.) and cladocerans (Bosmina sp.). Bluegills (Lepomis macrochirus) and yellow perch (Perca flavescens) are abundant with bullheads (Ictalurus sp.) and bowfins (Amia calva) present in smaller numbers. Painted turtles (Chrysemys picta) and waterfowl are extremely abundant.

PONDS

Station 6. This is a small seepage pond lying in an extinct lake basin approximately 100 feet in diameter whose depth has been increased to six feet by the removal of marl. *Potamogeton* spp. and *Chara* sp. are abundant with other plants being sparse. Few invertebrates are present, represented mainly by back swimmers (*Notonecta* sp.). Red-spotted salamanders (*Notopthalmus viridescens*) and tiger salamander axolotyls (*Ambystoma tigrinum*) are abundant along with painted turtles (*Chrysemys picta*).

RIVERS

Station 3. The Kalamazoo River is a large river passing through several heavily populated areas where its nature is altered considerably by the activities of man. Paper mill wastes are discharged into the river in the Kalamazoo area causing the water to become slate gray in color. Eel grass (*Vallisneria americana*), pondweeds (*Potamogeton* spp.), and yellow water lilies (*Nuphar advena*) are abundant. Pollution indicators such as chironomids (*Chironomus* sp.) and tubificids (*Tubifex tubifex*) are abundant. Snails (*Physa* sp.), clams (*Anodonta* sp.), planarians (*Dugesia* sp.), and amphipods (*Hyalella* sp.) are present in large numbers. Cyprinids are the dominant fish along with some bullheads (*Ictalurus* sp.) and few salmonids.

CREEKS

Station 2. Augusta Creek is an extensive clear unmodified stream. It is approximately ten feet in width along most of its course and two feet deep. The bottom consists of sand and gravel with some submerged sticks and logs. A variety of vegetation is present along its shores dominated by dogwood (*Cornus* spp.). Yellow water lilies (*Nuphar advena*) and pondweeds (*Potamogeton* spp.) are the dominant plants in the water. Planarians (*Dugesia* sp.), snails (*Helisoma* sp.), and mayfly naiads (*Hexigenia* spp.) are the dominant invertebrates. Cyprinids, salmonids, painted turtles (*Chrysemys picta*), and frogs (*Rana* spp.) are the dominant vertebrates.

Station 5. Gull Creek drains out of Gull Lake and is 10 feet wide and reaches a depth of two feet along most of its course. In some areas the waters are backed up into ponds by earth dams. The bottom consists of sand, rubble, and submerged wood. Yellow water lilies (*Nuphar advena*) and pondweeds (*Potamogeton* spp.) are abundant in the slow moving waters. Planarians (*Dugesia* sp.), bryozoa (*Cristatella mucedo*), and crayfish (*Orconectes* sp.) are the dominant invertebrates. Cyprinids are the dominant fish; frogs (*Rana* spp.) and snapping turtles (*Chelydra serpentina*) also occur.

Table 4. Physical Features of the Waters Investigated in Barry and Kalamazoo Counties.

Barry County

Station	Bottom	Depth (Ft.)	Color	Temp. °C	Date
1	Pulpy Peat, Detritus	.4	Brown	23	7/26/65
2	Muck	2	Clear	21	6/22/63
3	Marl	1	Green	27	7/22/65
4	Marl	2	Blue	22	6/29/63
5	Fibrous and Pulpy Peat	2	Yellow	21	7/20/61
6	Sand, Pulpy Peat	3	Clear	21	7/22/65

Kalamazoo County

Station	Bottom	Depth (Ft.)	Color	Temp. °C	Date
1	Sand, Rubble	3	Clear	22	7/10/61
2	Sand, Gravel, Rubble	2	Clear	20	6/20/63
3	Sand, Gravel	2	Brown	19	7/27/65
4	Fibrous and Pulpy Peat	3	Green	21	7/20/65
5	Sand, Rubble, Detritus	4	Clear	18	7/29/65
6	Marl	3	Clear	19	7/14/63

Table 5. Floral Inhabitants of the Waters Studied in Barry and Kalamazoo Counties.

Flora	Ceratophyllum	Myriophyllum	Nymphaea	Nuphar	Typha	Scirpus	Eleocharis	Potamogeton	Najas	Anacharis	Sagittaria	Vallisneria	Sparganium	Utricularia	Juncus	Equisetum	Chara
Barry County																	
Station																	
1			X	X	X			X						X			
2			X			X		X	X						X		X
3						X		X		X							
4			X	X		X	X	X	X								X
5				X		X		X						X			
6				X				X			X						
Kalamazoo County																	
1	X	X	X	X				X		X	X				X		X
2				X				X		X			X				
3				X				X				X					
4	X	X	X	X		X		X									X
5				X				X									
6								X									X

Table 6. Faunal Inhabitants of the Waters Studied in Barry and Kalamazoo Counties.

Fauna	Planaria	Oligochaetes	Clams	Snails	Copepoda	Cladocera	Amphipoda	Isopoda	Crayfish	Insect Larvae	Percidae	Centrarchidae	Cyprinidae	Salmonidae	Salamanders	Frogs	Turtles
Barry County																	
Station																	
1		X		X		X				X		X				X	X
2					X			X		X		X				X	X
3	X			X						X	X	X					
4				X	X	X				X		X				X	X
5		X		X				X		X		X				X	X
6							X			X						X	X
Kalamazoo County																	
1	X	X	X	X	X	X	X			X	X	X		X	X	X	X
2				X	X		X		X	X			X	X		X	X
3	X	X	X	X	X			X		X		X	X	X			
4				X	X	X		X		X	X					X	X
5	X						X		X	X			X			X	X
6										X					X	X	X

CHAPTER IV

RESULTS AND DISCUSSION

Abundance

Figure 4 shows the number of leeches of each species collected from fifty locations in Marquette County. Figure 5, page 63, indicates the frequency of occurrence of leeches in fifty waters in Marquette County.

The total number of each leech collected is based mainly on the number of adults. In some cases it was difficult to distinguish between true adults and young. Young attached to the venters of glossiphonids were not considered in the determination of total numbers, but are later considered under reproduction. The time spent collecting at each site was not recorded nor was any other quantitative method used; however, by comparing numbers of each species collected, relative abundance may be inferred.

As shown in Figure 4, *Helobdella stagnalis* was the most abundant leech found in Marquette County waters, 103 individuals having been taken. The following species are in order of abundance, *Erpobdella punctata*, *Haemopis marmorata*, *Nephelopsis obscura*, and *Dina fervida*. Sapkarev (1967) also found that *Helobdella stagnalis* was the most abundant leech in Lake Mendota, followed by *Glossiphonia complanata*, *Erpobdella punctata*, and *Nephelopsis obscura*.

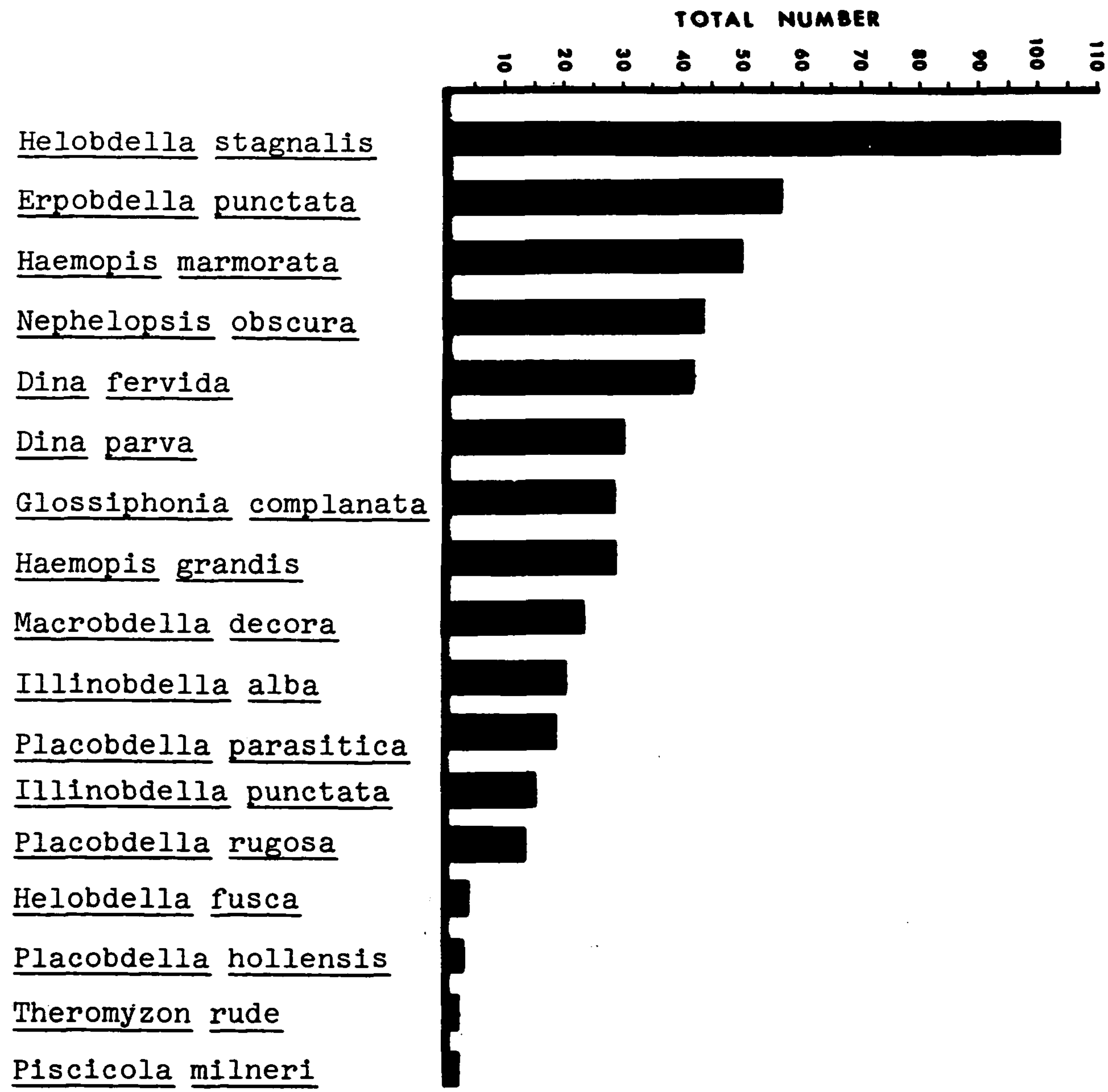


Fig. 4. Total number of individual leeches collected from fifty sites in Marquette County.

Noteworthy is the fact that, regarding the most abundant leeches, Sapkarev's findings for one lake reflect closely the findings for fifty bodies of water during the present study. The least abundant species found during the present study were Helobdella fusca, Placobdella hollensis, and Theromyzon rude.

Figure 5 shows that Erpobdella punctata was encountered more frequently than any other species in Marquette County waters, in 34% of the habitats studied. Bennike (1943) found a related species, Erpobdella octoculata, to be the most common leech in Danish waters. The following most frequently encountered species are in order, Dina fervida, Glossiphonia complanata, Placobdella parasitica, and Helobdella stagnalis. When a comparison is made between the five most abundant species and the five most frequently encountered species, it is found that Erpobdella punctata, Helobdella stagnalis, and Dina fervida fit into both categories. It might also be noted that Glossiphonia complanata and Helobdella stagnalis are abundant in Canada, Oliver (1958), J. E. Moore (1966), as well as in European waters, Pawlowski (1936), Bennike (1943), Sandner (1951), and Mann (1955). One must bear in mind that the young attached to the venters of the glossiphonids were not included in the total. Had these young been included, the abundance of glossiphonids would have perhaps superseded that of other groups. However, the data indicate that of the five most

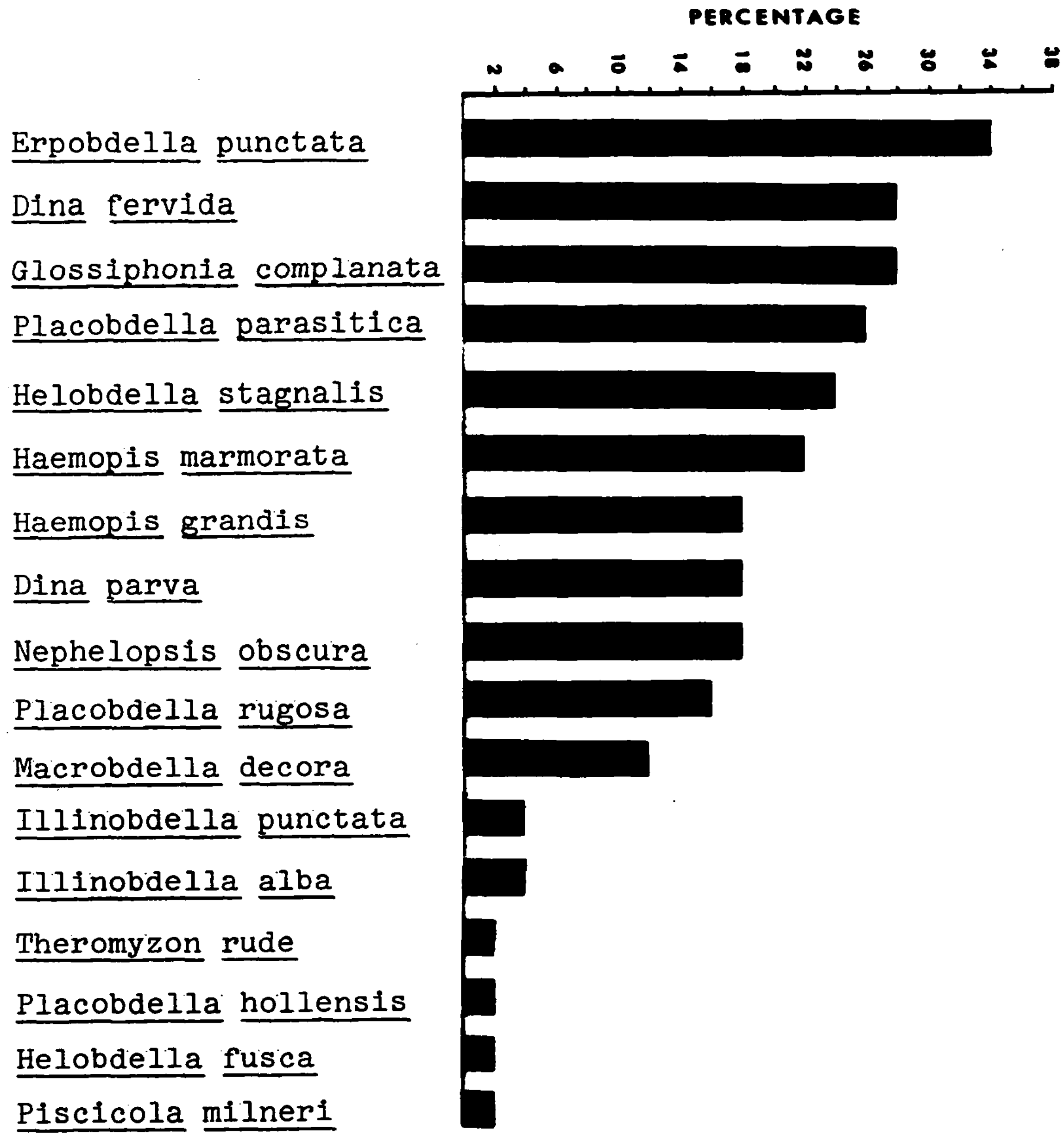


Fig. 5. Percentage of occurrence of leeches collected from fifty sites in Marquette County.

abundant leeches listed only Helobdella stagnalis is a glossiphonid.

The size and activity of leeches would influence both the total number taken and the frequency with which they were encountered during the present study. The erpobdellids and hirudids are large, active leeches which are very responsive to water agitation and swim away in an undulating manner. On the other hand, the glossiphonids are smaller, more sedentary leeches which move mainly in a looping fashion by alternate attachment of the suckers. Thus, the latter group would be less conspicuous and would require more extensive searching to discover. These facts might explain why two erpobdellid leeches, Erpobdella punctata and Dina fervida, were the two most frequently encountered species.

