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MUSEUM OF ZOOLOGY
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THE NAIAD FAUNA OF THE HURON RIVER, IN SOUTH-EASTERN MICHIGAN

BY
HENRY VAN DER SCHALIE

ANN ARBOR
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FREDERICK M. GAIGE
Director of the Museum of Zoology

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CONTENTS

PLATES

(Plates I–XII follow page 83)

FIGURES IN THE TEXT

MAPS

THE NAIAD FAUNA OF THE HURON RIVER, IN SOUTHEASTERN MICHIGAN *

INTRODUCTION

THE study of the naiad fauna of the Huron River system in southeastern Michigan was begun in the spring of 1930 with a small nucleus of material which had been set aside in the Museum of Zoology for that purpose. Subsequently, from 1931 to 1933 collections were made at approximately one hundred stations along the river, its tributaries, and most of the lakes included in the drainage basin. The information gathered during the three years of work has of necessity been broad in its scope. Many problems have appeared which could not be entered into, but which are open to various types of investigation. Particular stress has been laid upon problems relating to ecology and distribution, the origin of the Naiad fauna of the river, its relations to the fauna of neighboring streams, the relative richness of the fauna, and its economic importance. The taxonomic status of certain species has been revised, information bearing on life-history studies has been included, and an attempt has been made to contribute field data covering the physical, chemical, and biological aspects of the environment.

This study was made under the supervision of Mr. Calvin Goodrich, to whom I am indebted for many suggestions and constructive criticisms. I wish to express my appreciation for the innumerable facilities placed at my disposal by the staff of the Museum of Zoology. I also wish to thank Dr. Carl L. Hubbs for his suggestions, Dr. C. J. D. Brown for aid and suggestions in the winter-migration experiments, and many others who have contributed their time and services during the course of the work.

PHYSIOGRAPHY OF THE DRAINAGE BASIN

The Huron River has its source in Big Lake, located in west central Oakland County, at an elevation of about 950 feet. Its winding course runs southward for several miles, whence it enters a complex series of lakes, and then continues approximately fifty miles southwestward, crossing the southeastern corner of Livingston County. Below Portage Lake it turns southward for a short distance and then continues in a southeasterly direction, passing through a corner of Wayne County and finally forming the northeast border of Monroe County. It discharges into Lake Erie a few miles below Rockwood at an elevation of 573 feet. Its general shape is that of a Γ, whose top has a southwest trend and whose leg trends southeastward.

On the basis of topography the drainage basin can be divided conveniently

* A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, in the University of Michigan.

into three rather distinct regions. The first of these consists of a series of morainal hills surrounded by plains. This area, composed mainly of sand and gravel from the Saginaw–Erie interlobate moraine, is one of surface irregularities in which lakes abound. The region may be delimited as the portion of the river which trends in a southwest direction, that is, the section corresponding to the top of the Γ. The main course of the river flows among and between these morainal hills, and here, in places, the shores are low and marshy, or high and firm in stretches where the banks crowd between the hills. Elsewhere the river passes long marshy stretches where it spreads out, deepens, and then enters expanses of lakelike character. It is in these areas that river-lakes, such as Commerce, Proud, Kent, Strawberry, and Gallagher, occur. The tributaries in this region enter from all directions, carrying waters from innumerable lakes, large and small. In recent years the water table has been so reduced that many of the outlets of these former tributary lakes no longer carry water, though their courses can still be traced. The result of the lowering of the water table has therefore been an increase in the number of land-locked lakes.

The second topographical zone is an area of well-marked hills between Dover and Ypsilanti. These gradually sloping hills with broad basins contrast with those of the lake region, which are steep and numerous. The area is composed of glacial till plains and clay moraines. These deposits trend in a northeast–southwest direction, approximately paralleling the Saginaw–Erie interlobate moraine. The river in this region has no low, marshy stretches. The banks are for the most part several feet high and do not flare out to form lakelike river expansions. The tributaries, more prominent than in either of the other regions, enter the river approximately at right angles, a circumstance which in nonglaciated parts of America would suggest stream capture.

The third zone is a low-lying plain extending from Ypsilanti to the mouth of the river. This plain slopes gradually to the western shore of Lake Erie. In the northwestern portion it is composed largely of a deposit of glacial lake sand and sandy loam, which becomes thinner as it approaches the limestone outcrops and clay deposits near Lake Erie. Here, again, the river has definite characteristics in that its course is primarily a meandering one, and it runs in a trough varying from about fifty feet deep at Ypsilanti to about twenty-five feet at Rockwood. No important tributaries enter this section of the river.

GEOLOGICAL HISTORY OF THE HURON RIVER

A brief outline together with maps showing the early history of the Huron and Raisin rivers has been given by Russell and Leverett (1915: 12–14). Taylor (1913) has also contributed data on the geological history of these drainage basins. The following description has been made up largely from these and other sources.

South Bend outlet stage.—At a very early stage in the development of the drainage, the Saginaw and Huron–Erie ice lobes covered the headwaters of the present Huron River. As the ice receded and the lobes divided, the Huron River first made its appearance as a glacial stream between these major lobes. At that early stage it flowed westward past Pinckney, Livingston County, through South Bend, Indiana, into the Kankakee River on the way to the Mississippi River. During this period the headwaters of the River Raisin were just appearing, and that stream flowed northwestward through Jackson County to join the Grand River at Jackson.

Chicago outlet stage.—Later, when the Lake Michigan, the Saginaw, and the Huron–Erie ice lobes had receded more to the northwest, the waters of the Grand River flowed by way of the present Paw Paw River drainage into the early Lake Chicago. Through the Des Plaines and Illinois rivers, Lake Chicago discharged into the Mississippi River. The direction of drainage of the headwaters of the Huron and Raisin rivers remained unchanged.

Lake Maumee stage.—Thus far the drainage had been westward by way of the Grand River, but, when the Huron–Erie ice lobe had receded so as to uncover the Fort Wayne moraine, which crosses Ann Arbor in a northeast–southwest direction, the Huron and Raisin rivers no longer ran westward, but southward, and issued into Lake Maumee. At this stage the Huron River flowed into the River Raisin, and the combined waters entered Lake Maumee, which in turn drained by way of the Fort Wayne outlet into the Wabash River, and on to the Ohio and Mississippi rivers. This outlet stage is held by Ortmann (1912*b*: 146) and Walker (1913: 18, 58) to have been the route by which the Mississippian fauna entered the Maumee River and in turn Lake Erie.

Imlay–Grand outlet stage.—As the ice lobes receded farther, Lake Maumee became larger, and its shores extended to Ann Arbor. The Huron and Raisin rivers were no longer joined. The Huron (Leverett, 1915: 14) flowed directly into Lake Maumee at Ann Arbor. Waters of the lake found a northern outlet, known as the Imlay outlet, in the "Thumb" region of Michigan. It followed the course of the Grand River into Lake Chicago. Further retreat of the ice opened up successive outlets (the Ubly and Grand rivers), caused a lowering of the glacial lake level, brought about a gradual increase in the length of the Huron River, and formed a series of beaches below Ann Arbor and Ypsilanti (outer, middle, and lower Maumee; the Whittlesey, and the highest and lowest Arkona beaches).

The recession of the ice in western New York gave rise to the formation of Lakes Warren and Algonquin, which discharged their waters eastward. These final stages of lake formation created conditions which have an important bearing upon the present fauna of the Huron River.

Thus, the Huron River originated between the Huron–Erie and Saginaw ice lobes. It first flowed westward into the headwaters of the Grand River, and then southward into the River Raisin to Lake Maumee. Later, its course was deflected directly into Lake Maumee at Ann Arbor; it then continued to flow into Lake Maumee, but increased in length as that lake and the lakes that succeeded it lowered their shore lines.

RELATION OF THE HURON RIVER NAIAD FAUNA TO THE GEOLOGICAL HISTORY OF THE DRAINAGE BASIN

Walker (1913: 58) states:

> . . . the original pre-glacial fauna of the present St. Lawrence system was absolutely exterminated during the glacial period, and . . . the peculiar fauna now characteristic of Lake Erie is the result of modification from environmental causes of the post-glacial immigrants from the south, and not the result of any survival in that region of any part of the pre-glacial fauna.

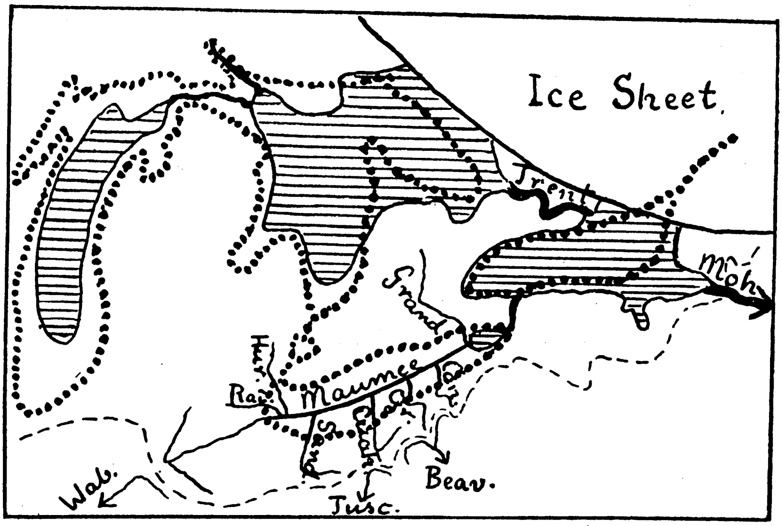
He has pointed out (1913: 58) that the present fauna of Lake Erie is presumably due to an invasion from the Mississippi Valley through the Maumee River outlet into glacial Lake Maumee. He has also noted (1908: 16) that several of the species entering Michigan by way of this Maumee route have not penetrated far into the rivers of the Lower Peninsula of Michigan:

> In the process of time as the level, first of Lake Maumee and then of both lakes, was lowered, and the present system of drainage was established, the Unionidae would naturally follow the retreating waters, and thus finally found their way into the rivers on either side of the state as we now find them. From the line of glacial lake beaches down to their mouths the Unionidae seem to have had no difficulty in occupying the rivers of the southern portion of the state. But in the upper waters of these streams above that line, few species seem to have been able to obtain a foothold. As has already been stated of the large number of species which are now found south of the Saginaw-Grand valley but five appear to range generally across the state. The remainder are found only in the lower waters of the rivers on either one or both sides of the state, and in the Saginaw-Grand valley. And it is certainly significant, that so far as the returns show, the range of these species, towards the interior, is substantially coincident with the beach line of the glacial lakes. That is to say that it would appear that the majority of our species, which come from the south, have migrated down stream from the place where they first obtained a foothold in the present river systems, but for some reason, with the exception of a few species, have not succeeded in spreading up-stream to any considerable extent.

Ortmann (1924) gives a more complete theory and explains just how the species which came into the Maumee River spread into the tributaries of Lake Erie, particularly in Ohio. He points out that most of these species have corresponding forms in Lake Erie, but that there are three distinctively river forms in these tributaries which do not have corresponding forms in the lake. These same three are present also in the Maumee River, and therefore have a discontinuous distribution. Ortmann (1924; 101–02) reviews the three theories advanced to account for this and shows that none of them are satisfactory. His own theory explains the situation, and is also much more plausible from a geological point of view. He shows that during the Trent and Nipissing outlet stages the glacial lake waters of the later Algonquin and early Nipissing Lake periods did not flow through Lake Erie. This lake must have been practically dry, with perhaps a remnant of it near Buffalo, close to its eastern end. Consequently, he (1924: 113) states:

> The Maumee River, entering the basin at its western end, must have traversed it in the direction of its long axis, so that all the present tributaries of the lake (except possibly the most eastern ones) *must have been tributaries of this continuation of Maumee River.*

He thus postulates a greater Maumee River to which the rivers now tributary to Lake Erie in northern Ohio, the Huron and Raisin rivers of Michigan, and the Grand River of Ontario were tributaries (Map 1).



MAP 1. Trent outlet stage of the Great Lakes. Adapted by Ortmann from Walker (1913: 44, Fig. 4).

At the end of the Trent and Nipissing outlet stages, the re-elevation of the continent at the northeast caused the waters again to flow by way of Detroit River into the Lake Erie basin, thus drowning the lower parts of the Maumee River and its tributaries, which then became tributaries to Lake Erie. The fauna in the flooded basin either died out or became modified to produce those forms which are recognized as lake forms of the earlier river types.

Ortmann derives the evidence for his theory from a faunistic study of the Naiades of the tributaries of Lake Erie in Ohio, and (1924: 114) suggests that there is also similar evidence for this in the fauna of the tributaries of Lake Erie in Michigan. To test his theory I have made a faunal com-

TABLE I

FAUNAL COMPARISON OF THE NAIADES IN RIVERS OF SOUTHEASTERN MICHIGAN

The species having discontinuous distribution are capitalized.

SPECIES	CLINTON RIVER	ROUGE RIVER	HURON RIVER	RAISIN RIVER	MAUMEE RIVER
Micromya fabalis	x	x*	x	x	x
Micromya iris	x	x	x	x	x
Lasmigona compressa	x	x	x	x	x
Lasmigona costata	x	x*	x	x	x
Lasmigona complanata	x	x	x	......	x
ALASMIDONTA MARGINATA	X	......	X	X	X
Alasmidonta calceolus	x	x	x	x	x
Ptychobranchus fasciolare	x	......	x	x	x
LAMPSILIS FASCIOLA	X	......	X	X	X
Elliptio dilatatus	x	x	x	x	x
Dysnomia triquetra	x	......	x	......	x
Fusconaia flava	x	x	x	x	x
Anodontoides ferussaciana	x	x	x	x	x
Strophitus rugosus	x	x	x	x	x
Ligumia recta latissima	x	x	x	x	x
Ligumia nasuta	x	x*	x	......	......
ACTINONAIAS CARINATA	X	......	X	X	X
Amblema costata	x	x	......	x	x
Lampsilis siliquoidea	x	x	x	x	x
Lampsilis ventricosa	x	x*	x	x	x
Proptera alata	x	......	......	......	x
Anodonta grandis	x	x	x	x	x

TABLE I—(*Continued*)

FAUNAL COMPARISON OF THE NAIADES IN RIVERS OF SOUTHEASTERN MICHIGAN

The species having discontinuous distribution are capitalized.

SPECIES	CLINTON RIVER	ROUGE RIVER	HURON RIVER	RAISIN RIVER	MAUMEE RIVER
Cyclonaias tuberculata	x	......	x	x	x
Pleurobema cordatum coccineum	x	x	x	x	x
Quadrula pustulosa	x	......	x	......	x
Carunculina parva	x	x	x	......	......
Obovaria subrotunda	x	x	x	x	x
Truncilla truncata	......	......	x	x	x
Leptodea fragilis	......	......	x	......	x
Anodonta imbecillis	......	......	x	......	x
Obovaria lens	......	......	......	x	x
Quadrula quadrula	......	......	......	......	x
Quadrula cylindrica	......	......	......	......	x
Pleurobema clava	......	......	......	......	x
Obliquaria reflexa	......	......	......	......	x
Truncilla donaciformis	......	......	......	......	x
Plagiola lineolata	......	......	......	......	x
Obovaria leibii	......	......	......	......	x
Carunculina glans	......	......	......	......	x
Dysnomia sulcata	......	......	......	......	x
Megalonaias gigantea	......	......	......	......	x
Obovaria retusa	......	......	......	......	x
Obovaria olivaria	......	......	......	......	x
Ligumia subrostrata	......	......	......	......	x
Simpsoniconcha ambigua	......	x*	......	......	x*

* Records kindly furnished by Calvin Goodrich.

parison table of the Naiades in the streams of southeastern Michigan and have condensed the data gathered into Table I. This indicates that if Ortmann's contentions are followed to their logical conclusions the Clinton, Huron, and Raisin rivers were former tributaries to the Maumee River, because the three species with discontinuous distribution not represented in Lake Erie—which Ortmann regarded as indices of the old Maumee River fauna, namely *Alasmidonta marginata, Lampsilis fasciola* and *Actinonaias carinata*—all occur in these three Michigan rivers.

