

MISCELLANEOUS PUBLICATIONS
MUSEUM OF ZOOLOGY, UNIVERSITY OF MICHIGAN NO. 43

AQUATIC MOLLUSKS OF THE
UPPER PENINSULA OF
MICHIGAN

BY
CALVIN GOODRICH and HENRY VAN DER SCHALIE

ANN ARBOR
UNIVERSITY OF MICHIGAN PRESS
DECEMBER 13, 1939

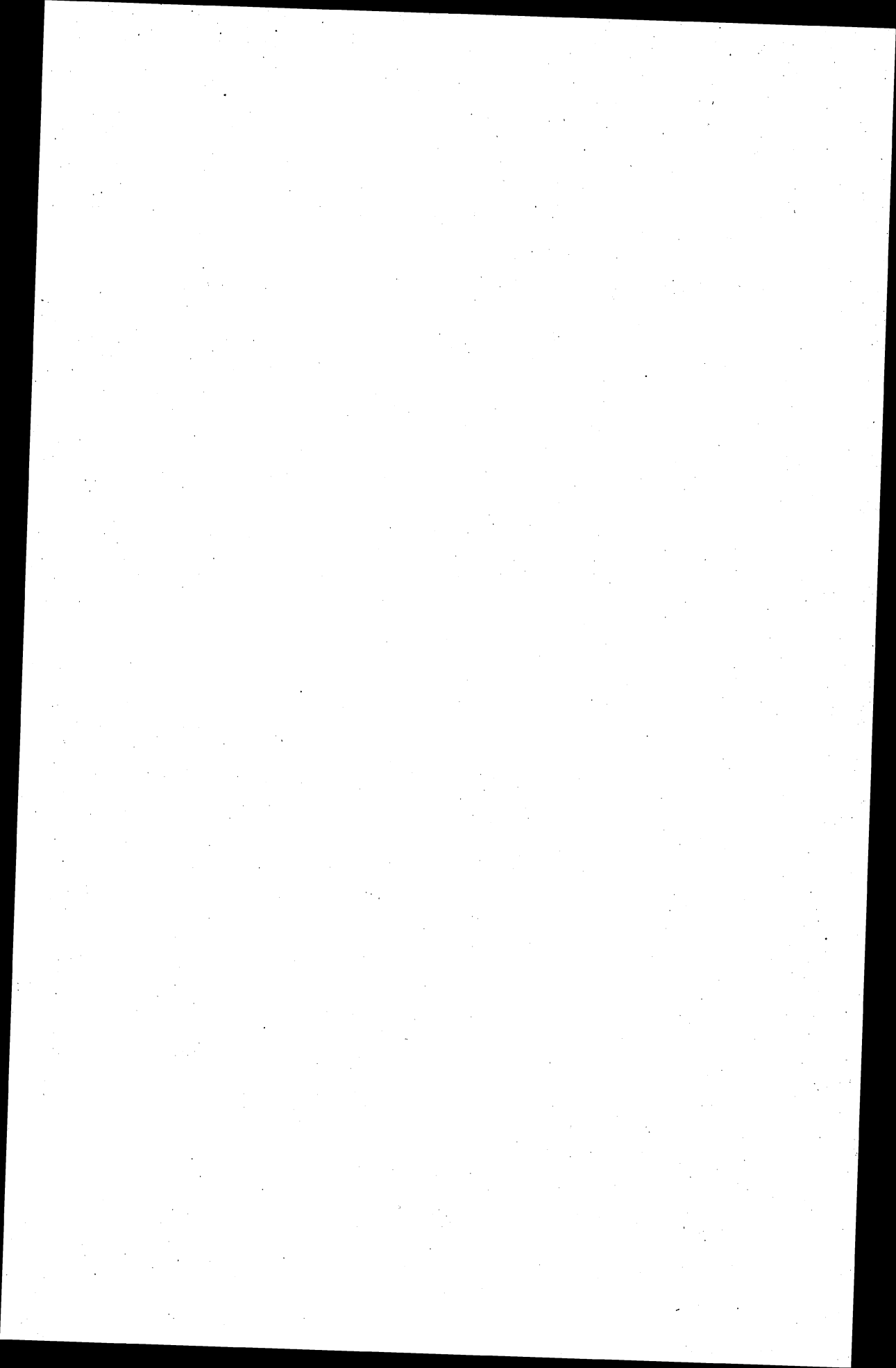
**PRICE LIST OF THE MISCELLANEOUS PUBLICATIONS
OF THE MUSEUM OF ZOOLOGY, UNIVERSITY OF MICHIGAN**

Address inquiries to the Director of the Museum of Zoology, Ann Arbor, Michigan.

Bound in Paper

No. 1.	Directions for Collecting and Preserving Specimens of Dragonflies for Museum Purposes. By E. B. WILLIAMSON. (1916) Pp. 15, 3 figures	\$0.25
No. 2.	An Annotated List of the Odonata of Indiana. By E. B. WILLIAMSON. (1917) Pp. 12, 1 map	\$0.25
No. 3.	A Collecting Trip to Colombia, South America. By E. B. WILLIAMSON. (1918) Pp. 24. (<i>Out of print</i>)	
No. 4.	Contributions to the Botany of Michigan. By C. K. DODGE. (1918) Pp. 14	\$0.25
No. 5.	Contributions to the Botany of Michigan, II. By C. K. DODGE. (1918) Pp. 44, 1 map	\$0.45
No. 6.	A Synopsis of the Classification of the Freshwater Mollusca of North America, North of Mexico, and a Catalogue of the More Recently Described Species, with Notes. By BRYANT WALKER. (1918) Pp. 213, 1 plate, 223 figures	\$3.00
No. 7.	The Anculosae of the Alabama River Drainage. By CALVIN GOODRICH. (1922) Pp. 57, 3 plates	\$0.75
No. 8.	The Amphibians and Reptiles of the Sierra Nevada de Santa Marta, Colombia. By ALEXANDER G. RUTHEVEN. (1922) Pp. 69, 13 plates, 2 figures, 1 map	\$1.00
No. 9.	Notes on American Species of Triacanthogyna and Gynacantha. By E. B. WILLIAMSON. (1923) Pp. 67, 7 plates. (<i>Out of print</i>)	
No. 10.	A Preliminary Survey of the Bird Life of North Dakota. By NORMAN A. WOOD. (1923) Pp. 85, 6 plates, 1 map. (<i>Out of print</i>)	
No. 11.	Notes on the Genus Erythemis, with a Description of a New Species (Odonata). By E. B. WILLIAMSON. The Phylogeny and the Distribution of the Genus Erythemis (Odonata). By CLARENCE HAMILTON KENNEDY. (1923) Pp. 21, 1 plate. (<i>Out of print</i>)	
No. 12.	The Genus Gyrotoma. By CALVIN GOODRICH. (1924) Pp. 29, 2 plates	\$0.50
No. 13.	Studies of the Fishes of the Order Cyprinodontes. By CARL L. HUBBS. (1924) Pp. 23, 4 plates	\$0.50
No. 14.	The Genus Perilestes (Odonata). By E. B. WILLIAMSON AND J. H. WILLIAMSON. (1924) Pp. 36, 1 plate. (<i>Out of print</i>)	
No. 15.	A Check-list of the Fishes of the Great Lakes and Tributary Waters, with Nomenclatorial Notes and Analytical Keys. By CARL L. HUBBS. (1926) Pp. 77, 4 plates. (<i>Out of print</i>)	
No. 16.	Studies of the Fishes of the Order Cyprinodontes. VI. By CARL L. HUBBS. (1926) Pp. 79, 4 plates	\$0.75
No. 17.	The Structure and Growth of the Scales of Fishes in Relation to the Interpretation of their Life-History, with Special Reference to the Sunfish Eupomotis gibbosus. By CHARLES W. CREASER. (1926) Pp. 80, 1 plate, 12 figures	\$2.00
No. 18.	The Terrestrial Shell-bearing Mollusca of Alabama. By BRYANT WALKER. (1928) Pp. 180, 277 figures	\$1.50
No. 19.	The Life History of the Toucan Ramphastos brevicarinatus. By JOSELYN VAN TYNE. (1929) Pp. 43, 8 plates, 1 map	\$0.75
No. 20.	Materials for a Revision of the Catostomid Fishes of Eastern North America. By CARL L. HUBBS. (1930) Pp. 47, 1 plate	\$0.75

(*Continued on inside back cover*)



ADVERTISEMENT

The publications of the Museum of Zoology, University of Michigan, consist of two series—the Occasional Papers and the Miscellaneous Publications. Both series were founded by Dr. Bryant Walker, Mr. Bradshaw H. Swales, and Dr. W. W. Newcomb.

The Occasional Papers, publication of which was begun in 1913, serve as a medium for original studies based principally upon the collections in the Museum. The papers are issued separately to libraries and specialists, and, when a sufficient number of pages have been printed to make a volume, a title page, tables of contents, and index are supplied to libraries and individuals on the mailing list for the entire series.

The Miscellaneous Publications, which include papers on field and museum techniques, monographic studies, and other contributions not within the scope of the Occasional Papers, are published separately, and, as it is not intended that they will be grouped into volumes, each number has a title page, and, when necessary, a table of contents.

FREDERICK M. GAIGE
Director of the Museum of Zoology

MISCELLANEOUS PUBLICATIONS
MUSEUM OF ZOOLOGY, UNIVERSITY OF MICHIGAN NO. 43

AQUATIC MOLLUSKS OF THE
UPPER PENINSULA OF
MICHIGAN

BY
CALVIN GOODRICH and HENRY VAN DER SCHALIE

ANN ARBOR
UNIVERSITY OF MICHIGAN PRESS
DECEMBER 13, 1939



CONTENTS

	PAGE
PART I. THE GASTROPODS AND THE SPHAERIDAE	7
PART II. THE NAIADES (FRESH-WATER MUSSELS)	35

AQUATIC MOLLUSKS OF THE UPPER PENINSULA OF MICHIGAN

PART I. THE GASTROPODS AND THE SPHAERIIDAE

CALVIN GOODRICH

DR. John N. Lowe, Associate Professor of Biology of the Northern State Teachers College at Marquette, Michigan, sent his accumulations of mollusks to the Museum of Zoology, University of Michigan, shortly before his death in July, 1938. These collections had been made in the course of several years of fisheries studies covering the Upper Peninsula of the state. They proved on examination to consist of two distinct classes, one class representing merely chance takings and the other a search and seeking for mollusks. These were taken during an examination of streams and lakes of Menominee County to which the summer of 1927 was devoted. In this work, habitat notes were taken—sometimes *in extenso*, sometimes in the form of hasty jottings that, evidently, were meant to be helped out from memory. Though Dr. Lowe's interest was in aquatic life, he did occasionally collect terrestrial shells. These make up about 1 per cent of the collections. They will be dealt with in a forthcoming paper concerned with all the land mollusks of Michigan.

The helpfulness of the Lowe collections lies in the distributional data that they supply more than in anything else. The problem of distribution, which once seemed fairly simple, has become complicated by questions of ecology. A species is not in a given spot merely because it succeeded in reaching there from some other spot. It is there because the physical conditions permit of existence, the chemistry of water or soil is the one to which the organism is suited, climate can be conformed to, reproduction is encouraged, and so on. In short, the final report on distribution will take innumerable factors into consideration. That cannot come short of many years of study and observation.

It has been known since comparatively early days that the Grand-Saginaw Valley acted as a barrier to the distribution of molluscan life in Michigan. This is to say that more species occur within and below it than above it. The statement requires a certain amount of modification inasmuch as there is a northward intrusion into Muskegon River, the mouth of which is not far north of the mouth of Grand River. The barrier, because of the lumber industry, probably is more sharply defined now than once it was. The industry affected the molluscan life by fire, sawdust, and rafting. Products of combustion that were washed into streams must at times have made the waters so alkaline that virtually all aquatic life was destroyed. A second recognizable barrier is the Strait of Mackinac. Yet how much of a barrier it is is still undetermined. Clearly, certain mollusks are shut off in their dispersal

by deep waters while others are not. There remains the further question of the effect of Lake Superior upon distribution—the degree to which relatively low temperatures, strong wave action, a small percentage of phytoplankton organisms serving as food, and long stretches of exposed and sandy shores act as barriers. Part of the faunistic reinvasion of north Michigan has been through Wisconsin from the Mississippi and, again, along the shallows of the western side of Lake Michigan. This will be dealt with in detail in the second part of this paper. In two small areas, the Upper Peninsula is within the drainage basin of the Mississippi River. There is no indication so far that crossings have occurred at these points from the Mississippi into the watershed of Lake Superior.

From a mass of ecological observations, L. E. Dice (1938) has defined a life zone for mammals which he terms the Canadian Biotic Province. The zone is of irregular shape, extending from the Maritime Provinces of Canada to the northwest corner of Minnesota. The south line cuts across Michigan along part of the Saginaw-Grand Valley, and a little to the north of Lake Erie in Ontario. All of New York, nearly all of New England, and a part of Pennsylvania are within the belt. The Canadian Biotic Province, so defined, is of peculiar interest to students of aquatic mollusca because it is the area in which the genera *Lymnaea* and *Physa* have reached their greatest development in North America, in which *Helisoma* has evolved subspecies of pronounced characteristics, and in which *Valvata* and *Amnicola* seem best to flourish. Several of the aquatic gastropods of the Upper Peninsula of Michigan are of the same species as those of Maine whose names have been compiled by N. W. Lermond (1908). Through the eastern part of the zone, the coastal plain naiad *Elliptio complanatus* reached northern waters of the Great Lakes (Walker, 1913).