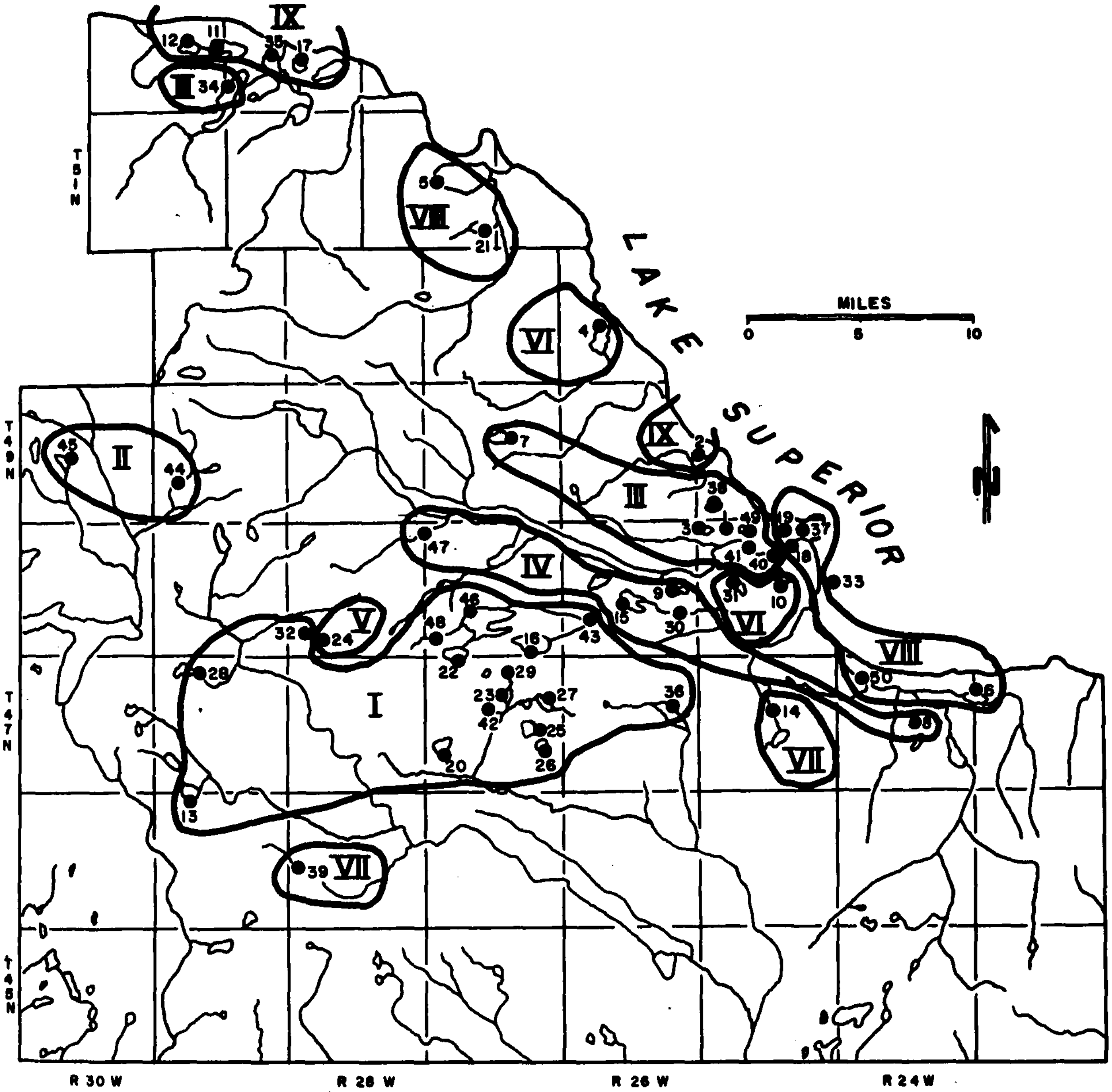
Too few piscicolid leeches were found to draw conclusions regarding their abundance and distribution. It was found during the present study that yellow perch (Perca flavescens) are a favorite host of Illinobdella alba and I. punctata. Keith (1960) also lists yellow perch as a host of I. alba but not of I. punctata. Perch collected from several locations during the present study were found to be parasitized by these two leeches. The examination of many cyprinids, salmonids, catostomids, and osmerids during the present study failed to produce any piscicolids, although fish in these families are attacked by these leeches according to other authors, Thompson (1927), Meyer (1940), Keith (1954), and Rupp (1954) et al.

Geographical Distribution

Figure 6 denotes the location of the fifty study areas in Marquette County. This is a duplicate of Figure 2, page 15, for reference to the following figures. Figures 7, 8, 9, and 10 on pages 67-70 show the geographical distribution of the members of four families of leeches in Marquette County.

The data show that the members of three families, namely, Glossiphonidae, Hirudidae, and Erpobdellidae, are uniformly distributed throughout the county. Too few specimens of piscicolid leeches were collected to draw conclusions regarding their distribution. *Illinobdella punctata* and *I. alba* are probably widely distributed throughout Marquette County, as well as throughout Michigan corresponding with the wide distribution of yellow perch (*Perca flavescens*). *Piscicola milneri*, on the other hand, seems to parasitize less widely distributed fish, such as smelt (*Osmerus mordax*), burbot (*Lota lota maculosa*), and whitefish (*Coregonus* spp.), and is probably more restricted in its distribution.

COLLECTING SITES
MARQUETTE COUNTY, MICHIGAN



1. REDBERRY POND
2. HARLOW LAKE
3. WALDO POND
4. SAUXHEAD LAKE
5. INDEPENDENCE LAKE
6. KAWBAWGAM LAKE
7. ROAD 510 POND
8. MANGUM ROAD DITCH
9. BAGDAD POND
10. CEMETERY POND
11. RUSH LAKE
12. HOWE LAKE
13. MINE SHAFT POND
14. ROAD 553 CREEK
15. HORSESHOE POND
16. TEAL LAKE
17. CRANBERRY BOG
18. DEAD RIVER
19. SMALL PONDS
20. VERNAL POND
21. SMALL CREEK
22. COOPER LAKE
23. BANCROFT LAKE
24. BOSTON LAKE
25. TILDEN LAKE
26. SCHOOLHOUSE LAKE
27. OGDEN LAKE
28. FISH LAKE
29. BACON LAKE
30. MORGAN CREEK
31. RAMSETH POND
32. HUMBOLDT POND
33. LAKE SUPERIOR
34. MOUNTAIN LAKE
35. PINE LAKE
36. GOOSE LAKE
37. ROD & GUN CLUB POND
38. WETMORE POND
39. WEST BRANCH CREEK
40. TOURIST PARK POND
41. DEAD RIVER
42. MINE SHAFT POND
43. CARP RIVER
44. DISHNO CREEK
45. ARFELIN LAKE
46. DEER LAKE
47. BARNHARDT CREEK
48. GOLDMINE CREEK
49. MIDDLE ISLE POINT BOG
50. CHOCOLAY RIVER

Fig. 6. Locations and soils of the waters studied.

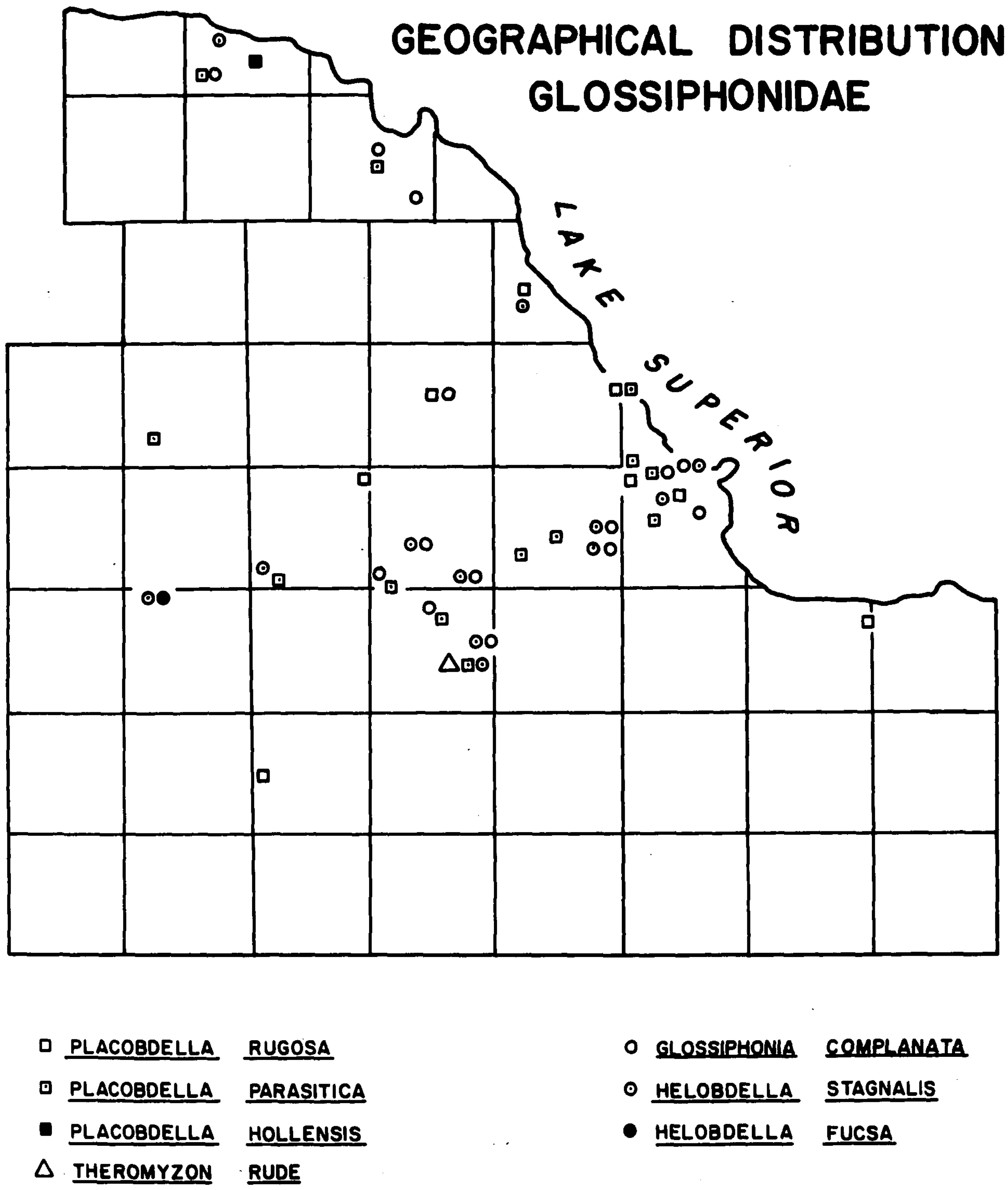

GEOGRAPHICAL DISTRIBUTION
GLOSSIPHONIDAE
LAKE SUPERIOR
PLACOBDELLA RUGOSA
PLACOBDELLA PARASITICA
PLACOBDELLA HOLLENSIS
THEROMYZON RUDE
GLOSSIPHONIA COMPLANATA
HELOBDELLA STAGNALIS
HELOBDELLA FUCSA