An objection which may be offered to this theory is that these river forms may have entered the Huron and Raisin rivers during the South Bend and Chicago outlet stages when they drained into the Grand River. The objection, however, cannot be sustained, since in Michigan *Lampsilis fasciola* is found only in the tributaries of Lake Erie, the Detroit River, and Lake Saint Clair and is absent in the Grand River and all other rivers draining into Lake Michigan. Furthermore, *Actinonaias carinata* has never been found in the headwaters of the Huron River or any other river of southern Michigan, though it would necessarily have had to be there if it had come into the Huron by way of the Grand River.

Another point brought out by the faunal comparison table is that not a single one of the three true river species is found in the River Rouge. Perhaps that drainage system is of more recent origin and has been formed since the return of the waters to the Lake Erie basin at the end of the Nipissing–Great Lake stage—a change which caused the formation of the modern Great Lakes. The Rouge drainage is largely confined to the low-lying plain of lacustrine sand (with clay near its mouth), and it is not unreasonable to suppose that it might be topographically younger than the Clinton, Huron, and Raisin drainages. If that be true, it is not difficult to see why it does not contain species which would point to a former connection with the Maumee River.

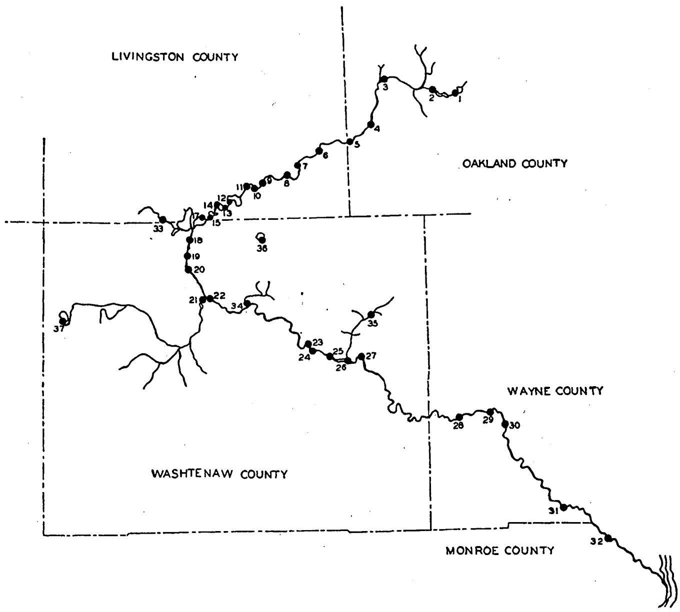
Map 1 shows that the Raisin and Huron rivers probably flowed directly into the Maumee River. Ortmann was not aware that the Clinton River also must, on the same evidence, have been a tributary to the Maumee at the same time. Just how the Clinton reached the Maumee is uncertain. It may have followed the course of what was left of the Detroit River.

ECOLOGICAL STUDIES

In order to give a graphic picture of the ecological conditions in the Huron River drainage, a series of type stations has been selected. These have been plotted on Map 2. With each station a short description is given. Some chemical data on the habitats are presented in Table II, with a brief statement of the conditions observed. The ecological data have been summarized into fourteen type habitats. For each of these the distinguishing characteristics and the associated fauna are given. A section is included to correct some prevalent erroneous notions concerning the habits of lake-dwelling Naiades. This section is followed by a brief account of the chief factors limiting the abundance of the Naiades in this drainage basin.

DESCRIPTIONS OF TYPE STATIONS

The following stations were selected as more or less typical of the various ecological regions of the drainage. The first thirty-two run in consecutive order from the headwaters toward the mouth of the river (Map 2); the last four (Stations 33 to 36) represent conditions in the tributaries and lakes.



MAP 2. Locations in the Huron River of the type stations referred to in the ecological studies.

These stations were visited on several occasions during the three years of work.

Stations in the Huron River and Huron River-Lakes

Station 1. Below the outlet of Commerce Lake, Oakland County, October 15, 1932. The river here is about twenty feet wide and flows about four miles an hour over an irregular and rather soft bottom of sand and mud covered with thick patches of *Chara*. The species of mussels present are *Lampsilis ventricosa, Lampsilis siliquoidea, Micromya iris,* and *Anodonta grandis.* Because of the soft bottom *Anodonta grandis* is the most abundant of these (Pl. I, Fig. 1).

Station 2. At the bridge just below Proud Lake, Oakland County, September 16, 1932. Conditions here are decidedly marshy. The current is variable, the bottom is pitted; the depth varies from three to five or six feet. The gravel and mud bottom is covered with thick patches of weeds, mainly *Chara.* The mussels here are *Lampsilis siliquoidea, Micromya iris, Anodonta grandis,* and *Lampsilis ventricosa. Anodonta* occurred mainly on soft mud areas; the other three species usually were found in the gravel (Pl. I, Fig. 2).

Station 3. Two miles below Milford, Oakland County, September 16, 1932. There is a fine shoal here of sand and gravel. Normally the current is about five miles an hour, but operations at the Milford dam cause marked fluctuations in the velocity and depth of the water. The depth normally varies from one to four feet. The gravel bars, scarce in vegetation, harbor an abundance of mussels, both in species and in numbers. Table IV gives a list of the species occurring here (Pl. I, Fig. 3).

Station 4. Two miles northwest of New Hudson, Oakland County, September 16, 1932. This station somewhat duplicates the conditions of Station 3. The river, widening to about forty to fifty feet, flows here through a lowland and approaches the backwaters of Kent Lake. The irregular bottom is composed largely of fine gravel and sand. The vegetation begins to increase, forming in patches, with *Chara* the predominating type. The twelve species taken here are listed in Table IV (Pl. II, Fig. 1).

Station 5. One mile below Kent Lake, Oakland County, September 17, 1932. This station proved rather puzzling. The chemistry of the water and the physical conditions indicate that the area ought to be productive. The bottom is hard and rough. It is evident from the shells that at one time mussels lived here, but for unknown reasons they have died out (Pl. II, Fig. 2).

Station 6. One mile south of Woodruff Creek, Livingston County, September 17, 1932. This station and Station 7, located four miles south of Woodruff Creek, are in a marshy area, where the irregular bottom is composed of fine mud, sand, and light gravel. The abundant vegetation at both stations occurs in thick patches. The species taken (see Table IV) indicate that small-river conditions still prevail (Pl. II, Fig. 3).

Station 7. See Station 6.

Station 8. One mile east of Ore Lake, Livingston County, October 22, 1932. At this very productive station the river is sixty feet wide and flows at a rate of about three miles an hour over a solid bottom of sand, gravel, and stones. The vegetation consists of small amounts of *Potamogeton, Valisneria,* and filamentous green algae. Here again Naiades thrive in a region which does not have an excess of vegetation. The species found here are listed in Table IV. *Dysnomia triquetra,* a rare species at most stations, is abundant here (Pl. III, Fig. 1).

Station 9. Below the bridge, one mile north of Hamburg, Livingston

County, October 22, 1932. The river here is about fifty feet wide, has a current of three miles an hour, and flows over an irregular bottom composed largely of sand and gravel. The depth varies from one to three feet. The vegetation is sparse. The fauna, similar to that of the preceding station, is of the medium-sized river type. *Ligumia recta latissima,* rare in this drainage, was taken here (Pl. III, Fig. 2).

Station 10. At the bend east of Buck Lake, Livingston County, September 17, 1932. There is a very productive bar at this station. The water varies in depth from two feet at one bank to five feet at the other. In the shallower areas the current is three to four miles an hour. The sparse vegetation consists mainly of *Potamogeton pectinatus.* Of special interest is the series of *Dysnomia triquetra* obtained here (Pl. III, Fig. 3).

Station 11. Northwest of Buck Lake, Livingston County, October 22, 1932. At this low, marshy zone the river widens to ninety feet and flows at the rate of about one mile an hour over a soft, irregular bottom. The species taken are unexpected on such a bottom. The vegetation is abundant, with *Chara* the predominant form. Conditions would indicate that this is an *Anodonta* habitat, but no specimens of this genus were found. Instead, the fauna (see Table IV), though not rich, was more of the river type (Pl. IV, Fig. 1).

Station 11*a*. Near the railroad bridge above Strawberry Lake, Livingston County, October 22, 1932. This transitional zone stretches between a low, marshy area and one with a more solid bottom and high, wooded banks. The river has flared into a lakelike expansion, at the outlet of which there is the usual thick mat of dead river shells. Thereafter the bottom becomes solid and is composed of sand and gravel. Vegetation occurs in thick patches; *Chara, Potamogeton, Valisneria,* and filamentous green algae are predominant. The water is fairly shallow, with a maximum depth of about three feet. As Table IV shows, this station is rather productive (Pl. IV, Fig. 2).

Station 12. Outlet of Strawberry Lake, Livingston County, September 28, 1932. Here conditions are typical of those found at the outlet of most of the river-lakes. The bottom is covered with a huge mass of dead shells, as it has been for years past. No completely satisfactory explanation occurs for this condition. The species represented are predominantly river forms (Pl. IV, Fig. 3).

Station 13. One-half mile below Strawberry Lake, Livingston County, September 28, 1932. The river here is forty to fifty feet wide and two to five feet deep and has a very irregular bottom of sand and gravel on which are dense patches of vegetation. *Pontedaria,* filamentous green algae, and *Chara* are the most common plants. Conditions are those of a medium-sized river. Of the species taken, *Ligumia recta latissima* deserves mention because of its rarity or absence elsewhere (Pl. V, Fig. 1).

Station 14. Gallagher (Loon) Lake, Livingston County, September 28, 1932. This station is a shoal in a typical river-lake. The bottom consists of a fine mixture of sand, marl, and mud. The vegetation is mainly *Carex, Scirpus,* and filamentous green algae, with small quantities of *Chara* and *Potamogeton.* This shoal does not differ much from shoals found in certain land-locked lakes, and yet it yields twice as many species. Besides the usual *Anodonta grandis* and *Lampsilis siliquoidea,* two other species, *Lampsilis ventricosa* and *Elliptio dilatatus,* occur. On similar shoals in river-lakes *Strophitus rugosus* also occurs (Pl. V, Fig. 2).

Station 15. Whitewood Lake, near the outlet, Livingston County, September 28, 1932. The bottom is mainly marl and mud. The vegetation for the most part is *Scirpus,* with small amounts of *Chara.* Algae are restricted mainly to those forming marl concretions. This soft shoal, extending about fifteen feet from shore, is covered by six inches to three feet of water; it drops off suddenly into deep water. Like other shoals of its type, it is not very productive, even though there are river-lake conditions. It harbors only two species, *Lampsilis siliquoidea* and *Anodonta grandis* (Pl. V, Fig. 3).

Station 16. About one hundred yards below the outlet of Whitewood Lake, Livingston County, September 28, 1932. At the outlet of Whitewood Lake there is another bed of dead shells, below which this station was established. The river is forty feet wide and flows four to five miles an hour over a solid bottom composed of marl, sand, and gravel. The vegetation is sparse, but becomes more abundant as one approaches the backwaters of Base Line Lake. This section of the river is fairly productive, yielding almost a dozen species (see Table IV).

Station 17. Base Line Lake, near the inlet, Livingston County, September 28, 1932. There is an extensive shoal at this station, composed of a mixture of marl and sand, and sloping gradually into deeper water. It is an excellent habitat for Naiades. Five species, many for a lake, have been taken here (see Table IV). The rarest form is *Dysnomia triquetra,* which occasionally occurs in river-lakes (Pl. VI, Fig. 1).

Station 18. At Dover, Washtenaw County, September 25, 1932. Conditions here and at Station 19, in the river near Hudson Mills, are so similar that the situations may be considered together. The river is seventy-five feet wide and flows about five miles an hour over a nearly solid bottom composed of sand, coarse gravel, and boulders, partly cemented together by marl. In places there are rapids. The depth varies from a few inches to four feet. *Cyclonaias tuberculata* makes its first appearance among the stones and boulders of this region. Young *Micromya iris* are also common here (Pl. VI, Fig. 2).

Station 19. See Station 18.

Station 20. Two miles northwest of Dexter, Washtenaw County, September 25, 1932. Conditions are similar to those already enumerated for the preceding station. Of all the stations visited, this one yielded the finest series of immature forms, representing practically all the stages of growth. The young usually occur in soft, sandy places around the larger stones (Pl. VI, Fig. 3).

Station 21. Millrace in the Huron River, at Dexter, Washtenaw County, October 4, 1932. At this site of a long-abandoned mill the water flows about one mile an hour. The bottom here is sand and gravel, and there are muddy areas along the banks. It is a relatively productive situation, though the species are not essentially different from those in the river near-by. This station should not be confused with the millrace adjoining Mill Creek at Dexter (Pl. VII, Fig. 1).

Station 22. Near the Boy Scout Camp, at Dexter, Washtenaw County, October 4, 1932. Conditions here are more or less similar to those found at Stations 18, 19, and 20. *Cyclonaias tuberculata* is very common, more so than where it occurs in the lower reaches of the river (Pl. VII, Fig. 2).

Station 23. At the Island, Ann Arbor, Washtenaw County, October 8, 1932. Here the river is about one hundred and thirty feet wide and flows three to four miles an hour over a firm bottom composed largely of sand and gravel. The depth of the water is subject to much fluctuation due to operations at the power dam. Few of the Naiades that once occurred here still remain (Pl. VII, Fig. 3).

Station 24. Near the Arboretum, below Ann Arbor, Washtenaw County, October 8, 1932. This is just below the Ann Arbor sewage effluent. The bottom is covered by thick deposits of sludge in which no Naiades can exist. Chemical tests of the water indicate that the water has not yet changed greatly, although very near the source of the pollution. The effect of the pollution on the bottom has been so pronounced that even though it should be discontinued, a long time would elapse before Naiades could find favorable conditions in which to establish themselves (Pl. VIII, Fig. 1).

Station 25. About two miles below Ann Arbor, Washtenaw County, October 8, 1932. No Naiades occur at this station in the polluted zone. The station lies in the upper reaches of the backwaters above the Geddes dam. The current is sluggish, and the water is decidedly filthy, with a large amount of debris in suspension. The bottom is a thick, sludgy mud. Not only do the bottom conditions rule out any possibilities for the existence of Naiades, but the amount of debris in suspension constitutes a very adverse condition (Pl. VIII, Fig. 2).