Environmental factors that may have a bearing on the numbers of any one species of mollusks in a given place are suggested by certain papers on the fishes of lakes of northeastern Wisconsin. Hile and Deason (1934) found that “the white-fish of Trout Lake . . . shows the slowest growth yet recorded for any North American population of that species. This slow growth is probably the result of the great density of the fish population, particularly of the lake herring, in the hypolimnion of the lake. The crowding may impede growth through the creation of intense competition for food or through the operation of a ‘space factor.’” By “space factor” is meant crowding that checks growth without regard to the effect that crowding may have on a population’s food supplies. Hile (1936), after a study of the cisco in four lakes, came to the conclusion that growth rate was not affected by differences in temperature and that the same thing was true of differences in oxygen conditions. However, “the abundance of bound CO₂ and the closely related hydrogen-ion concentration and conductivity” do have a correlation with

growth rate, even though it be indirect. Not only may the growth of mollusks be governed by the same or a similar environmental influence, but the actual occurrence of mollusks, in small or in large numbers, or their absence may likewise be determined. The discontinuous distribution of shell life, almost spectacular within a very small area, is evidence that environment is a ruling power over dispersal and not the mere chance or accidental entrance into a locality by fecund individuals.

The following aquatic species and subspecies which have been found by F. C. Baker (1928) in Wisconsin, in fairly close proximity to the boundary line of the Upper Peninsula of Michigan, have not been seen in the peninsula :

<i>Lymnaea emarginata canadensis</i>	<i>Physa integra billingsi</i>
<i>Lymnaea emarginata vilasensis</i>	<i>Physa obrussoides</i>
<i>Lymnaea emarginata wisconsinensis</i>	<i>Ferrissia fusca</i>
<i>Lymnaea exilis</i>	<i>Ferrissia kirklandi</i>
<i>Lymnaea palustris elodes</i>	<i>Ferrissia shimckii</i>
<i>Lymnaea umbrosa</i>	<i>Valvata lewisii helicoidea</i>
<i>Lymnaea winnebagoensis</i>	<i>Valvata tricarinata basalis</i>
<i>Helisoma antrosom cahni</i>	<i>Valvata tricarinata mediocarinata</i>
<i>Helisoma antrosom sayi</i>	<i>Valvata winnebagoensis</i>
<i>Helisoma pseudotrivolvis</i>	<i>Lioplax subcarinata wisconsinensis</i>
<i>Helisoma trivolvis winstowi</i>	
<i>Gyraulus circumstriatus</i>	

Campeloma and the families Amnicolidae and Sphaeriidae have been ignored in this comparison because of disagreement as to specific designations. It is possible that some of the forms of the Baker list are among collections of the Upper Peninsula, but under other names. To the compilation can be added four species and a subspecies that were found in north Wisconsin by J. P. E. Morrison (1932) :

<i>Lymnaea columella</i>	<i>Gyraulus arcticus</i>
<i>Lymnaea haldemani</i>	<i>Physa laphami</i>
<i>Helisoma campanulatum ferrissi</i>	

The peculiar *Lymnaea haldemani* has been taken on Manitoulin Island, Ontario, at the head of Georgian Bay of Lake Huron. A Morrison locality in Wisconsin is in the basin of Lake Superior. The Michigan Upper Peninsula lies on a nearly east and west line between the two localities, and so probably contains the species.

For purposes of comparison, lists of the mollusca of Dickinson and Menominee counties are brought together (Table I). Dickinson County lies wholly in the drainage basin of Lake Michigan, the southern border abutting on Menominee River. Collecting was carried out by H. Burrington Baker, mostly as a habitat study (1922). Lakes, ponds, swamps, springs, brooks, creeks, and rivers were visited. A small part of the differences in the findings

of gastropods as between the two counties is due to differences of determination, some is due to the fact that penetration of the molluscan fauna of Lake Michigan has not been as deep in Dickinson County as in Menominee County. It is true also that Menominee County has not received as thorough a combing for mollusca as has a part of Dickinson County.

TABLE I

	Dickinson Co.	Menominee Co.
<i>Succinea retusa</i>	×	×
<i>Lymnaea stagnalis appressa</i>	×	×
<i>Lymnaea megasoma</i>	×	×
<i>Lymnaea caperata</i>	×
<i>Lymnaea catascopium</i>	×
<i>Lymnaea humilis</i>	×
<i>Lymnaea humilis modicella</i>	×	×
<i>Lymnaea kirtlandiana</i>	×
<i>Lymnaea lanceata</i>	×
<i>Lymnaea obrussa decampi</i>	×	×
<i>Lymnaea obrussa exigua</i>	×
<i>Lymnaea obrussa peninsulae</i>	×
<i>Lymnaea palustris</i>	×
<i>Helisoma antrosom</i>	×	×
<i>Helisoma antrosom striatum</i>	×
<i>Helisoma campanulatum</i>	×	×
<i>Helisoma campanulatum minor</i>	×
<i>Helisoma campanulatum rudentis</i>	×
<i>Helisoma trivolvis</i>	×	×
<i>Gyraulus deflectus</i>	×
<i>Gyraulus hirsutus</i>	×	×
<i>Gyraulus parvus</i>	×	×
<i>Gyraulus umbilicatellus</i>	×
<i>Menetus exacuus</i>	×
<i>Planorbula armigera</i>	×	×
<i>Physa ancillaria</i>
<i>Physa ancillaria vinosa</i>	×
<i>Physa elliptica</i>	×
<i>Physa gyrina</i>	×	×
<i>Physa heterostropha</i>
<i>Physa integra</i>	×	×
<i>Physa michiganensis</i>	×
<i>Physa sayii</i>	×	×
<i>Physa walkeri</i>
<i>Aplexa hypnorum</i>	×
<i>Ferrissia parallela</i>	×
<i>Ferrissia tarda</i>	×
<i>Campeloma decisum</i>	×	×
<i>Valvata sincera</i>	×
<i>Valvata sincera nylanderii</i>	×	×
<i>Valvata tricarinata</i>	×	×
<i>Valvata tricarinata confusa</i>	×
<i>Valvata tricarinata simplex</i>
<i>Valvata tricarinata unicarinata</i>	×
<i>Amnicola limosa</i>	×
<i>Amnicola limosa porata</i>	×
<i>Amnicola lustrica</i>	×
<i>Amnicola walkeri</i>
<i>Pleurocera acuta</i>	×
<i>Goniobasis livescens</i>	×

Table II is a comparison of the Sphaeriidae of Dickinson and Menominee counties. Baker's Dickinson County material was determined by Victor Sterki. The distinctions drawn by Sterki appear to be based on minute variations of shell characters without allowance for environmental modifications.

TABLE II

	Dickinson Co.	Menominee Co.
<i>Sphaerium accuminatum</i>	×	×
<i>Sphaerium occidentale</i>	×	×
<i>Sphaerium ohioense</i>	×	×
<i>Sphaerium rhomboideum</i>	×	×
<i>Sphaerium solidulum</i>	×	×
<i>Sphaerium stamineum</i>	×
<i>Sphaerium striatinum</i>	×	×
<i>Sphaerium sulcatum</i>	×	×
<i>Musculium pusillum</i>	×
<i>Musculium rosaceum</i>	×
<i>Musculium ryckholti</i>	×
<i>Musculium securis</i>	×	×
<i>Musculium truncatum</i>	×	×
<i>Pisidium abditum</i>	×	×
<i>Pisidium affine</i>	×
<i>Pisidium ambiguum</i>	×
<i>Pisidium compressum</i>	×	×
<i>Pisidium compressum laevigatum</i>	×
<i>Pisidium medianum</i>	×
<i>Pisidium noveboracense</i>	×
<i>Pisidium pauperculum</i>	×
<i>Pisidium pauperculum crystalense</i>	×
<i>Pisidium pauperculum nylanderi</i>	×
<i>Pisidium peraltum</i>	×
<i>Pisidium punctatum simplex</i>	×
<i>Pisidium roperi</i>	×
<i>Pisidium sargenti</i>	×
<i>Pisidium splendidulum</i>	×
<i>Pisidium tenuissimum</i>	×
<i>Pisidium variabile</i>	×	×
<i>Pisidium variabile brevis</i>	×
<i>Pisidium vesiculare</i>	×

Dr. Phil L. Marsh has compiled a list of molluscan species which he has collected on the eastern border of Chippewa County. Most of the shells were taken on Drummond Island:

- | | |
|--|-----------------------------------|
| <i>Lymnaea stagnalis appressa</i> | <i>Helisoma antrosom</i> |
| <i>Lymnaea stagnalis sanctaemariae</i> | <i>Helisoma campanulatum</i> |
| <i>Lymnaea megasoma</i> | <i>Helisoma trivolvis</i> |
| <i>Lymnaea dalli</i> | <i>Helisoma trivolvis binneyi</i> |
| <i>Lymnaea emarginata</i> | <i>Gyraulus deflectus</i> |
| <i>Lymnaea humilis modicella</i> | <i>Gyraulus hirsutus</i> |
| <i>Lymnaea lanceata</i> | <i>Gyraulus parvus</i> |
| <i>Lymnaea obrussa peninsulæ</i> | <i>Gyraulus parvus walkeri</i> |
| <i>Lymnaea palustris</i> | <i>Gyraulus umbilicatellus</i> |

<i>Planorbula armigera</i>	<i>Sphaerium crassum</i>
<i>Physa ancillaria vinosa</i>	<i>Sphaerium fallax</i>
<i>Physa elliptica</i>	<i>Sphaerium occidentale</i>
<i>Physa gyrina hildrethiana</i>	<i>Sphaerium rhomboideum</i>
<i>Physa heterostropha</i>	<i>Sphaerium striatinum</i>
<i>Physa integra</i>	<i>Sphaerium sulcatum</i>
<i>Physa michiganensis</i>	<i>Sphaerium sulcatum planulatum</i>
<i>Physa sayii</i>	<i>Musculium declive</i>
<i>Aplexa hypnorum</i>	<i>Musculium securis</i>
<i>Campeloma decisum</i>	<i>Musculium truncatum</i>
<i>Campeloma integrum</i>	<i>Pisidium abditum</i>
<i>Valvata sincera nylanderi</i>	<i>Pisidium adamsi affine</i>
<i>Valvata tricarinata</i>	<i>Pisidium canadense</i>
<i>Valvata tricarinata perconfusa</i>	<i>Pisidium compressum</i>
<i>Amnicola integra</i>	<i>Pisidium compressum laevigatum</i>
<i>Amnicola limosa</i>	<i>Pisidium fallax</i>
<i>Amnicola lustrica</i>	<i>Pisidium sargenti</i>
<i>Amnicola walkeri</i>	<i>Pisidium scutellatum</i>
<i>Pomatiopsis lapidaria</i>	<i>Pisidium superius</i>
<i>Goniobasis livescens</i>	<i>Pisidium variabile brevius</i>
<i>Sphaerium abruptum</i>	<i>Pisidium virginicum</i>

Lymnaea stagnalis appressa (Say)

The first example of this subspecies that came to Say's attention was collected by Henry Schoolcraft in Lake Superior, presumably near Sault Ste Marie, where Schoolcraft was located as Indian agent. The incident is somewhat curious since this mollusk occurs relatively near Philadelphia, where Say lived in the early 1800's, when he wrote his description, and the lakes country was so remote that members of the lighthouse service at Washington took the phrase "inland seas" to mean salt water. *L. s. appressa* was found by Lowe in one river, one creek, and four lakes of Menominee County, and in two lakes of Schoolcraft County. Inasmuch as the shell once inhabited innumerable bodies of stagnant water in Michigan, the small collections made by Lowe may be taken to mean that the inroads of civilization have been nearly as destructive to the subspecies in the Upper Peninsula as they have been in the Lower. From Ford Lake, Blaney Park, Schoolcraft County, Lowe collected a specimen the spire of which is much twisted out of the perpendicular.

Lymnaea stagnalis perampla Walker

Of short spire and very much enlarged body whorl. Originally described as from Houghton Lake, Roscommon County. Gradations with the subspecies *appressa* occur in Douglas Lake, Cheboygan County. Only one lot was taken by Lowe. This was in Au Train Lake, Alger County. As seen in Houghton Lake, *perampla* lives in the shallow water of a shore exposed to westerly winds. The large body whorl, indicating a large foot, is probably

an ecological adaptation to a need for strong attachment to boulders and gravel.

Lymnaea palustris (Müller)

This circumboreal species is seemingly much more rare in the Upper Peninsula than is *lanceata* Gould, to which it is related. Five specimens were taken by Lowe in Duck Lake, Simmons, Mackinac County, and one at Gould City, the same county. The Walker collection contains specimens from Nathan, Menominee County.

Lymnaea lanceata Gould

The original lot of this species was collected by the Agassiz expedition of 1848 in Pie Lake, north shore of Lake Superior. It is a slender form, somewhat cylindrical, and has a flattish body whorl. The shell usually shows frequent rest periods that register short seasons of activity. This is a characteristic also of Lymnaeidae which occupy woods pools in the vicinity of Ann Arbor and sometimes go through months of aestivation and hibernation. In distribution, the species is credited to northern Ohio and southeastern Michigan, but its typical colonies are in the northern parts of Michigan, Wisconsin, and Ontario. One lot in the Museum of Zoology collection is from Lake Superior, the exact locality not given, but ordinarily the shell occupies swampy bayous of small lakes, mucky ponds, and the stagnant parts of streams. In two of four places of Little River, Menominee County, where Lowe found *lanceata* the water was, in one instance, swift, of moderate current in the other—the bottom in both places being mucky. Shells taken in Kelly Creek, Menominee County, were in bog-stained water, the bottom muddy. The largest numbers were collected in Jones Pond and a cemetery pond, Marquette. Lowe also took the shell in Independence Lake, Marquette County, and Pelky Lake, Blaney Park, Schoolcraft County.