Fig. 7

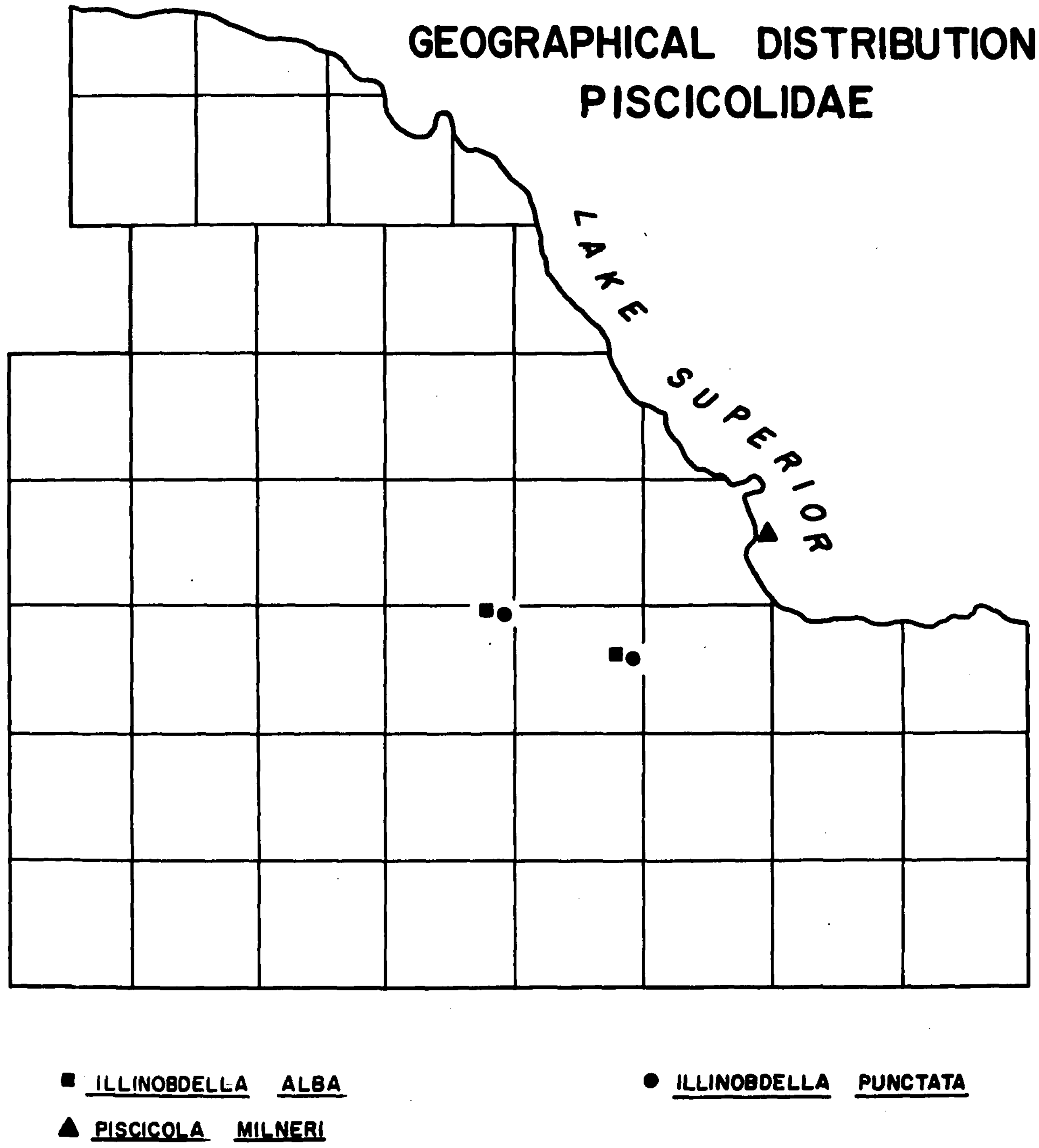

GEOGRAPHICAL DISTRIBUTION
PISCICOLIDAE
LAKE SUPERIOR
ILLINOBDELLA ALBA
ILLINOBDELLA PUNCTATA
PISCICOLA MILNERI

Fig. 8

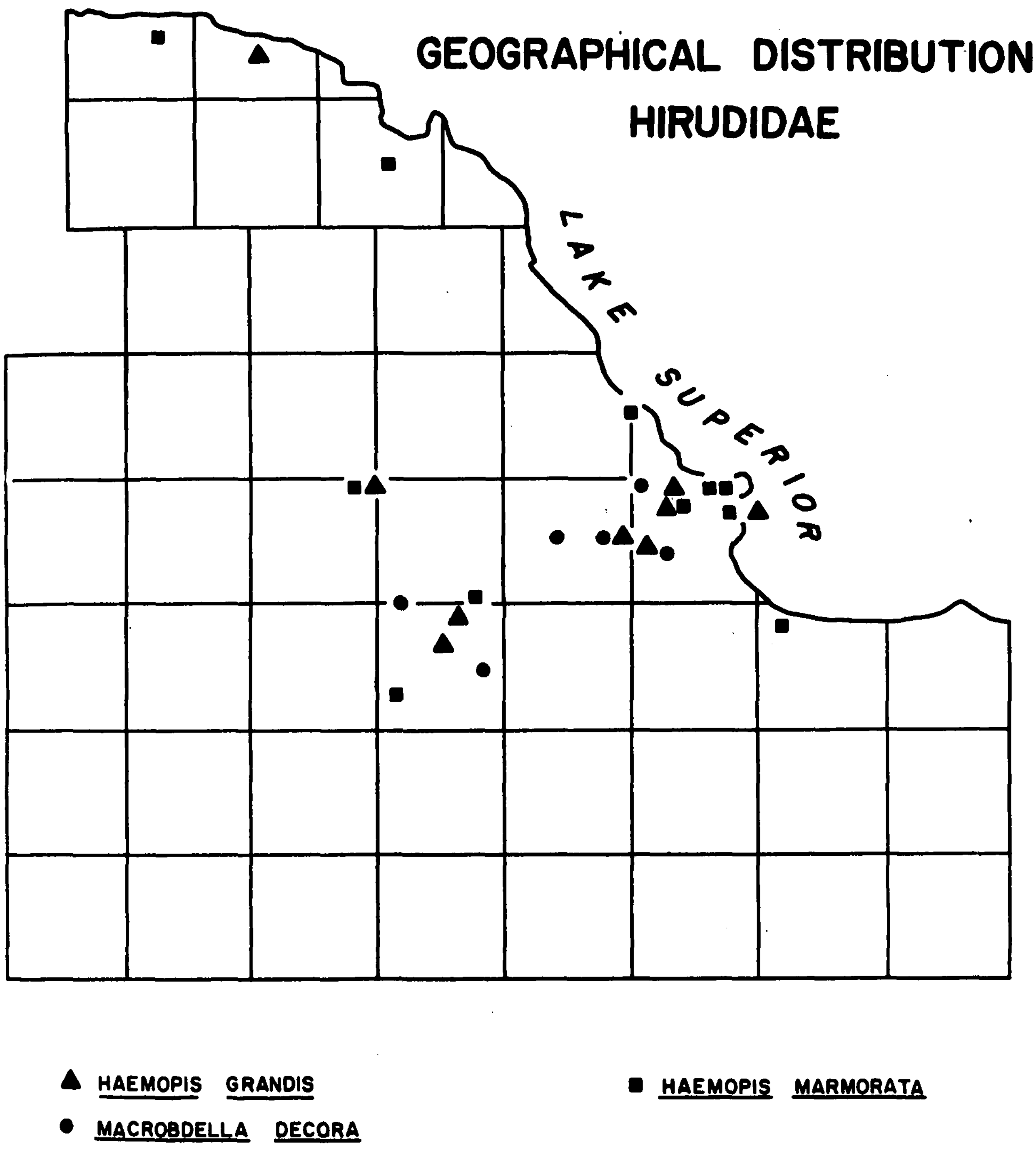

GEOGRAPHICAL DISTRIBUTION
HIRUDIDAE
LAKE SUPERIOR
HAEMOPIS GRANDIS
HAEMOPIS MARMORATA
MACROBDELLA DECORA

Fig. 9

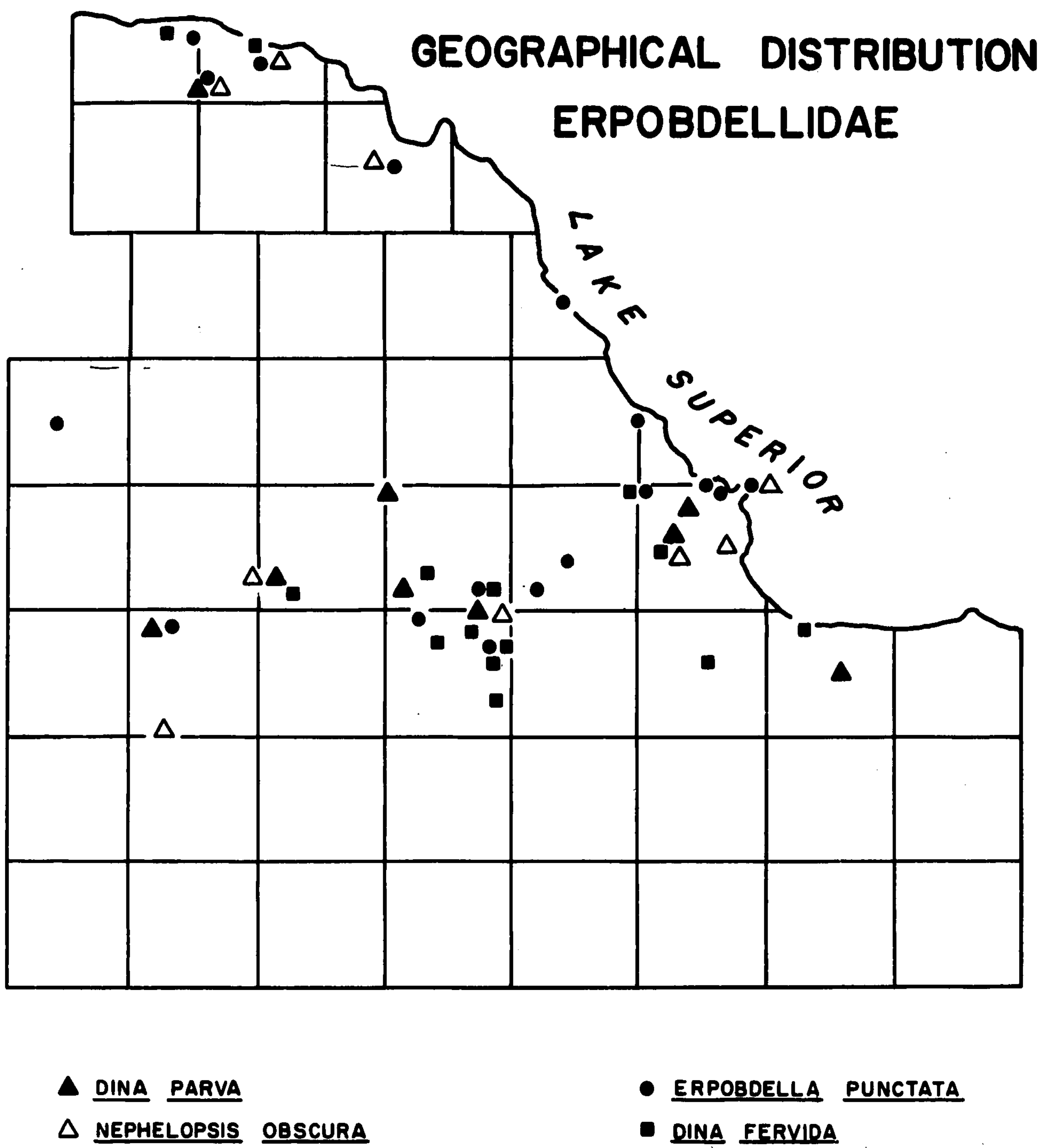

GEOGRAPHICAL DISTRIBUTION
ERPOBDELLIDAE
LAKE SUPERIOR
▲ DINA PARVA
△ NEPHELOPSIS OBSCURA
● ERPOBDELLA PUNCTATA
■ DINA FERVIDA

Fig. 10

Table 7 shows a comparison between leeches collected in the Upper and Lower Peninsulas. The data indicate, with few exceptions, the presence of the same species in both peninsulas. As only twelve bodies of water were examined in the Lower Peninsula, the collection records of Metzelaar et al. (1925, 1926, and 1927) in Miller (1937) are included in the comparison. Most of Metzelaar et al. work was done on Lower Peninsula waters, all their Upper Peninsula records having been obtained from Luce County. Seemingly significant species differences between the Upper and Lower Peninsulas and the factors thought to be involved will be described later. The species differences between the two peninsulas and their geographical distribution patterns in the midwest are as follows.

Placobdella hollensis: This leech was found at only two locations in Marquette County and was not encountered in the Lower Peninsula by either Metzelaar or in the present study. This leech is known to be present in Minnesota, Nachtrieb, Hemingway, and J. P. Moore (1912), but not in the states of Illinois, Wisconsin, or Ohio. Perhaps it is a northerly species in regard to its distribution in the Midwestern states.

Placobdella picta: This leech was collected at one location in the Lower Peninsula by Metzelaar in 1926. It was not found in either peninsula during the present study. Bere (1931) reported it for Wisconsin. Sapkarev (1967) found only one specimen of this leech in Lake Mendota.

Table 7. A Comparison of Leeches Collected in the Upper and Lower Peninsulas of Michigan.

M = Collected by Metzelaar et al. (1925-1927)
K = Collected by Kopenski (1961-1966)
M-K = Collected by Metzelaar et al. and Kopenski

Species	Upper Peninsula	Lower Peninsula
Glossiphonia complanata	M-K	M-K
Helobdella stagnalis	K	M-K
Helobdella fusca	K	K
Theromyzon rude	K	K
Placobdella montifera	K	M
Placobdella hollensis	K	---
Placobdella rugosa	M-K	M-K
Placobdella parasitica	M-K	M-K
Placobdella picta	---	M
Illinobdella alba	K	---
Illinobdella punctata	K	---
Piscicola milneri	K	---
Macrobdella decora	K	M-K
Haemopis marmorata	M-K	M-K
Haemopis lateralis	---	M
Haemopis plumbeus	M	M
Haemopis grandis	M-K	M-K
Philobdella gracilis	---	K
Erpobdella punctata	M-K	M-K

Table 7 (cont'd.)

Species	Upper Peninsula	Lower Peninsula
Dina parva	K	K
Dina fervida	K	M-K
Nephelopsis obscura	K	---

Not enough information is available to postulate a geographical pattern in its distribution.

Haemopis lateralis: Metzelaar collected this leech at two locations in the Lower Peninsula in 1926 and 1927. It was not found in either peninsula during the present study. This leech has been reported for Ohio, Miller (1929), Illinois, J. P. Moore (1901), and Minnesota, J. P. Moore et al. (1912).

Haemopis plumbeus: Metzelaar found this leech in Luce County in the Upper Peninsula in 1925 and in Montmorency County in the Lower Peninsula. It has been reported for Ohio, Miller (1929), and Minnesota, J. P. Moore et al. (1912).

Philobdella gracilis: Several specimens of this leech were collected from Otis Lake in Barry County in the Lower Peninsula during this study, but none were found in Marquette County waters. It has been reported for Illinois, J. P. Moore (1901), but not for Wisconsin nor Minnesota. Perhaps it is confined to the southern regions of the midwest area.

Nephelopsis obscura: This leech is abundant in Marquette County waters. It was not found in the Lower Peninsula during the present study nor by Metzelaar. It has been reported for Wisconsin, Bere (1931), Sapkarev (1967), and Minnesota, J. P. Moore et al. (1912). It is also abundant in Canadian waters, Oliver (1958),

J. E. Moore (1966). It is not listed for Illinois nor Ohio. It appears to be a northerly species.

As previously noted, too few specimens of piscicolids were obtained to draw conclusions as to their distribution. The same species are probably present in both peninsulas of Michigan since the fish which they parasitize are present in both peninsulas.

When one compares the leeches present in a larger geographical area, such as the states of Michigan, Minnesota, Wisconsin, Illinois, and Ohio as illustrated in Table 8, one finds a uniformity of species distribution with a few exceptions as discussed in the preceding paragraphs. The smaller number of species listed for some states is undoubtedly due to a lack of investigation rather than to a lack of species present. Consequently, an attempt to explain the presence or absence of a given species in each state would be non-justifiable. The large number of leeches known for Minnesota is due to the early thorough investigations of J. P. Moore et al. (1912) and more recently by Keith (1954, 1960). To my knowledge, no up-to-date species listing has been compiled for Illinois.

Table 8. A Comparison of Leeches in Five Midwestern States.

Species	Ohio	Ill.	Minn.	Wisc.	Mich.
(Glossiphonidae)					
Glossiphonia complanata	X	X	X	X	X
Glossiphonia heteroclita				X	
Helobdella stagnalis	X	X	X	X	X
Helobdella fusca	X		X	X	X
Helobdella nepheloidea	X		X	X	
Helobdella punctata				X	
Helobdella lineata		X		X	
Helobdella elongata				X	
Theromyzon rude			X		X
Theromyzon occidentalis			X		
Hemiclepsis carinata		X			
Hemiclepsis occidentalis			X		
Placobdella parasitica	X	X	X	X	X
Placobdella rugosa	X	X	X	X	X
Placobdella montifera	X		X	X	X
Placobdella pediculata			X	X	
Placobdella picta	X			X	X
Placobdella hollensis			X		X
Placobdella phalera	X			X	
Actinobdella inequiannulata	X	X	X		
(Piscicolidae)					
Piscicola punctata	X		X	X	
Piscicola milneri			X		X

Table 8 (cont'd.)

Species	Ohio	Ill.	Minn.	Wisc.	Mich.
Piscicola geometra			X	X	
Illinobdella alba			X		X
Illinobdella richardsoni			X		
Illinobdella punctata			X		X
(Hirudidae)					
Macrobdella decora	X	X	X		X
Haemopis marmorata	X	X	X	X	X
Haemopis grandis	X		X	X	X
Haemopis lateralis	X	X	X		X
Haemopis plumbeus	X		X	X	X
Haemopis latero-maculatum			X		
Philobdella gracilis		X			X
(Erpobdellidae)					
Erpobdella punctata	X	X	X	X	X
Nephelopsis obscura			X	X	X
Dina fervida	X	X	X		X
Dina parva			X	X	X
Dina microstoma	X	X			
(total)	19	14	29	22	22

Ecological Factors Related to Leech Distribution

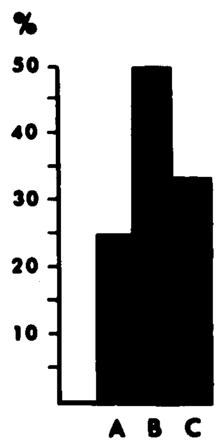
Chemical Factors

Total Alkalinity: A listing of the waters tested and their total alkalinity is shown in Table A6, page 153. Table A7 on page 154 shows the number of stations sampled, the mean total alkalinity, standard deviation, and range found for eleven species of leeches. Figure 11 depicts the percentage of occurrence of eleven species of leeches in relation to total alkalinity of the water. The alkalinity ranges used are patterned after those of Mann (1955). Analysis of the data by families is as follows:

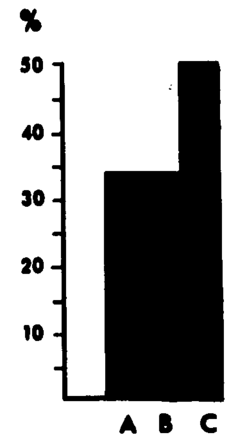
Glossiphonidae:

The glossiphonids were most frequently encountered in waters having a total alkalinity of 100ppm. or more. Forty-six percent of these waters contained at least one species of glossiphonid, whereas only 33% contained erpobdellids and 8% hirudids. An average, irrespective of species, of three glossiphonids were found in each body of water with a total alkalinity of less than 74ppm. On the other hand, an average of nine glossiphonids were found in each body of water with a total alkalinity of 74ppm. or more. Although all glossiphonids studied were found more frequently in the higher alkaline waters, they were also present in waters with a lower total alkalinity as shown in Figure 11.

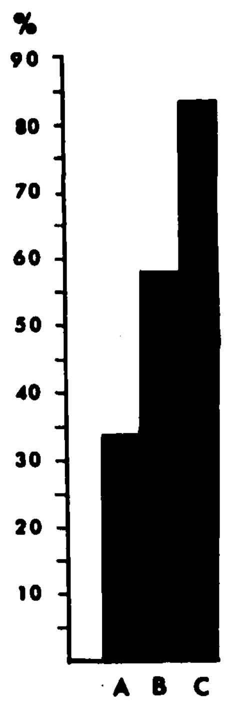
Helobdella stagnalis was found in 33% of the lentic waters in the 18-59ppm. range and in 39% of the waters in



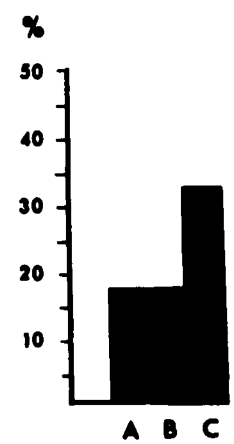
Glossiphonia complanata



Helobdella stagnalis



Placobdella parasitica



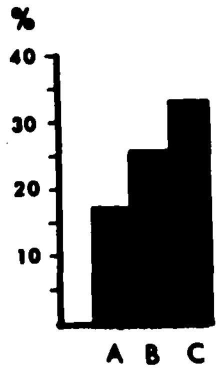
Placobdella rugosa

A = Intermediate Standing Waters 18-59ppm. $CaCO_3$

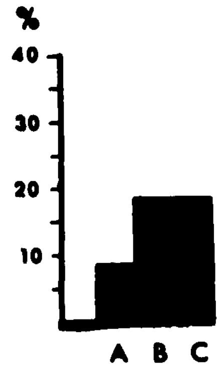
B = Hard Standing Waters 60-99ppm. CaCO3

C = Hard Standing Waters 100- +ppm. $CaCO_3$

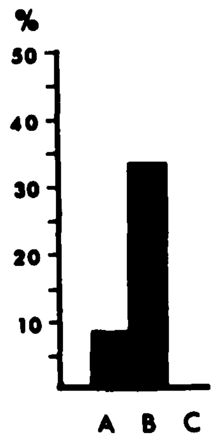
Fig. 11. Percentage of occurrence of eleven species of leeches at different alkalinities.



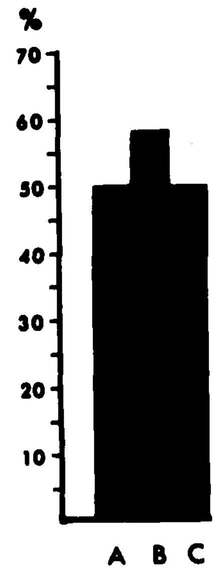
Macrobdella decora



Haemopis grandis



Haemopis marmorata



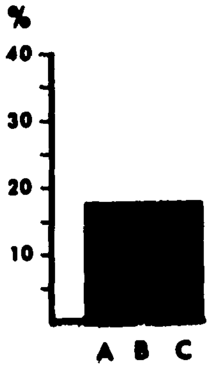
Erpobdella punctata

A = Intermediate Standing Waters 18-59ppm. $CaCO_3$

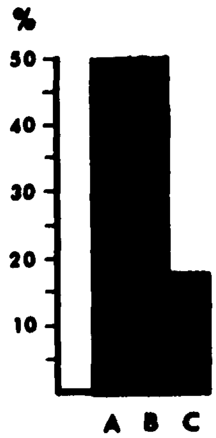
B = Hard Standing Waters 60-99ppm. $CaCO_3$

C = Hard Standing Waters 100- +ppm. $CaCO_3$

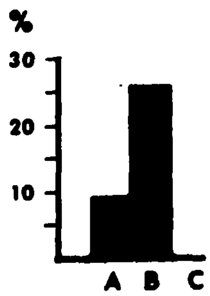
Fig. 11 (Cont'd.)



Dina parva



Dina fervida



Nephelopsis obscura

A = Intermediate Standing Waters 18-59ppm. $CaCO_3$

B = Hard Standing Waters 60-99ppm. $CaCO_3$

C = Hard Standing Waters 100- +ppm. $CaCO_3$

Fig. 11 (Cont'd.)

the 60-250ppm. range. Mann (1955) found this leech in 60% and 75% respectively of the waters in the same ranges in England. Considering both lentic and lotic waters, Helobdella stagnalis was found within an alkalinity range of 47-200ppm. in comparison to Mann's range of 8-249ppm.

Glossiphonia complanata was encountered in 25% of the lentic waters in the 18-59ppm. range and in 44% in the 60-250ppm. range. Mann (1955) found this leech in 42% and 62% respectively, of the waters in the same ranges in England. This leech was encountered most frequently in waters in the 60-99ppm. range which agrees with the findings of Mann. Considering both lentic and lotic waters, G. complanata was found within an alkalinity range of 24-200ppm. in comparison to Mann's range of 10-280ppm.

Sizeable percentage differences between the results of this study and that of Mann (1955) regarding the two leeches discussed are evident. This might be accounted for in several ways. (1) Mann's percentages for the 18-59ppm. waters are based on nineteen waters in comparison to twelve waters used in this study. (2) Eleven of the sixteen 60-250ppm. waters considered by Mann had total alkalinities of over 100ppm., four of which were over 200ppm. and contained one or both of the two leeches concerned. In comparison, only six of eighteen waters considered in the present study had total alkalinities above 100ppm., one of which was over 200ppm. and contained neither of the two leeches in question. Since the conclusion has been reached that both *Helobdella stagnalis* and *Glossiphonia complanata* prefer waters with a high alkalinity, their frequency of occurrence would undoubtedly be higher when a larger number of highly alkaline waters is considered. (3) The time spent collecting at each site was not uniform in these studies, and (4) a variation in other chemical, physical, and biological characteristics of the waters considered in the two studies.