Station 26. About two miles above Geddes Dam, Washtenaw County, October 8, 1932. Conditions are rather similar to those at Station 25, differing, however, in that the largely sand and gravel bottom is firmer, although covered by sludge. No Naiades occur, although a few live Gastropods were found on the vegetation (Pl. VIII, Fig. 3).

Station 27. Below the new Ford dam, one mile above Rawsonville, Washtenaw County, October 24, 1932. This dam, just completed at the time of my investigation, held back whatever water was coming to it, and the dam at French Landing below was open. This circumstance afforded exceptionally fine conditions for work at all succeeding stations down to French Landing. The bottom was a thick mud along the south shore, but of fine sand in the bed of the river. It was a surprise to find *Cyclonaias tuberculata,* a species I had always associated with gravel bars, living in the soft sand at this station. Other species, such as *Elliptio dilatatus, Micromya iris,* and *Lampsilis fasciola* were found, but only as dead shells. Large-river conditions inimical to these species are developing here (Pl. IX, Fig. 1).

Station 28. Mud flats, two miles above Belleville, Wayne County, October 25, 1932. It was unusual to be able to work under such favorable conditions on these extensive mud flats, which are normally covered by several feet of water. Due to the great quantity of phytoplankton the water here was turbid. The predominant species are *Lasmigona complanata* and *Carunculina parva.* My greatest surprise was to find *Alasmidonta calceolus* and *Anodontoides ferussacianus,* two typical creek species, in this section of the river. They were very rare, but their occurrence indicates that they can live and develop under unusual ecological conditions, provided the fish which carry them as glochidia are able to reach such situations (Pl. IX, Fig. 2).

Station 28*a*. Across the bridge north of Belleville, Wayne County, October 24, 1932. This continuation of the backwater area from the dam at French Landing for several miles approximates the size of a lake about a quarter of a mile wide. The bottom is largely gravel and soft mud. The most common species is *Carunculina parva,* which normally occurs on the sand and gravel stretches near shore. It was migrating toward deeper water as the water level lowered. *Lasmigona complanata* was found in the soft mud areas (Pl. IX, Fig. 3).

Station 29. Mud flat, just above the dam at French Landing, Wayne County, October 24, 1932. The water here was decidedly turbid because of the large amount of phytoplankton in suspension. The fine mud shoal was very productive. Both *Lasmigona complanata* and *Carunculina parva* were abundant. The young of the former were found close to the water margin. Though many individuals of *parva* migrated with the drop in water level, a large number dug down into the mud instead. The *Lampsilis ventricosa* taken here were very highly polished. All of them were taken in the deeper water, indicating that this species responds definitely to the lowering of the water and is able to migrate to adjust itself to the change. *Anodonta imbecillis,* a member of the "floater" group, was not very successful in its attempt to migrate and in most cases it merely dug into the mud. Consequently, most of the individuals of this species were stranded when collected (Pl. X, Fig. 1).

Station 29*a*. Gravel bar, above the dam at French Landing, Wayne County, October 24, 1932. The south shore of the backwater above the dam does not have mud flats. Here there is a steep rock and gravel bank. In the gravel and softer sections along this bank a few stranded specimens of *Anodonta imbecillis* were found. *Carunculina parva*, which was abundant in a similar habitat at Station 28*a*, was not found here (Pl. X, Fig. 2).

Station 30. At Huron River Park, Wayne County, October 25, 1932. Large-river conditions exist. The river is about one hundred and twenty feet wide and three to six feet deep, and flows about four miles an hour over a hard rock and gravel bottom. Pollution attributable to a garbage reduction plant just below the dam at French Landing has destroyed the fauna downstream as far as Flat Rock. In recent years, with control of the pollution, the fauna has been coming back, and at present mussels occur as far upstream as within two miles of New Boston (Pl. X, Fig. 3).

Station 31. One mile east of Willow, Wayne County, October 28, 1932. A mile above this station, pollution has affected the river and the naiad fauna has completely disappeared. The river is one hundred to one hundred and twenty feet wide, three to six feet deep, and flows at about three miles an hour over mud, sand, and gravel. Vegetation is sparse. *Actinonaias carinata* was taken alive. This is the first station where it occurs below the pollution zone. *Anodonta imbecillis* was very abundant, especially on a sandy bottom. In all, fourteen species were found here (see Table IV, and Pl. XI, Fig. 1).

Station 32. One-half mile above Rockwood, Monroe County, October 28, 1932. This station is located well above the backwater from Lake Erie, which extends upstream about five miles—as far as Rockwood. Normally, mussels can be taken in this lower region by means of a dredge only. The river is one hundred feet wide, three to seven feet deep, and flows at a rate of three miles an hour over a gravel and clay bottom. Mussels are abundant in the gravel, but the clay is usually barren. Vegetation is scanty. Species common to Lake Erie occur here (Pl. XI, Fig. 2).

Stations in Tributaries and Lakes

Station 33. Portage River, at the bridge north of Silver Lake, Livingston County, September 11, 1932. This station represents typical small-river conditions. The stream, about twenty feet wide, flows at a varying speed, one to four miles per hour, over an irregular bottom composed of gravel, sand, and mud. The shores tend to be marshy. Vegetation is abundant and occurs in patches. The fauna is typically that of a small river (see Table IV, and Pl. XI, Fig. 3).

Station 34. Outlet of Loch Alpine, Washtenaw County, October 4, 1932. This creek is about six to eight feet wide and has a depth of six inches to two feet. The bottom consists of alternating patches of fine silt and a sandy gravel. The fauna (see Table IV) is typically that of a small creek. *Anodonta* here occurs on the silt near the mouth of the creek, as a river intrusion (Pl. XII, Fig. 1).

Station 35. Fleming Creek, one mile northeast of Dixboro, Washtenaw County, September 10, 1932. This station represents typical creek conditions. The stream is six to eight feet wide and has a constant flow. It has an irregular gravel and sand bottom. The depth varies from a few inches in the riffles to two or three feet in the pools. There are patches of weed irregularly scattered. The fauna consists of four species which are true creek forms (see Table IV) and which occur in abundance (Pl. XII, Fig. 2).

Station 36. South end of Whitmore Lake, Washtenaw County, October 9, 1932. Land-locked lake conditions exist here. There is a long shallow shoal composed of alternating areas of sand, gravel, and marl. The vegetation is sparse with only small scattered patches of *Chara.* This station is peculiar in that, of the two species commonly found in such a lake, *Anodonta grandis* was by far the more abundant. Usually, on a bottom as solid as occurs here, *Lampsilis siliquoidea* is more abundant than *Anodonta* (Pl. XII, Fig. 3).

Station 37. Southeast end of Cavanaugh Lake, Washtenaw County, October 1, 1932. This lake is located in the headwaters of Mill Creek. It has lost its connection with this outlet in comparatively recent times. The station was established on a wind-swept shoal composed of firm gravel and sand. With the exception of small patches of *Chara,* very little vegetation was present. In this situation only *Lampsilis siliquoidea* of the true, stunted lake form (*rosacea*) was found, and there was a complete absence of *Anodonta grandis.* Station 37*a,* on the south shore of Cedar Lake, located just east of Cavanaugh Lake, represents similar lake conditions. The combination of soft mud shoals with others of sand and gravel accounts for the presence of both *Lampsilis siliquoidea* and *Anodonta grandis.*

CHEMICAL CONDITIONS AT THE TYPE STATIONS

Table II gives the temperature and certain chemical conditions which were recorded between September 11 and October 28, 1932, at the various stations (Map 2). The methods employed and the data recorded may be summarized as follows: The tests for dissolved oxygen were made by the Rideal Stewart modification of the Winkler method as outlined by *Standard Methods for the Examination of Water and Sewage* (1925: 59). The smallest amount recorded was 6.72 p.p.m.; the largest, 14.59 p.p.m.

A Hellige color-disk comparator was used for pH determinations. The pH throughout the drainage ranged between 7.8 and 8.4, with a mean of 8.0. The water was therefore decidedly on the alkaline side of neutrality.

The alkalinity tests were made by titration, using N/50 sulphuric acid with methyl orange as an indicator. The alkalinity was high, indicating an abundance of carbonates for the production of shell material. The lowest alkalinity reading was 133 p.p.m.; the highest, 233 p.p.m. The fact that

TABLE II

CHEMICAL CONDITIONS AT THE TYPE STATIONS

See Map 2 for location of stations. 1 to 32 are in the river, from the headwaters down, 33 to 37*a* are in creeks and lakes.

STATION NO.	DATE (1932)	TEMP. °C.	OXYGEN		M.O. ALKALINITY	pH
			P.P.M. Per Cent	Saturation		
1	IX: 16	20.0	10.4	114	160	8.0
2	IX: 16	22.0	9.9	112	159	7.9
3	IX: 16	21.5	10.9	122	179	7.9
4	IX: 16	20.5	10.3	113	184	......
5	IX: 17	18.0	7.7	81	194	8.4
6	IX: 17	18.0	7.9	82	199	8.2
7	IX: 17	18.0	10.3	108	202	8.4
8	X: 22	10.0	....	....	....	7.9
9	X: 22	10.5	....	....	....	8.0
10	IX: 17	18.0	10.2	106	209	8.4
11	X: 22	11.0	....	....	....	8.0
12	IX: 28	16.5	7.9	80	195	......
13	IX: 28	19.0	7.6	81	191	8.0
14	IX: 28	19.0	....	....	192	8.2
15	IX: 28	18.5	10.2	107	187	8.0
16	IX: 28	18.5	8.7	92	190	8.0
17	IX: 28	19.0	9.3	99	189	8.4
18	IX: 25	19.5	12.3	133	....	8.2
19	IX: 25	15.5	14.6	145	180	......
20	IX: 25	19.0	12.9	138	185	8.0
20	IX: 27	19.0	10.5	112	210	7.8
21	X: 4	16.5	9.4	96	187	7.8
22	X: 4	16.5	9.4	96	188	7.8
23	X: 8	14.0	12.7	123	200	8.4
24	X: 8	14.0	6.7	65	218	8.0
25	X: 8	13.0	12.4	117	199	8.1
26	X: 8	12.0	8.0	74	185	7.8
27	X: 27	11.5	7.6	69	212	7.8
28	X: 24	14.0	13.0	126	203	8.0
29	X: 24	14.5	9.7	95	195	8.1
29	X: 24	14.5	10.7	105	191	8.1
30	X: 25	14.0	10.3	99	192	8.1
31	X: 28	14.0	13.3	128	199	8.0
32	X: 28	9.5	12.4	109	195	8.1
33	IX: 11	20.5	11.4	126	133	8.2
34	X: 4	17.0	11.0	113	198	7.9
35	IX: 10	22.0	....	....	233	8.0
36	X: 9	15.0	10.3	102	109	8.1
37	X: 1	16.5	12.0	122	137	8.0
37a	X: 1	17.0	10.3	106	143	8.1

marl is being formed in the river and in the lakes is further evidence of a permanently high carbonate content.

HABITAT TYPES AND FAUNAL ASSOCIATIONS

It is difficult to define accurately all the characteristics of an environment which determine the occurrence or absence of a particular species. This is especially true in a group such as the Naiades, for the presence or absence of a species of this group is perhaps more definitely dependent upon the distribution of the fish host than upon any special group of physical and chemical factors in the environment. There are, however, a number of clearly defined habitats within this drainage basin, each with characteristics peculiar to it and each with its own association of species. The following types of habitat have been selected as those most common to the drainage.

Habitat Type 1

Lakes without an outlet, and lacking solid shoals.—This type of marshy lake is surrounded by very soft shoals on which only shells of the "floater" type seem to be able to live. There are not many of these lakes in the Huron River drainage. Two examples, Harvey Lake and Wolverine Lake, may be cited. Such lakes harbor but one species, *Anodonta grandis* Say, a thin-shelled, swollen form, capable of maintaining itself on a soft substratum.

Habitat Type 2

Lakes without an outlet and having at least one firm shoal.—The shoal may be composed of sand or gravel, or a combination of both, or, at times, a mixture of fine sand, mud, and marl. The important condition, however, is that there be a firm shoal, the texture of which is not too hard for the mussels to embed themselves in and move through. A majority of the lakes in the system belong to this type. Examples are: Duck, Grass, Wild Goose, Pleasant, Cedar, Cooley, Oxbow, and Whitmore lakes. Invariably the fauna of a lake of this kind consists of only two species:

Anodonta grandis *Lampsilis siliquoidea*

Habitat Type 3

Larger lakes having a sizable outlet, and, usually, an inlet.—In these lakes there are usually more or less firm shoals composed of sand and gravel, or of a fine mud. White, Reed, and Union are lakes of this type. They produce, in addition to the two species common to lakes of Type 2, a third species:

Anodonta grandis *Lampsilis siliquoidea*
Strophitus rugosus

Habitat Type 4

Lakes arranged to form a chain series.—These might well be classed under the previous type (Type 3), because most of the physical and chemical conditions are the same. Yet in such lakes we find a slight change in the fauna in that *Strophitus rugosus* (Swainson), though it may be present, often is not. In its stead is *Lampsilis ventricosa* (Barnes), a species common to the river, but entering lakes arranged in a chain series. An example of such a series of lakes is Lower, Middle, and Upper Straits. The fauna is made up of:

Anodonta grandis
Lampsilis siliquoidea
Lampsilis ventricosa

Habita Type 5

Lakes of the river-lake type.—R. E. Coker (1914: 9) has defined this type of lake as follows: "By 'river-lake,' I mean such a body of relatively still water as would ordinarily be called a lake, which is yet intimately connected with a river, either as interpolated in the course of the river, or as an arm of a river." Within the Huron drainage there are several of these lakes: Commerce, Proud, Strawberry, Gallagher, Whitewood, and Base Line. Each of these appears as an expansion of the river. The physical features are, for the most part, similar to those of other lakes, but the one outstanding distinction is regular renewal of water. There is a marked increase in the number of species, usually including:

Lampsilis siliquoidea
Lampsilis ventricosa
Anodonta grandis
Strophitus rugosus
Elliptio dilatatus
Dysnomia triquetra

Habitat Type 6

Very small creeks or brooks, about three feet wide.—Creeks which seem almost too small to be of any faunistic significance, with mud, sand, or a sand and gravel bottom, constitute this type. Ordinarily, such streams yield very little, but they may contain one species, provided they have a constant flow such as would be supplied by a permanent spring. Within the drainage there are two examples of this type which have been investigated—Brewery Creek, which flows into the Huron River at Ann Arbor, and a small creek north of Williamsville Lake in Livingston County. Both have yielded *Lasmigona compressa.* Where such a stream becomes just a little larger, *Anodontoides ferussacianus* is usually added to the fauna.