Lymnaea emarginata angulata (Sowerby)

Lowe's localities for this subspecies are Rapid River, Delta County; Gulliver's Lake, Mackinac County; Maitland Lake, Marquette County; and McDonald Lake, Schoolcraft County. The colonies in all four instances appear to have been large. The mollusk is a modification of *emarginata*, abundant in favorable localities of all northern Michigan. A wide aperture gives the body whorl a shouldered or angled appearance. The inference can be drawn from observation and studies of other mollusks that this is an ecological response rather than a genetic phenomenon.

Lymnaea walkeriana F. C. Baker

A globose species which has a very large body whorl. It appears to be the one lymnaeid which can withstand the heavy wave action of Lake

Superior. It was taken by Lowe in this lake at Little Presque Isle, Marquette County. Material somewhat less globose is from streams of Gogebic, Iron, Ontonagon, and Chippewa counties.

Lymnaea catascopium Say

This species is a common one in all the Great Lakes except Lake Superior. In Lowe's collections, the species is from four creeks of Menominee County, one of Delta County, and one of Mackinac County—all of them small streams emptying directly into Lake Michigan. *L. catascopium* of Schram's Creek, Mackinac County, is of the normal or typical form where it occurs in the middle parts of the stream, but dwarfed and scalariform in the headwaters.

Lymnaea caperata Say

One specimen only was taken by Lowe. This was in Little River, just below the mouth of Kelly Creek, Menominee County. As this is a species of pools, ponds, and small streams, the single individual was probably a drift specimen from near-by stagnant waters.

Lymnaea megasoma Say

This species, once fairly common in the upper parts of the Lower Peninsula of Michigan and throughout the Upper Peninsula, is becoming one of the conchological rarities of the state. The shell was abundant as recently as 1922 in marshes bordering Lake Huron in Mackinac County. It was absent when the place was revisited in 1936. The fact that summer residents of the area appeared to prefer the burnt stubble of reeds to the living plants and were using the shallows as a dumping ground for wastes probably had something to do with the extinction. Measurements of the collections made by Lowe are:

	Number of Specimens Measured	Number of Whorls	Average Size in mm.	
			Altitude	Diameter
Wagner Lake, Menominee Co.	13	5½-6	43.09	24.50
Deer Creek, Menominee Co.	1	5	36.00	19.50
Big Cedar River, Menominee Co.	1	6	42.50	23.50
Wilson Creek, Menominee Co.	5	5-6	34.75	24.85
Pratt's Lake, Marquette Co.	2	5	34.12	19.62

The largest specimen reported upon by F. C. Baker (1911) measured 47.00 mm. in altitude by 27.00 mm. in diameter.

The habitats for this species which were noted by Lowe varied from mucky, bog-stained, shallow water to "riffles; water three feet deep." A locality in which *L. megasoma* was unusually abundant in 1922 was Dog Lake, Mis-

sanabie, Ontario. Here the water in which the shells occurred was shallow, clear, and contained numbers of rounded glacial boulders. Vegetation was not plentiful.

Lymnaea humilis modicella (Say)

Three specimens taken in Walton River, Menominee County, appear to be of this species. The stream, as observed by Lowe, is "thirty feet wide; current moderate; full of lumber debris." When occurring in streams, this subspecies lives commonly on mud flats of either stagnant or slowly moving waters. The mollusk probably inhabited mud lakes and ponds which Lowe did not examine.

Lymnaea obrussa Say

A shell of muddy ponds and the mud flats of streams. Typical specimens are not common in the Upper Peninsula. The only place in which Lowe took the species in numbers was from an accumulation of subfossil mollusks in the bottom of Ford Lake, Blaney Park, Schoolcraft County. Smaller lots were: one specimen, outlet of Lake Mary, Dickinson County; two specimens, Puffy Creek, Delta County; eight specimens from the drift of Crow River, Mackinac County.

Lymnaea obrussa decampi (Streng)

In this subspecies the body whorl is very much shouldered, the aperture elliptical and often constricted. The shell appears to have been particularly common in Michigan in Pleistocene times, since it occurs in numbers in deposits of that period. Living specimens have been taken from a wave-washed pier of Lake Erie, and it is possible that the large body whorl, accommodating a large foot, is a response to such conditions. *L. o. decampi* was collected by Lowe in one creek of Menominee County, two lakes of Marquette County, and a lake of Alger County.

Lymnaea obrussa exigua (Lea)

This is a slender form, deeply sutured, that may be called scalariform, especially in northern colonies. It was taken by Lowe in eleven creeks, two brooks, and a river of Menominee County. In this last occurrence, only one specimen was collected, and it may have washed into the river from a small pool or stream. One was taken in a creek of Dickinson County. Other localities were a pond of Mackinac County, the drift of Crow River in the same county, and a creek of Marquette County. The cold water of streams of the Upper Peninsula and the short active period there for all mollusks may be influences determining the characteristics of *exigua*.

Helisoma antrosom (Conrad)

This species occurs in brooks, creeks, rivers, lakes, and ponds of the area in which Lowe collected. Naturally, the types of habitat of such a distribu-

tion varied extremely, but it could not be seen that there was anything like a corresponding variation in the mollusk. Except in the matter of size, the shells were quite uniform. The earliest specimens taken were collected in June in Menominee County. In these lots were numbers of individuals which had but recently added new shell material, which is to say that they had just put on new growth. As the season advanced, new-growth mollusks tended to disappear, and before the end of the collecting period all the mollusks had come to the rest period in which shell growth is suspended.

Helisoma antrosum percarinatum (Walker)

This was collected in Joe's Lake, Alger County, and Milakokia Lake, Mackinac County. In each case, the superior and basal carinae were elevated into the distinct keels to which Walker called attention.

Helisoma campanulatum (Say)

Not so generally distributed through the Upper Peninsula as *antrosum*. It does, however, appear to inhabit lakes that contain colonies of *antrosum*, although never in large numbers. Habitats that were noted by Lowe were:

- Little Shaky River, Menominee County....."bottom sand mixed with mud,
roils easily."
Lake Mary, Menominee County....."shallow, shaky."
Spring Lake, Menominee County "Water clear as crystal; chara,
yellow and white water lilies."

The majority of the specimens taken in Menominee County lacked varices indicating rests that represent hibernation. In other words, these 1927 shells were, apparently, of 1927 growth. The "belling" of the lip, a character which suggested the scientific name to Say, was not as prominent as in material seen from the Lower Peninsula.

Helisoma campanulatum minor (Dunker)

A single lot was taken by Lowe. This was in Perch Lake, Marquette County, July 7, 1928. The shells range in size from 8 mm. in diameter and 4 mm. in altitude to 10 mm. in diameter and 5.25 mm. in altitude. The whorls, which are from five and a half to six in number, rise above the plane of the shell and are crowded.

Helisoma trivolvis (Say)

Collections of this species, or its subspecies, were made in brooks, creeks, rivers, lakes, and ponds of Baraga, Iron, Mackinac, Marquette, Menominee, and Schoolcraft counties. The forms ranged from those that can be accepted as typical, being relatively low of altitude, to the large-whorled, frequently campanulate specimens which appear to correspond with *H. trivolvis pilsbryi*.

(F. C. Baker). Measurements were taken of shells from twenty-seven localities, the greatest height as well as the widest diameter. In the tables which follow, the specimens are uniformly of four whorls:

	Number of Specimens	Average Size in mm.	
		Diameter	Altitude
<i>Typical trivolvis</i>			
Little River, Menominee Co.	4	20.31	10.50
Birch Creek, Menominee Co.	4	21.81	10.25
Devil's Creek, Menominee Co.	3	24.00	11.75
Average of 11 specimens		23.04	10.83
<i>Apparently between typical trivolvis and subspecies pilsbryi</i>			
W. Br. Sturgeon River, Baraga Co.	4	21.25	11.56
Dead River, Marquette Co.	6	25.79	12.16
Outlet of Chip Lake, Schoolcraft Co....	8	23.34	10.87
Chip Lake, Schoolcraft Co.	6	23.24	11.58
Bear Creek, Schoolcraft Co.	2	23.50	12.00
Hay's Creek, Menominee Co.	4	22.93	11.31
Spruce Lake, Menominee Co.	6	22.37	10.50
Average of 36 specimens		23.20	11.42
<i>Subspecies pilsbryi</i>			
Mud Lake, Caspian, Iron Co.	8	26.84	11.56
Chocolay River, Marquette Co.	10	27.20	14.80
Wilson Creek, Menominee Co.	4	24.62	13.06
S. Br. Ford River, Menominee Co.	6	25.83	13.79
Average of 28 specimens		26.12	12.30

The difference between typical *trivolvis* and shells approaching *pilsbryi* is, obviously, simply one of altitude—the difference being slight. In *pilsbryi* of the table, both diameter and altitude are greater than in the other two instances. It is possible to work out an index of obesity by dividing the altitude by the diameter. Using the averages of the three groups, this is: typical *trivolvis*, 47.0; transition forms, 49.1; typical *pilsbryi*, 47.00.

It is clear that the distinction between typical *trivolvis* and typical *pilsbryi* is one simply of size of whorls, other factors being ignored. Or, put in another way, *pilsbryi* of four-whorl size is, first of all, a bigger shell than *trivolvis* of four-whorl size. That size alone represents a subspecific difference is very much open to question, at least among fresh-water mollusks. There is left, then, other distinctions upon which to establish subspecific rank. These involve the carina or keels, depth of umbilical region, the spacing of growth lines, and the flaring or nonflaring of the outer lip. Probably, only experi-

mental studies would show whether or not any one of these characters is a constant genetically or is subject to environmental modification.

Planorbula armigera (Say)

Taken by Lowe in Menominee and Cedar rivers, Kelly and Birch creeks, Menominee County; Crow River and Big Rock Pond, Mackinac County; Peltry Lake, Schoolcraft County. Only one of these localities appears to be a natural habitat, to judge by observations elsewhere. In the Lower Peninsula, for example, the mollusk has been found alive in woods pools, ditches, bogs, swamps, and other places of stagnant waters. The specimens usually are drift material when come upon elsewhere. *Planorbula* has the ability to lie dormant through long periods of the year. It has been known in some instances to have an active season of only a few weeks. Shells sent to Bryant Walker by Lowe from Bois Blanc Island, Mackinac County, were identified as *P. crassilabris* (Walker). In Michigan, this species is found most commonly in sandy areas where standing waters are not of long duration, and there is reason to suspect that the thickened aperture, the chief characteristic of *crassilabris*, is an environmental response, as it is also in the case of *Lymnaea palustris (michiganensis)* of the same districts.

Gyraulus deflectus (Say)

This species is an occupant of waters which often are choked with vegetation. It is not found living in rapids, on wave-beaten shores, or on sandy and rocky beaches. Collected by Lowe in Bat and Perch lakes, Marquette County, and in Joe's Lake, Alger County. Previous findings were in Dickinson, Baraga, Luce, Delta, and Marquette counties.

Gyraulus hirsutus (Gould)

The species appeared among collections made by Lowe in Mackinac, Marquette, Menominee, and Schoolcraft counties. The greatest number of individuals was separated from drift of the mouth of Crow River, Mackinac County. They may have come from a variety of habitats, most of them of stagnant water. Collections earlier than Lowe's were in Chippewa, Baraga, Houghton, Keweenaw, and Ontonagon counties.

Gyraulus parvus (Say)

Known previously from all the counties of the Upper Peninsula except Gogebic and Iron. Taken by Lowe in two creeks and a lake of Menominee County, one lake of Alger County, and one of Luce County. A common habitat for this small species is the underside of water lily leaves. *G. parvus* is probably the commonest mollusk of Pleistocene deposits of Michigan and occurs in numbers among the minute shells at the wave line of Great Lakes

beaches. This might be taken to point to very large populations, but it rather represents the power of currents and waves to bring small and light materials together.

Genus *Physa*

Thirteen species and four subspecies of *Physa* are listed in Miss Mina Winslow's compilation of the mollusca of Michigan, issued in 1926. Since then, three additional species have been credited to the state and a fourth has been found in the Bryant Walker collection. Also, there has been some rearrangement among the various forms. W. J. Clench, of the Museum of Comparative Zoology, has raised *P. gyrina elliptica* to specific rank, made *oneida* a subspecies of *sayii* and *vinosa* a subspecies of *ancillaria*.

Two of the species of the 1926 check list may be disposed of at once: *P. aplectoides* Sterki. The Michigan specimens under that name are small examples of *Aplexa hypnorum*. *P. deformis* Currier, type locality, Grand Rapids, Michigan, is identical with *elliptica*.

No general rules have been laid down as yet that are helpful toward a certain and confident determination of the species of *Physa*. Descriptions have mentioned whether the shells are large or small, of high or short spire. Usually, something is said of the thickness or thinness of the shells. The existence or nonexistence of a twist in the columella has been a point which impressed describers. The shape of the aperture has been remarked, and it has been noted if the aperture was feebly or conspicuously produced. At one time it was thought that the presence or absence of microscopic sculpture would permit the establishment of distinctions between at least two species. One author thought that the variceal lines or bands represented pauses in annual growth, and that by observing the number of such markings—whether they stood for one, two, or three years of life—true boundaries among species could be established. It is proposed to consider these various factors.