Although percentage differences are evident, a definite pattern is indicated in both studies, *i.e.*, the frequency of occurrence of both species increases from the 18-59ppm. waters to the 60-250ppm. waters.

Undoubtedly, the relationship between the distribution of the two leeches discussed and others is confined to the abundance of food organisms. One of the major food organisms of *G. complanata* and *H. stagnalis* is snails. Snails are most abundant in alkaline waters as they need $CaCO_3$ to construct their shells. This may explain why these two species of leeches are more common in the higher alkaline waters.

Glossiphonia complanata and *Helobdella stagnalis* are the only species common to North America and Europe in which alkalinity relationships have been studied and upon which direct comparisons can be made. All subsequent alkalinity comparisons between European and North American leeches will be on a generic basis.

Placobdella parasitica and *Placobdella rugosa* exhibit distribution patterns similar to each other in regard to total alkalinity. They were most frequently found in waters above 100ppm. Considering lentic and lotic waters *P. parasitica* was found within an alkalinity range of 24-250ppm. with a mean of 93ppm. *P. rugosa* was found within a range of 23-195ppm. with a mean of 89ppm. The main food of these two leeches consists of turtle blood. As turtles are widely distributed and do not appear to be restricted by alkalinity, the distribution of these two species is undoubtedly correlated with the distribution of turtles. Turtles would also act as disseminators of these leeches as they move from one body of water to another. No alkalinity studies on the distribution of the genus *Placobdella* in relation to water alkalinity have been done in Europe; thus comparisons cannot be made.

Hirudidae:

Haemopis marmorata and *H. grandis* exhibit distribution patterns similar to each other in regard to total alkalinity. Both were found more commonly in waters with a total alkalinity of less than 100ppm. *H. marmorata*, which was taken at six stations, was not collected in waters with a total alkalinity above 100ppm. *H. grandis*, recorded at four stations, was found in only one of the six waters above 100ppm. Similarities in distribution between these two species might be explained by the fact that their feeding habits, which will be discussed later, are alike. The alkalinity range and mean of *Haemopis* spp. are narrower than those of the glossiphonids. Interestingly, Mann (1955) reported a related leech, *Haemopis sanguisuga*, more commonly in waters of less than 100ppm. in England.

Macrobdella decora, on the other hand, was frequently encountered in waters of high alkalinity, as well as in lower alkalinities. Undoubtedly, the distribution difference between this species and the previous two hirudids lies in their feeding habits. *Macrobdella decora* is a voracious parasite which will attack fish, frogs, salamanders, turtles, and other vertebrates. Many of its hosts appear not to be restricted by alkalinity. This may explain why this leech is distributed over a wide range of alkalinities.

Erpobdella punctata was found with almost equal frequency (50-60%) over the three alkalinity ranges shown in Figure 11. The findings during this study for *E. punctata* compare closely with those of Mann (1955) and Sandner (1951) for a related species, *E. octoculata*, in Europe. Both *E. punctata* and *E. octoculata* are found over a wide range of alkalinities.

Dina parva, found at five stations, occurred with equal frequency throughout the three alkalinity ranges as shown in Figure 11. It was found within a range of 24-140ppm. On the other hand, *Dina fervida* was found more often in waters below 100ppm. Twelve of the thirteen stations at which this leech was found had an alkalinity of less than 100ppm. *Dina lineata*, a related species in Europe, has not been thoroughly investigated in regard to alkalinity; thus comparisons cannot be made.

Nephelopsis obscura, although found only at four stations, appeared most commonly in waters in the 60-100ppm. range and was not found in waters above 100ppm. No corresponding genus of leeches is present in Europe for comparison purposes.

Piscicolidae:

Not enough data were obtained to draw conclusions regarding the relationship of members of this family to total alkalinity.

The data indicate that most of the leeches present in Michigan are tolerant of a wide range in alkalinity. The data also indicate that the percentage of occurrence of most species of the leeches studied is highest above a total alkalinity of 60ppm. This is particularly true of the glossiphonids and compares closely with the data obtained by Pawlowski (1936) and Sandner (1951) in Poland, Bennike (1943) in Denmark, and Mann (1955) in England.

pH: A listing of the waters tested and their pH is shown in Table A8 on page 155. The pH mean, standard deviation, and range found for eleven species are illustrated in Table A9 on page 156. Figure 12 shows the pH values for waters in which each of eighteen species of leeches occurred based on 38 waters. Most of the pH readings obtained for both Upper and Lower Peninsula waters were in the alkaline

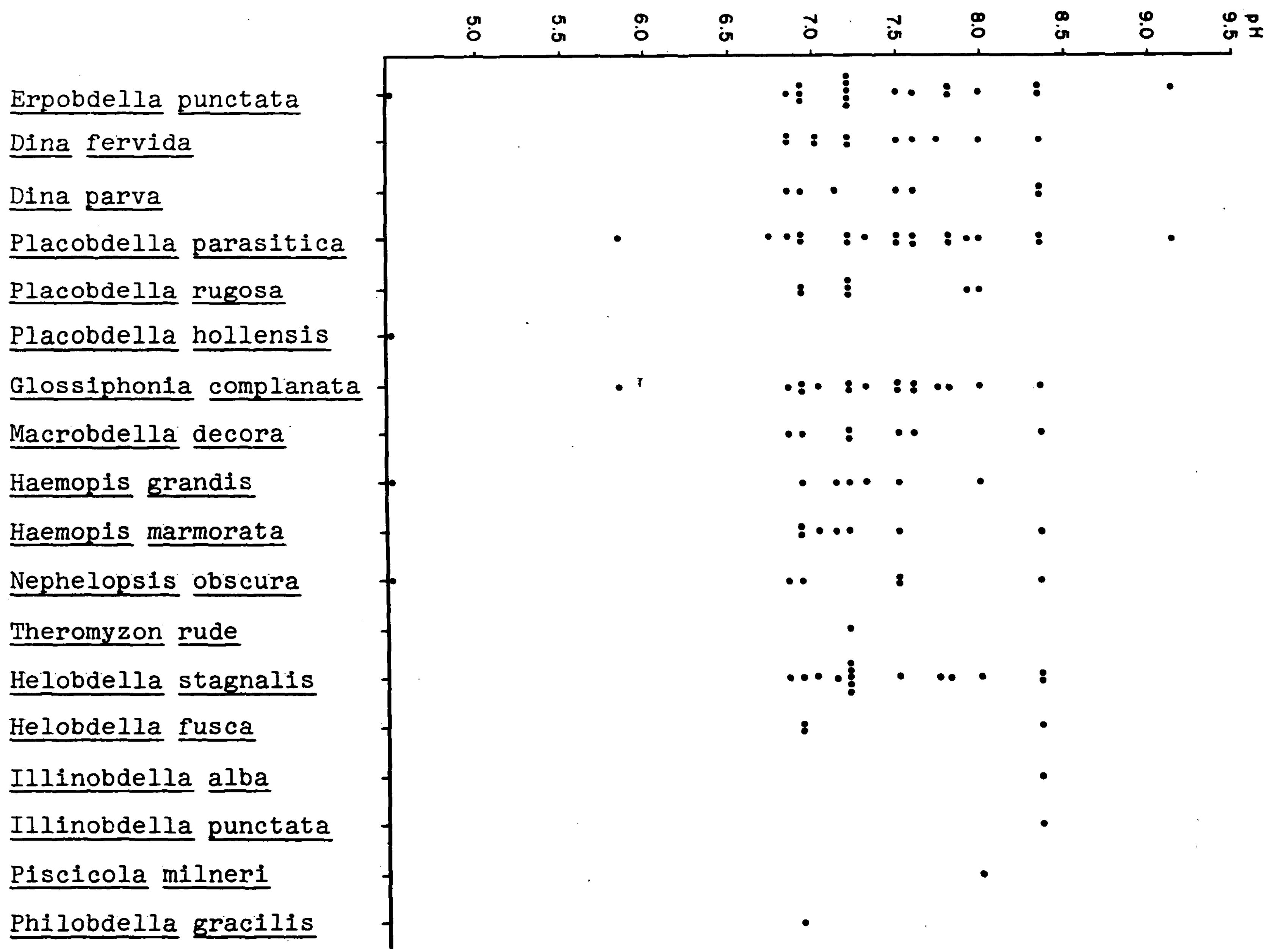


Fig. 12. Occurrence of eighteen species of leeches in relation to the pH of water.

range. Because only a few acid readings were obtained, only a general comparison can be made.

The data show that leeches are abundant in alkaline waters and that the mean pH for most species was 7.5. Bennike (1943) states that his investigations regarding leech distribution and pH indicate that leeches are not abundant in acid waters. During this study *Glossiphonia complanata* and *Placobdella parasitica* were found at a pH of 5.9, while *Placobdella hollensis*, *Haemopis grandis*, *Erpobdella punctata*, and *Nephelopsis obscura* were encountered at a pH of 4.5, but were not abundant in these waters.

Helobdella stagnalis was found in waters ranging in pH from 6.9-8.5. Mann (1955) found this leech within a pH range of 5.3-9.4 in England. Bennike (1943) found this leech at such low pH levels as 4.0 and 4.2. He states that sphagnum bogs are the only areas where this species is absent. In the present study, *H. stagnalis* was encountered in Middle Isle Point bog in Marquette County, a body of water surrounded by a sphagnum mat which could be considered a bog although the pH of the water was 7.3. Bennike's conclusion is based on acid sphagnum bogs and does not hold true for bogs containing alkaline waters. Bennike also states that *H. stagnalis* is especially prevalent in polluted waters. During this study, this leech was found in the Kalamazoo River, as well as in Deer Lake in Marquette County and Crooked Lake in Barry County. The Kalamazoo River receives the wastes from several paper mills along its shores and also sewage materials from various sources. Organisms characteristic of polluted waters, such as tubificids and chironomids, are abundant as are the blue green algae, Oscillatoria sp., Microcystis sp., and Anabaena sp. Deer Lake received the sewage wastes of the City of Ishpeming for several years. Oligochaetes and chironomids are abundant as are blue green algae, Anabaena sp. and Microcystis sp. Certain sections of this lake are completely covered by a layer of duckweed (Lemna minor) probably due to the unnatural addition of nitrates and phosphates. Crooked Lake probably receives sewage materials by way of seepage from septic tanks along its shores. Oligochaetes are abundant and blue green algal blooms of Anabaena sp. and Microcystis sp. are common. The finding of numerous specimens of H. stagnalis in these modified waters during this study substantiates Bennike's conclusion that this species is especially prevalent in polluted waters. However, H. stagnalis is also present in clear, unmodified waters, such as Gull Lake in Kalamazoo County and Teal and Sauxhead Lakes in Marquette County. Thus, H. stagnalis is a very euryoecious leech which is able to adapt to many habitats and whose presence is not an indication of polluted waters. Sandner (1951) also found H. stagnalis to be a versatile leech in regard to its distribution in Poland as did Mann (1955) in England.

Glossiphonia complanata was found over a pH range of 5.9-8.5 during this study. Mann (1955) found this species over a range of 6.1-9.4. Bennike (1943) lists the pH range for this leech as 6.3-7.2. He also states that this leech is not found in dystrophic waters. This conclusion would depend on the criteria used to designate a dystrophic lake. During the present study, this leech was taken from Purdy Lake in Barry County and Middle Isle Point bog in Marquette County, two bodies of water which could be classified as dystrophic on the basis of being shallow, poorly productive waters with heavily sedimented bottoms and crowded with *Nuphar advena* and other emergent aquatic plants. This leech is widely distributed in Europe as well as in North America. *Helobdella stagnalis* and *Glossiphonia complanata* are the only two leeches common to Europe and North America whose distribution in relation to the pH of water have been studied.

The majority of leeches collected were found in waters which ranged in pH from 7.0-8.5. A large number and diversity of species were collected in waters which had a pH in the 8.1-9.3 range, *e.g.*, Teal, Gull, and Crooked Lakes. Mann (1955) also found leeches to be most abundant over this range in England. Although the frequency of occurrence of leeches in acid waters was much less than in alkaline waters, most species were encountered over a wide range of pH.

Undoubtedly, the relationship of pH, which is directly correlated with total alkalinity, and leech distribution are directly linked to the distribution of food organisms. This relationship has also been described by Pawlowski (1936), Bennike (1943), Sandner (1951), and Mann (1955).

It is difficult to draw conclusions regarding leech distribution in relation to only two chemical characteristics of water. Undoubtedly, total alkalinity and pH of water do have an effect upon the distribution of leeches indirectly by affecting the food organisms able to survive in such waters. Sandner (1951) states that in the majority of cases the influence of chemical factors on leech distribution may not appear at all. It may be true that a combination of many chemical factors operating collectively, not individually, indirectly regulates the distribution of leeches by directly affecting the food organisms present.

Physical Factors

Lentic versus Lotic Waters: Figure 13 shows the percentages of occurrence found for eleven species of leeches in thirty-nine lentic and ten lotic waters in Marquette County. A listing of the specific habitats compared is found on page 66. A comparison between the occurrence of leeches in these two types of waters is considered by families as follows:

Glossiphonidae:

The glossiphonids were found to be the best adapted to the two types of waters. No glossiphonid varied more than 8% in its distribution in lentic and lotic waters. *Glossiphonia complanata* was found to be 2% more common in lotic waters during this study. Mann (1955) found this leech to be 29% more common in lotic waters in England; however Sandner (1951) found *G. complanata* more frequently in lentic waters in Poland. Bennike (1943) encountered this leech with equal frequency in lentic and lotic waters in Denmark. From the results of the present study and those of the three European works, it would seem that *G. complanata* is equally adapted for life in both standing and running waters.

Helobdella stagnalis was found to be 6% more common in lentic waters than in lotic during the present study. Mann (1955) found this leech to be only 1% more common in lentic waters while Bennike (1943) found it with equal frequency in lentic and lotic waters. From the results of

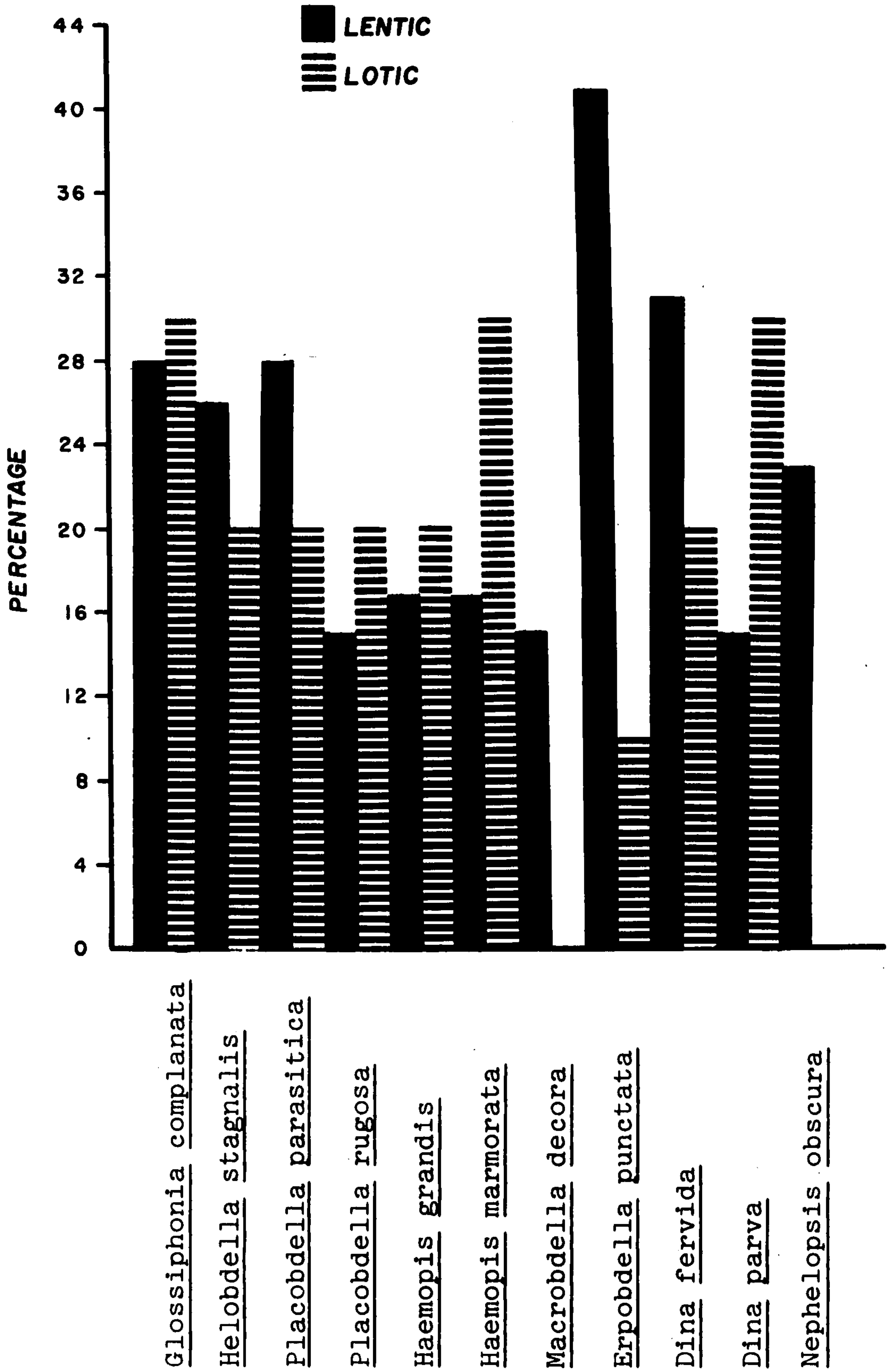


Fig. 13. Percentage of occurrence of eleven species of leeches in thirty-nine lentic and ten lotic waters in Marquette County.

the present study and those of the European works, it seems that *H. stagnalis* has no preference for either standing or running waters.