Habitat Type 7

Small creeks, about ten feet in width.—Creeks of this type have a depth of one to three feet, a constant supply of clear water, and flow over a mud, sand, or sand and gravel bottom. Examples are: Davis Creek and Honey Creek above Pinckney, both in Livingston County, and Fleming Creek, Washtenaw County. The fauna of these streams is very characteristic and usually includes all or any of the following four species:

Lasmigona compressa
Alasmidonta calceolus
Anodontoides ferussacianus
Strophitus rugosus

Habitat Type 8

Large creeks having a width of about ten feet.—These streams have a depth of one to three feet; the bottom is mud, sand, sand and gravel, or glacial till. This type has practically the same conditions as the one which precedes it, but it differs mainly in size. In fact, the headwaters of a creek may be of Type 7, while the lower reaches may become Type 8. This is true of Honey Creek, above and below Pinckney. The lower reaches of Mill Creek, Washtenaw County, also belong to this type. With an increase in size, two species are added. Whereas normally four species live in a stream of Type 7, six commonly inhabit a stream of Type 8:

Lasmigona compressa
Anodontoïdes ferussacianus
Alasmidonta calceolus
Strophitus rugosus
Elliptio dilatatus
Micromya iris

Habitat Type 9

Small river.—These conditions are exhibited in Portage River, Livingston County, and in the Huron River from Commerce Lake through Milford to the backwaters of Kent Lake. Much variation may exist in such long stretches of river and yet the general habitat conditions and the fauna are rather typical in these areas. The stream has now assumed the appearance of a small river. It has a width of twenty to fifty feet, and there is an abundant supply of water which flows uniformly at a rate of four to five miles an hour over a solid bottom of sand and gravel and a mixture of mud and sand. The depth is not uniform, varying from broad shoal areas covered with only six inches of water to pools four or five feet deep and lined with sand or mud. There is a remarkable increase in the number of species which occupy such a habitat. Not only do all the species common to the larger creeks remain, but also several which are characteristic of small-river conditions are added. The fauna now includes the following species:

Lasmigona compressa
Anodontoides ferussacianus
Alasmidonta calceolus
Strophitus rugosus
Elliptio dilatatus
Micromya iris
Alasmidonta marginata
Ptychobranchus fasciolare
Lampsilis fasciola
Lampsilis siliquoidea
Lampsilis ventricosa
Dysnomia triquetra
Anodonta grandis
Anodonta imbecillis

Habitat Type 10

Medium-sized river.—Conditions of this character are exhibited in the part of the main river which lies between the Ann Arbor-Brighton highway (U. S. 23) bridge north of Whitmore Lake and the backwaters of Strawberry Lake. The river here has a width of from fifty to seventy feet. There is a steady current which flows about four miles an hour over the shoals and becomes very sluggish where the river widens and deepens in the marshy areas. The solid shoals are largely composed of a mixture of gravel and sand, and the vegetation is typically sparse. Under such conditions the largest numbers of mussels, both in species and in individuals, are found. In other places the bottom becomes somewhat irregular and is then often composed of patches of weed on a muddy substratum. These situations are usually less productive. There are also areas where the shores become marshy, the river deepens, the bottom is covered with a dense mat of vegetation, and the current is sluggish. Usually, such places harbor considerably fewer species than do the hard shoals. The species of this zone are as follows:

Elliptio dilatatus	*Ligumia recta latissima*
Strophitus rugosus	*Lampsilis fasciola*
Anodonta grandis	*Lampsilis siliquoidea*
Alasmidonta marginata	*Lampsilis ventricosa*
Ptychobranchus fasciolare	*Dysnomia triquetra*
Micromya iris	*Lasmigona costata*

A comparison of this list with that under Type 9 reveals that *Lasmigona compressa, Anodontoides ferussacianus,* and *Alasmidonta calceolus* have disappeared, and that *Lasmigona costata, Dysnomia triquetra,* and *Ligumia recta latissima* are added.

Habitat Type 11

River of fairly large size.—This zone, found in the region between the outlet of Base Line Lake and Ann Arbor, somewhat resembles that discussed under Type 10. It differs in that the river is without the pools, the low marshy areas, and the lake-like river expansions common to that zone. The water, except where artificially dammed, flows over a hard bottom of stones, coarse gravel, and sand. Rapids occur in several places. The width varies from ninety to one hundred and twenty-five feet, and the depth in the productive areas is six inches to about four feet. The vegetation in these areas is sparse. The list of the species is similar to that given under Type 10, but with the addition of *Cyclonaias tuberculata,* which is abundant among the stones and coarse gravel in the rapids. Some of the species enumerated under Type 10 become scarce in this zone. *Dysnomia triquetra* disappears entirely.

Habitat Type 12

Large river.—Much of this zone, which lies between the Ford dam above Rawsonville and Flat Rock, has been changed by power dams and by pollution from the garbage reduction plant at French Landing. However, those areas in the river itself which are still productive have a characteristic ecology and fauna. The width of the river varies from one hundred to one hundred and fifty feet. The bottom is not hard gravel as in the previous zone, but is sandy mud, sand, or clay, with relatively little vegetation. The depth is normally from four to eight feet. The following species are found:

Cyclonaias tuberculata	*Ptychobranchus fasciolare*
Elliptio dilatatus	*Actinonaias carinata*
Anodonta grandis	*Micromya fabalis*
Anodonta imbecillis	*Micromya iris*
Lasmigona costata	*Ligumia recta latissima*
Lasmigona complanata	*Lampsilis ventricosa*
Alasmidonta marginata	*Fusconaia flava*

Carunculina parva

In this zone *Elliptio dilatatus* and *Ptychobranchus fasciolare* become very scarce, and *Lampsilis fasciola* and *Lampsilis siliquoidea* almost disappear entirely. *Dysnomia triquetra* is absent.

Habitat Type 13

Impounded waters above artificial dams.—These are found within the zone delimited under Type 12. The bottom in these backwaters is of fine mud. The following species thrive:

Lampsilis ventricosa	*Ligumia recta latissima*
Lasmigona complanata	*Carunculina parva*

Anodonta imbecillis

This habitat is peculiar in that *Alasmidonta calceolus* and *Anodontoides ferussacianus,* which are typical creek forms, were found. They were scarce and their occurrence must be considered at least unusual, if not abnormal.

Habitat Type 14

Lower river.—Close to the mouth of the river an invasion of Lake Erie species occurs. Some of these invading species go upstream as far as Flat Rock. This zone contains a fauna which is somewhat different from that discussed under Type 12. The river between Flat Rock and Rockwood is deep, about eighty feet wide, and flows over a more or less firm bottom of patches of clay and gravel. Vegetation is very sparse. There are practically no shells in the clay areas, but there is a rich fauna in the gravel. In addition to the species listed under Type 12, the following are found as invaders from Lake Erie:

Quadrula pustulosa	*Ligumia nasuta*
Obovaria subrotunda	*Dysnomia triquetra*

Apparently *Lasmigona complanata,* which was very common in Types 12 and 13, does not occur in this zone.

The preceding account of the distribution of the Naiades in the different

TABLE III

DISTRIBUTION OF NAIADES IN THE DIFFERENT HABITAT TYPES IN THE HURON RIVER SYSTEM

Degrees of abundance of the species in each habitat occupied is indicated by: r = Rare; C = Common; A = Abundant.

SPECIES	LAKE SERIES 1–5					STREAM SERIES 6–14								
	Lakes Without Outlet		Lakes With Outlet			Brooks and Creeks			Rivers					
	Shoals All Soft	Shoals Partly Firm	Large Lakes	Chain Lakes	River-lakes	Brooks	Small Creeks	Larger Creeks	Small Rivers	Medium-Sized Rivers	Fairly Large Rivers	Large Rivers	Ponded Areas	Lower Rivers (Lake Influx)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Anodonta grandis	C	C	C	C	C	......	......	r	r	r	r	r	r	r
Lampsilis siliquoidea	......	A	C	C	C	......	......	r	r	r	r	r	......	......
Strophitus rugosus	......	......	C	r	C	......	C	C	C	C	r	......	......	......
Lampsilis ventricosa	......		r	C	C	......	......	......	A	C	r	r	r	r
Elliptio dilatatus	......	......	......	......	r	......	......	C	A	A	A	r	......	r
Lasmigona compressa	......	......	......	......	......	C	A	C	C	r	......	......	......	......
Anodontoides ferussacianus	......	......	......	......	......	r	A	C	C	......	......	......	r	......
Alasmidonta calceolus	......	......	......	......	......	......	A	A	r	r	......	......	r	......
Micromya iris	......	......	......	......	r	......	r	C	A	A	C	r	......	r
Alasmidonta marginata	......	......	......	......	......	......	......	r	C	C	r	r	......	......
Ptychobranchus fasciolare	......	......	......	......	......	......	......	......	A	C	C	r	......	r
Lampsilis fasciola	......	......	......	......	......	......	......	......	A	C	C	r	......	r
Dysnomia triquetra	......	......	......	......	r	......	......	......	r	C	r	......	......	r
Ligumia recta latissima	......	......	......	......	......	......	......	......	......	r	r	r	......	r
Lasmigona costata	......	......	......	......	......	......	......	......	......	C	r	r	......	r
Cyclonaias tuberculata	......	......	......	......	......	......	......	......	......	......	A	C	......	r
Anodonta imbecillis	......	......	......	......	......	......	......	......	r	......	r	C	r	r
Lasmigona complanata	......	......	......	......	......	......	......	......	......	......	......	C	A	......
Actinonaias carinata	......	......	......	......	......	......	......	......	......	......	......	C	......	C
Micromya fabalis	......	......	......	......	......	......	......	......	......	......	......	C	......	r
Fusconaia flava	......	......	......	......	......	......	......	......	......	......	......	C	......	C
Carunculina parva	......	......	......	......	......	......	......	......	......	......	......	C	A	C
Quadrula pustulosa	......	......	......	......	......	......	......	......	......	......	......	......	......	r
Obovaria subrotunda	......	......	......	......	......	......	......	......	......	......	......	......	......	r
Ligumia nasuta	......	......	......	......	......	......	......	......	......	......	......	......	......	r

major types of habitat through the Huron River system is summarized graphically in Table III. The basic data are given in detail in Table IV, and on the distribution maps.

The species which occupy various types of habitat show a progressive increase in number as the size of the body of water increases. This principle, which has been stated for streams but not for lakes, is clearly illustrated in the Huron River system for the lakes (series 1–5 in Table III) as well as for the rivers (series 6–14). Several workers have provided data, particularly for certain lakes in northern Indiana, which show that not only size but also the amount of stream influence on a lake decidedly increases the number of species occupying such lakes. In the faunal section of this paper, for example, repeated references are made to the unusual occurrence of certain river species in Lake Maxinkuckee, Indiana. The workers have merely given faunal lists, failing to note that the reason for the increase in number of species lies in the larger size of the lake or in its stream influence. Table III illustrates the principle that the number of species in a lake is directly proportional to the amount of river influence on the lake. The river series (6–14) show a decided increase in the number of species as the stream becomes larger, running from one or two species in tributary brooks to eighteen or more in the lower reaches of the Huron River. The principle was found to hold in practically all the streams studied, and is presumably of general significance. Table III not only indicates a progressive increase in the number of species, but also shows to which type of habitat the more common species of this drainage are best adapted.

FAUNAL STUDIES

KEY FOR THE IDENTIFICATION OF THE HURON RIVER NAIADES

The Naiades of the Huron River are represented by three subfamilies which are recognized in the family Unionidae. The key that follows and the illustrations of the shells have been prepared to enable one who is unfamiliar with the local Naiad fauna readily to learn the diagnostic shell characters. I have limited myself to the use of shell characters simply because as a rule one has only the shell when attempting classification. However, a brief outline of the major anatomical characters of each subfamily is included so as not to leave one without knowledge of the characters which distinguish these natural groups. Unless the subfamily to which a specimen belongs is known, one will have to run it through each part of the key. For an explanation of the terms used in the key, see the glossary in Goodrich's *The Mollusca of Michigan* (1932: 117–18).

Subfamily I. Unioninae

Chief characters: Tachytictic (short-term breeders); water tubes not divided; all four, or only the outer gills marsupial (in either case, the whole

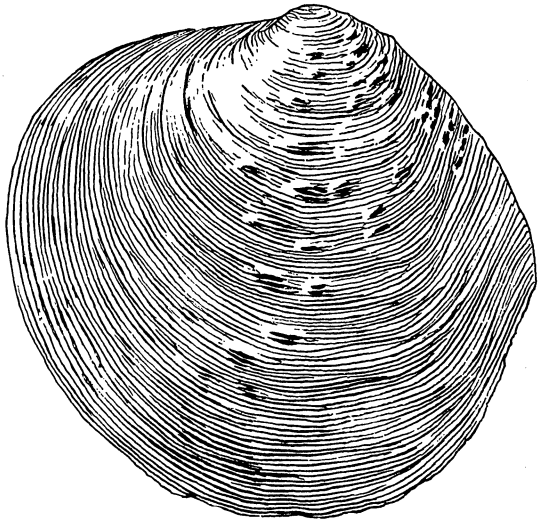


FIG. 1. *Cyclonaias tuberculata.*

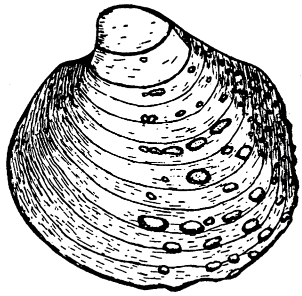


FIG. 2. *Quadrula pustulosa.*

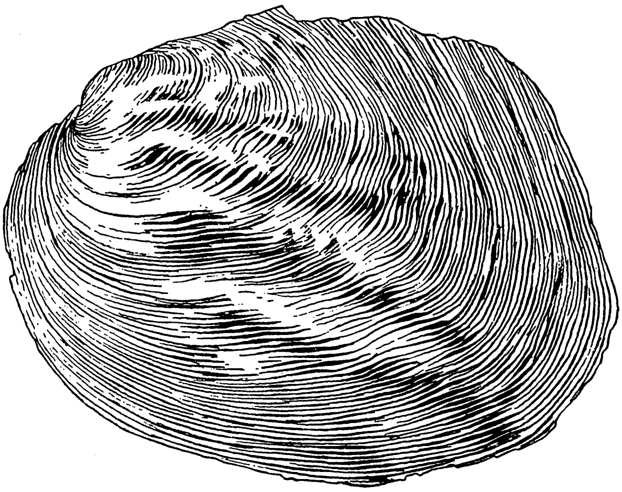


FIG. 3. *Amblema costata.*

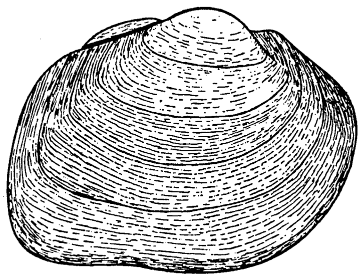


FIG. 5. *Fusconaia flava.*

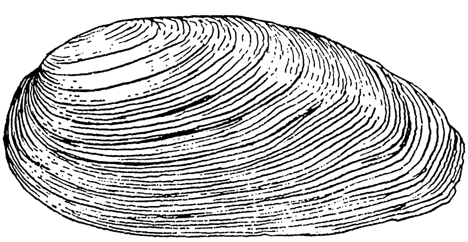


FIG. 4. *Elliptio dilatatus.*

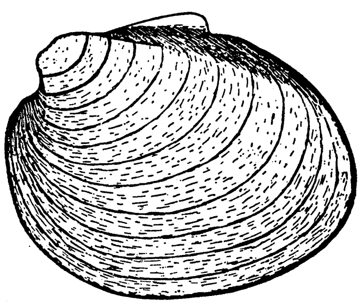


FIG. 6. *Pleurobema cordatum coccineum.*

gill becomes marsupial); edge of the gill always sharp, and not modified for distension. Glochidium semielliptical or semicircular, and without a spine. Shell generally heavy and solid, rounded or elongate. Surface of shell smooth or irregular. Hinge always complete. Generally no sexual dimorphism.