In the present study it was found that large shells occurred among small shells of the same colony, and that, to all appearances, the large specimens and the small were alike mature. In most instances, the mollusks of different sizes had the same number of whorls. Size alone, it was clear, would have to be ruled out in differentiating species. Thickness or thinness was of uncertain value because it might be explained as due either to age or to the chemistry of the waters. In the same lot shells with twisted columellae and shells with straight columellae were discovered. Also in any one lot might occur specimens that were shouldered and specimens that were not; shape of aperture was frequently correlated with the presence or absence of this character. The fine spiral lines, first observed in *P. gyrina*, were found to occur in young irrespective of species. Stream erosion could wear them away, and they can be removed artificially with an alkali of moderate strength. This sculpture is undependable as a means for distinguishing species. As for the varices, they are not annual thickenings, but simply such deposits as may be made

in any rest period; the number of rest periods may be several in the course of a year.

Minute differences in the anatomy of the Physidae have been pointed out. The assumption has been that these differences are of specific value. This is open to question. Methods of dissection vary with students. They vary in the same student, in time at least. Differences that are seasonal, as between the reproductive period and the nonreproductive, for example, are physiological rather than anatomical, and yet are apparently set down as anatomical. Certainly, so far as I can discover, they are not pointed out as physiological. A characteristic of the gross anatomy of *Physa* is the extensions of the mantle that are called digitations. Their number, shape, and whether or not they are lobed are recited as though these factors constituted specific distinctions. Nevertheless, they are known to vary as between individuals of the same colony. In this matter of anatomy, there is a want of careful comparisons in anything so far published on the subject. Very much the same thing can be said of the radulae. In certain American fresh-water groups, the Amnicolidae for illustration, the radula has developed strong individualism in each species. In other groups, such as the Pleuroceridae, it has not. Illustrations of the radulae of the Physidae suggest that with small changes, all of which may be noted among the members of the same colony, the type of radula is identical for all species.

Simply as a new approach, the attempt was made in this study to separate or group the Michigan physas according to their manner of whorl coiling. Shells were found to be:

1. Tightly coiled; that is, the new growth overlapped the old growth entirely above the periphery.
2. Moderately coiled; that is, the growth representing the body whorl was in contact with the periphery of the penultimate whorl.
3. Loosely coiled; that is, the new growth in its overlapping quickly fell below the periphery of the whorls of the old growth. This coiling was observable in at least three whorls which succeeded the protoconch.

Grouping was in this wise:

1. Tightly coiled:

ancillaria
parkeri
sayii
sayii crassa
sayii magnalacustris

2. Moderately coiled:

elliptica
sayii oneida
sayii vinosa

3. Loosely coiled:

gyrina
gyrina hildrethiana
integra
michiganensis
walkeri
warreniana

The grouping is not hard and fast. Modifications were found as between colonies and also among individuals of the same colony. *P. ancillaria* of the type locality, Delaware River, is tightly coiled consistently. New growth is at a marked angle to the old growth, and so the whorls might be spoken of as steep-roofed. This is not a feature of *P. sayii*, the sutures of which are deeply impressed. In this species, too, the whorls are sometimes moderately rather than tightly coiled, and occasional specimens are even loosely coiled. The same thing is somewhat less true of the subspecies *P. sayii crassa* and *s. magnalacustris*. A decided irregularity occurs in *P. ancillaria vinosa*, which ranges from tightly to loosely coiled. In regard to manner of coiling, *vinosa* appears to be in closer relationship with *P. sayii* than with *P. ancillaria*, and even to be near to *gyrina*.

Certain impressions have been formed from these examinations. They are here recited: *P. elliptica* is a modification of *P. gyrina*, and should be considered a subspecies. The *P. sayii oneida* credited to Michigan seems to be a depauperate race of *sayii* of less importance than a subspecies. It is of local occurrence and is to be judged rather on its size than on anything else. Though individuals of *P. gyrina* are moderately coiled, loose coiling is a specific characteristic. *P. bayfieldensis* Baker and *P. brevispira* Lea, though tightly coiled, appear in their Michigan manifestations to be depauperate races, or perhaps only depauperate instances, of *P. gyrina*. *P. integra* is commonly a small, thick shell, whose whorls are loosely coiled after the protoconch, and has no puzzling modifications. To judge by Michigan material, *P. warreniana* is a robust form of *P. integra*, probably ecological. *P. walkeri* and *michiganensis* are extreme examples of loose coiling.

Measurements were made in quest of further clues to specific distinctions. By dividing the altitude by diameter, the excess of altitude over diameter was obtained in percentages:

<i>ancillaria</i> . Type locality	1.43
<i>ancillaria vinosa</i> . Marquette	1.54
<i>ancillaria vinosa</i> . Sault Ste Marie	1.44
<i>deformis</i> . Paratype	1.90
<i>elliptica</i> . Mackinac County	1.80
<i>gyrina</i> . Detroit, elongate form	1.82
<i>gyrina</i> . Menominee County	1.69
<i>heterostropha</i> . Type locality	1.57
<i>integra</i> . Wabash River	1.56
<i>michiganensis</i> . Near Fenton	1.76
<i>parkeri</i> . Douglas Lake	1.33
<i>sayii</i> . Third Sister Lake	1.54
<i>sayii</i> , near <i>parkeri</i> . Alger County	1.41
<i>sayii crassa</i> . Higgins Lake	1.43
<i>sayii magnalacustris</i> . Crystal Lake	1.44
<i>sayii oneida</i> . Bear Lake	1.48

<i>walkeri</i> . Petoskey	1.45
<i>warreniana</i> . Delta County	1.44
<i>warreniana</i> . Mackinac County	1.57

The figures are not satisfactory so far as the establishment of specific differences is concerned. They do seem to show a similarity of proportions among the tightly coiled forms. This cannot be said of loosely coiled shells. On the whole, the conclusion that may be drawn is that differences in proportions are not indicative of differences in species. If the characteristics in general are considered, the well-differentiated species are *P. gyrina* and *integra*, both loosely coiled. Using each as a sort of bench mark, we find that development in one direction is toward tight coiling and a low ratio of diameter to altitude; in another direction, toward still more loose coiling and a higher ratio of diameter to altitude.

Two species credited to Michigan, so far not mentioned, are *P. microstoma* Haldeman of the southwestern part of the state, and *P. niagaraensis* Lea, of wider distribution. Specimens of the first are indistinguishable from *elliptica* save that they are somewhat more loosely coiled. The second, which is assigned to several parts of the Lower Peninsula, appeared among the shells of the Walker collection. It is a form of *P. integra*.

These studies of *Physa* admittedly cannot be considered conclusive in their findings save as they have permitted the elimination of Michigan forms that are not distinctively specific. It can be said, at the same time, that earlier studies of this perplexing genus have left it in a state equally inconclusive. The opinion is that too little attention has been given to the possibilities of ecological conditions as an influence on shell shape, shell size, and the manner of whorl coiling. It is reasonable to believe that very little experimental work would answer this question.

The species (or formae) taken by Lowe are:

P. gyrina Say. Inhabits a river of Baraga County, a river and brook of Delta County; two creeks of Dickinson County; thirteen creeks, four rivers, and two brooks of Menominee County; a river, a lake, and two ponds of Marquette County; and two creeks of Schoolcraft County. The habitats in Menominee County, so far as they were noted, were mucky and stagnant, usually bog-stained, and sometimes filled with aquatic vegetation.

P. ancillaria vinosa (Gould). One lot only. It was from Lake Superior, Marquette County.

Physa elliptica Lea. Found in a creek of Dickinson County, a creek and lake of Mackinac County, as well as in the drift of Crow River of the same county; four creeks of Menominee County; and a creek and a lake of Schoolcraft County. The habitats of Menominee County corresponded to those occupied by *P. gyrina*.

Physa integra Haldeman. Taken in a creek of Dickinson County, a river

of Delta County, fourteen creeks, five rivers, and a brook of Menominee County. In this last county, the habitats were "sandy, stony, and with gravel bottoms."

Physa michiganensis Clench. Collected in two creeks of Menominee County, one of which was noted as "sandy, with a few rocks" and the other as the discharge of a lake.

Physa sayii Tappan. One lake and three rivers of Menominee County, two of which rivers were impounded into lakes; a lake of Marquette County.

Physa warreniana Lea. A lake of Mackinac County and a creek of Delta County.

Aplexa hypnorum (Linnaeus)

The species was taken by Lowe in Hayward Creek, Menominee County; the headwaters of Schram's Creek, Mackinac County; and in Pelkey Lake, Blaney Park, Schoolcraft County. The specimens of the first two localities appear to be drift material. Those of the third are of the shining, transparent character which marks shells taken in their natural habitat. *Aplexa* is commonly an occupant of woods pools and ditches.

Ferrissia parallela (Haldeman)

A single specimen of this species was taken in Three Bay Lake, Blaney Park, Schoolcraft County. It is probably distributed throughout the Upper Peninsula, since previous collections of it have been made in Baraga, Houghton, Keweenaw, Mackinac, Marquette, Ontonagon, and Schoolcraft counties.

Ferrissia tarda (Say)

Five specimens were collected in Reed's Creek, a tributary of Cedar River, Menominee County. Known previously from Baraga and Houghton counties.

Campeloma decisum (Say)

About thirty different lots of *Campeloma* were collected by Lowe in counties of the Upper Peninsula. Of those taken in Menominee County, June to September, 1927, the soft parts of only two lots contained undischarged embryos. One lot from Dead River, Marquette County, collected on May 29, 1937, was heavy with young. Sinistral shells are relatively common in *Campeloma*, but only three were found among about four hundred specimens of Lowe's takings.

Five species and two subspecies of the genus are credited to Michigan. Distinctions drawn between the several species of the United States have to do with shape of shell, height of spire, rotundity of whorls, and thickness of shell substance. *C. rufum* (Haldeman) is described as distinguished from *C. decisum* "by its more polished surface and entire apex, and more particularly by its interior coloration." Now the brightness or dullness of surface

is an environmental, exterior effect, and varies not only between streams, but also between parts of a stream. The retention of the apical whorls into maturity is due to the absence of erosive agencies, which may be mechanical or chemical. These, of course, are environmental. There is left the color of the shell material as the determining factor in *rufum*. Fresh shells of any species may have pinkish or reddish apertures. It is a common experience to find red shells among the *Campeloma* tossed on the beaches of the Great Lakes, and it has seemed that this coloration was part of the process of disintegration. It has been noticed also among drift individuals of the terrestrial genus *Polygyra*.

In this study, comparisons have been carried out in the matter of obesity, expressed in percentages. The index, as it may be termed, ranged in river specimens of Menominee County from 72.0 to 76.4, with an average of 74.4. Creek shells were virtually of the same index, lake shells slightly less. River shells of Mackinac County had an average index of 74.2, creek shells about the same. River specimens of Dickinson County ranged in indexes from 72.6 to 74.9. River shells of Marquette County averaged 72.0; lake shells, 70.3. The fact that some of the river material was taken in impounded areas may have a bearing on the percentages that were obtained.

Seemingly marked differences occurred when comparisons were made between the indexes of Upper Peninsula *Campeloma* and those of the genus in the Lower Peninsula. Specimens taken in Grand River from near the source to the vicinity of the mouth ranged irregularly from 80.4 to 89.5 per cent. In Looking Glass River, a Grand River tributary, the range was found to be from 84.9 to 86.5; in three other tributaries, 82.5 to 86.8. The index of obesity of Muskegon River *Campeloma* varied from 82.2 to 89.2. The contrast between Upper Peninsula and Lower Peninsula shells as shown by these percentages can point to environmental effects quite as much as to specific differences, and these environmental effects should be taken into the consideration of the problem. Upper Peninsula aquatic mollusca have a shorter active season than those farther south and live under less favorable climatic conditions. A short period of activity limits the time for storing adipose tissue, and this in turn limits the size of the aperture which determines the diameter of the shell.

One of the subspecies, so called, of Michigan is *C. integrum obesum* (Lewis). Specimens of it have a shouldered lower whorl which increases the diameter of the shells at the sutures and gives an angular appearance to the body whorls. Such shells have been taken in numbers in a dammed section of the Huron River below Ann Arbor. Occasional specimens have been found in a higher part of the river, and still others in Whitmore Lake, Washtenaw County. Similar individuals were taken by Lowe in Johnson Lake, Menominee County. It seems very likely that all these queerly shaped mollusks represent pathological responses to trematode infection.

The oldest name in the genus, *decisum*, is applied to the Upper Peninsula *Campeloma*.

Valvata tricarinata Say

This species was collected in three creeks of Menominee County, Twin Lake of Luce County, and at the mouth of Crow River, Mackinac County—all by Lowe. These records, together with earlier ones, show that *V. tricarinata* occurs throughout the Upper Peninsula. H. B. Baker found *V. tricarinata perconfusa* in Brown Lake, Dickinson County, and the same subspecies, collector unknown, is in the Bryant Walker collection as from Pickerel Lake, Marquette County. The striking character of *V. tricarinata* is the three revolving keels. These are sometimes worn away by attrition in waves and sand. A result of this is that some of the drift material of the Great Lakes, which at times is very extensive, appears to be of those subspecies one or more keels of which are absent.