Placobdella rugosa was encountered 5% more frequently in lotic waters, whereas *Placobdella parasitica* was found to be 8% more common in lentic waters. These percentage differences for *Placobdella* spp. are small and probably inconsequential.

Pawlowski (1936) considers current the most important factor limiting the abundance of leeches. In this connection, one might expect that the glossiphonids would be best adapted for living in lotic waters for several reasons as follows: (1) The glossiphonids are dorsoventrally flattened; therefore they present less surface area to the running water. Also their venters are flat and smooth enabling them to better adhere to submerged objects. (2) Mann (1955) suggests the mode of reproduction of leeches as a factor determining their habitats. *Glossiphonia complanata* is able to cement its cocoons to rocks, thereby decreasing the chances that they would be washed away by currents. (3) Another factor would be the care afforded the young by the parents. The young of the glossiphonids remain attached to the venters of the parents for a variable period of time and in this way would be protected somewhat from the actions of currents.

Hirudidae:

Haemopis grandis and *Haemopis marmorata* were encountered slightly more often in lotic waters. These leeches are not dorsoventrally flattened nor do they possess the other adaptive characteristics of the glossiphonids. Consequently, one would not expect them to be abundant in lotic waters. This may be explained by the fact that these two leeches were usually collected in the eddies of the stream and not in the faster moving waters, whereas glossiphonids were commonly found in the faster moving waters. Cocoons of *H. grandis* were found in holes in logs along the shoreline of Waldo Pond, Marquette County. Since *Haemopis* spp. are able to deposit their cocoons on moist soil, their progeny would not be subjected to the action of the current.

Macrobdella decora was encountered in 15% of the 39 lentic waters sampled and was not found in any of the 10 lotic habitats. It is by no means inferred that this leech is not present in running waters, since it has been observed in running waters not considered in this study.

Erpobdellidae:

Erpobdella punctata, *Nephelopsis obscura*, and to a lesser extent, *Dina fervida* were more frequently encountered in lentic waters. *N. obscura* was not found in any of the ten lotic waters examined, while *E. punctata* was found in only one. It may be that current does influence the distribution of these three leeches. On the other hand, *Dina parva* was found more commonly in lotic waters, primarily in the eddies. Since *D. parva* is a smaller leech than the other three and presents less surface area to the currents, it is therefore theorized that this species is not as affected by the currents.

In summary, water current could be an important regulating factor to the distribution of some hirudids and erpobdellids, but not to any great extent to the glossiphonids.

Water Temperature: Table 9 shows the water temperature range found for eleven species of leeches. The temperature ranges listed are based on temperatures taken at the time of collecting. Undoubtedly, these waters would reach higher and lower temperatures than indicated; consequently it is not contended that these ranges are fixed. The data indicate that water temperature is not a major limiting factor to leech distribution. Two exceptions to this may be *Nephelopsis obscura* and *Philobdella gracilis*. *N. obscura*, found at nine stations, was not found in waters above 16°C. This leech was not found in the Lower Peninsula, nor has it been reported for Ohio or Illinois. However, it is common in the Upper Peninsula, Wisconsin, Bere (1931), Sapkarev (1967), and Minnesota, Nachtrieb, Hemingway, and Moore (1912). It is also common in Saskatchewan, Oliver (1958), and Alberta, J. E. Moore (1966). It seems therefore that *N. obscura* prefers colder waters. *P. gracilis* was encountered along the shore of

Table 9. The Water Temperature Range Found for Eleven Species of Leeches

Leeches	Temperature Range °C
Glossiphonia complanata	7-27
Helobdella stagnalis	8-27
Placobdella parasitica	8.5-27
Placobdella rugosa	7-27
Haemopis grandis	8-24
Haemopis marmorata	8-27
Macrobdella decora	8.5-27
Nephelopsis obscura	8-16
Erpobdella punctata	8-27
Dina fervida	8-24
Dina parva	8-25

Otis Lake, Barry County. The water temperature was 27°C and eight leeches were found underneath moist logs on shore two feet from the water's edge. The inference, therefore, is that these leeches took refuge out of the water because of the high temperature. This leech has been reported in Illinois by J. P. Moore (1901), but was not found in Minnesota, Wisconsin nor Canada. A postulation hereupon assumes that this leech is a warm water dweller and that water temperature is a limiting factor in its distribution.

Sandner (1951) does not consider water temperature a major limiting factor to leech distribution. Bennike (1943), however, considers water temperature a controlling factor of leech distribution since it affects their reproduction. He states that leech eggs will not mature in waters whose summer maximum temperature is less than 11°C. This low summer maximum temperature listed by Bennike is atypical of most waters and probably only pertains to springs. Bennike found that high water temperature was of no importance in Danish waters. In small ponds, however, temperatures may become so high as to be critical for certain leeches. Bennike's conclusion may fit the situation previously described for Philobdella gracilis; however, the leech acclimated to the high temperature problem by moving temporarily to a moist and probably cooler area on land.

Aside from the two exceptions mentioned, water temperature did not appear to constitute a limiting factor to distribution of the leeches studied.

Water Color: Since no quantitative measurements were made of color, only a few cursory remarks can be made, on the basis of gross observations.

In most cases a greater number and variety of leeches were found in clear waters, *e.g.*, Teal, Independence, and Mountain Lakes, Marquette County, and Gull Lake, Kalamazoo County. Mann (1955) also found a greater number and variety of leeches in clear waters. However, exceptions did occur during this study, whereby a large number and variety of leeches were found in brown waters with high amounts of dissolved organic matter, namely Otis Lake, Barry County, and Ramseth Pond, Marquette County. Therefore, a suggestion is proposed that water color plays a minor role if any in determining the abundance and distribution of leeches. Neither is it a good criterion for predicting what leeches may be present in a body of water.

Water Depth: Most collecting during this study was done at depths from 0 to 1.2 meters, the exceptions being some piscicolid leeches which were removed from fish taken at depths of 3.6 and 6.0 meters. Eckman dredge sampling was attempted both from a boat and through the ice, but proved ineffective in obtaining a good representation of the leech fauna within a body of water.

Bennike (1943) found leeches down to a depth of 12 meters and discontinued sampling beyond this depth for lack of sufficient findings. He cites lack of vegetation, absence of substratum for attachment, and low oxygen content as reasons for the scarcity of leeches at greater depths. Bere (1931) took *Helobdella stagnalis* from a depth of six and seven meters in Trout Lake, Wisconsin. These leeches were adhering to a gill net. Bennike (1943) found *H. stagnalis* at 5 and 12 meters in Denmark. Sapkarev (1967) found *H. stagnalis* at a depth of 12 meters in Lake Mendota.

During the present study, leeches were found to be most abundant within a depth range of 0 to 1.2 meters. Sapkarev (1967) found that the maximum density of glossiphonids occurred at a depth of 0 to 3 meters and that the maximum density of erpobdellids occurred at 0 to .5 meters. He found that all species inhabited the littoral zone and that in all cases the number of species decreased with an increase in depth. Therefore, leeches are probably restricted by great depth for the reasons cited by Bennike (1943).

Bottom Composition: Table A10, page 157, shows the bottom composition of the fifty waters studied in Marquette County and the number of times each of eleven species of leeches occurred along these bottoms. Too many variables exist to draw statistical conclusions regarding the relationship of leeches to particular bottoms. The primary problem encountered is the accuracy with which a given bottom can be described. Other variables are differences in the amount of time spent collecting at each site, the number of times each site was visited, and the few sites representing certain bottoms. Because of these problems, only general conclusions can be made.

The data indicate that all eleven species of leeches were present along sandy bottoms with some combination of submerged matter and along all the bottoms without a sand base. Discounting disturbed leeches, none were found along a pure sand bottom without submerged objects. Likewise, few species occurred along clay, peat, or muck bottoms without the presence of submerged materials. Although few bottoms were found without submerged objects, probably plain peat and muck bottoms would be more suitable to leeches since they would be better able to burrow into them.

The difference between the submerged materials lying above the base materials is too slight to show preference for one over the other. Consequently, a comparison was made between the percentage of occurrence of a given species along four types of bottoms irrespective of the submerged materials overlying each. The results of this comparison are shown in Table 10. The data indicate that *Placobdella rugosa*, *Haemopis marmorata*, and *Dina parva* occurred slightly more often along sand bottoms. *Glossiphonia complanata*, *Helobdella stagnalis*, *Haemopis grandis*, *Erpobdella punctata*, and *Dina fervida* occurred more

Table 10. The Percentage of Occurrence of Eleven Species of Leeches along Four Types of Water Bottoms.

(Numbers in Parentheses Represent Number of Waters Sampled)

Species	Sand (31)	Clay (3)	Peat (7)	Muck (9)
Glossiphonia complanata	19	0	57	44
Helobdella stagnalis	26	0	29	22
Placobdella parasitica	26	0	43	22
Placobdella rugosa	19	0	14	11
Haemopis grandis	13	33	29	22
Haemopis marmorata	29	0	0	22
Macrobdella decora	10	0	14	22
Erpobdella punctata	39	0	71	11
Dina fervida	23	33	29	22
Dina parva	23	0	0	22
Nephelopsis obscura	13	33	14	33

commonly along peat bottoms, while *Nephelopsis obscura* and *Macrobdella decora* tended to be more common along muck bottoms. Clay bottoms were discounted as only three of the habitats studied possessed clay bottoms.

In most cases leeches were found under the submerged objects typical of water bottoms. However, some more interesting locations of certain leeches can be mentioned. *Helobdella stagnalis* were found adhering to the undersides of *Nuphar advena* leaves. *Dina parva* were found fastened to the roots of *Typha latifolia*, and submerged pieces of concrete produced an abundance of *Glossiphonia complanata*. An interesting correlation may be exhibited by the latter situation. There is a possibility that the lime dissolving out of the concrete acts as an attractant to snails, as lime is needed for shell construction. Since snails are the main source of food for *G. complanata*, this might account for its abundance in this situation.

In summary, it is difficult to assign a given leech to a particular type of bottom. The main requirement for the occurrence of any leech, regardless of the nature of the bottom, appears to be the presence of submerged objects, such as wood, rocks, debris, rooted aquatic plants, etc. Seldom were leeches found along plain bottoms where no attachment materials were available. Submerged materials protect leeches from predation, enhance their resistance to currents, provide habitats for their food organisms, and provide a substratum upon which they may deposit their cocoons.

Soils: A description and designation of the soils surrounding the fifty bodies of water sampled in Marquette County is found on pages 14 and 15. A Chi-square test was performed attempting to correlate the soils surrounding each body of water with the leeches inhabiting it. Due to the same variables encountered when attempting to correlate leeches with bottom types, it was impossible to obtain a valid statistical answer. Only a general conclusion regarding the relationship of leeches to soils can be given.

Certainly the nature of the surrounding soils would be reflected in the chemical characteristics of the water due to the leaching out of materials from the soils by rain, streams, and springs. Waters in limestone areas would undoubtedly have a high total alkalinity and consequently a high pH. On the other hand, waters in igneous rock areas would likely have a low total alkalinity and thus a low pH. Therefore, surrounding soils would only exert an indirect effect on leech distribution by altering the chemical nature of the water. Moreover, the chemical nature of the water, which has been discussed previously, probably exerts only an indirect effect by regulating the abundance and distribution of the food organisms of leeches.

Biological Factors

Feeding Habits: Table 11 shows the preferred foods of twenty-two leeches inhabiting Michigan waters. This listing was compiled from personal observations as well as from the findings of J. P. Moore et al. (1912), Miller (1937), Meyer (1954), Rupp (1954), Keith (1960), J. E. Moore (1964 and 1966), and Sapkarev (1967).

Glossiphonidae:

Members of this family possess a pore-like mouth through which a muscular proboscis is extruded. The proboscis is inserted into the tissues of the host and blood or the entire soft parts of the animal are withdrawn. *Glossiphonia complanata* was observed feeding on the snail, *Physa* sp. Sapkarev (1967) observed this leech preying upon the snails *Physa gyrina* and *Planorbis parvus*. It is generally agreed by other workers that snails of several species are the main food items of this leech. Neither *Helobdella stagnalis* nor *H. fusca* was observed feeding during this study. Other investigators list aquatic insects and snails as the favored foods of *Helobdella* spp., plus others listed in Table 11.

The few specimens of *Theromyzon rude* encountered during this study were found in the non-parasitic state. Other workers list the blood of aquatic birds as the main source of nutrition for this leech. Meyer (1954) found this leech parasitizing waterfowl in a pond in Manitoba and suggests that they may cause the death of small

Table 11. Foods of Michigan Leeches.

Leeches \ Foods	Other leeches	Earthworms	Aquatic annelids	Snails	Crustaceans	Aquatic insects	Fish	Salamanders	Frogs	Turtles	Birds	Mammals
(Glossiphonidae)												
Glossiphonia complanata	X		X	X		X						
Helobdella stagnalis	X		X	X		X	X		X			X
Helobdella fusca			X	X		X						
Theromyzon rude											X	
Placobdella parasitica			X			X		X	X	X		
Placobdella rugosa			X			X			X	X	X	
Placobdella hollensis										X		
Placobdella montifera				X			X		X	X		
Placobdella picta										X		
(Piscicolidae)												
Illinobdella alba							X					
Illinobdella punctata							X					
Piscicola milneri							X					
(Hirudidae)												
Haemopis grandis		X	X	X	X	X	X					
Haemopis marmorata	X	X	X	X	X	X	X					X
Haemopis lateralis		X	X			X						

Table 11 (cont'd.)

Foods	Other Leeches	Earthworms	Aquatic annelids	Snails	Crustaceans	Aquatic insects	Fish	Salamanders	Frogs	Turtles	Birds	Mammals
Leeches												
Macrobdella decora			X				X	X	X	X		X
Philobdella gracilis												X
(Erpobdellidae)												
Erpobdella punctata	X	X	X	X		X			X			X
Dina fervida			X		X	X						
Dina parva			X		X	X						
Nephelopsis obscura			X	X		X						

aquatic birds. J. E. Moore (1966) lists grebes (Podilymbus spp.) as well as the gadwall (Anas strepera), pintail (Anas acuta), shoveler (Spatula clypeata), baldpate (Marcea americana), coot (Fulica americana), and other aquatic birds as hosts of T. rude in Alberta. Infestation occurs mainly in the nasal cavities of these birds and J. E. Moore also suggests that this leech may be responsible for a considerable degree of mortality in young birds. Since T. rude seems to feed exclusively on the blood of aquatic birds, its abundance and distribution would tend to be correlated with the abundance and distribution of waterfowl.

Turtle blood is the main food of Placobdella spp. During this study, Placobdella parasitica and P. rugosa were found adhering to the following turtles: western painted (Chrysemys picta belli), midland painted (Chrysemys picta marginata), Blandings (Emydoidea blandingi), snapping (Chelydra serpentina), spotted (Clemmys guttata), eastern box (Terrapene carolina), and musk (Sternothaerus odoratus). Twenty-five specimens of P. parasitica were removed from one musk turtle found along the shore of Pleasant Lake, Barry County. This turtle died in the laboratory the following day and it is conceivable that death may have been due to a loss of blood. Placobdella spp. attach mainly in the axillae of turtles, undoubtedly because the skin is more tender and moist in these areas and possibly more vascularized. Besides attacking turtles, one specimen of P. parasitica was removed from the head of a red-spotted newt (Notopthalmus viridescens louisianensis) taken from Redberry Pond, Marquette County. P. hollensis was not observed feeding, while P. picta and P. montifera were not encountered during this study, although three specimens of P. montifera were removed from the skin of a leopard frog (Rana pipiens) taken from Chicagoan Creek, Iron County. Other foods of Placobdella spp. as mentioned by other investigators are aquatic annelids, snails, aquatic insects, fish, and waterfowl.

P. parasitica and P. rugosa are abundant and widely distributed in Michigan. This is undoubtedly correlated with the abundance and distribution of turtles in the state. P. hollensis, P. picta, and P. montifera, however, are not common in Michigan waters. Since these three species also parasitize turtles, their abundance and distribution are probably regulated by some factor or factors other than food. Unfortunately these species were not found often enough to determine what the regulating factor or factors might be.

Piscicolidae:

The members of this family possess a pore-like mouth through which a muscular proboscis may be protruded. The proboscis is inserted into the bodies of fish where blood and body fluids are extracted.