A. Surface of shell irregular; pustulate or undulate. Usually quadrate or subquadrate in outline.
  B. Surface of shell pustulate or tuberculate. Beak sculpture not concentric.
    C. Shell more or less compressed. Beak sculpture well developed, consisting of wavy ridges usually broken on the disk by a distinct sinus. Nacre usually purple. Genus *Cyclonaias* (Fig. 1).
    Cyclonaias tuberculata (Raf.)
    CC. Shell rounded. Beak sculpture indistinct, consisting of a few concentric ridges. Nacre always white. Genus *Quadrula* (Fig. 2).
    Quadrula pustulosa (Lea)
  BB. Surface of shell with a few oblique, heavy undulations (washboard-like). Beak sculpture concentric. Nacre always white. Genus *Amblema* (Fig. 3).
  Amblema costata (Raf.)
AA. Surface of shell smooth. Triangular (trapezoidal), subtriangular (subtrapezoidal), or ellipsoidal in outline; rarely quadrate.
  V. Shell more or less elliptical in outline; about twice (or more) as long as high. Nacre usually purple or pink (occasionally white). Epidermis usually a uniform dull dark gray-black. Genus *Elliptio* (Fig. 4).
  Elliptio dilatatus (Raf.)
  VV. Shell triangular (trapezoidal) or subtriangular (subtrapezoidal) in outline. Shell less than twice as long as high. Nacre pink or white, never purple.
    W. Posterior ridge usually distinct. Outline of shell more nearly triangular (trapezoidal). Epidermis yellowish or reddish brown. Genus *Fusconaia* (Fig. 5) .... *Fusconaia flava* (Raf.)
    WW. Posterior ridge indistinct (absent). Outline of shell subtriangular (subtrapezoidal), usually with the ventral margin and posterior point widely rounded. Epidermis dark brown or blackish. Genus *Pleurobema* (Fig. 6) .... *Pleurobema cordatum coccineum* (Conrad)

Subfamily II. Anodontinae

Chief characters: Bradytictic (long-term breeders); water tubes of the gravid females divided into three tubes, the central one used as an ovisac; whole of outer gills marsupial; edge of the gill thickened to permit distended gill to stretch. Glochidium semicircular or triangular, with a spine. Shell usually thin and teeth usually reduced. Generally no sexual dimorphism.

A. Beak sculpture double looped.
  B. Hinge teeth lacking. Shell very thin, more or less papery. Genus *Anodonta*.
    C. Umbonal region inflated, prominent. Shell slightly thickened. Beak sculpture prominent. Color green or brown (Fig. 7) .... *Anodonta grandis* Say
    CC. Umbones not prominent, but appearing flush with the hinge line. Shell usually very thin. Beak sculpture fine and not prominent. Color usually brilliant green (Fig. 8) .... *Anodonta imbecillis* Say

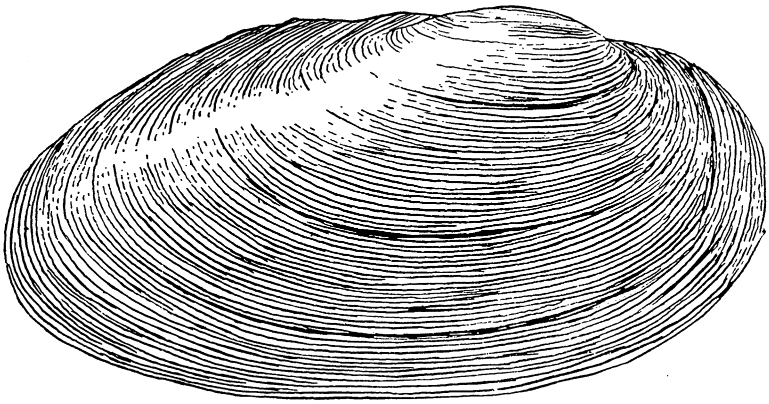


FIG. 7. *Anodonta grandis.*

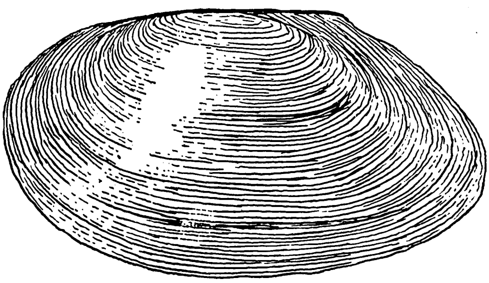


FIG. 8. *Anodonta imbecillis.*

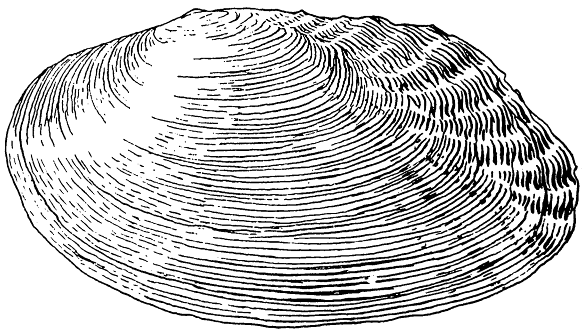


FIG. 10. *Lasmigona costata.*

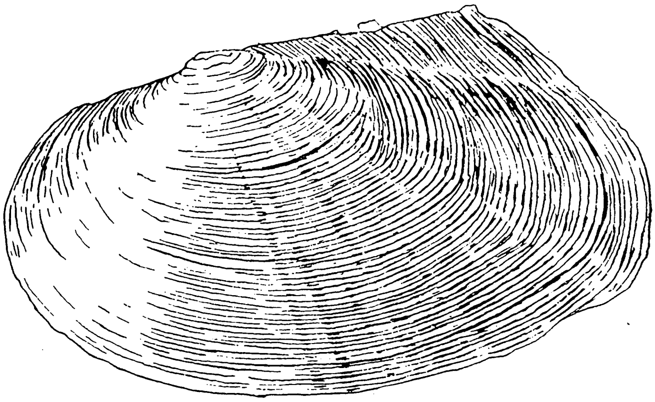


FIG. 9. *Lasmigona compressa.*

BB. Hinge teeth usually present; pseudocardinals always present, but the laterals rudimentary or absent. Shell more or less compressed, with a tendency to become alate. Genus *Lasmigona.*

D. Lateral teeth present. Shell smooth and usually distinctly compressed (Fig. 9) .... *Lasmigona compressa* (Lea)

DD. Lateral teeth absent.

E. Shell with distinct posterior ridge, and with costae on posterior slope. Beak sculpture indistinctly double looped (Fig. 10).
Lasmigona costata (Raf.)

EE. Shell smooth, compressed, without a distinct posterior ridge, and usually decidedly alate. Beak sculpture distinctly double looped (Fig. 11) .... *Lasmigona complanata* (Barnes)

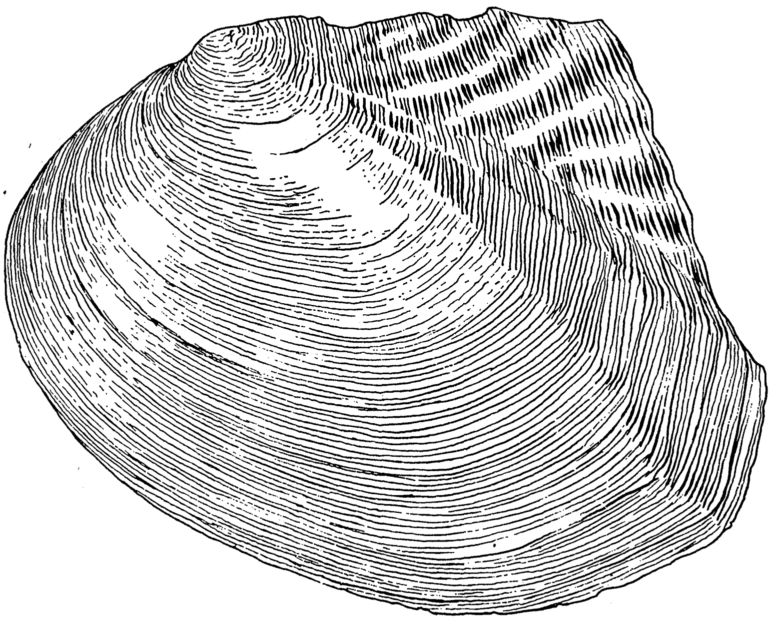


FIG. 11. *Lasmigona complanata.*

AA′. Beak sculpture concentric.

B′. Hinge teeth lacking; never having laterals or pseudocardinals. Beak sculpture finely concentric. Shell very thin. Nacre bluish. Genus *Anodontoides* (Fig. 12) .... *Anodontoides ferussacianus* (Lea)

BB′. Hinge teeth present but rudimentary; laterals absent or poorly developed (pseudocardinals rudimentary in *Strophitus,* but always developed in *Alasmidonta*).

C′. Hinge almost edentulous; with merely a slight protuberance to represent the pseudocardinals. Shell somewhat thickened. Nacre white, often with a salmon tinge in the beak cavities. Genus *Strophitus* (Fig. 13).
Strophitus rugosus (Swainson)

CC′. Hinge fairly well developed; with definite pseudocardinals, but with the laterals greatly reduced. Genus *Alasmidonta.*

D′. Shell small, not exceeding 5 cm. in length. Posterior ridge more or less rounded. Beak with heavy bars. Epidermis an ashy gray (Fig. 14) .... *Alasmidonta calceolus* (Lea)

DD′. Shell large, adults always exceeding 5 cm. in length. Posterior ridge high and well developed, giving the posterior slope a truncated appearance. Beak sculpture very distinct, consisting of three to four thick bars. Epidermis yellowish green (Fig. 15).
Alasmidonta marginata (Say)

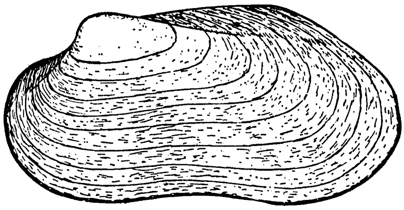


FIG. 12. *Anodontoides ferussacianus.*

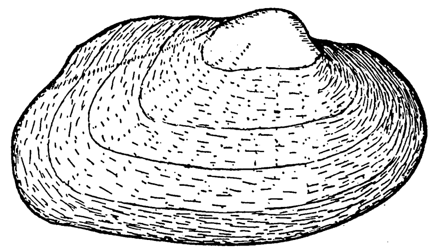


FIG. 13. *Strophitus rugosus.*

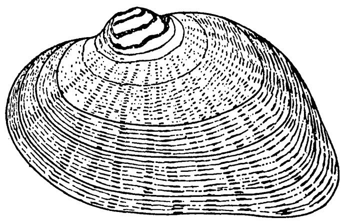


FIG. 14. *Alasmidonta calceolus.*

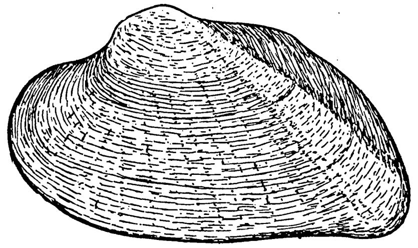


FIG. 15. *Alasmidonta marginata.*

Subfamily III. Lampsilinae

Chief characters: Bradytictic (long-term breeders); water tubes simple; marsupium generally only formed by the posterior part of outer gill; edge of gill not thickened, causing the distended gill to bulge beyond the original edge of the gill; glochidium semicircular or semielliptical, without a spine (rarely ax-shape with two spines). Shell varied in shape. Teeth usually well developed. Sexual dimorphism often apparent.

A. Shell usually elliptical in outline (occasionally subtriangular in *Micromya fabalis*). Posterior not prominent.

B. Shell with a subelliptical or subtriangular outline; posterior ridge rounded and arched so as to give the shell a humped appearance. Nacre white. Hinge heavy, with lateral teeth swollen posteriorly. Genus *Ptychobranchus* (Fig. 16) .... *Ptychobranchus fasciolare* (Raf.)

BB. Shell elliptical; not humped dorsoposteriorly.

C. Shell usually not twice as long as high; of small or medium size, usually not exceeding 6 cm. in length. Genus *Micromya*.

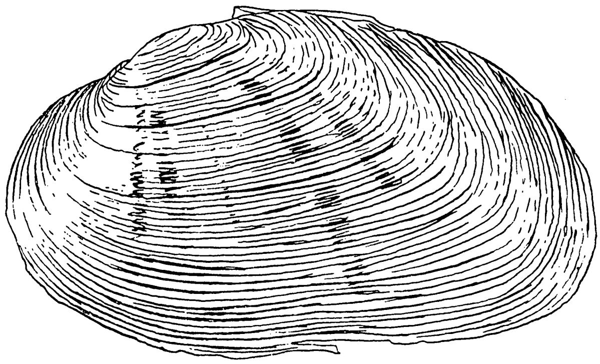


FIG. 16. *Ptychobranchus fasciolare.*

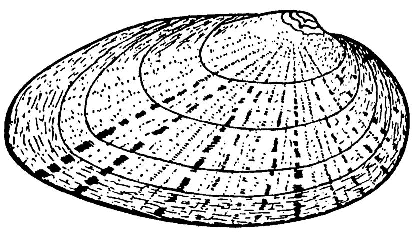


FIG. 17. *Micromya iris.*

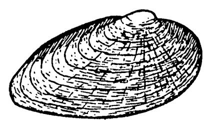


FIG. 18. *Micromya fabalis.*

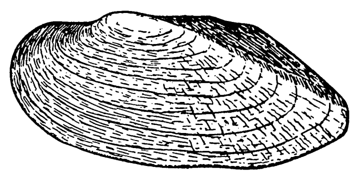


FIG. 19. *Ligumia nasuta.*

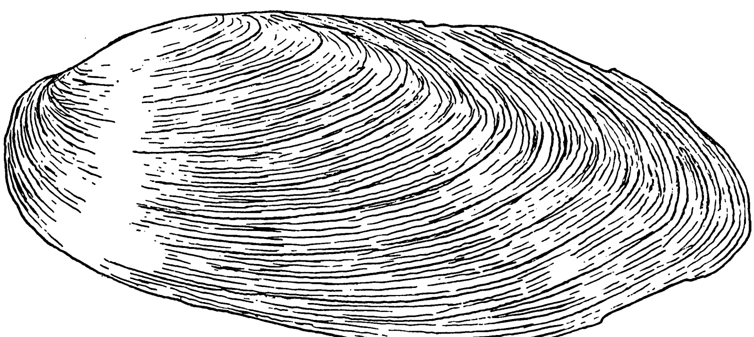


FIG. 20. *Ligumia recta latissima.*

D. Shell of medium size. Hinge teeth thin and delicate. Bright green rays often present; rays not undulating but often interrupted at growth rests. Shell thin. Nacre often bluish white, and thinner posteriorly where it is usually iridescent (Fig. 17).

Micromya iris (Lea)

DD. Shell always small, adults rarely exceeding 3 cm. in length. Hinge teeth thick and heavy. Rays not prominent, often undulating.