Valvata sincera Say

Taken by Lowe in a branch of Dead River, Marquette County, and at the mouth of Crow River, Mackinac County. Former collections are from lakes of Dickinson, Keweenaw, Marquette, and Schoolcraft counties. Two of the Lowe lots are assigned to Crow River, and may possibly be from different spots. One is of the normal or typical form. The other consists of specimens in which the whorls are partly or wholly detached from one another. Some of these have a distinct ramshorn appearance. It may be that these abnormalities were brought about through emersion in alcohol or formalin or by drying in the vial. Yet specimens of the kind, though in fewer numbers, do turn up occasionally among other groups of mollusca; that they grew this way cannot be doubted. My belief is that these pathological shells of *V. sincera* are not of what might be called artificial fabrication.

Valvata sincera nylanderi Dall

This very coarsely sculptured form, first noted in shells of Maine, was found in two small streams of Menominee County. It had been found previously in Dickinson, Marquette, and Chippewa counties of the Upper Peninsula, and on Isle Royale of Keweenaw County. Other Valvatidae of the peninsula of which there are records are: *V. lewisii* Currier, Rush Lake, Marquette County, and Isle Royale, Keweenaw County; *V. bicarinata* Lea, Schlatter's Lake, Keweenaw County; and *V. bicarinata perdepressa* Walker, Lake Michigan, Engadine, Mackinac County.

Amnicola limosa (Say)

The Lowe collections of this species were confined to one lake and two creeks in Menominee County, a river and a creek of Dickinson County, a

river and a lake of Mackinac County, one river and one lake of Marquette County, a lake of Luce County, and a lake of Schoolcraft County. The mollusk is of general distribution in the Upper Peninsula. The takings were in small numbers except in Ford Lake, Schoolcraft County. Here two or three hundred specimens were scooped from a marly deposit and probably represented many generations of *A. limosa*.

Amnicola lustrica Pilsbry

The species appeared in very small numbers among mollusca from a creek of Dickinson County, a lake and a river of Mackinac County, a lake of Marquette County and one of Schoolcraft County. One other *Amnicola* of the Upper Peninsula is: *A. walkeri* Pilsbry, Brown Lake, Dickinson County, and two lakes of Luce County.

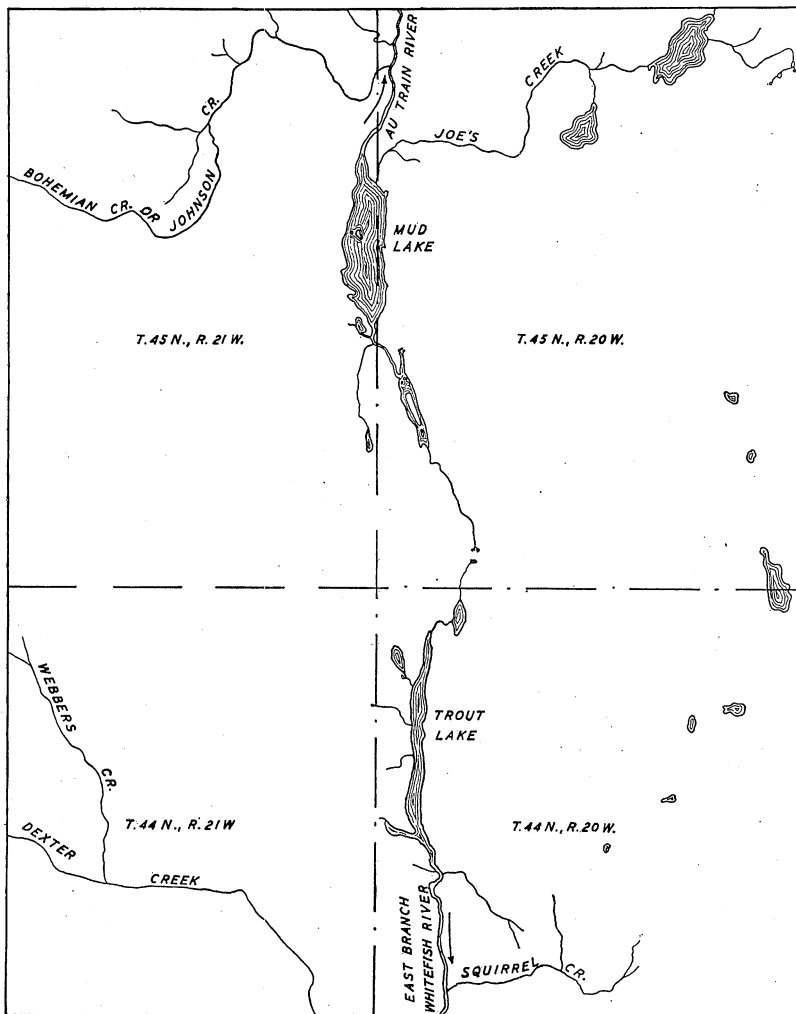
Pleurocera acuta Rafinesque

Taken by Lowe in Menominee River, Menominee County, at Chappee Falls, and in Trudell Creek, a tributary one mile above the falls. No other records exist of the occurrence of this species in Upper Peninsula counties of Michigan. *P. acuta* is fairly common in the lowermost counties of the Lower Peninsula. Specimens are in the Walker collection as from Lake Michigan as far north as Charlevoix and Petoskey. It is possible that these were sporadic colonies, living precariously in an unfavorable environment. They were not seen during a search for them in 1933. F. C. Baker did not come upon the species on the Wisconsin side of Lake Michigan, though early collectors discovered it at Milwaukee and Sheboygan. The shell has been found in Green Bay of Lake Michigan within Michigan boundaries in recent years. Baker discovered *P. acuta* on the shores of Lake Superior at Bayfield, Bayfield County. This, again, was a sporadic colony, seemingly, since no sign of it was found during a search of a few years ago. Usually, the species is a mud-dweller, burying itself so deeply that only a part of the aperture shows above a mucky bottom. It does, however, occupy more exposed positions in Lake Erie.

Goniobasis livescens (Menke)

Lowe collected the species in two rivers of Menominee County, in a creek, a river, and two lakes of Mackinac County, two rivers of Delta County, and Au Train River of Alger County. This last locality is especially of interest because it is in the drainage basin of Lake Superior. *G. livescens* lives in shallow water. It requires a large amount of aeration. In streams of the Great Lakes it thrives in rapids, and in the lakes themselves its large colonies occupy spots that are swept by waves. Distribution is from stream to stream, and not overland as is the case with *Physa* or *Lymnaea*, the eggs of which can be borne by birds and winds. In the northward reinvasion of mollusca

which followed the glacial period, the Goniobases, in all probability, reached the Great Lakes through those stream joinings which, even in recent times, have occurred in the vicinity of Chicago and Fort Wayne. The question arises whether *G. livescens*, absent from Lake Superior, could have crossed the



MAP 1. The headwaters of the East Branch of the Whitefish River and of the Au Train River.

divide into Au Train River by some such process. The river rises on a low watershed on the southern side of which are streams flowing into Lake Michigan. A base map of the Land Economic Survey of the Michigan Department of Conservation shows a separation of scarcely one-sixth of a mile between a headstream of the northward flowing Au Train River and a headstream

of the southward flowing Whitefish River. If the lowness of the divide is considered, it would be strange if stream capture had not occurred several times. The nature of the divide is made clear by the same land survey map which shows the Minneapolis, St. Paul, and Sault Ste Marie Railroad keeping in a straight line for seven miles across the watershed (see Map 1). A considerable variation in *G. livescens* is traceable to environmental influences. Most of the shells of the species in streams of northern Michigan are of dark coloration, a pigmentation that may be caused by the bog stain of flowing waters of the region.

The Family Sphaeriidae

Victor Sterki is the only person in recent years who has made a thorough study of the American Sphaeriidae. He examined a vast number of specimens and named many species. When he died, he appeared to have left no writings which show the basis of his differentiation of species. This can be inferred only from his descriptions, a somewhat difficult matter since all characters of the shells received equal treatment or nearly so. It is assumed, it may be erroneously, that he considered shape, size, and surface sculpture of more importance than the hinge and hinge teeth to which one or two English authors gave most attention. He was inclined to rescue species that Temple Prime, his predecessor in this study, rejected.

Independently, Henry van der Schalie and I went over the specimens of *Sphaerium* of the collections of the Museum of Zoology. We found at the end of the examinations that we had come virtually to the same conclusions, namely: *S. sulcatum* and *striatinum* should, between them, absorb several species that were recognized by Sterki as distinct. We differed as to the position of *S. occidentale*. Shape, it was learned, is a highly variable factor. So also is surface sculpture. A single lot of *S. striatinum*, for example, contained specimens in which the striae were pronounced and specimens that were nearly smooth; specimens wherein striae were strongest during the juvenile growth and others that took on stout striae only in the adolescent or mature periods. Differences in size seemed of trivial importance in the few measurements that were made. A number of species so called have the same tooth formation that *S. sulcatum* has. About the same number grouped with *S. striatinum* in this matter. A possible basis of distinction, van der Schalie thought, is the position of the beaks on the hinge line, whether they are at the center or are placed anteriorly. The findings are put forth here as a suggestion for a careful review of the Sphaeriidae and not as a proposal for a new classification. Ecological observations should accompany the review.

In *Musculium*, teeth are much the same. Sculpture consists of fine growth lines. The differentiation has been according to shape more than anything

else. Confusion is foregone. Of the *Pisidia* of Lowe's collecting, the species *P. abditum* and *compressum* were found to be distinct as to shape and form of teeth. The *P. variabile* so identified has characteristics of both these species. *P. adamsi* and *ambiguum* appear to be very close to *abditum*, scarcely to be differentiated from it biologically. It is clear that room exists for a restudy of the Sphaeriidae that is uninfluenced by previous work on the genera.

Sphaerium sulcatum (Lamarck)

This species is dealt with first because it is the largest in Michigan and the most widely distributed. It occurs at times in great numbers, and accumulations of "dead" shells may form a sort of pavement at the discharges of some lakes. Growth is by short, regular steps. The young are quadrilateral in shape, and the growth lines are nearly evenly spaced. There comes a period in which these lines narrow in spacing anteriorly and posteriorly, sometimes coalescing, whereas lines in the center of the disk continue well apart from one another. The result of this alternation of manner of growth is an alteration in shape from quadrilateral to ovate. Teeth are observed best when held sidewise, the beaks down. The cardinals are then seen to stand out conspicuously, and to vary from squarish or oblong to triangular as between individual shells. A variation occurs, too, in size. Inner ridges of the laterals are higher than the outer ridges. Young are ordinarily compressed, adults obese. Juvenile and embryo shells are usually whitish yellow. The color darkens with age, although the new growth in adolescence may be yellow as with the embryonic. Specimens from Big Rock Pond, Marquette County, remain brightly yellow throughout life, as if material for pigmentation in the water was here absent. The same phenomenon is observable in other Sphaeriidae of this pond.

The species appears to occur throughout both the Upper and the Lower Peninsulas. To judge by Pleistocene material, *S. sulcatum* was among the earliest mollusks that entered the region at the close of the glacial age.

Sphaerium striatinum (Lamarck)

This shell is smaller, more nearly triangular than *S. sulcatum*, and in general it is markedly obese. The manner of growth is identical with that of *sulcatum*. The cardinal teeth are small, the laterals much more strongly developed and ridged to a summit at their centers. The dentition was found to vary little among specimens of about forty lots that were examined. The chief variation is in surface sculpture. This ranges from pronounced striae occupying the whole disk of the shell to very weak striae; a secondary variation in sculpture is frequently to be noted in respect to age. The collections of this species by Lowe were in four rivers, two creeks, and two lakes of Menominee County; two rivers and a creek of Dickinson County; a river

and a lake of Marquette County; and a lake of Mackinac County. The only previously collected samples of the species in the Upper Peninsula were from Houghton and Marquette counties.

Sphaerium accuminatum (Prime)

The species was rejected by Prime himself and restored by Sterki. In this study, comparisons were made with specimens identified by Sterki. The dentition of *S. accuminatum* is that of *striatinum*. The shape of the two shells is identical so far as may be concluded from outlines of them that were drawn. The conspicuous differences are in sculpture. This may be coarse to delicate in *striatinum*, but is uniformly fine in *accuminatum*. With this doubtful distinction to go upon, the Lowe specimens were determined. Two lakes of Menominee County contain *accuminatum*, two of Marquette County, one of Mackinac County, and a lake and a creek of Schoolcraft County. Earlier collections from the Upper Peninsula, all passed on by Sterki, were in a lake of Dickinson County, one of Luce County, two of Marquette County, and the Bête Grès lagoon of Keweenaw County. Shells also are from Lakes Huron, Michigan, and Superior.

Sphaerium ohioense Sterki

One specimen and a single valve of another were taken by Lowe in a lake of Menominee County, associated with *S. rhomboideum*. The shell is much like *S. striatinum* in sculpture, but it is elongate, subquadrate of shape instead of ovate. This is the first finding of the species in Michigan. It was collected by F. C. Baker in Wisconsin, not far from Menominee County, Michigan.

Sphaerium fallax Sterki

Identifications of this species among the Lowe collections were by means of careful comparisons with material named by Sterki. If a good species, it groups with *S. sulcatum*. Lowe's localities were two creeks and three lakes of Menominee County, a lake of Marquette County, a lake outlet and a creek of Schoolcraft County. Of nine lots of *S. fallax* previously taken in Michigan, eight were from the Upper Peninsula. The habitats of seven of the eight were lakes. The counties in which these shells were found are Keweenaw, Luce, Mackinac, and Marquette.