Illinobdella alba and I. punctata were found adhering to the bodies of yellow perch (Perca flavescens). They were found attached mainly to the fins, in some cases to the gills, and in one case to the lining of the mouth. The pectoral and pelvic fins were the favored sites of attachment possibly due to the nature of their vascular supply. As many as seven or eight leeches were removed from a single fin in some cases. Individuals of both species were found adhering to the same fin at the same time on some perch. They were found on perch ranging from four to ten inches in length and no preference for any particular size could be determined. Keith (1960) also found I. alba on yellow perch in Minnesota. The examination of a total of twenty-five northern pike (Esox lucius) from Goose, Bear and Sauxhead Lakes, Marquette County, and ten walleyes (Stizostedion vitreum) from Teal Lake, Marquette County, produced no piscicolids. Yellow perch in Goose and Teal Lakes, however, were heavily parasitized by I. alba and I. punctata. The preference shown for yellow perch might be due to the fact that their fins are thinner than the other two species and probably the blood vessels supplying them are closer to the surface. Yellow perch may spend more time near the bottom or shore than either northern pike or walleyes and thus be more prone to leech attachment. Lewis E. Peters (personal communication) took I. punctata from the fins of walleyes in Portage Lake, Houghton County. It seems therefore that although yellow perch are the favored host of these two leeches, walleyes and possibly other fish are also attacked. Piscicola milneri was found adhering to the body of a burbot (Lota

lota maculosa) taken from Lake Superior. Attachment to the body of this fish is undoubtedly not impeded by its small cycloid scales. Meyer (1954) took this leech from land-locked salmon (Salmo salar sebago) in Maine. Keith (1960) lists smelt (Osmerus mordax) and whitefish (Coregonus spp.) as hosts of this leech in Minnesota, and J. E. Moore (1964) found P. milneri on white suckers (Catostomus commersonnii) in Alberta. The examination of fifty smelt and twenty-five white suckers during this study failed to produce this leech.

I. alba and I. punctata were encountered in only two lakes during this study probably because yellow perch from these two lakes were extensively examined. It is suspected that these two leeches are abundant and widely distributed in Michigan correlating with the abundance and distribution of yellow perch. On the other hand, P. milneri might be more closely associated with Lake Superior and waters in close proximity to it. The three fish, namely smelt (Osmerus mordax), whitefish (Coregonus spp.), and burbot (Lota lota maculosa), known to be attacked by P. milneri are typically Lake Superior fish. To my knowledge this leech has been found in only two Lake Superior states, Minnesota and Michigan; thus the previous conclusion is based on these findings.

Hirudidae:

The members of this family possess a large mouth surrounded by lips and do not possess a muscular proboscis.

The mouths of *Macrobdella decora*, *Haemopis marmorata*, *H. lateralis*, and *Philobdella gracilis* contain jaws bearing numerous teeth. Consequently, these leeches are able to bore into the tissues of various hosts or devour whole organisms. Other representatives, namely *Haemopis grandis* and *H. plumbeus*, lack jaws and must feed on whole organisms or attach to wounds created by other leeches.

Several observations were made regarding the feeding habits of *H. marmorata*. Two specimens were found adhering to the detached cheliped of a crayfish. One individual was observed devouring an earthworm. Two specimens were encountered feeding on a portion of a dead fish. One specimen, 82 mm. in length, was discovered with a specimen of *Nephelopsis obscura*, 72 mm. in length, protruding from its mouth. Several individuals were observed breaking up frog egg masses and devouring the eggs. These findings during this study show that the feeding habits of this leech are varied. J. P. Moore (1912) and J. E. Moore (1966) reached the same conclusion in regard to the feeding habits of this leech. *H. grandis* was not observed feeding during this study. According to other investigators, its feeding habits are similar to those of *H. marmorata*. Rupp (1954) observed *H. grandis* attached to the wounds on brook trout (*Salvelinus fontinalis*) caused by *Macrobdella decora* in a pond in Maine.

The feeding habits of *M. decora* were studied in an aquarium in the laboratory. Several guppies were introduced into an aquarium containing several specimens of this leech. One leech fastened to a guppy, pulled it to the bottom, and killed it. Since guppies are not associated with this leech in nature, this incident shows that this leech can adapt to a new source of food. Several individuals attacked green frogs (Rana clamitans), adults and tadpoles, and spotted salamanders (Ambystoma maculatum) when they were introduced into the aquarium. In the case of the salamanders, attachment was centered primarily on the digits, whereas no pattern of attachment was evident in the case of the frogs. In neither case were the hosts able to dislodge the leeches despite attempting to scratch them off with their limbs. Rupp (1954) observed M. decora attacking and killing brook trout (Salvelinus fontinalis) weighing from one to two pounds in a Maine pond. Philobdella gracilis was not observed feeding, while Haemopis lateralis and H. plumbeus were not found during this study. The main foods of these leeches, as listed by other workers, are earthworms, aquatic annelids, and aquatic insects.

The data indicate that H. marmorata, H. grandis, and M. decora feed on a variety of animals which are abundant and widely distributed in Michigan waters. This probably accounts for the great abundance and wide distribution of these species in the state. The foods of H. lateralis and H. plumbeus, as determined by other investigators, do not seem to be as varied as those of H. marmorata and H. grandis. Perhaps this accounts for the scarcity of these leeches in Michigan waters. Philobdella gracilis was encountered only once during this study. It has previously been noted that water temperature, rather than food, seems to be the most important limiting factor to the distribution of this leech.

Erpobdellidae:

The members of this family possess a large jawless mouth with rounded lips and are not equipped with a proboscis. Therefore, they must swallow their food whole. No representatives of this family were observed feeding. A listing of their preferred foods, according to other authors, includes aquatic annelids, snails, crustaceans, and aquatic insects.

Erpobdella punctata feeds on a wide variety of organisms which enables it to inhabit many types of waters. This possibly accounts for its great abundance and its having been encountered more frequently than any other leech during this study. Dina fervida and Dina parva seem to have a more restricted diet than E. punctata. These two species, however, feed on aquatic insects which are probably never absent in any body of water and consequently these leeches are widely distributed in Michigan. The abundance and distribution of Nephelopsis obscura, although probably influenced somewhat by its food organisms, seems to be more regulated by high water temperature.

Parasites and Predators of Leeches:

Parasites. Information dealing with organisms parasitizing leeches is scanty. Mann (1962) discovered the protozoans *Entamoeba aulastomi* in the gut of *Haemopis* sp. and *Orcheobius herpobdellae* in the testes of *Erpobdella* sp. Mann also states that many species of *Trypanosoma* spp. from fresh water fishes are transported by *Piscicola* spp. J. E. Moore (1964) reports collecting *Haemopis marmorata* in Alberta with numerous metacercariae in its body wall. He also found several specimens of *Erpobdella punctata* and *Nephelopsis obscura* containing the metacercariae of strigeid trematodes in their body walls.

Predators. J. P. Moore (1923) lists crayfish, turtles, snakes, crows, kingfishers, and mink as predators of leeches based on observations made at leech farms in the environs of Philadelphia. Mann (1962) states that the erpobdellids in particular are preyed upon by trout, perch, tench, sticklebacks, eels, herons, swans, ducks, and bitterns in England. He also suggests that aquatic amphibians and mammals as well as carnivorous Hemiptera and Odonata may also feed on leeches. J. E. Moore (1966) found a single specimen of *Erpobdella punctata* and three specimens of *Nephelopsis obscura* in the esophagus of a Lesser Scaup (*Aythya affinis*) in Alberta.

Certain species of leeches have been observed feeding on others. J. P. Moore (1923) observed *Haemopis grandis* devouring specimens of *Macrobdella decora* in the

Palisades Park area of New York. Mann (1962) cites Glossiphonia complanata as a predator of Erpobdella octoculata in England. G. complanata may possibly attack E. punctata in North America. During the present study, Haemopis marmorata was observed eating a specimen of Nephelopsis obscura. J. E. Moore (1966) reports finding H. marmorata feeding on Helobdella stagnalis, Erpobdella punctata, and Dina dubia in Alberta. Haemopis spp., being large in size (6-12") with large mouths, probably take more leeches than any of the others. Erpobdellids, being medium sized (2-4") active leeches, are probably preyed upon more than others.

Due to our incomplete knowledge of leech parasites and predators, it is not possible to determine what effect they may have on the abundance and distribution of leeches. The parasites probably exert little or no effect. Fish, aquatic birds, and other leeches, being the principal predators, may exert some effect especially in the case of the erpobdellids.

Reproduction: The leeches encountered in the breeding condition during the present study are discussed with comparisons being made with the findings of other investigators. An attempt is made to relate the reproductive characteristics of three leech families to their abundance and distribution in Michigan waters.

Glossiphonidae:

Most glossiphonids lack an eversible penis and sperm is transferred by means of spermatophores. The spermatophores are attached to the body of another leech. These spermatophores are attached at various positions along the dorsal surface of the leech. Placobdella rugosa was found during the present study with spermatophores attached near the anus which is some distance from the reproductive organs. The sperm pass through the epidermis into the dermal connective tissue and from there to the coelomic spaces in which the ovaries lie, Mann (1962). In some cases, e.g. Glossiphonia complanata, the thin-walled cocoons produced are cemented to some submerged object and the adults cup themselves over the cocoons, thereby sheltering them with their bodies. In other cases, e.g. Helobdella spp., the thin-walled cocoons remain attached to the venters of the adults. In both cases, when the young develop, they fasten to the venter of the parent by means of their embryonic attachment organs.

Six specimens of Helobdella stagnalis were found in Harlow Lake, Marquette County, on May 15, 1968, with cocoons containing developing young attached to their venters. These cocoons contained the following number of embryos: 37, 37, 37, 31, 15, and 13. Probably the latter two cocoons ruptured during collecting or preservation as free embryos were observed floating in the medium. This species was found with young attached in the Dead River and

Deer Lake, Marquette County, on July 7, 1964, and August 4, 1964, respectively. *H. stagnalis* were also taken with young from Gull Creek, Kalamazoo County, on July 29, 1965. The number of young attached ranged from 12-24 averaging 18 per adult. Undoubtedly, this leech produces two broods a year or is a continuous breeder through the summer months judging from the extended period over which it was found with young attached. This agrees with the findings of J. P. Moore (1912) in Minnesota, Mann (1962) in England, and J. E. Moore (1964) in Alberta. Sapkarev (1967) found *H. stagnalis* with eggs as early as May 10 in Lake Mendota. His collections of this species during the period from May 20 to May 30 showed 80% of the individuals with eggs, 10% with young, and 10% with neither eggs nor young. During the period June 1-9, Sapkarev found that 60% of the individuals captured had young attached, 30% were with eggs, and approximately 10% had neither eggs nor young. He found that the breeding period of *H. stagnalis* covered less than two months (May and June). Bennike (1943) found *H. stagnalis* with young attached from June 1 to September 11 in Denmark with the number of young averaging 20 per parent. J. E. Moore (1964, 1966) found this species with young attached from May to September in Alberta. He found that the number of young ranged from 17-23 averaging 20. According to J. E. Moore the eggs hatch in five days, embryos are present for three days, and the young are carried by the parent for 15-30 days. Of interest is the fact that the number of young found attached during the studies of Bennike, J. E. Moore, and Kopenski averaged 20. Since four cocoons examined during the present study contained over 30 developing embryos, some embryos must fail to develop into young. It appears that the breeding period of H. stagnalis and the number of young produced is similar in North America and Europe.

Helobdella fusca were found with young attached in Crooked Lake, Barry County, on July 22, 1965, and in the Kalamazoo River, Kalamazoo County, on July 27, 1965. The number of young found attached averaged 16 per adult. J. E. Moore (1966) found four specimens of this leech on August 10 in Alberta, each bearing egg capsules. H. fusca probably also produce two broods a year and a similar number of young as H. stagnalis.

No specimens of Glossiphonia complanata were found with eggs or attached young during this study. Sapkarev (1967) found this leech with eggs from the end of May through July and encountered young during all of July and August. Bennike (1943) found this leech with young attached in June and July in Denmark. The number of young he found ranged from 25-67 averaging 45. Mann (1962) found G. complanata in a breeding condition from March to May in England with an average of 26 young produced per adult. He suggests that this leech produces two broods a year. J. E. Moore (1964, 1966) found this leech in a breeding condition from May to July in Alberta. He found one specimen covering 121 eggs (apparently in four capsules) which is considerably more than produced by this leech in Europe. He found no evidence that *G. complanata* produced two broods a year in Alberta.

Placobdella parasitica was found with young attached in Cooper Lake and Redberry Pond, Marquette County, on August 28, 1963, and November 11, 1961, respectively. This species was also found with young attached in Augusta Creek, Kalamazoo County, on June 20, 1963. The specimen taken from Cooper Lake had 98 young attached to its venter. The specimen collected on November 11 was kept in an aquarium in the laboratory until it died on April 19 of the following year. During this time the young remained attached to it. Metzelaar et al., in Miller (1937), found *P. parasitica* with young attached from March 15 to July 22 in Michigan. Miller suggests that this leech produces several broods per year. The finding of *P. parasitica* with young attached in June and November during the present study seems to substantiate Miller's suggestion. Three specimens of *Placobdella rugosa* were collected with spermatophores attached in Harlow Lake on May 15, 1968. This species was found with young attached in Otis Lake, Barry County, and Barnhardt Creek, Marquette County, on July 26, 1965, and August 4, 1964, respectively. The specimen taken from Otis Lake had 50 young attached while the three specimens collected from Barnhardt Creek had an average of 91 young per adult. The latter number compares closely with the 98 young removed from a specimen of *P. parasitica*. J. E. Moore (1964) found a specimen of *P. rugosa* in Alberta carrying 95 young. It appears, therefore, that *P. parasitica* and *P. rugosa* produce 90-100 young and may produce more than one brood a year.

Placobdella montifera, *P. hollensis*, and *Theromyzon rude* were not encountered in a breeding condition during this study. Since all members of the genus *Placobdella* whose reproductive habits are known reproduce in a similar manner, it is suspected that the breeding habits of *P. montifera* and *P. hollensis* may be similar to those described. J. E. Moore (1964) found *T. rude* with young attached from June through August in Alberta. One specimen found in the Kakisa River, Northwest Territories, had 234 young attached to it. Another specimen taken from a pond near Edmonton produced four capsules containing a total of 191 young. J. E. Moore states that the young of *T. rude* remain attached to the parent for a month or longer.

The data for the glossiphonid leeches indicate that most species produce a sizable number of young. This is particularly true of *Placobdella parasitica*, *P. rugosa*, and *Theromyzon rude*. These three leeches are mainly parasitic and tend to follow the general biological pattern of parasitic animals producing a large number of young. *Helobdella* spp. and *Glossiphonia complanata* appear to produce a somewhat smaller, but yet substantial number of young. These leeches are not commonly parasitic, but feed on other leeches, aquatic annelids, snails, and aquatic insects. Undoubtedly, the great abundance and wide distribution of P. parasitica, P. rugosa, H. stagnalis, and G. complanata are somewhat due to their high reproductive capacities. The survival rate of the young of these leeches is also probably high since they are carried by the parents for a variable length of time. H. fusca and T. rude were not found frequently enough to determine a relationship between their distribution and reproductive characteristics.

Hirudidae:

The members of this family possess an eversible penis by which sperm transfer takes place. The cocoons produced are rounded with small papillae at each end where they were sealed. Since members of this family abandon their cocoons after depositing them, it is difficult to obtain information concerning their reproductive characteristics. Consequently, no information was obtained about the breeding habits of Haemopis marmorata, Macrobdella decora, or Philobdella gracilis. J. E. Moore (1966) reports collecting a large specimen of H. marmorata with a swollen clitellum on July 31 in Alberta. He also states finding juvenile individuals on October 16. These two records constitute the only information on the breeding habits of this leech in Alberta. Five cocoons of Haemopis grandis were found in holes in a log on the shore of Waldo Pond, Marquette County, on July 15, 1964. The examination of the contents of two cocoons revealed no developing young. An attempt was made to continue the development of the other three in the laboratory without success. J. P. Moore (1923) found cocoons of *Macrobdella decora* in June and July in New York. The eggs hatched in about three weeks and young were frequently found in July and August.

Erpobdellidae:

The erpobdellids, like the glossiphonids, produce spermatophores which are deposited by one leech onto another. The cocoons produced are flattened and are cemented to the undersurface of submerged rocks and water-logged wood. The cocoons are deserted by the parents after deposition.

Twenty cocoons of *Nephelopsis obscura* were collected from a bayou of Lake Superior, Marquette County, on August 7, 1967. Examination of these cocoons showed a range in the number of young from 3-17, averaging seven young per cocoon. It is suspected that the number of young per cocoon was probably closer to 17 as some young were partially out of some cocoons and others had probably left. It could not be determined whether a given adult had deposited one or several cocoons. The young leave the cocoon by way of the two papillae on the ends where the cocoon has been sealed. The cocoon does not rupture releasing all the young at one time. It was also noted that different cocoons contained young in varied stages of development, whereas all the young in a given cocoon were similar in appearance. J. E. Moore (1964) found *N. obscura* young from May 5 to

August 25 in Alberta. Sapkarev (1967) found young of this leech in July and August in Lake Mendota. Therefore this leech reproduces during the spring and summer months and might produce more than one brood a year.

Although spent cocoons of *Erpobdella punctata* were commonly found attached to submerged rocks and wood, none were found with eggs or developing young in them. As leech cocoons do not deteriorate rapidly, it was impossible to determine when they had been deposited. J. E. Moore (1966) states that the breeding habits of *E. punctata* are similar to those of *N. obscura*, commencing in May and continuing through much of the summer. Sapkarev (1967) found cocoons with eggs from May through August in Lake Mendota. The number of eggs per cocoon varied with most containing 2-6. He found that most young leave the cocoon in July and that young appear in July and August. No information was obtained concerning the reproductive habits of *Dina fervida* or *Dina parva*.

In summary the glossiphonids are prolific and exhibit a high degree of parental care, whereas the hirudids and erpobdellids are probably not as prolific nor do they provide any parental care. These two extremes regarding parental care could affect the abundance and distribution of these three families of leeches.

One might expect that a higher mortality rate would occur among the cocoons and young of the hirudids and erpobdellids. The cocoons, however, possess relatively the venters of the adults other ecological factors become involved, such as transport by turtles, frogs, and possibly waterfowl, movement to areas of abundant food, etc. These cause a dispersion of glossiphonids throughout a body of water and also to other waters. Consequently, most members of this family are abundant and widely distributed in Michigan waters.