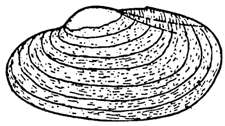


FIG. 21. *Carunculina parva.*

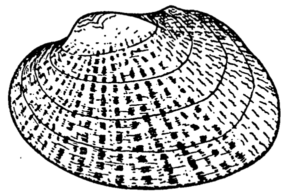


FIG. 22. *Lampsilis fasciola.*

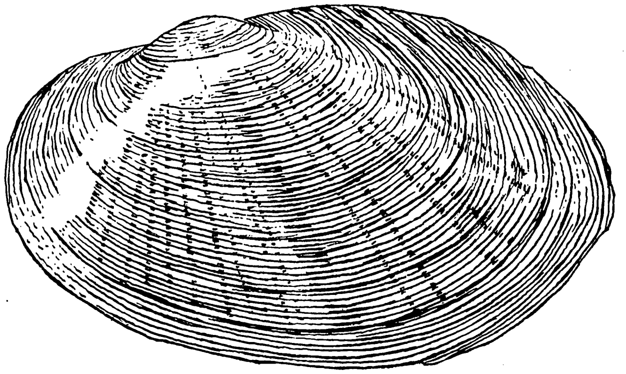


FIG. 23. *Lampsilis siliquoidea.*

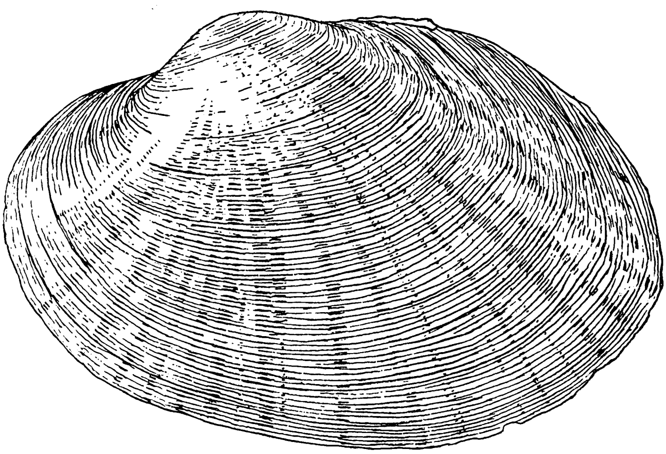


FIG. 24. *Lampsilis ventricosa.*

Shell thick. Nacre thick and white, never iridescent posteriorly (Fig. 18) .... *Micromya fabalis* (Lea)

CC. Shell twice (or more) as long as high; medium or large size, usually exceeding 6 cm. in adult length. (Genus *Ligumia*).

E. Shell of medium size, rarely exceeding 12 cm. in adult specimens; usually thin; with a prominent posterior ridge. Epidermis olive-green or olive-brown, often with a yellowish cast (Fig. 19) .... *Ligumia nasuta* (Say)

EE. Shell thick and large, usually exceeding 12 cm. in length; without a distinct posterior ridge. Epidermis dark green or black, rarely brown, often smooth and polished (Fig. 20).
Ligumia recta latissima (Raf.)

AA″. Shell oval or round in outline. Posterior ridge not distinct.
B″. Shell oval or subelliptical.
C″. Shell small, rarely exceeding 4 cm. in length; subelliptical; without rays. Epidermis thick and of a uniform gray-black color. Growth rests not indicated by concentric bands. Genus *Carunculina* (Fig. 21).
Carunculina parva (Barnes)

CC″. Shell of medium size or large, usually exceeding 4 cm. in mature specimens; oval in outline; usually distinctly rayed. Epidermis usually a yellowish brown, often covered with distinct green rays. Growth rests usually prominent.
D″. Beak sculpture more or less pronounced. Pseudocardinals usually ragged (toothed) at edges; the prominent one in the right valve usually flexed upward. Genus *Lampsilis.*
E″. Shell of medium size, adults rarely exceeding 7 cm. in length; never large. Rays usually numerous, fine and wavy. Beak sculpture rudimentary (Fig. 22) ....*Lampsilis fasciola* (Raf.)

EE″. Shell large, adults usually exceeding 7 cm. in length. Rays often present, but seldom fine and wavy. Beak sculpture more prominent.
F″. Usually more than 1½ times as long as high. Beak sculpture consisting of a number of fine wavy bars (Fig. 23).
Lampsilis siliquoidea (Barnes)

FF″. Shell usually not more than 1½ times as long as high. Beak sculpture consisting of a few coarse, concentric nonwavy lines (Fig. 24) ....*Lampsilis ventricosa* (Barnes)

DD″. Beak sculpture not prominent. Pseudocardinals usually large and triangular; the prominent one under the beak in the right valve rarely flexed upward. Genus *Actinonaias* (Fig. 25).
Actinonaias carinata (Barnes)

BB″. Shell round or short-ovate; of small to medium size. No posterior ridge. Epidermis usually a uniform dark brown, with light brown or yellowish posterior slope. Genus *Obovaria* (Fig. 26)............*Obovaria subrotunda* (Raf.)

AAA‴. Shell triangular in outline, with a distinct posterior ridge.
B‴. Posterior ridge very prominent; posterior slope very wide; shell less compressed, and rather elongate. Epidermis green or yellowish, with fine, radiating, spotted, green rays. Sexual dimorphism pronounced. Genus *Dysnomia* (Fig. 27) ....*Dysnomia triquetra* (Raf.)

BB‴. Posterior ridge prominent, more prominent and sharper at the beaks than in the preceding genus; posterior slope narrower and more compressed; shell more compressed than high. Epidermis a dark green, usually marked with V-shaped mottling arranged to form the rays. Genus *Truncilla* (Fig. 28) ....*Truncilla truncata* (Raf.)

DISTRIBUTION, ECOLOGY, AND VARIATION

The distributional data on the twenty-eight species treated in this section are supplemented in most instances by record maps, toward the interpreta-

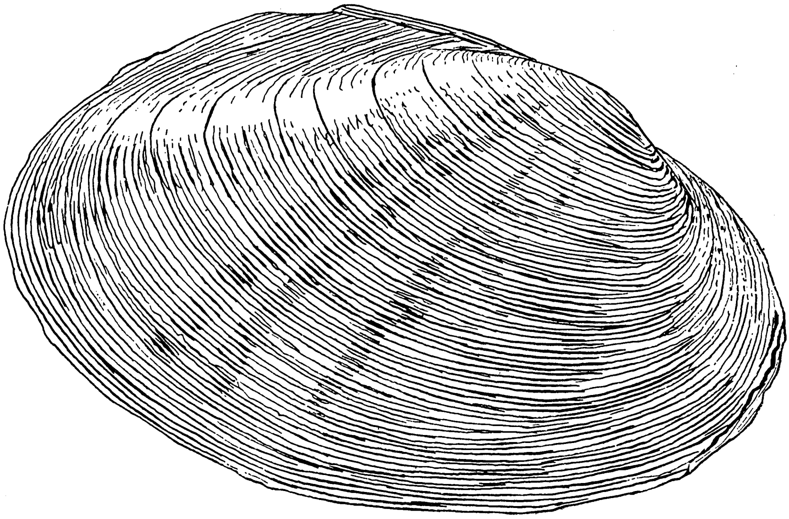


FIG. 25. *Actinonaias carinata.*

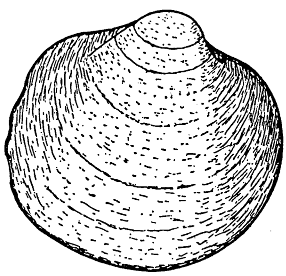


FIG. 26. *Obovaria subrotunda.*

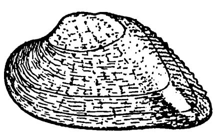


FIG. 27. *Dysnomia triquetra.*

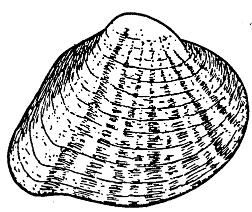


FIG. 28. *Truncilla truncata.*

tion of which a synoptic table (Table IV) and a map of all the stations in the Huron River system (Map 3) are given.

Under "Ecology" habitat preferences are discussed; a new approach to this problem is considered important. It is accompanied by tables showing the habitat preferences of the more abundant and widespread species.

Variation has been correlated with the environment. The use of small average differences in obesity for the purpose of differentiating species or

TABLE IV

Synoptic Table Showing the Distribution of Naiades by Collecting Stations in the Huron River

	Quadrula pustulosa	*Cyclonaias tuberculata*	*Elliptio dilatatus*	*Strophitus rugosus*	*Anodonta grandis*	*Anodonta imbecillis*	*Anodontoides ferrussaciana*	*Lasmigona compressa*	*Lasmigona costata*	*Lasmigona complanata*	*Alasmidonta calceolus*	*Alasmidonta marginata*	*Ptychobranchus fasciolare*	*Obovaria subrotunda*	*Actinonaias carinata*	*Micromya iris*	*Micromya fabalis*	*Ligumia recta latissima*	*Lampsilis fasciola*	*Lampsilis siliquoidea*	*Lampsilis ventricosa*	*Truncilla truncata*	*Dysnomia triquetra*	*Fusconaia flava*	*Carunculina parva*
1. Monroe County																									
East Rockwood	...	...	...	...	×	...	...	...	...	...	...	...	...	...	×	...	...	...	...	×	...	×	...	...	...
Rockwood	×	×	×	...	...	...	...	...	×	...	...	...	×	×	×	...	...	×	×	×	×	×	×	...	...
½ mile above Rockwood	×	×	×	×	×	×	...	...	...	...	...	×	×	×	×	×	...	×	...	...	...	×	×	×	×
2. Wayne County																									
Flat Rock	...	×	×	...	×	×	...	...	×	...	...	...	×	...	×	×	×	...	...	...	×	...	...	...	...
1 mile E. of Willow	...	×	...	...	...	×	×	...	×	×	...	×	×	...	×	×	×	×	...	...	×	...	...	×	×
2 miles E. of Willow	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...
Near Willow Rd., New Boston	...	×	×	...	...	...	...	...	×	...	...	...	×	...	×	...	×	...	...	...	×	...	...	...	...
Huron River Park	...	×	×	...	...	...	...	...	...	...	...	...	×	×	×	×	×	...	...	...	...	...	...	...	...
Below dam, French Landing	...	...	×	...	...	...	...	...	...	...	...	...	...	...	×	...	×	...	...	...	...	...	...	...	...
Above dam, French Landing	...	...	...	...	...	×	...	...	...	×	...	...	...	...	...	...	...	...	...	...	×	...	...	...	×
Just above Belleville	...	...	...	...	...	×	×	...	...	×	...	...	...	...	...	...	...	...	...	×	×	...	...	...	×
Mud flats, 2 miles above Belleville	...	...	...	...	...	×	×	...	...	×	×	...	...	...	...	...	...	×	...	...	×	...	...	...	×
3. Washtenaw County																									
Below new Ford dam	...	×	×	×	×	×	×	...	×	×	...	×	...	...	...	×	...	×	×	...	×	...	...	...	...
2 miles below Ypsilanti	...	×	...	×	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Ann Arbor	...	×	×	×	×	...	...	...	×	...	×	×	×	...	...	×	...	...	×	×	×	...	...	×	...
Delhi	...	×	×	...	...	...	...	×	...	...	×	×	×	...	...	×	...	...	×	...	...	...	...	...	...
Outlet of Loch Alpine	...	×	...	...	×	...	...	×	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Dexter	...	×	×	...	×	...	...	...	...	...	×	×	×	...	...	×	...	...	×	...	...	...	...	...	...
2 miles NW. of Dexter	...	×	×	...	...	...	...	...	...	...	×	...	×	...	...	×	...	×	×	...	×	...	...	...	...
Dover	...	×	×	×	...	...	...	...	...	...	×	×	×	...	...	×	...	...	×	...	×	...	...	...	...
Portage L.	...	...	×	×	×	...	...	...	...	...	...	...	×	...	...	×	...	...	...	×	×	...	×	...	...
Mouth of Base Line L.	...	...	×	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Whitmore L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Independence L.	...	...	...	×	×	...	...	...	...	...	×	...	...	...	...	×	...	...	...	×	...	...	...	...	...

TABLE IV—(*Continued*)

Synoptic Table Showing the Distribution of Naiades by Collecting Stations in the Huron River

	Quadrula pustulosa	*Cyclonaias tuberculata*	*Elliptio dilatatus*	*Strophitus rugosus*	*Anodonta grandis*	*Anodonta imbecillis*	*Anodontoides ferrussaciana*	*Lasmigona compressa*	*Lasmigona costata*	*Lasmigona complanata*	*Alasmidonta calceolus*	*Alasmidonta marginata*	*Ptychobranchus fasciolare*	*Obovaria subrotunda*	*Actinonaias carinata*	*Micromya iris*	*Micromya fabalis*	*Ligumia recta latissima*	*Lampsilis fasciola*	*Lampsilis siliquoidea*	*Lampsilis ventricosa*	*Truncilla truncata*	*Dysnomia triquetra*	*Fusconaia flava*	*Carunculina parva*
North L.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Wild Goose L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Pleasant L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Cedar L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Cavanaugh L.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Silver L.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Fleming Cr.	...	...	...	×	...	...	×	×	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mill Cr. mouth at Dexter	...	×	×	...	...	...	...	...	...	...	×	×	×	...	...	...	...	...	×	...	×	...	...	...	...
Mill Cr. millrace at Dexter	...	×	×	×	...	...	...	...	...	...	×	...	...	...	...	×	...	...	×	...	×	...	...	...	...
Mill Cr. below dam at Dexter	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	×	...	...	×	...	...	...	...	...	...
Mill Cr. 1½ miles S. of Dexter	...	...	×	×	...	...	×	×	...	...	×	×	...	...	...	×	...	...	...	...	...	...	...	...	...
Mill Cr. 2 miles S. of Dexter	...	...	×	...	...	...	×	...	...	...	×	...	...	...	...	×	...	...	...	...	...	...	...	...	...
Mill Cr. 3 miles S. of Dexter	...	...	×	×	...	...	×	...	...	...	×	...	...	...	...	×	...	...	...	...	...	...	...	...	...
Arms Cr.	...	...	×	...	...	...	...	...	...	...	×	...	...	...	...	×	...	...	...	...	...	...	...	...	...
4. Livingston County																									
Base Line L.	...	...	×	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	×	...	×	...	...
Between Base Line L. and Whitewood L.	...	...	×	×	×	...	...	...	×	...	...	×	×	...	...	×	...	...	×	×	×	...	×	...	...
Whitewood L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Between Whitewood L. and Gallagher L.	...	...	×	×	×	...	...	...	×	...	...	...	×	...	...	×	...	...	...	×	...	...	...	...	...
Gallagher L.	...	...	×	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	×	...	...	...	...
Between Gallagher L. and Strawberry L.	...	...	×	×	×	...	...	...	...	...	...	...	×	...	...	...	...	×	×	×	×	...	...	...	...
Strawberry L. discharge	...	...	×	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Strawberry L.	...	...	...	×	×	...	...	...	...	...	...	...	...	...	...	×	...	...	...	×	...	...	...	...	...
Zukey L.	...	...	×	×	×	...	...	...	...	...	...	...	...	...	...	×	...	...	...	×	×	...	...	...	...
Near RR. bridge above Strawberry L.	...	...	×	×	...	...	...	...	...	...	...	×	...	...	...	×	...	...	×	×	...	...	×	...	...
NW. of Buck L.	...	...	×	...	×	...	...	...	...	...	...	×	×	...	...	×	...	...	×	×	×	...	×	...	...
Bend E. of Buck L.	...	...	×	×	...	...	...	...	...	...	...	×	×	...	...	×	...	...	×	×	×	...	×	...	...