Sphaerium rhomboideum (Say)

This is a decidedly obese species, nearly rhomboidal in outline until extreme maturity is reached. Infants are much compressed, smooth or nearly smooth, coarse striae being an age development. Commonly, there is a tinge of red in the color of the shells, but sometimes this is a pronounced feature. Specimens from Big Rock Pond, Marquette County, are pale yellow. Some

shells from Silver Lead Lake, the same county, that are apparently senile are ovate rather than rhomboidal. Cardinal teeth are of the form of those of *S. sulcatum*; the laterals knifelike and raised to a point at their centers. The distinguishing character of this species is that the quadrate, or quadrilateral, shape of infancy, common to other species, is retained into maturity. Lines of growth do coalesce at the margins, but this occurs above the line of greatest length. Taken by Lowe in two streams and three lakes of Menominee County, a pond and a creek of Marquette County, and two lakes of Schoolcraft County. Other Upper Peninsula records are from Chippewa, Luce, Mackinac, and Ontonagon counties. An examination of all the records for Michigan leads to the conclusion that the natural habitat of the species is stagnant water; a rare habitat, fast moving water.

Sphaerium solidulum (Prime)

Four specimens taken from Cedar River, Menominee County, appear to be this species. It is a rather globose shell, triangular and thick, and with heavy striae which decrease in prominence with age. Cardinal teeth are small, the laterals pyramidal.

Sphaerium occidentale (Prime)

This is a thin, orbicular mollusk, yellow to dark brown, that has faint growth lines. Cardinal teeth are poorly developed. Laterals are slightly raised. The species was collected by Lowe in only one place, pools at Dukes, Marquette County. The shell is an occupant of shallow pools, ponds, and ditches, and it has been taken in moist situations under logs. The species is one of the common molluscan inhabitants of woods pools. It appears to be able to endure a great amount of desiccation. Found over the most of Michigan, and known to occur in the Upper Peninsula in Chippewa, Dickinson, Luce, and Ontonagon counties, besides Marquette County.

Musculium partumeium (Say)

One specimen, recognizable by its size and color, was taken by Lowe in Spring Lake, Marquette County. This is the first of the species that has been seen from the Upper Peninsula of Michigan. Of its distribution in Wisconsin, F. C. Baker says that "only a few scattered records are known from the State."

Musculium rosaceum (Prime)

The Lowe specimens are from Bass Lake, Big Rock Pond, and Dead River at Hoist Dam, Marquette County; Pelkey Lake, Blaney Park, Schoolcraft County. Previously, it was known from Baraga, Chippewa, Dickinson, Houghton, Keweenaw, and Marquette counties. It appears to have, besides, a general distribution in the Lower Peninsula.

Musculium ryckholti (Norman)

This species, in Sterki's opinion, supercedes the *Sphaerium jayana* of Prime, the distribution of which is given by that author as "North America, in the region of Lake Superior?, Iowa and Canada." One specimen was collected in Wagner Lake, Menominee County, by Lowe. It is recorded from a swale near Gogebic Lake, Ontonagon County, and Lakes Deer and Eliza, Keweenaw County.

Musculium securis (Prime)

A common species of Michigan. Lowe's specimens are from South Stonington, Houghton County; Three Bay Lake, Blaney Park, Schoolcraft County; and a roadside ditch near Daggett, Menominee County. Earlier Upper Peninsula collections of the species were in Alger, Keweenaw, Luce, and Marquette counties.

Musculium truncatum (Linsley)

Taken by Lowe only in Little River below the junction with Kelly Creek, Menominee County. The Bryant Walker collection contains lots from three localities of Marquette County. Other recorded species of *Musculium* of which specimens have been found in the Upper Peninsula are *M. declive* Sterki, Marquette and Luce counties; *pusillum* Sterki, Dickinson County; *securis crocea* Lewis, Ontonagon County, and *steinii* Schmidt, Keweenaw County. The determinations were all made by Sterki.

Pisidium abditum Haldeman

The shells which have been identified as this species during this study correspond with specimens named by Sterki as well as with original descriptions. The chief determining characters of the genus are shape, prominence of beaks or lack of prominence, and the forms of cardinal and lateral teeth. In the sixteen lots believed to be *abditum* which were found in the Lowe takings were small variations in shape, and the cardinal teeth were sometimes wholly absent. The differences were noticeable within lots of the same locality as well as when lots coming from different localities were compared. Some of the specimens collected by Lowe show as many as four rest varices. Plainly, they do not represent winter pauses of growth. The Lowe *abditum* came from two creeks of Dickinson County, one creek and two lakes of Marquette County, the mouth of Crow River in Mackinac County, and two brooks, seven creeks, and one river of Menominee County. The habitats in Menominee County were mucky bottoms in most instances. These records, together with earlier ones, show that the species is distributed throughout the Upper Peninsula.

Pisidium adamsi Prime

The shells which appear to belong to this species are from a pond at Mar-

quette and a lake of Mackinac County. The determination has been based on specimens named by Sterki, but it is not in agreement with that of F. C. Baker (1928: 385). It is possible that the error is the writer's. Earlier collections of *adamsi* were from Luce, Houghton, Keweenaw, and Marquette counties. A more abundant form in Michigan is *P. adamsi affine* Sterki, examples of which were found in Brown Lake, Dickinson County; Carp Lake, Ontonagon County; and lakes and streams of Marquette County.

Pisidium ambiguum Sterki

A single lot, taken in Koss Creek, two miles north of Koss, Menominee County. Known also from Houghton, Marquette, and Ontonagon counties.

Pisidium compressum Prime

In Michigan, this species appears to be a common inhabitant of streams, a rare one of lakes and ponds. It is well marked as to shape and the form of the teeth. Of material collected in thirteen streams of Menominee County, only one lot varied distinctly from the others in the matter of teeth, and this was in their conspicuousness, not their form. The species was collected by Lowe in all the counties of the Upper Peninsula that he visited. It can be considered the commonest one of the state.

Pisidium variabile Prime

This mollusk was found in five creeks of Menominee County by Lowe. It is possible that the identifications are in error, although seeming to be the same as Sterki's. The teeth are those of Prime's description, but the shells are not heavy as Prime says they are. Neither are they "large for the genus," as was remarked by F. C. Baker. In the Upper Peninsula, *variabile* has been collected previously in Dickinson, Gogebic, Houghton, Keweenaw, Mackinac, Marquette, and Ontonagon counties. It may be that the shells taken by Lowe are *P. variabile brevius* Sterki, a race of small mollusks. Dwarfing is so definitely an environmental response that I hesitate to employ a designation based on depauperization.

REFERENCES

- BAKER, F. C.
1911 *Lymnaeidae of North America*. Chicago. P. 185.
1928 *The Fresh Water Mollusca of Wisconsin*. Wis. Geol. and Nat. Hist. Surv., Bull., 70, Pt. 1: i-xx, 1-507, Pls. 1-28.
- BAKER, H. B.
1922 *The Mollusca of Dickinson County, Michigan*. Occ. Papers Mus. Zool. Univ. Mich., No. 111: 1-44.
- DICE, L. E.
1938 *The Canadian Biotic Province with Special Reference to the Mammals*. Ecology, 19: 503-14.

HILE, R.

- 1936 Age and Growth of the Cisco *Leucichthys artedi* (Le Sueur), in the Lakes of the Northeastern Highlands, Wisconsin. U. S. Bur. Fish. Bull., 19: 211-317.

HILE, R., AND H. J. DEASON

- 1934 Growth of the Whitefish, *Coregonus Clupeaformis* (Mitchill), in Trout Lake, Northeastern Highlands, Wisconsin. Trans. Amer. Fish. Soc., 64: 231-37.

LERMOND, N. M.

- 1908 Shells of Maine. Thomaston, Maine. Pp. 1-46.

MORRISON, J. P. E.

- 1932 A Report on the Mollusca of the Northeastern Wisconsin Lake District. Trans. Wis. Acad. Sci., Arts and Letters, 27: 359-96.

WALKER, B.

- 1913 The Unione Fauna of the Great Lakes. Nautilus, 27: 18-23, 29-34, 40-47, 56-59.

WINSLOW, M. L.

- 1926 A Revised Check List of Michigan Mollusca. Occ. Papers Mus. Zool. Univ. Mich., No. 181: 1-28.

PART II. THE NAIADES (FRESH-WATER MUSSELS)

HENRY VAN DER SCHALIE

A careful study of the distribution and ecology of the Naiades of the Upper Peninsula of Michigan has never been made. The collections recently received by the Museum of Zoology from the late Dr. John N. Lowe have added greatly to our knowledge, particularly of the mussels of Menominee County. By combining the data furnished by the Lowe collections with the information given by H. B. Baker (1922) for Dickinson County and by adding records available in the Museum of Zoology no less than seventeen species of mussels are shown to have been reported from this region of the Upper Peninsula. The number becomes significant when we consider that only eight species are known normally to inhabit the remainder of the Upper Peninsula. Although it is true that there is much to be learned regarding the details of ecology and distribution in this area, sufficient information is now available to show that the presence of several Mississippi drainage basin species in the region of Menominee and Dickinson counties is not an accident, but can be substantiated by geological history.

Through the publications of Bryant Walker (1898; 1913) and A. E. Ortmann (1924) it has become generally known that the great influx of species characteristic of the Mississippi River fauna into Lake Erie and southern Michigan is due to the invasion of species from the Mississippi Valley during the glacial period. Because of the lack of available data it was not known that a similar invasion of Mississippi River species also took place in the Upper Peninsula. The Lowe collections have made it possible to recognize this intrusion clearly. A discussion of the faunal evidence for this confluence between the waters of the Mississippi and St. Lawrence drainage basins in the Upper Peninsula will be presented later. It is perhaps advisable first to list the species reported from the Menominee-Dickinson region and to give such general information as will be pertinent to a proper understanding of the theoretical discussion which follows.

Amblema costata (Rafinesque)

Single specimens of this species were taken by Lowe from the following localities: Resort Lake, Menominee County; outlet Lake Mary, Dickinson County. Ecologically, *A. costata* is not common to a lake environment. It is, however, often found in small tributaries, such as the outlet of Lake Mary referred to above. Distributionally, the presence of *A. costata* in Menominee and Dickinson counties is of decided interest. All available records show that *costata* in Michigan is common only in streams in and below the Saginaw-Grand Valley. It has not been reported from either the upper half

of the Lower Peninsula, or from any portion of the Upper Peninsula, except in the region of Dickinson and Menominee counties. This distribution will be referred to again.

Fusconaia flava (Rafinesque)

Only one lot of this species was represented in the recent collections of Lowe. This was collected in Little River, at Shaky, Menominee County. Other records for *flava* in the Museum of Zoology include a lot collected by C. A. Davis from the Menominee River, below falls opposite Carney, Dickinson County. Ecologically, *flava* in Michigan is common to creeks and rivers and is not found in inland lakes. It is reported by Walker (1898: 6) as one of "five species which have a general range over the whole southern portion of the state." Records in the collections of the Museum of Zoology indicate that *flava* has not been reported from any of the drainage basins north of the Muskegon River on the west side of the state, or north of the Tittibawassee River drainage basin in eastern Michigan. The Menominee-Dickinson area is the only region from which authentic records are available for the presence of *flava* in the Upper Peninsula.

Elliptio complanatus (Dillwyn)

In the Lowe collections this species is represented by two lots from Schoolcraft County and one from Mackinac County. It is of interest that *complanatus* was not found in either Menominee or Dickinson counties, although Lowe collected intensively in Menominee County. Records in the Museum of Zoology show that *complanatus* has been found in the following counties of the Upper Peninsula: Chippewa, Mackinac, Luce, Schoolcraft, Alger, Marquette, Houghton, and Keweenaw. In the Lower Peninsula the only authentic records are from Alpena and Presque Isle counties. Bryant Walker (1913: 30) has mapped the distribution of *complanatus* and reveals it to be a characteristic mussel in the northern St. Lawrence drainage basin. Its presence in northern Michigan is an indication of the faunal similarity between species common to New England and northern Michigan. Ecologically, it inhabits both streams and lakes.

Elliptio dilatatus (Rafinesque)

Lowe collected one lot of *dilatatus* from the west branch of the Cedar River, Menominee County. The Museum of Zoology has a lot collected by C. A. Davis from the Menominee River in Dickinson County. These are the only counties in northern Michigan from which *dilatatus* has been reported. In Michigan *dilatatus* ranges generally through the Lower Peninsula (Bryant Walker, 1913: 30), and is usually found in streams; it is not to be considered an inhabitant of inland lakes.

Strophitus rugosus (Swainson)

One specimen of *rugosus* was taken by Lowe from Birch Creek, Menominee County. In view of the wide range of this species throughout both the Upper Peninsula and the Lower Peninsula, it was rather surprising that *rugosus* was not more abundantly represented in his collections. Both C. A. Davis and H. B. Baker (1922) have reported *rugosus* from the Menominee River drainage basin in Dickinson County, so that there is no doubt that it is represented in that region. *S. rugosus* is usually found in creeks and small streams, but may inhabit certain inland lakes and larger rivers.