The hirudids and erpobdellids, although probably not as prolific as the glossiphonids, possess individual characteristics which enable most of them to survive in substantial numbers and become widely distributed in Michigan.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

A study attempting to correlate several environmental factors with the abundance and distribution of leeches in Michigan was conducted from 1961 through 1966. A few observations made in 1967 and 1968 were included.

Fifty bodies of water were examined in Marquette County in the Upper Peninsula of Michigan and six each in Barry and Kalamazoo Counties in the Lower Peninsula. A comparison was made between the leeches found in the two peninsulas. A comparison was also made between the leech fauna of Michigan and that of Ohio, Illinois, Minnesota, and Wisconsin. A representative number of the waters studied were tested for pH and total alkalinity and their effect on the abundance and distribution of leeches was considered. The temperature, color, depth, bottom composition, and soil type of these waters were determined and their effect on leech distribution was discussed. The effects of the feeding habits, enemies, and reproductive habits of leeches on their abundance and distribution were determined.

Conclusions

1. Nineteen species of leeches were taken from the 62 waters examined in Michigan. This brings the number of leeches known to inhabit Michigan waters to 22.

2. The leech fauna of the Upper Peninsula compares closely with that of the Lower Peninsula. Placobdella hollensis, Illinobdella alba, I. punctata, Piscicola milneri, and Nephelopsis obscura were found in the Upper Peninsula, but not in the Lower Peninsula. Placobdella picta, Haemopis lateralis, and Philobdella gracilis have been found in the Lower Peninsula, but not in the Upper. The leech fauna of Michigan compares closely with that of Ohio, Illinois, Minnesota, and Wisconsin.

3. Helobdella stagnalis was the most abundant leech found during this study, while Erpobdella punctata was the most frequently encountered species.

4. Most of the leeches in the four families, Glossiphonidae, Piscicolidae, Hirudidae, and Erpobdellidae, found in Michigan were widely distributed in the parts of the state studied.

5. The glossiphonids were most frequently encountered in waters having a total alkalinity of 100ppm. or more. The hirudids, Haemopis marmorata and H. grandis were most frequently encountered in waters with a total alkalinity of less than 100ppm. In contrast, Macrobdella decora showed no preference in relation to total alkalinity, whereas Dina

fervida and Nephelopsis obscura occurred more frequently in waters with a total alkalinity of less than 100ppm.

6. The abundance and distribution of the leeches studied appeared to be restricted by waters with low pH. Glossiphonia complanata, Placobdella parasitica, Placobdella hollensis, Haemopis grandis, Erpobdella punctata, and Nephelopsis obscura were found in waters with a pH below 6.0; however, they were not abundant in these waters. Waters with pH readings as high as 9.3 have no apparent effect on either the abundance or distribution of the leeches studied.

7. Water current is a major limiting factor to the abundance and distribution of the leeches studied. None were found in extremely fast moving waters. The glossiphonids are best able to withstand moderate currents. Haemopis grandis, H. marmorata, and Dina parva were commonly found in lotic waters, but primarily in the eddies.

8. Nephelopsis obscura seems to be restricted in its distribution by high water temperature, whereas Philobdella gracilis is possibly restricted by low water temperature. All the other leeches encountered were found over a wide range of temperatures and seemed unaffected.

9. The leeches studied were most abundant at depths ranging from .6-1.2 meters. They are undoubtedly present beyond this depth. They are probably restricted at great depths, however, by a lack of vegetation, absence of substratum for attachment, and low oxygen content.

10. Most of the leeches studied were found along a variety of bottoms, with no preference for any particular bottom shown. The important requirement for their presence seems to be the existence of submerged objects.

11. The soils surrounding a body of water may indirectly influence the abundance and distribution of leeches by altering the chemical contents of the water.

12. The reproductive habits of the leeches studied undoubtedly affect their abundance and distribution. The glossiphonids are very prolific and exhibit parental care and as a group were the most abundant leeches found during this study.

13. Parasites undoubtedly have no effect on the abundance and distribution of leeches. Predators may exert a minor effect especially in regard to the erpobdellids.

14. The feeding habits of most leeches undoubtedly exert the greatest effect on their abundance and distribution. It is conceivable that all of the other factors considered have only an indirect effect in that they influence the abundance and distribution of the food organisms of leeches.

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APPENDIX

Table A1. A Taxonomic Classification of Michigan Leeches Adapted from J. P. Moore (1959).

Class: Hirudinea Lamarck, 1818.

Order Rhynchobdellida

Family Glossiphonidae Vaillant, 1890.

Genus _Glossiphonia_ Johnston, 1816.

Glossiphonia complanata (Linnaeus, 1758).

Genus _Helobdella_ Blanchard, 1876.

Helobdella stagnalis (Linnaeus, 1758).

Helobdella fusca (Castle, 1900).

Genus _Theromyzon_ Philippi, 1867.

Theromyzon rude (Baird, 1863).

Genus _Placobdella_ Blanchard, 1893.

Placobdella montifera Moore, 1912.

Placobdella hollensis (Whitman, 1872).

Placobdella parasitica (Say, 1824).

Placobdella picta (Verrill, 1872).

Placobdella rugosa (Verrill, 1872).

Family Piscicolidae Johnston, 1865.

Genus _Illinobdella_ Meyer, 1940.

Illinobdella alba Meyer, 1940.

Illinobdella punctata Meyer, 1940.

Genus _Piscicola_ Blainville, 1818.

Piscicola milneri (Verrill, 1871).

Table A1 (cont'd.)

Order Gnathobdellida

Family Hirudidae

Genus _Macrobdella_ Verrill, 1872.

Macrobdella decora (Say, 1824).

Genus _Haemopis_ Savigny, 1820.

Haemopis grandis (Verrill, 1874).

Haemopis plumbeus Moore, 1912.

Haemopis marmorata (Say, 1824).

Haemopis lateralis (Say, 1824).

Genus _Philobdella_ Verrill, 1874.

Philobdella gracilis Moore, 1901.

Order Pharyngobdellida

Family Erpobdellidae

Genus _Erpobdella_ Blainville, 1818.

Erpobdella punctata (Leidy, 1870).

Genus _Dina_ Blanchard, 1892.

Dina parva Moore, 1912.

Dina fervida (Verrill, 1874).

Genus _Nephelopsis_ Verrill, 1872.

Nephelopsis obscura Verrill, 1872.

Table A2. A Key to the Leeches of Michigan.

1. Mouth a small pore in the anterior sucker, from which a muscular proboscis may be protruded; jaws absent.

Order Rhynchobdellida, 3

Mouth large occupying entire cavity of the anterior sucker, no proboscis 2

2. Five pairs of eyes arranged in a submarginal arch (Fig.A1 A); jaws present or absent.

Order Gnathobdellida

Hirudidae, 14

Three or four pairs of eyes in separate labial and buccal groups (Fig.A1 B,C,D); jaws absent.

Order Pharyngobdellida

Erpobdellidae, 19

3. Body flattened and not divided into anterior and posterior regions, anterior sucker confluent with the body ....Glossiphonidae, 4

Body cylindrical, usually divided into anterior and posterior regions, anterior sucker distinctly separated from the body (Fig.A2 A)

Piscicolidae, 12

4. One or more pairs of eyes well separated (Fig.A1 E,F,G) 5

One pair of eyes close together (Fig.A1 H) 8

5. One pair of eyes 6

Three or four pairs of eyes 7

Table A2 (cont'd.)

6. A conspicuous dorsal horny scute (Fig.A2 B); no distinct dorsal papillae <u>Helobdella</u> <u>stagnalis</u>

No dorsal scute, three dorsal longitudinal rows of papillae (Fig.A2 C) .... <u>Helobdella</u> <u>fusca</u>

7. Three pairs of eyes (Fig.A1 E); two longitudinal dorsal and ventral bands.

<u>Glossiphonia</u> <u>complanata</u>

Four pairs of eyes (Fig.A1 G) ..... <u>Theromyzon</u> <u>rude</u>

8. Anterior segments widened to form a head-like structure, three dorsal longitudinal keels (Fig.A2 D) .... <u>Placobdella</u> <u>montifera</u>

Anterior segments not widened, no dorsal keels 9

9. Papillae prominent, abundant, rough, and pointed.

<u>Placobdella</u> <u>rugosa</u>

Papillae small, few, smooth, and rounded 10

10. Accessory eyes present (Fig.A1 I).

<u>Placobdella</u> <u>hollensis</u>

No accessory eyes present 11

11. Color variable, usually dark greenish-brown, ventrally striped, no rows of semicircular orange spots along the margin.

<u>Placobdella</u> <u>parasitica</u>

Dark greenish-brown, not ventrally striped, a row of semicircular orange spots along the lateral margins .... <u>Placobdella</u> <u>picta</u>

12. Suckers distinctly marked off from the body,

Table A2 (cont'd.)

pulsatile vesicles on the sides of the body (Fig.A2 E) .... <u>Piscicola</u> <u>milneri</u>

Suckers not distinctly marked off from the body, pulsatile vesicles absent 13

13. Body divided into two regions of different width, a narrow anterior region and a wide posterior region (Fig.A2 F) ..... <u>Illinobdella</u> <u>punctata</u>

Body not divided into regions of different width. <u>Illinobdella</u> <u>alba</u>

14. Large jaws with 35 or 65 teeth on each jaw, not arranged in pairs 15

Jaws small or absent, teeth arranged in pairs 16

15. Thirty-five teeth on each jaw, dorsal surface brown with a continuous median orange stripe, ventral surface orange . <u>Philobdella</u> <u>gracilis</u>

Sixty-five teeth on each jaw, dorsal surface green with a median row of orange spots and lateral black spots, ventral surface orange. <u>Macrobdella</u> <u>decora</u>

16. Jaws small with few teeth 17

Jaws and teeth absent 18

17. With 10-16 pairs of teeth on each jaw, coloration variable but generally black with gray flecks. <u>Haemopis</u> <u>marmorata</u>

With 20-25 pairs of teeth on each jaw, color dark olive green, a dark median dorsal

Table A2 (cont'd.)

longitudinal stripe ...... _Haemopis lateralis_

18. Lip narrow and arched, grayish in color with dark blotches, up to 300mm. long _Haemopis grandis_

Lip broad and flat, grayish in color with few or no dark blotches, with a reddish or orange band along lateral margins _Haemopis plumbeus_

19. Three pairs of eyes, first pair largest (Fig.A1 B); rows of longitudinal black spots on the dorsum .... _Erpobdella punctata_

Four pairs of eyes, no longitudinal black spots on the dorsum 20

20. Anterior and posterior two pairs of eyes arranged in parallel (Fig.A1 C); coloration gray, spotted with black, up to 100mm. long. _Nephelopsis obscura_

Lateral eyes of each pair arranged slightly posterior to the medial eyes (Fig.A1 D); reddish in color, up to 50mm. long 21

21. Gonophores separated by 3 to 3.5 annuli, small, may attain a length of 25mm. ......_Dina parva_

Gonophores separated by two annuli (Fig.A2 G); may attain a length of 50mm. .... _Dina fervida_

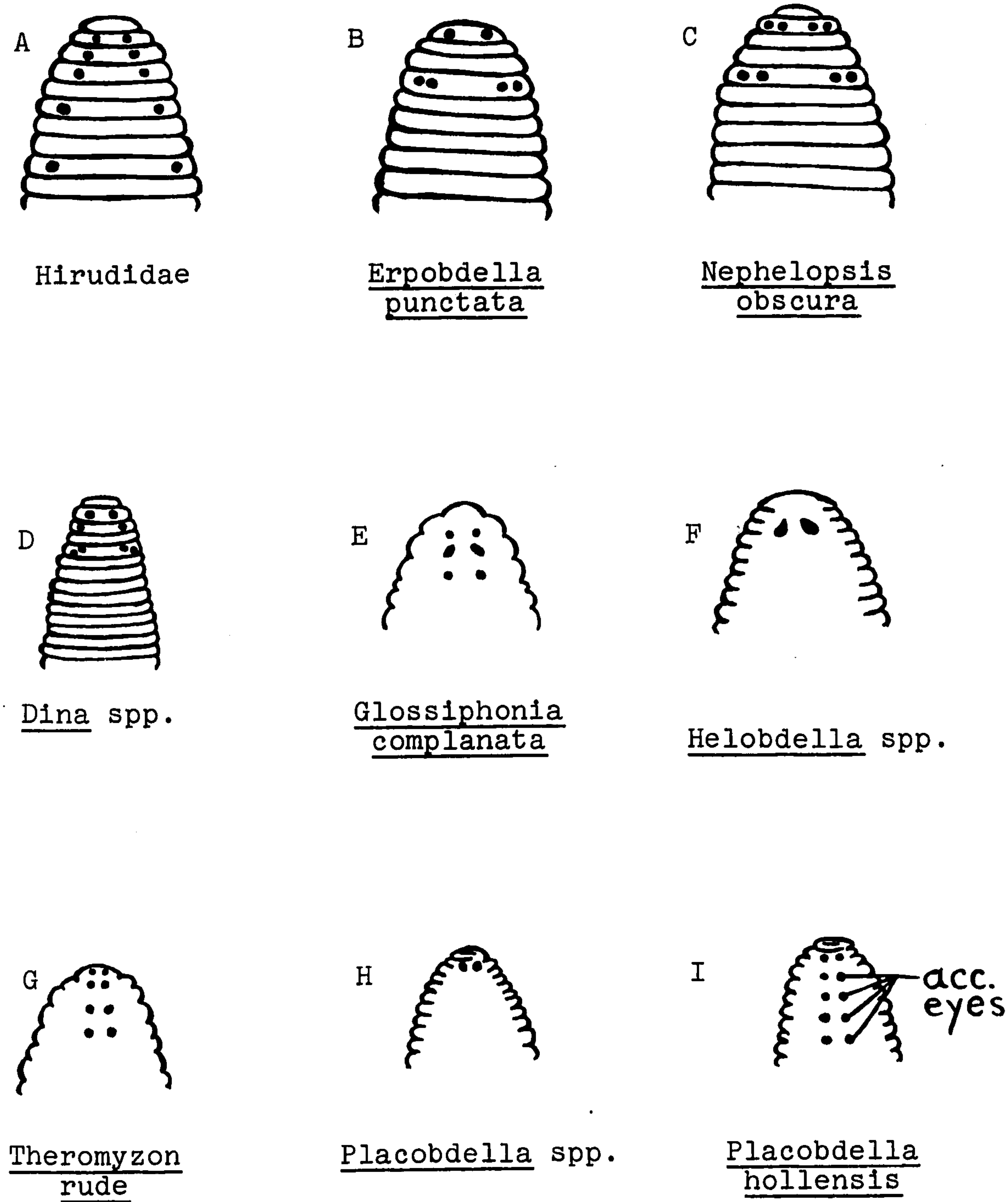

Fig. A1. The eye patterns of several leeches.

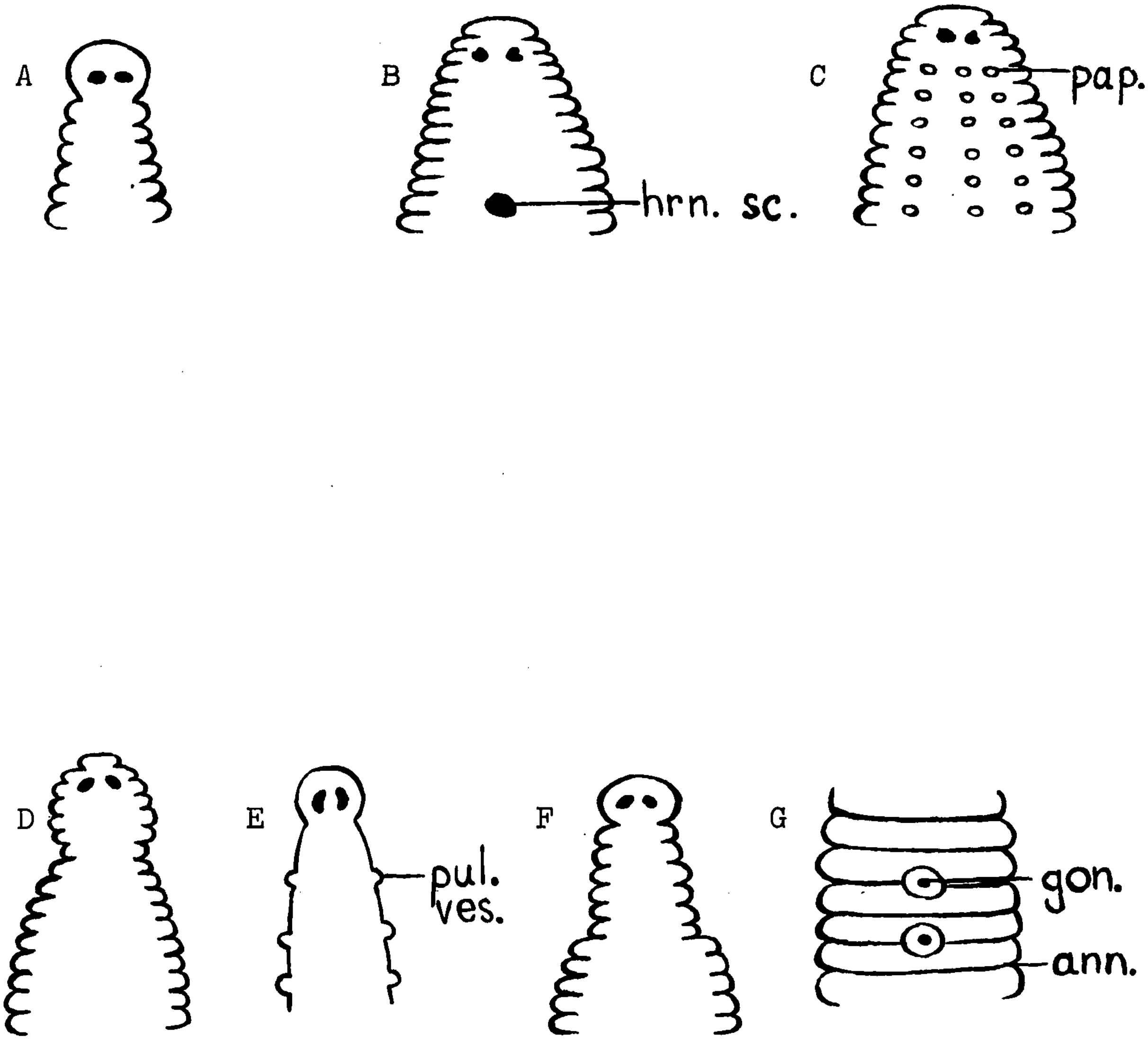

Fig. A2. Structure of leeches. A, separated sucker of piscicolids; B, horny scute of Helobdella stagnalis; C, dorsal papillae of Helobdella fusca; D, head-like structure of Placobdella montifera; E, pulsatile vesicles of Piscicola milneri; F, narrow anterior region of Illinobdella punctata; G, gonophores and annuli of Dina fervida.