TABLE IV—(*Continued*)

Synoptic Table Showing the Distribution of Naiades by Collecting Stations in the Huron River

	Quadrula pustulosa	*Cyclonaias tuberculata*	*Elliptio dilatatus*	*Strophitus rugosus*	*Anodonta grandis*	*Anodonta imbecillis*	*Anodontoides ferrussaciana*	*Lasmigona compressa*	*Lasmigona costata*	*Lasmigona complanata*	*Alasmidonta calceolus*	*Alasmidonta marginata*	*Ptychobranchus fasciolare*	*Obovaria subrotunda*	*Actinonaias carinata*	*Micromya iris*	*Micromya fabalis*	*Ligumia recta latissima*	*Lampsilis fasciola*	*Lampsilis siliquoidea*	*Lampsilis ventricosa*	*Truncilla truncata*	*Dysnomia triquetra*	*Fusconaia flava*	*Carunculina parva*
Below bridge 1 mile N. of Hamburg	...	...	×	...	...	...	...	...	...	...	...	×	×	...	...	×	...	×	×	×	×	...	×	...	...
1 mile E. of Ore L.	...	...	...	×	...	...	...	...	...	...	×	×	×	...	...	×	...	...	×	×	×	...	×	...	...
3 miles N. of Whitmore L.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	×	...	...	...	...
Below Sandy Bottom L.	...	...	×	×	×	...	...	...	...	...	...	×	×	...	...	×	...	...	×	...	×	...	×	...	...
Fish L.	...	...	...	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Greenoak L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
River at Greenoak L.	...	...	...	×	×	...	...	...	×	...	×	×	×	...	...	×	...	×	×	×	×	...	×	...	...
4 miles below entrance of Woodruff Cr.	...	...	×	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	×	×	...	...	...	...
1 mile below entrance of Woodruff Cr.	...	...	...	...	...	...	×	...	×	...	...	...	...	...	...	×	...	...	...	...	×	...	...	...	...
1 mile below Kent L.	...	...	×	...	...	...	...	...	...	...	...	×	...	...	...	×	...	...	×	...	...	...	...	...	...
Below Kent L.	...	...	×	×	...	...	...	...	...	...	...	...	×	...	...	×	...	×	...	...	...	...	...	...	...
Portage River 2 miles N. of Portage L.	...	...	×	×	...	...	...	...	...	...	×	×	×	...	...	×	...	...	×	...	...	...	×	...	...
Portage River 2 miles SW. of Pinckney	...	...	×	×	...	...	...	×	...	...	...	×	×	...	...	×	...	...	×	×	×	...	×	...	...
Portage River near Hiland L.	...	...	×	×	...	×	...	...	...	...	...	...	×	...	...	×	...	...	×	×	...	...	...	...	...
Portage Cr. at Williamsville	...	...	×	×	×	...	...	...	...	...	×	...	...	...	...	×	...	...	×	×	...	...	...	...	...
Portage Cr. N. of Williamsville L.	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Honey Cr. below Pinckney	...	...	...	×	...	...	×	×	...	...	×	...	...	...	...	×	...	...	×	×	...	...	...	...	...
Honey Cr. branch 2 miles NW. of Pinckney	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Davis Cr. above Crooked L.	...	...	...	×	...	...	...	×	...	...	...	...	...	...	...	×	...	...	...	...	×	...	...	...	...
5. Ingham County																									
Lowe L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	×	...	...	...	...
6. Oakland County																									
Kent L. outlet	...	...	×	...	×	×	...	...	...	...	...	...	×	...	...	...	...	...	×	...	...	...	...	...	...
Above Kent L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
1½ miles NW. of New Hudson	...	...	×	×	×	...	×	×	...	...	×	×	×	...	...	×	...	...	×	×	×	...	...	...	...
2 miles NW. of New Hudson	...	...	×	×	×	...	...	...	...	...	...	×	...	...	...	...	...	...	×	...	×	...	...	...	...

TABLE IV—(*Concluded*)

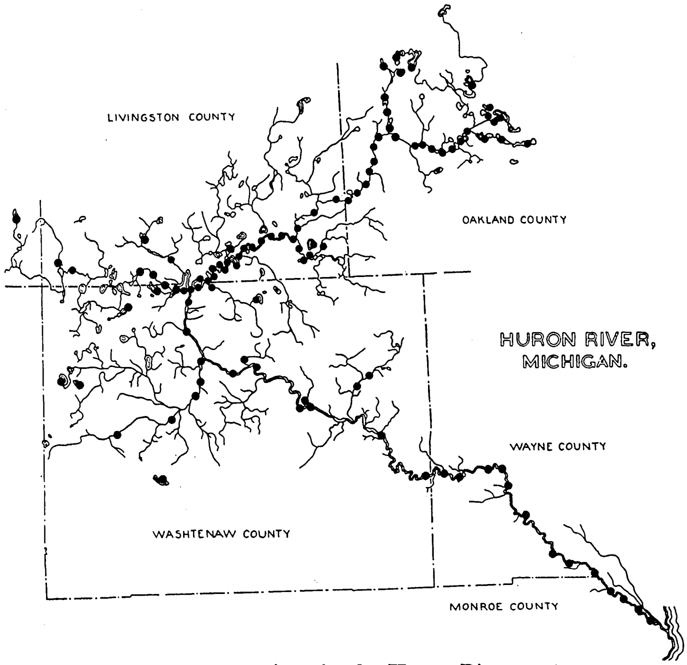
Synoptic Table Showing the Distribution of Naiades by Collecting Stations in the Huron River

	Quadrula pustulosa	*Cyclonaias tuberculata*	*Elliptio dilatatus*	*Strophitus rugosus*	*Anodonta grandis*	*Anodonta imbecillis*	*Anodontoides ferrussaciana*	*Lasmigona compressa*	*Lasmigona costata*	*Lasmigona complanata*	*Alasmidonta calceolus*	*Alasmidonta marginata*	*Ptychobranchus fasciolare*	*Obovaria subrotunda*	*Actinonaias carinata*	*Micromya iris*	*Micromya fabalis*	*Ligumia recta latissima*	*Lampsilis fasciola*	*Lampsilis siliquoidea*	*Lampsilis ventricosa*	*Truncilla truncata*	*Dysnomia triquetra*	*Fusconaia flava*	*Carunculina parva*
3 miles NW. of New Hudson	...	...	×	×	×	...	×	×	...	...	×	×	...	...	...	×	...	...	×	×	×	...	×	...	...
2 miles SW. of Milford	...	...	×	×	...	...	×	×	...	...	×	×	×	...	...	×	...	...	×	...	×	...	×	...	...
1 mile SW. of Milford	...	...	×	×	...	...	×	×	...	...	×	×	×	...	...	×	...	...	×	×	×	...	...	...	...
2 miles N. of Wixom	...	...	...	×	×	×	×	×	...	...	...	...	×	...	...	×	...	...	×	×	×	...	...	...	...
At bridge below Proud L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	×	...	...	...	×	×	...	...	...	...
2 miles below Commerce L.	...	...	...	×	×	...	...	...	...	...	...	...	...	...	...	×	...	...	×	...	×	...	...	...	...
¼ mile below Commerce L.	...	...	...	×	×	...	...	...	...	...	...	...	...	...	...	×	...	...	...	×	...	...	...	...	...
Outlet of Commerce L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	×	...	...	...	×	×	...	...	...	...
Commerce L.	...	...	×	×	×	...	...	...	...	...	...	...	...	...	...	×	...	...	...	×	...	...	...	...	...
Above Commerce L.	...	...	×	...	...	...	...	...	...	...	×	×	...	...	...	×	...	...	×	...	×	...	...	...	...
Union L. at mouth of Hayes Cr.	...	...	...	×	×	...	...	×	...	...	...	...	...	...	...	×	...	...	...	×	...	...	...	...	...
Union L.	...	...	...	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	×	...	...	...	...
Long L.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Cooley L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Sugden L.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Oxbow L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Pettibone Cr.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Grass L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Br. at Alderman L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...
Duck L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
White L.	...	...	...	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Harvey L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Wolverine L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Reed L.	...	...	...	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Lower Straits L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	×	...	...	...	...
Middle Straits L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	×	...	...	...	...
Upper Straits L.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	×	...	...	...	...

erecting new ones has been avoided. For a few species certain original observations have been supplied, particularly in the matter of alterations in obesity and nacreous color in relation to size and position in the river.

Cyclonaiás tuberculata (Rafinesque)

Distribution.—This species (Map 4) has a very definite distribution in the Huron River, occurring only in the lower part of the drainage where true river conditions prevail. It has never been found in any of the tributaries, lakes, or river-lakes. In portions of the river above Base Line Lake the ecological conditions appear to be favorable for this species, but its absence from



MAP. 3. The stations in the Huron River system.

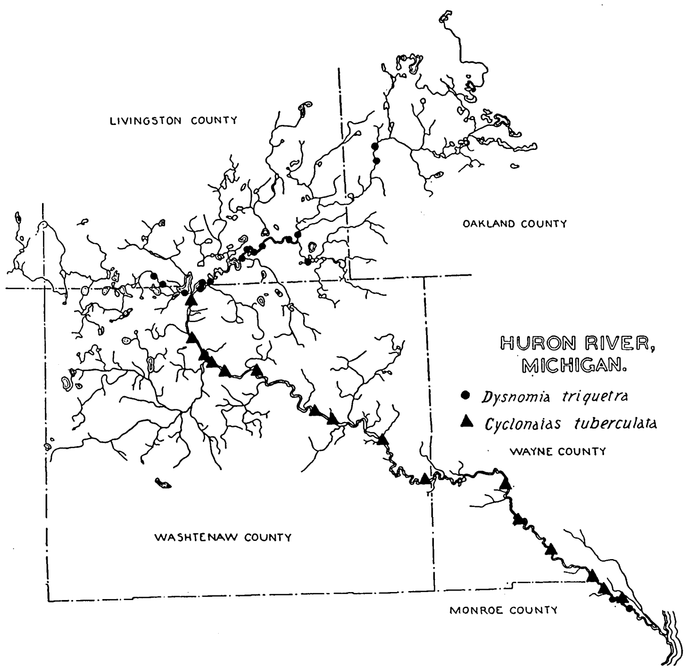
such areas may be accounted for by the presence of the lakes there which act as barriers in an upstream direction. The fact that this species has never been found in the impounded waters of the lower river power dams may substantiate this observation.

Ecology.—The most favorable conditions for *tuberculata* are to be found in the rapids just below Dexter, where there is a coarse gravel and boulder bottom. Although the form occurs in parts of the lower section of the river on sand and gravel where the current is less rapid, it is much scarcer in such places. F. C. Baker (1928: 106) reports this species as "found usually on a mud bottom in fairly deep water," and Ortmann (1919: 60) states:

"It is hard to say what the ecological preferences are, but the specimens I have collected alive always came from riffles with rather coarse gravel and a rapid flow of water."

Variation.—F. C. Baker (1928 : 107) states:

In Illinois, Indiana and Michigan (probably also in other states) there is a much compressed, very elongate form, heavily pustulose, especially on the flattened alate portion posteriorly, with a remote pallial line, which lives in the smaller tributaries; in Illinois this form is found in shallow water on a gravel bottom in riffles. This compressed form has not been seen from Wisconsin. For the compressed variety I propose the varietal



MAP 4. Distribution of *Dysnomia triquetra* and *Cyclonaias tuberculata* in the Huron River drainage. *Dysnomia triquetra* occurs under small and medium-sized river conditions. It enters the river from Lake Erie where it normally occurs. *Cyclonaias tuberculata* is a species limited to the main stream and does not enter the tributaries or lakes.

name *compressa,* the type locality being the Middle Fork at mouth, Vermilion River, Vermilion Co., Ill. . . . Two specimens measure as follows: L. 98 mm. H. 82 mm. D. 40 mm. (type). L. 83 mm. H. 71 mm. D. 35 mm. (paratype). The same variety is in the Hinkley collection from Huron River, Ann Arbor, Michigan.

When actually calculated the index of obesity of Baker's new variety is: type, 40.81 per cent; paratype, 42.16 per cent.

Ball (1922) has made a careful study of variation within the genus *Cyclonaias,* and he has given (p. 109) a reasonable solution to our taxonomic difficulties in that group. His work was under the guidance of the late A. E.

Ortmann, who was one of the best students of the Naiades. Ball concluded that all specimens that have an obesity of 57 per cent or less are the typical form of *Cyclonaias tuberculata,* and that those having an obesity of more than 57 per cent should be considered *Cyclonaias tuberculata granifera* (Lea). This division is arbitrary and is made primarily to straighten taxonomic difficulties which were brought about by the application of specific names to ecological varieties. Baker has failed to recognize Ball's work and does not give any reasons why the variety *compressa* should be differentiated from the typical form recognized by Ball, who gives measurements to indicate that specimens of the typical form may have an obesity as low as 36.8 per cent. I fail to see why we should recognize the variety *compressa* F. C. Baker, for the specimens of the Huron River.

This taxonomic method introduces the question of naming ecological forms solely on the basis of percentage differences in obesity. Originally, Ortmann (1920: 271) used such names arbitrarily because he thought it advisable to preserve the old names that had been wrongly used specifically, and not because he felt that these differences warranted new names. Later workers have misinterpreted this, and tended to clutter the literature by the addition of names which are unwarranted.

Quadrula pustulosa (Lea)

Distribution.—The species has been found in the Huron River only near the mouth. It is known from Lake Erie, where, along with other Naiades, it tends to become stunted. The occurrence of this form in the mouth of the river is of special interest because at the station about one-half mile above Rockwood true river conditions prevail, and it is here that this species resembles the large, well-developed river form. Though I do not have any experimental data, I am inclined to believe that the differences between the shells of Lake Erie and those from the mouth of the river are of environmental and not genetic significance.

Ecology.—In this drainage the species is decidedly a large-river form. It is rarely found alive in the lower reaches of the river, though I have taken it there from a gravel bottom. It is not restricted to gravel and may occur in sand or even mud.