Anodonta grandis Say

About twenty-four lots of *grandis* and the lake form, *A. grandis footiana*, were collected by Lowe in Menominee, Marquette, Baraga, Schoolcraft, and Mackinac counties. Most of these collections are from Menominee County. This species, and its ecological forms, are among the most common mussels in Michigan. The shell is represented in the Lowe collections from brooks, creeks, rivers, and lakes. This wide range of habitats has resulted in the appearance of many forms, several of which have been given subspecific names. Since these nominal subspecies are only ecological forms, they are all considered here under the specific name of *grandis*. Eleven lots of this series were collected from lakes and are the usual swollen lake form, *grandis footiana* (Lea).

Anodonta marginata Say

Eighteen lots of *marginata* were collected by Lowe from much the same area mentioned above under *A. grandis*. Most of the collections were made in Menominee County, where *marginata* inhabits lakes and creeks. Distributionally, *marginata* is most common in the Upper Peninsula and the northern part of the Lower Peninsula. It is often found with *grandis footiana*.

Anodontoides ferussacianus (Lea)

Twenty-four lots of this species were collected by Lowe from Menominee, Dickinson, Marquette, and Mackinac counties. Most of this series came from Menominee County, where *ferussacianus* is reported mainly from a creek and small-river habitat. A few of the lots are from lakes. In Michigan *ferussacianus* is one of the most common mussels and is found extensively in both peninsulas.

Lasmigona compressa (Lea)

Eight lots of this species are in the Lowe collections. Seven were collected in Menominee County and one in Marquette County. All *compressa* were taken from creek and small-river habitats. This species has an extensive distribution in Michigan and is found widely in both peninsulas.

Lasmigona costata (Rafinesque)

This species is not represented in the Lowe collections. Davis collected it from the Menominee River drainage basin at three localities in Dickinson County, and it should be included as part of the naiad fauna of the region. In Michigan, *costata* ranges through the Lower Peninsula. In the Upper Peninsula it has been reported only from Dickinson, Mackinac, and Chippewa counties. It appears to be absent from the central and northern portion of the Upper Peninsula.

Alasmidonta calceolus (Lea)

Thirteen lots of this species are in the Lowe collections, distributed as follows: nine from Menominee County, two from Dickinson County, and one each from Delta and Schoolcraft counties. At these stations it inhabits mainly creeks and small rivers and is rarely found in lakes. The species is well distributed throughout both peninsulas.

Alasmidonta marginata (Say)

The one lot of this species collected by Lowe is from Wilson Creek, at Wilson, Menominee County. There is also a collection in the Museum of Zoology made by C. A. Davis from the Menominee River, below the falls, Dickinson County. Distributionally, *marginata* in Michigan occurs in the southern half of the Lower Peninsula, but it is apparently absent from the northern half. It does not seem to have reached north of the Saginaw-Grand Valley region. In the Upper Peninsula it is entirely absent except in the extreme southwestern portion which includes the area of Dickinson and Menominee counties. The species is partial to small-river conditions, though occasionally it appears in larger streams.

Actinonaias carinata (Barnes)

This species was not collected by Lowe. H. B. Baker (1922: 44) reported it from the east branch of the Sturgeon River, in Dickinson County. Although there are no records in the Museum of Zoology to show that *carinata* occurs in Menominee County, there is every reason to believe that it will eventually appear in the lower portions of the Menominee River drainage basin. In Michigan, *carinata* is not found north of the Saginaw-Grand Valley of the Lower Peninsula, nor anywhere in the Upper Peninsula except in this Dickinson-Menominee region. The distribution pattern is considered significant and will be referred to later.

Micromya iris (Lea)

The Lowe collections provide the first record of this species in the Upper Peninsula. It was found in Wilson Creek, near Wilson, Menominee County.

In Michigan there are records to show that *iris* occupies about the same range as *Amblema costata* and *Alasmidonta marginata*, with the exception that in the Lower Peninsula *iris* seems to be well established in the Muskegon drainage basin on the west side of the state and has found its way as far north as the Thunder Bay drainage basin on the east. It is a species common to small and medium-sized streams.

Ligumia recta latissima (Rafinesque)

There are two lots of this species in the Lowe collections: one from Menominee River, Menominee County, the other from Ostrangio Creek, near mouth, Menominee County. D. S. Bullock also collected two lots of this species from the lower part of the Menominee River, near Marinette, Wisconsin. In Michigan, *recta latissima* usually inhabits the larger streams and is not common in creeks. The stunted form, *recta*, inhabits lakes which are usually part of or in proximity to the Great Lakes. *L. recta latissima* ranges mainly through the lower half of the Lower Peninsula. It has, however, been reported from Ocqueoc Lake in Presque Isle County by F. E. Eggleton. In the Upper Peninsula it has also been found by Eggleton in the Taquamenon River, below the upper falls, Luce County.

Lampsilis siliquoidea (Barnes)

Of the sixteen lots of *siliquoidea* in the Lowe collections nine are from Menominee County, four from Marquette County, two from Schoolcraft County, and one from Dickinson County. This species is common in both peninsulas and occupies a wide range of habitats including rivers, creeks, and lakes. In lakes it tends to become stunted, and the name *siliquoidea rosacea* is often applied to the depauperate lake form.

Lampsilis ventricosa (Barnes)

Though the range of *ventricosa* in Michigan is as extensive as that of *siliquoidea*, the former appears to be far less common than the latter in the collections of Lowe. Only four lots of *ventricosa* are represented: three are from Menominee County, and one is from Marquette County. *L. ventricosa* inhabits both rivers and lakes. In lakes it becomes stunted, as do many other species of naiads, and the stunted form is referred to as *ventricosa canadensis*.

DISCUSSION OF THE NAIAD FAUNA OF THE MENOMINEE-DICKINSON REGION

In the following discussion an attempt will be made to show that certain species of mussels inhabiting the Menominee-Dickinson region reveal that there has been an invasion of Mississippi River naiads into the St. Lawrence drainage basin in this portion of the Upper Peninsula. In order to prove

this contention it will be necessary to show (1) that the naiad fauna of the Menominee-Dickinson region differs decidedly from that of the remainder of the Upper Peninsula; (2) that there is a great similarity between the fauna of the Menominee-Dickinson region and that reported for northeastern Wisconsin by Morrison (1932); and (3) that certain of the species in the Menominee-Dickinson region must have reached there when there was a confluence between the waters of the Menominee drainage basin and the headwaters of tributaries of the Mississippi River in Wisconsin.

The following nine species of naiads are widely distributed throughout the Upper Peninsula of Michigan:

<i>Elliptio complanatus</i>	<i>Anodontooides ferussacianus</i>
<i>Strophitus rugosus</i>	<i>Lasmigona compressa</i>
<i>Anodonta grandis</i>	<i>Alasmidonta calceolus</i>
<i>Anodonta marginata</i>	<i>Lampsilis siliquoidea</i>
	<i>Lampsilis ventricosa</i>

Of this list all but *Elliptio complanatus* have been reported from the Menominee-Dickinson region. If the species of mussels inhabiting the Menominee-Dickinson region were exactly the same as those occupying the remainder

TABLE III

A COMPARISON OF THE SPECIES OF NAIADES REPORTED FROM MENOMINEE AND DICKINSON COUNTIES, MICHIGAN, WITH THOSE REPORTED FROM NORTHEASTERN WISCONSIN BY MORRISON (1932)

MENOMINEE-DICKINSON COUNTIES	NORTHEASTERN WISCONSIN
* <i>Amblema costata</i> , L,B,M	<i>Amblema costata</i>
* <i>Fusconaia flava</i> , L,B,M	<i>Fusconaia flava</i>
	<i>Pleurobema cordatum coccineum</i>
* <i>Elliptio dilatatus</i> L,B,M	<i>Elliptio dilatatus</i>
<i>Strophitus rugosus</i> , L,B,M	<i>Strophitus rugosus</i>
<i>Anodonta grandis</i> , L,B,M	<i>Anodonta grandis</i>
	<i>Anodonta imbecillis</i>
<i>Anodonta marginata</i> L,B,M	<i>Anodonta marginata</i>
<i>Anodontooides ferussacianus</i> L,B,M	<i>Anodontooides ferussacianus</i>
	<i>Lasmigona complanata</i>
<i>Lasmigona compressa</i> L,B,M	<i>Lasmigona compressa</i>
* <i>Lasmigona costata</i> B,M	<i>Lasmigona costata</i>
<i>Alasmidonta calceolus</i> L,B,M	
* <i>Alasmidonta marginata</i> L,B,M	<i>Alasmidonta marginata</i>
* <i>Actinonaias carinata</i> B	<i>Actinonaias carinata</i>
* <i>Micromya iris</i> L	
* <i>Ligumia recta latissima</i> L,M	<i>Ligumia recta latissima</i>
<i>Lampsilis siliquoidea</i> L,B,M	<i>Lampsilis siliquoidea</i>
<i>Lampsilis ventricosa</i> L,B,M	<i>Lampsilis ventricosa</i>

* An invader from the Mississippi River.

L—Specimens represented in the Lowe collections.

B—Records taken from the Dickinson County report by Baker (1922).

M—Records available in the collections of the Museum of Zoology.

of the Upper Peninsula, the species list would end here. Actually, eight more species are added, which brings the number known to inhabit the region of Menominee and Dickinson counties to sixteen (see Table III). The species found in this region, but not known to range throughout the remainder of the Upper Peninsula, are:

<i>Amblema costata</i>	<i>Alasmidonta marginata</i>
<i>Fusconata flava</i>	<i>Actinonaias carinata</i>
<i>Elliptio dilatatus</i>	<i>Micromya iris</i>
<i>Lasmigona costata</i>	<i>Ligumia recta latissima</i>

We have, then, ample evidence to show that the naiad fauna of the Menominee-Dickinson region differs decidedly from that of the remainder of the Upper Peninsula of Michigan both quantitatively and qualitatively.

In order to show that there is a greater similarity between the fauna of the Menominee-Dickinson region and that reported from northeastern Wisconsin than between the fauna of the remainder of the Upper Peninsula of Michigan, Table III has been prepared. In it a comparison is made between species of naiads reported by Morrison (1932: 377-83) for the lake region of northeastern Wisconsin and the species collected in the Menominee-Dickinson region by Lowe, Baker (1922), Davis, and others who have contributed specimens now in the Museum of Zoology. The similarity among these collections is striking, and there is sufficient evidence to prove that the mussels of these two regions are essentially the same, both numerically and specifically. Morrison (1932) reported twenty-six forms belonging to the Unionidae which inhabit the northeastern Wisconsin lake district. Since many of his forms are as yet questionable as taxonomic entities, his list of twenty-six forms should be reduced to seventeen well-defined species for comparative purposes (Table III). It will then be necessary to correct the following statement made by Morrison (1932: 365):

The number of species of Unionids in the small headwater streams of the Lake Superior and Green Bay (Lake Michigan) drainages is about one half that found in similar streams, under comparable conditions, in the headwaters of the Flambeau, Tomahawk, and Wisconsin drainages.

Evidently Morrison was under the impression that most of us would have if we assumed that the fauna of the Menominee-Dickinson region (Greene Bay drainage) was similar to that found in the remainder of the Upper Peninsula of Michigan. The fauna, however, is here shown to be dissimilar, and the number of species in the Menominee-Dickinson region is almost the same as (and not one half of) that reported for northeastern Wisconsin.

By applying the information available from this and other studies concerning the ecology and distribution of the naiads in Michigan, it can now be shown that certain of the species listed in Table III could have entered the Menominee-Dickinson region only by way of a connection between the

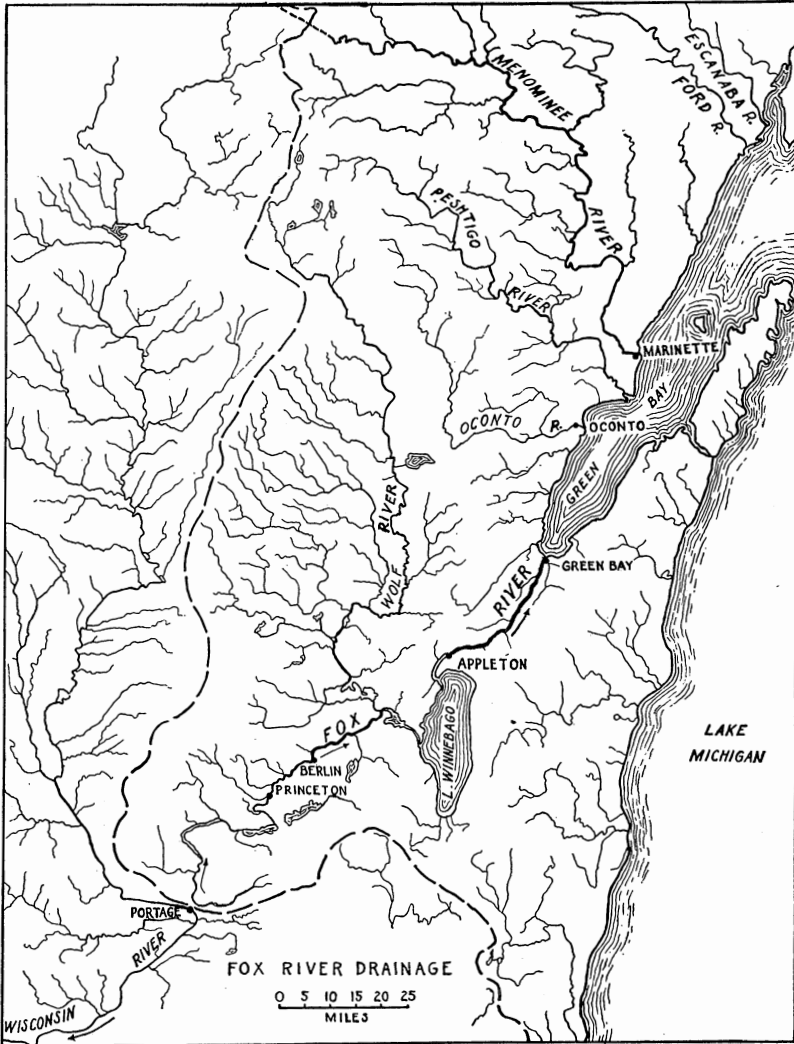
waters of the Mississippi and the St. Lawrence drainages. Naturally the species (preceded by an asterisk in Table III) of particular interest are those which have a restricted distribution in the region under consideration. These species will now be considered in accordance with the role they play in showing what route they followed to reach the Menominee-Dickinson region.