Table A3. Marquette County Stations, Their Location, Dates Sampled, Chemistry, Species, and Number Collected.

	Stations	Dates	pH	Total Alkalinity ($ppm\ CaCO_3$)	Glossiphonia complanata	Helobdella stagnalis	Helobdella fusca	Theromyzon rude	Placobdella hollensis	Placobdella parasitica	Placobdella rugosa	Illinobdella alba	Illinobdella punctata	Piscicola milneri	Macrobdella decora	Haemopis grandis	Haemopis marmorata	Erpobdella punctata	Dina parva	Dina fervida	Nephelopsis obscura
1	Redberry Pond T48N, R25W, S8	9/23/61 11/11/61	7.4	24	1					1						2					
2	Harlow Lake T49N, R25W, S19	9/23/61 4/25/63 9/22/63	7.3	60						1	1						1	4			
3	Waldo Pond T48N, R25W, S8	9/23/61 7/ 6/63 4/22/64 5/10/64	7.3	23							1				2			2		2	
4	Sauxhead Lake T50N, R26W, S20	10/1/61 10/10/65	7.3	48		9					2							7			
5	Independence L. T51N, R27W, S22	10/ 6/61 9/22/63 10/10/65	7.6	65	1					3							13	10			1
6	Kawbawgam Lake T47N, R23W, S18	10/13/61	7.4								2										

Table A3 (Cont'd.)

	Stations	Dates	pH	Total Alkalinity (ppm $CaCO_3$)	G. complanata	H. stagnalis	H. fusca	T. rude	P. hollensis	P. parasitica	P. rugosa	I. alba	I. punctata	P. milneri	M. decora	H. grandis	H. marmorata	E. punctata	D. parva	D. fervida	N. obscura
7	Road 510 Pond T49N, R27W, S23	10/14/61	6.9		1						1										
8	Mangum Rd. Ditch T47N, R24W, S22	10/16/61	6.5																4		
9	Bagdad Pond T48N, R26W, S24	10/22/61 4/18/64 6/25/64	7.3	105	3	4									6	1					
10	Park Cem. Pond T48N, R25W, S14	11/ 5/61	7.0	65	3																1
11	Rush Lake T52N, R29W, S24	5/ 6/62	7.3	29														2			
12	Howe Lake T52N, R29W, S23	5/ 6/62	7.1	24													2			1	
13	Mine Shaft Pond T47N, R29W, S32	5/13/62																			10

Table A3 (Cont'd.)

	Stations	Dates	pH	Total Alkalinity (ppm $CaCO_3$)	G. complanata	H. stagnalis	H. fusca	T. rude	P. hollensis	P. parasitica	P. rugosa	I. alba	I. punctata	P. milneri	M. decora	H. grandis	H. marmorata	E. punctata	D. parva	D. fervida	N. obscura
14	Road 553 Creek T47N, R25W, S15	5/19/62																		2	
15	Horseshoe Pond T48N, R26W, S27	8/25/62 4/20/63 8/28/65	7.0	62						2					10			1			
16	Teal Lake T48N, R27W, S36	8/26/62 4/10/63 10/13/63 4/30/63 5/27/63 8/28/63 1/ 5/64 1/19/64 8/26/65 9/28/65	8.5	74	1	29						8	1				6	6	1	4	18
17	Cranberry Bog T52N, R28W, S27	9/29/62 9/28/63	4.5	29					2							1		1			1
18	Dead River T48N, R25W, S11	4/26/63	7.2	77													8				

Table A3 (cont'd.)

	Stations	Dates	pH	Total Alkalinity (ppm $CaCO_3$)	G. complanata	H. stagnalis	H. fusca	T. rude	P. hollensis	P. parasitica	P. rugosa	I. alba	I. punctata	P. milneri	M. decora	H. grandis	H. marmorata	E. punctata	D. parva	D. fervida	N. obscura
19	Small Ponds T48N, R25W, S11	4/27/63															6	1			
20	Vernal Pond T47N, R27W, S18	5/ 4/63	7.5	13													5				
21	Small Creek T51N, R27W, S36	4/26/63			1																
22	Cooper Lake T48N, R27W, S32	8/28/63	7.7	65						1					1			8			
23	Bancroft Lake T47N, R27W, S3	8/28/63	7.7	95	7					1										8	
24	Boston Lake T48N, R28W, S32	9/ 1/63		55																2	
25	Tilden Lake T47N, R27W, S23	9/ 5/63 7/ 5/64	6.9	30											1					1	

Table A3 (cont'd.)

	Stations	Dates	pH	Total Alkalinity (ppm $CaCO_3$)	*G. complanata*	*H. stagnalis*	*H. fusca*	*T. rude*	*P. hollensis*	*P. parasitica*	*P. rugosa*	*I. alba*	*I. punctata*	*P. milneri*	*M. decora*	*H. grandis*	*H. marmorata*	*E. punctata*	*D. parva*	*D. fervida*	*N. obscura*
26	Schoolhouse L. T47N, R27W, S23	9/ 5/62 10/ 5/65	7.3	57		10		1		2										3	
27	Ogden Lake T47N, R27W, S13	9/ 5/63 10/ 5/65	7.1	47	4	3												3		1	
28	Fish Lake T47N, R29W, S5	9/ 8/63		50		3	3											3	1		
29	Bacon Lake T47N, R27W, S3	9/ 8/63		70												1				1	
30	Morgan Creek T48N, R26W, S26	9/14/63	7.6	90	1	8															
31	Ramseth Pond T48N, R25W, S20	9/14/63 7/17/64 5/ 8/64	7.6	85						1					3	1			1	1	1
32	Pond near Humboldt T48N, R28W, S31	9/15/63		61		1				1									5		2

Table A3 (cont'd.)

	Stations	Dates	pH	Total Alkalinity (ppm $CaCO_3$)	*G. complanata*	*H. stagnalis*	*H. fusca*	*T. rude*	*P. hollensis*	*P. parasitica*	*P. rugosa*	*I. alba*	*I. punctata*	*P. milneri*	*M. decora*	*H. grandis*	*H. marmorata*	*E. punctata*	*D. parva*	*D. fervida*	*N. obscura*
33	Lake Superior	9/25/63	8.1	75										1		2					
	T48N, R25W, S23	5/ 5/66																			
34	Mountain Lake	9/28/63	6.9	55	1					1								1	4		7
	T52N, R28W, S31																				
35	Pine Lake	9/28/63	6.9	65		2														1	
	T52N, R28W, S21																				
36	Goose Lake	1/ 2/64										12	14								
	T47N, R26W, S15	1/25/64																			
		2/15/64																			
37	Rod & Gun Club Pond																1	1			2
	T48N, R25W, S2	5/ 5/64																			
38	Wetmore Pond	5/16/64								1											
	T49N, R26W, S31																				
39	West Branch Creek										2										
	T46N, R28W, S20	6/28/64																			

Table A3 (cont'd.)

	Stations	Dates	pH	Total Alkalinity (ppm $CaCO_3$)	G. complanata	H. stagnalis	H. fusca	T. rude	P. hollensis	P. parasitica	P. rugosa	I. alba	I. punctata	P. milneri	M. decora	H. grandis	H. marmorata	E. punctata	D. parva	D. fervida	N. obscura
40	Tourist Park Pond T48N, R25W, S10	6/29/64									1										
41	Dead River T49N, R25W, S9	7/ 7/64 9/16/65	7.2	77		8										1	2		1		
42	Mine Shaft Pond T47N, R27W, S10	7/ 5/64														12					
43	Carp River T48N, R26W, S29	7/ 8/64	7.9	90						1								1			
44	Dishno Creek T49N, R29W, S29	8/ 2/64								2											
45	Arfelin Lake T49N, R30W, S21	8/ 2/64																4			
46	Deer Lake T48N, R27W, S29	8/ 4/64	7.8	95	1	20														10	
47	Barnhardt Creek T48N, R28W, S1	8/ 4/64	7.0	52							3					7	1		10		

Table A3 (cont'd.)

	Stations	Dates	pH	Total Alkalinity (ppm $CaCO_3$)	G. complanata	H. stagnalis	H. fusca	T. rude	P. hollensis	P. parasitica	P. rugosa	L. alba	I. punctata	P. milneri	M. decora	H. grandis	H. marmorata	E. punctata	D. parva	D. fervida	N. obscura
48	Goldmine Creek T48N, R27W, S29	8/ 4/64	7.7	140	1														3		
49	Middle Isle Point Bog T48N, R25W, S4	9/ 5/65	7.3	80	2	6												1			
50	Chocolay River T47N, R24W, S6	11/ 4/65		95													1			1	

Table A4. Barry County Stations, Their Location, Dates Sampled, Chemistry, Species, and Number Collected.

	Stations	Dates	pH	Total Alkalinity (ppm $CaCO_3$)	*Glossiphonia complanata*	*Helobdella stagnalis*	*Helobdella fusca*	*Placobdella parasitica*	*Placobdella rugosa*	*Haemopis marmorata*	*Philobdella gracilis*	*Erpobdella punctata*	*Dina parva*
1	Otis Lake T3N, R10W, S30	7/ 1/63 6/20/65 7/26/65	7.0	70	1		2	6	3	1	8	5	
2	Pleasant Lake T1N, R9W, S8	6/22/63	7.5	45				25					
3	Crooked Lake T1N, R10W, S1	6/29/63 7/22/65	8.5	115		8	1	1				7	2
4	Lawrence Lake T1N, R9W, S27	6/29/63 7/13/65	8.0	195				1	1				
5	Purdy Lake T1N, R9W, S36	7/ 6/65 7/18/65	5.9	25	7			2					
6	Strewins Lake T1N, R9W, S36	7/22/65	6.8	35				1					

Table A5. Kalamazoo County Stations, Their Location, Dates Sampled, Chemistry, Species and Number Collected.

	Stations	Dates	pH	Total Alkalinity (ppm $CaCO_3$)	*Glossiphonia complanata*	*Helobdella stagnalis*	*Helobdella fusca*	*Placobdella parasitica*	*Placobdella rugosa*	*Macrobdella decora*	*Erpobdella punctata*	*Dina fervida*
1	Gull Lake T1S, R9W, S7	6/19/63 7/23/65	8.1	177	5	1		2	1		2	1
2	Augusta Creek T1S, R9W, S27	6/20/63						9				
3	Kalamazoo River T2S, R10W, S23	7/27/65	7.0	200		1	12				5	
4	Wintergreen Lake T1S, R9W, S8	4/10/65 4/20/65 7/20/65	9.3	127				2			1	
5	Gull Lake Creek T2S, R9W, S7	7/29/65 7/30/65	7.9	200	3	17		6			12	
6	Marl Pond T1S, R9W, S6	7/14/63	8.5	250				1		1		

Table A6. Habitats Compared in Regard to Total Alkalinity.

A. Intermediate Standing Waters (18-59 ppm. $CaCO_3$)

Habitat	ppm.
Waldo Pond	23
Howe Lake	24
Redberry Pond	24
Rush Lake	29
Tilden Lake	30
Strewins Lake	35
Ogden Lake	47
Sauxhead Lake	48
Fish Lake	50
Boston Lake	55
Mountain Lake	55
Schoolhouse Lake	57

B. Hard Standing Waters (60-99 ppm. $CaCO_3$)

Habitat	ppm.
Harlow Lake	60
Horseshoe Pond	62
Cooper Lake	65
Independence Lake	65
Pine Lake	65
Bacon Lake	70
Otis Lake	70
Teal Lake	74
Middle Island Point Bog	80
Ramseth Pond	85
Bancroft Lake	95
Deer Lake	95

C. Hard Standing Waters (100-250 ppm. $CaCO_3$)

Habitat	ppm.
Bagdad Pond	105
Crooked Lake	115
Wintergreen Lake	127
Gull Lake	177
Lawrence Lake	195
Marl Pond	250

Table A7. Total Alkalinity Mean, Standard Deviation and Range for Eleven Species of Leeches. Both Lentic and Lotic Waters Considered.

Species	No. of Samples	Mean	σ	Range (ppm. $CaCO_3$)
Glossiphonia complanata	16	88	47.5	24-200
Helobdella stagnalis	16	96	50.0	47-200
Placobdella parasitica	21	93	63.8	24-250
Placobdella rugosa	7	89	62.7	23-195
Macrobdella decora	7	88	71.1	23-250
Haemopis grandis	8	64	25.5	24-105
Haemopis marmorata	10	61	23.8	13- 95
Erpobdella punctata	20	83	52.4	23-200
Dina parva	10	73	31.8	24-140
Dina fervida	13	74	37.2	23-177
Nephelopsis obscura	7	61	15.2	29- 80

Table A8. Waters Tested and Their pH.

Station	pH	Station	pH
Cranberry Bog	4.5	Rush Lake	7.3
Purdy Lake	5.9	Sauxhead Lake	7.3
Strewins Lake	6.8	Redberry Pond	7.4
Mountain Lake	6.9	Morgan Creek	7.6
Pine Lake	6.9	Ramseth Pond	7.6
Tilden Lake	6.9	Independence Lake	7.6
Otis Lake	7.0	Goldmine Creek	7.7
Kalamazoo River	7.0	Bancroft Lake	7.7
Barnhardt Creek	7.0	Cooper Lake	7.7
Horseshoe Pond	7.0	Deer Lake	7.8
Park Cemetery Pond	7.0	Gull Lake Creek	7.9
Ogden Lake	7.1	Carp River	7.9
Howe Lake	7.1	Lawrence Lake	8.0
Dead River	7.2	Gull Lake	8.1
Middle Island Point Bog	7.3	Lake Superior	8.1
Bagdad Pond	7.3	Teal Lake	8.5
Waldo Pond	7.3	Marl Pond	8.5
Harlow Lake	7.3	Crooked Lake	8.5
Schoolhouse Lake	7.3	Wintergreen Lake	9.3

Table A9. pH Mean, Standard Deviation and Range for Eleven Species of Leeches. Both Lentic and Lotic Waters Considered.

Species	No. of Samples	Mean	σ	Range
Glossiphonia complanata	17	7.4	.635	5.9-8.5
Helobdella stagnalis	13	7.6	.520	6.9-8.5
Placobdella parasitica	20	7.6	.714	5.9-9.3
Placobdella rugosa	9	7.4	.413	6.9-8.1
Macrobdella decora	7	7.5	.497	6.9-8.5
Haemopis grandis	7	7.0	1.076	4.5-8.1
Haemopis marmorata	9	7.4	.453	6.9-8.5
Erpobdella punctata	19	7.4	.934	4.5-9.3
Dina parva	8	7.5	.685	6.5-8.5
Dina fervida	11	7.5	.488	6.9-8.5
Nephelopsis obscura	6	7.0	2.968	4.5-8.5

Table A10. The Occurrence of Eleven Species of Leeches Along Various Bottoms.

Bottoms / No. of Sites	Sand (1)	Sand, Detritus (8)	Sand, Bedrock (1)	Sand, Rubble (10)	Sand, Rubble, Detritus (6)	Sand, Rubble, Boulders (1)	Sand, Gravel, Detritus (3)	Sand, Gravel, Boulders (1)	Clay (1)	Clay, Detritus (2)	Fibrous peat, Pulpy peat (1)	Fibrous peat, Detritus (2)	Pulpy peat, Detritus (4)	Muck (2)	Muck, Detritus (7)
Glossiphonia complanata	0	0	1	3	2	0	0	0	0	0	0	1	3	0	4
Helobdella stagnalis	0	3	1	3	0	0	1	0	0	0	0	0	2	0	2
Placobdella parasitica	0	2	0	2	3	0	1	0	0	0	0	1	2	0	2
Placobdella rugosa	0	2	0	3	0	0	1	0	0	0	0	1	0	0	1
Haemopis grandis	0	1	0	2	0	1	0	0	1	0	1	1	0	0	2
Haemopis marmorata	0	2	1	2	2	0	1	1	0	0	0	0	0	1	1
Macrobdella decora	0	0	1	2	0	0	0	0	0	0	0	0	1	0	2
Erpobdella punctata	0	3	1	1	4	0	3	0	0	0	1	0	4	0	1
Dina fervida	0	2	1	2	2	0	0	0	0	1	0	0	2	0	2
Dina parva	0	1	1	3	1	0	1	0	0	0	0	0	0	1	1
Nephelopsis obscura	0	1	1	0	2	0	0	0	0	1	1	0	0	0	3