Perhaps the first question that arises is whether the eight Mississippi River species may not have entered the Menominee-Dickinson region by way of Lake Michigan and Green Bay. There are strong lines of evidence which would render this impossible. In the first place, none of the following six species have ever been reported from any portion of Lake Michigan: *Amblyema costata*, *Fusconaia flava*, *Elliptio dilatatus*, *Lasmigona costata*, *Micro-myia iris*, and *Ligumia recta latissima*. Furthermore, the two remaining species, *Actinonaias carinata* and *Alasmidonta marginata*, are restricted by their ecological demands to a river environment, and there is no evidence that they have ever been found normally to inhabit lakes of any kind. Consequently, we cannot accept a theory that would propose to bring these species into the Menominee-Dickinson region by way of Lake Michigan or any other lakelike body of water.

The fact that *Actinonaias carinata* and *Alasmidonta marginata*, particularly, and the remaining six species generally, are inhabitants of streams strongly suggests that they reached the Menominee-Dickinson region during a period when there was a confluence, even if temporary, between the waters of the Menominee River drainage with streams in the headwaters of the Mississippi River in Wisconsin. Unfortunately, information concerning the distribution of these eight species in eastern Wisconsin is insufficient to trace the route they followed in their migration into the St. Lawrence drainage basin. Data bearing on the glacial history of this region might indicate how they arrived in the Menominee-Dickinson region. Since many of the details of the geological history of northeastern Wisconsin have not yet been worked out, only the broad outline of the history can be given here.

Dr. Frank Leverett suggested to me interesting lines of evidence to indicate the way in which the Mississippi and the St. Lawrence drainages were connected during the late Wisconsin stage of glaciation. There is some evidence to show that during that period the waters from the retreating Green Bay glacier went south to the Wisconsin and the Mississippi rivers by way of the present Fox River Valley. The course must have been out of Green Bay into the Fox River, through the valley of Lake Winnebago, southwest in the Fox River Valley, through the region of the present towns of Omro, Berlin, and Princeton, and south to join the Wisconsin River at Portage. At present, there is no natural connection between the Fox River and the Wisconsin River at Portage, but there is evidence that there was such a con-

nection during postglacial time. This gives us a general outline of the course which could have been followed by river-inhabiting mussels in going across the Mississippi-St. Lawrence divide into the Fox River drainage (Map 2).



MAP 2. The Fox River Drainage Basin.

The proximity of the Fox River to the Wisconsin River at Portage was known to pioneers in America. A. B. Hulbert (1903: 184-85) quoted Father Marquette in regard to the carrying place:

... the road is broken by so many swamps and small lakes that it is easy to lose one's way, especially as the River leading thither is so full of wild oats that it is difficult to find the channel. For this reason we greatly needed our guides, who safely Conducted us to a portage of 2,700 paces, and helped us transport our canoes to enter That river.

The date of this description is 1754. The account shows that the divide between the Fox and the Wisconsin rivers here was very low and about a mile and a half across. In flood time there may have been an overflow permitting an invasion of the fauna. More recently a canal has been dug joining the two drainages at this point (Martin, 1916: 336).

In order to account for the presence of such river-inhabiting species as *Actinonaias carinata* and *Alasmidonta marginata* in the Menominee drainage basin, there must have been a continuity of river conditions throughout the Fox River Valley. Major difficulties in the way of this would have been the presence of lakelike regions such as Green Bay and Lake Winnebago. Leverett suggested that if we allow some seventy-five feet for tilting in the Green Bay region, there is a likelihood that the southern end of Green Bay and perhaps the bed of Lake Winnebago, which has a maximum depth of but twenty-one feet (Martin, 1916: 269), may have been nonexistent, and an ancient Fox River might have flowed in a northeastern direction through this bed.

The details connected with the matter of bringing the Menominee drainage in conjunction with the Wisconsin River by way of the Fox River Valley are not simple. According to Martin (1916: 267-71) there were two rivers in the present Fox River Valley. The one, which was active during the glacial period, is still represented by that portion of the present Fox River drainage extending from Lake Winnebago to the headwaters of the Fox River at Portage. This region has the unusually small gradient of only one-half foot per mile. Such a gradient in the headwaters of a stream becomes significant when we consider that it is less than the gradient in the Mississippi River itself. In contrast to the flat grade of the upper Fox, the lower Fox River, extending from Lake Winnebago to Green Bay, drops on an average of five feet per mile. This represents a later development than that in the headwaters, and it may have some connection with the drop in lake level which Stanley (1938: 972-74) has described as occurring during a low stage in the Lake Algonquin level. The waters of Lake Michigan and Green Bay are reported to have subsided as much as 150 feet. In another paper soon to be published, Stanley claims that the lake level may have dropped as low as 200 feet below its present level in the Green Bay area. At present the depth in Green Bay opposite the mouth of the Menominee River is 114 feet. Consequently, there is no question but that the low-water stages during the Algonquin period were sufficient to give a dendritic river pattern which would have connected the lower Menominee with the greater Fox

River flowing through the valley of Green Bay. In this connection, it is of interest to note that on the basis of soundings in Green Bay there is evidence that remnants of a former river valley exist in the bed of this bay. A number of other streams, including the Peshtigo and the Oconto rivers in Wisconsin and the Ford, Escanaba, Whitefish, and Sturgeon rivers in Michigan, might have also been connected to form this greater Fox River system.

It may be said in conclusion that the explanation proposed herein for the distribution of naiads in the western part of the Upper Peninsula of Michigan was greatly strengthened for me in 1939 by a visit to the region under consideration. This detailed survey was made possible by a grant of money, in part expressly for the purpose, by the Horace H. Rackham School of Graduate Studies, to which I wish to express my sincere gratitude.

REFERENCES

- ALDEN, W. C.
1918 The Quaternary Geology of Southeastern Wisconsin. U. S. Geol. Surv., Prof. Papers, 106: 111-12.
- BAKER, F. C.
1928 The Fresh Water Mollusca of Wisconsin. Part II. Pelecypoda. Bull. Univ. Wis., No. 1527: 1-485, Pls. 29-105, Figs. 203-99.
- BAKER, H. B.
1922 The Mollusca of Dickinson County, Michigan. Occ. Papers Mus. Zool. Univ. Mich., 111: 1-44, 1 map.
- GOODRICH, CALVIN, AND HENRY VAN DER SCHALIE
1932 II. The Naiad Fauna of the Great Lakes. Occ. Papers Mus. Zool. Univ. Mich., 238: 8-14.
- HULBERT, A. B.
1903 Portage Paths. The Keys of the Continent. ("Historic Highways of America," Vol. 7.) Cleveland: Arthur H. Clark Co. Pp. 184-85.
- MARTIN, LAWRENCE
1916 The Physical Geography of Wisconsin. Wis. Geol. Surv. Bull., 36: 1-549, maps.
- MORRISON, J. P. E.
1932 A Report on the Mollusca of the Northeastern Wisconsin Lake District. Trans. Wis. Acad. Sci., 27: 359-96.
- ORTMANN, A. E.
1924 Distributional Features of Naiades in Tributaries of Lake Erie. Amer. Mid. Nat., 9, 3: 101-17, Figs. 1-2.
- STANLEY, GEORGE
1938 The Submerged Valley through Mackinac Straits. Journ. Geology, 46: 972-74.
- VAN DER SCHALIE, HENRY
1938 The Naiad Fauna of the Huron River, in Southeastern Michigan. Misc. Publ. Mus. Zool. Univ. Mich., 40: 1-83, Pls. I-XII, Figs. 1-28, Maps 1-18.
- WALKER, BRYANT
1898 The Distribution of the Unionidae in Michigan. Detroit: Privately printed by the Author. 23 pp., Pls. 1-3.
1913 The Unione Fauna of the Great Lakes. Nautilus, 27: 2-5, 18-23, 29-34, 40-47, 56-59.





No. 21. A Revision of the Libelluline Genus <i>Perithemis</i> (Odonata). By F. RIS. (1930) Pp. 50, 9 plates	\$0.75
No. 22. The Genus <i>Oligoclada</i> (Odonata). By DONALD J. BORROR. (1931) Pp. 42, 7 plates	\$0.50
No. 23. A Revision of the Puer Group of the North American Genus, <i>Melanoplus</i> , with Remarks on the Taxonomic Value of the Concealed Male Genitalia in the Cyrtacanthacrinae (Orthoptera, Acrididae). By THEODORE H. HUBBELL. (1932) Pp. 64, 3 plates, 1 figure, 1 map	\$0.75
No. 24. A Comparative Life History Study of the Mice of the Genus <i>Peromyscus</i> . By ARTHUR SVIELA. (1932) Pp. 39	\$0.50
No. 25. The Moose of Isle Royale. By ADOLPH MURIE. (1934) Pp. 44, 7 plates	\$0.70
No. 26. Mammals from Guatemala and British Honduras. By ADOLPH MURIE. (1935) Pp. 30, 1 plate, 1 map insert	\$0.35
No. 27. The Birds of Northern Petén, Guatemala. By JOSSELYN VAN TYNE. (1935) Pp. 46, 2 plates, 1 map	\$0.45
No. 28. Fresh-water Fishes Collected in British Honduras and Guatemala. By CARL L. HUBBS. (1935) Pp. 22, 4 plates, 1 map	\$0.25
No. 29. A Contribution to a Knowledge of the Herpetology of a Portion of the Savanna Region of Central Petén, Guatemala. By L. C. STUART. (1935) Pp. 56, 4 plates, 1 figure, 1 map	\$0.50
No. 30. The Darters of the Genera <i>Hololepis</i> and <i>Villora</i> . By CARL L. HUBBS AND MOTT DWIGHT CANNON. (1935) Pp. 93, 3 plates, 1 figure	\$0.50
No. 31. Goniobasis of the Coosa River, Alabama. By CALVIN GOODRICH. (1936) Pp. 60, 1 plate, 1 figure	\$0.35
No. 32. Following Fox Trails. By ADOLPH MURIE. (1936) Pp. 45, 6 plates, 6 figures	\$0.50
No. 33. The Discovery of the Nest of the Colima Warbler (<i>Vermivora crissalis</i>). By JOSSELYN VAN TYNE. (1936) Pp. 11, colored frontispiece, 3 plates, 1 map	\$0.25
No. 34. Mollusca of Petén and North Alta Vera Paz, Guatemala. By CALVIN GOODRICH AND HENRY VAN DER SCHALIE. (1937) Pp. 50, 1 plate, 1 figure, 1 map	\$0.50
No. 35. A Revision of the Lamprey Genus <i>Ichthyomyzon</i> . By CARL L. HUBBS AND MILTON B. TRAUTMAN. (1937) Pp. 109, 2 plates, 5 figures, 1 map	\$1.00
No. 36. A Review of the Dragonflies of the Genera <i>Neurocordulia</i> and <i>Platycordulia</i> . By C. FRANCIS BYERS. (1937) Pp. 36, 8 plates, 4 maps	\$0.50
No. 37. The Birds of Brewster County, Texas. By JOSSELYN VAN TYNE AND GEORGE MIKSCHE SUTTON. (1937) Pp. 115, colored frontispiece, 5 plates, 1 map	\$1.25
No. 38. Revision of <i>Sciurus variegatoides</i> , a Species of Central American Squirrel. By WILLIAM P. HARRIS, JR. (1937) Pp. 42, 3 plates (2 colored), 3 figures, 1 map	\$0.50
No. 39. Faunal Relationships and Geographic Distribution of Mammals in Sonora, Mexico. By WILLIAM H. BURT. (1938) Pp. 77, 26 maps	\$0.75
No. 40. The Naiad Fauna of the Huron River, in Southeastern Michigan. By HENRY VAN DER SCHALIE. (1938) Pp. 83, 12 plates, 28 figures, 18 maps	\$1.00
No. 41. The Life History of Henslow's Sparrow, <i>Passerherbulus henslowi</i> (Audubon). By A. SIDNEY HYDE. (1939) Pp. 72, 4 plates, 3 figures, 1 map	\$0.75
No. 42. Studies of the Fishes of the Order Cyprinodontes. XVI. A Revision of the Goodeidae. By CARL L. HUBBS AND C. L. TURNER. (1939) Pp. 80, 5 plates	\$0.90
No. 43. Aquatic Mollusks of the Upper Peninsula of Michigan. By CALVIN GOODRICH AND HENRY VAN DER SCHALIE. (1939) Pp. 45, 2 maps	\$0.50

Price lists are available for the *Occasional Papers*, *Handbook Series*, and *Circulars* of the Museum of Zoology.