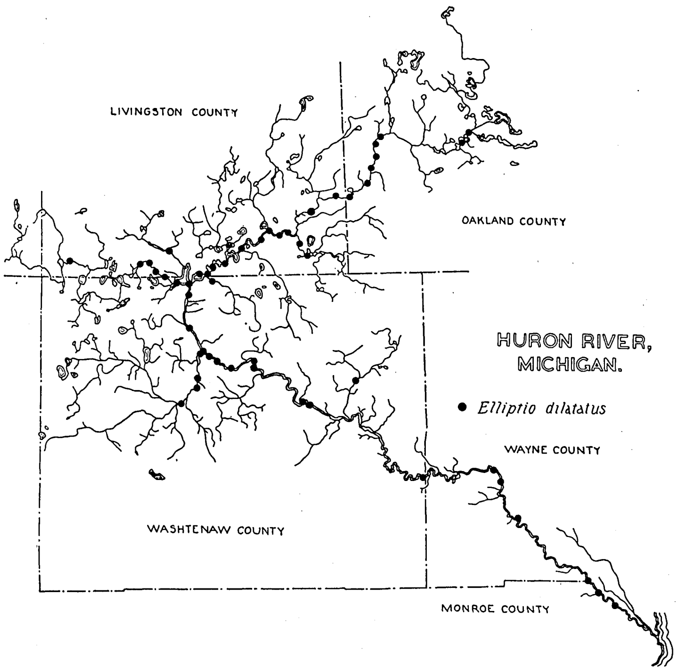
Amblema costata (Rafinesque)

Distribution.—This species cannot be said to belong to the fauna of the Huron River. It occurs in the Clinton, Rouge, and Raisin rivers. During the three years of collecting in this drainage, I have only found one specimen. A single individual was taken from the millrace adjoining Mill Creek at Dexter. I have on several occasions searched, unavailingly, for more specimens. Evidently, this naiad has in some way been introduced, possibly while parasitizing minnows used as commercial fish bait. Conditions in the

Huron River are favorable for the propagation of this species, as is clearly evident from the healthy specimen secured in the millrace. It is perhaps a matter of fish distribution which determines the absence or presence of this species in the different drainage basins.

Elliptio dilatatus (Rafinesque)

Distribution.—This is one of the most abundant species in the drainage. Map 5 indicates that it has a widespread distribution. It is predominantly a small-river form, though it does occur in the larger river and in the large creeks. Unfortunately, we do not have complete records for its relative abundance in the lower reaches of the river prior to the time of pollution. At present, it is only sparsely represented in that section of the stream. Such areas in the lower river which are not polluted are for the most part lakelike, and formed as backwater to the power dams. That the species is not found in these areas is strong evidence that it is primarily adapted to living under river conditions. My records, as well as several records in the literature with reference to other drainage basins, indicate that, occasionally, this species is found in lakes, but of the river-lake type. Since Lake Erie has many river Naiades, it can be considered in an environmental sense a river-lake. In brief, the records in this drainage indicate that the form lives predominantly



MAP 5. Distribution of *Elliptio dilatatus* in the Huron River drainage.

in large creeks and small and medium-sized rivers, and that in those areas in the lower part of the river which are still undisturbed by pollution and power dams it is rare.

Ecology.—

TABLE V

BOTTOM PREFERENCE EXHIBITED BY *ELLIPTIO DILATATUS* IN DIFFERENT TYPES OF WATER IN THE HURON RIVER DRAINAGE

The figures given represent average abundance based on an arbitrary scale of 1 to 5: 1 = rare; 2 = average; 3 = common; 4 = abundant; 5 = very abundant.

	MUD	MARL	MUCK	SAND	GRAVEL	BOULDERS	CLAY
River-lakes	1	1.5	......	2.0	3.5	....	....
Brooks	......	....	......	....	1.0	....	....
Large creeks	......	....	......	2.6	3.1	....	....
Rivers							
Small	......	....	......	3.6	3.8	....	....
Medium-sized	......	....	......	4.0	4.2	2.5	....
Large	......	....	......	1.0	2.0	....	1.0

Table V shows the types of bottom from which this species has been obtained. The fundamental requirement is not so much a matter of the kind of substratum as it is of its firmness. It can and does do well on practically all types of bottom with the exception of muck, which is too soft, and clay, which is too hard.

It is noticeable that the beaks of practically all of the specimens taken from this drainage are intact. In many streams beak erosion is common to most specimens and is particularly so among those advanced in age. Normally, one might expect to find the beaks of a species living in sand and gravel to be eroded. The factor of erosion is apparently more chemical here than abrasive.

Variation.—Several varieties of this widely distributed species have been recognized. Only one of these is supposed to occur within the Huron River drainage. This is *delicatus* recognized by Simpson (1914: 600) as a rather thin and subsolid form whose outline is more or less evenly elliptical, but never arcuate. An examination of specimens from many localities where this variety is likely to occur has led me to believe that it is not entitled to subspecific rank, although many of the younger specimens do have a tendency to be thin and lack the arcuate character. The same colonies contain both typical and "*delicatus*" individuals.

One of the striking characters of this species is the wide range of colors which its nacre may exhibit. Wilson and Clark (1912*a*: 45) in their study of the mussels of the Kankakee drainage basin were the first to suggest that the nacreous color in *dilatatus*, as well as in *Ligumia recta latissima*, becomes more nearly white in a downstream direction. Grier (1920) attempted to learn whether there is any correlation between the nacreous color among the Naiades of the upper Ohio drainage and their corresponding species in the environmentally contrasting Lake Erie. He found that this species has no less than seventy-six relative nacreous colors, which is some twenty-three more than the next highest (*Pleurobema cordatum coccineum*) in his list of twelve species studied. In his conclusions, he (1920: 235–36) agrees with Wilson and Clark, stating: "In practically all the species dealt with, a change in nacreous color is observed going down-stream from the headwaters to the mouth. The usual tendency is for the nacreous color to considerably lighten or become bluish." An examination of my Huron River material fails to support Grier's contention. Most of my specimens from Oakland County (the upper reaches of the river) are not dark nacred. On the whole, these specimens are light colored. There is much variation in this material between specimen and specimen, and there is also frequently a distinct color variation within each shell. Many individuals have a light, almost white, zone around the outer half of the shell with a darker zone in the region of the beaks. These colors do not blend into one another, but are rather sharply differentiated. An examination of the material obtained from Livingston County revealed that, in general, it is dark nacred; the specimens are distinctly darker than those from Oakland County. They also proved very variable. Usually young specimens were lighter than older ones. Grier's findings are not in agreement with mine here. He states (p. 240) "that as a rule deeper colors in all species fade with age, most of them tending to revert back to the pearl blue or whitish ground color." The material from Washtenaw County is largely from above Ann Arbor, since pollution has destroyed the naiad fauna below it. However, the material from this county is like that from Livingston County in that a majority of the older and larger specimens are very dark nacred, while the younger specimens tend to be light. It is unfortunate that I have so little material from the river below Ann Arbor. The species has apparently always been scarce in the lower part of this drainage, and because of the present polluted conditions it is impossible to get sufficient shells to make a thorough study of the problem.

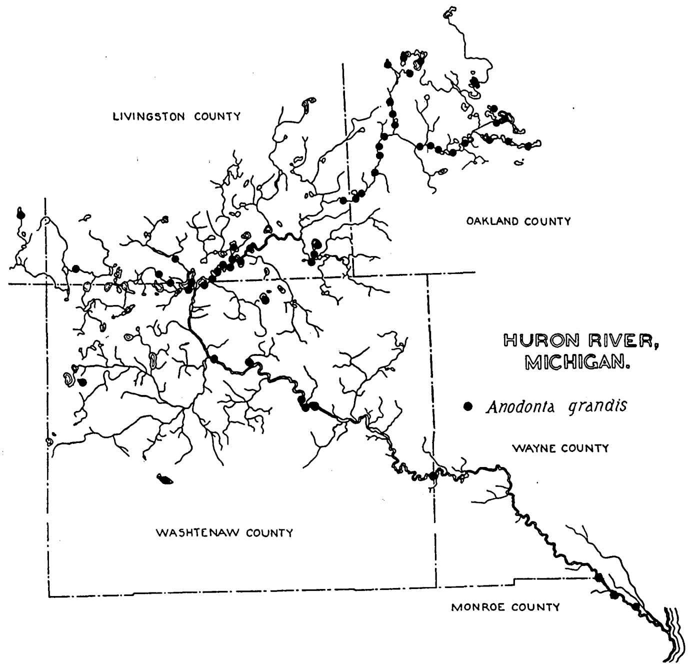
Fusconaia flava (Rafinesque)

Distribution.—The map (Map 16) indicates the present distribution of the species. The two records in Washtenaw County are old ones, and at present the form is found only in the lower part of the river. Its distribution is not necessarily restricted to the lower sections of the river, as is evident from the fact that it has been taken from Fleming Creek, Washtenaw County, and as I have also found it the most abundant species in the Middle Branch of the Clinton River, where both the physical characters of the stream and the faunal associations indicated that conditions were typically those of a large creek. I believe that formerly it may have occupied the entire section of the river below Ann Arbor, but that the changes due to pollution have now restricted it.

Ecology.—In the Huron River it is found on a firm bottom of sand or fine gravel. In the Clinton River it was seen on a firm sand bottom. It usually burrows itself deeply so that only the siphons are seen.

Pleurobema cordatum coccineum (Conrad)

This species has not been found in the Huron River. I have found it in the lower reaches of both the Clinton and Rouge rivers, and it may yet appear



MAP 6. Distribution of *Anodonta grandis* in the Huron River drainage; a species especially common in lakes, but sparsely distributed throughout the main course of the river.

in the lower parts of this drainage. It is included here because of that possibility.

Anodonta grandis Say

Distribution.—The distribution map (Map 6) makes clear how widespread this species is in the drainage. It is particularly common in lakes of all kinds. Usually if a lake harbors any Naiades, this species will be among them. It is found throughout the main course of the river. The only part of the drainage in which it was not found is in some of the creeks where

Anodontoides ferussacianus seems to take its place. It is sparsely represented in the river between Base Line Lake and Ann Arbor, the greater part of this area having rapid water flowing over a hard gravel and boulder bottom. Below Ann Arbor and French Landing there are stretches where *grandis* with other species in those areas has suffered from pollution.

One of the peculiarities of the distribution of *grandis* is its absence in the backwater areas above the power dams. Here conditions are almost lakelike in character, and seemingly suitable. Conditions other than physical factors are probably responsible for this. A knowledge of the fish host together with data on the possibilities for the infection of the hosts by glochidia of this species may solve this problem.

Ecology.—The species live under a wide range of conditions (Table VI) with which its limits of variation appear to be correlated.

TABLE VI

BOTTOM PREFERENCE EXHIBITED BY *ANODONTA GRANDIS* IN DIFFERENT TYPES OF WATER IN THE HURON RIVER SYSTEM

The figures given represent average abundance, based on an arbitrary scale of 1 to 5: 1 = rare; 2 = average; 3 = common; 4 = abundant; 5 = very abundant.

	MUD	MARL	MUCK	SAND	GRAVEL	BOULDERS	CLAY
Lakes	....	3.6	3.3	3.5	....	....	....
Brooks	2.0	....	....	....	....	....	....
Creeks	....	....	....	2.0	2.0	....	....
Small river	2.0	2.5	2.7	2.7	2.5	....	....
Medium-sized river	2.0	....	....	2.0	2.0	....	....
Large river	....	....	....	3.0	3.0	....	....

The data can be summed up by the statement that this species is most common on a relatively soft bottom in more or less quiet bodies of water. It is especially adapted for living on a soft bottom and can exist on muck where few other species survive.

Variation.—The wide range of conditions under which it lives has caused much difficulty in arriving at suitable names for the various forms. We do not have sufficient ecological and life-history data to enable us to solve the systematic difficulties which arise in this group. For instance, specimens occurring in lakes tend to be more inflated anteriorly and in the region of the beaks and usually have a finer beak sculpture than those found in rivers. But there are all kinds of intergrades so that forms from lakes, usually labeled *Anodonta grandis footiana,* often resemble more closely the true river form *Anodonta grandis.* Other varieties have been named, and in some instances varieties have been raised to specific rank without due consideration to the ecological conditions which might have brought about the variation.

F. C. Baker (1927*b*: 364) reports *Anodonta marginata* Say from White Lake. The diagnostic characters of this so-called species are according to Say's original description, reprinted by Binney (1858: 53): a very thin, subovate shell with "a bluish-white nacre edged with whitish." Others, notably Simpson (1914: 388), have improved on Say's description by describing the nacre as "bluish white with a peculiar dull, silvery tint, often yellowish or salmon in the cavities, somewhat iridescent behind." I do not believe a thin shell and a bluish-white or silvery nacre—two variable characters in a very variable species—are sufficient for specific distinction. I have a large series of specimens of *Anodonta* from this drainage. They intergrade to such an extent that there is a perfect connection between what might be called the typical *grandis,* through various forms which may be labeled *grandis footiana,* to so-called *marginata.* What we have are ecological races, and not varieties or distinct species. Baker reports finding *marginata* on a clay bottom. Such a bottom is usually unfavorable to *A. grandis,* which is best suited to a soft bottom. It is of significance that almost all the paper-thin shells labeled *marginata* in collections from Michigan were taken in northern lakes and streams of low pH. Except for this thinness and the conspicuous growth-rests, these shells correspond to typical *grandis.*

Anodonta imbecillis Say

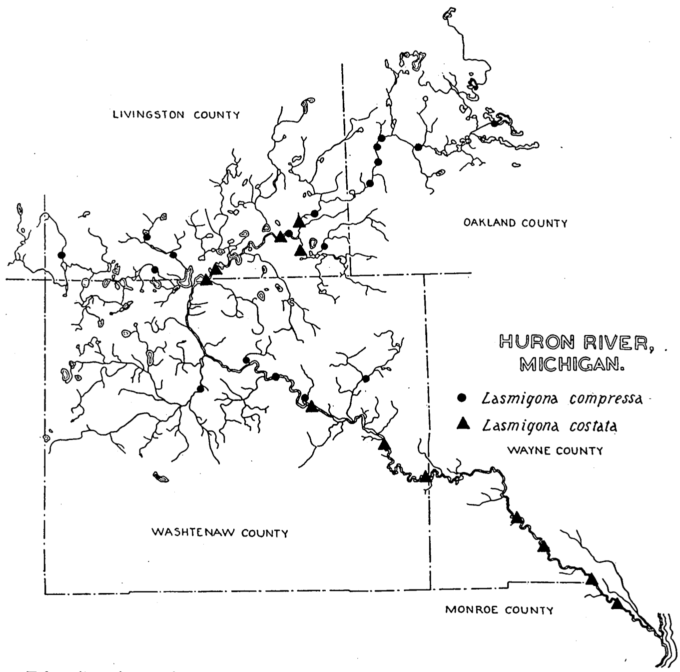
Distribution.—The distribution of this species (Map 14) is rather sporadic in the upper reaches of the Huron River drainage. It was found here only under "small-river" conditions. I have never taken it in any of the lakes or creeks of this drainage, though Wilson and Clark (1912*a*: 47) in their studies of the mussels of the Kankakee drainage report it as "a shell of ponds and small streams."

The single record at Ann Arbor is one of long standing, and it has been included to show that it did once occur in this locality. I also found this species abundant in the backwater areas above the dam at French Landing. From there it extends upstream to the end of the ponded zones. Below French Landing there is a barren, polluted zone, immediately below which the species was found to be plentiful. It occurs at Flat Rock and above Rockwood, but it is only sparsely represented there.

Ecology.—Reference has already been made to the absence of this species in the lakes of this drainage. Blatchley (1901: 251), however, reports it from Lake Maxinkuckee as "being found in the bays whose bottoms are muck and mud; also in the outlet." F. C. Baker (1928: 174) gives its habitat as "small rivers and ponds in shallow, quiet water along shore on a fine sand and mud bottom." In this drainage, I found it in numbers one mile east of Willow, Wayne County (Station 31), where it was mainly on a sand bottom near shore. Just above Rockwood (Station 32) it occurred on gravel and sand. In the backwater area above the dam at French Landing it was common on the fine mud and sand bottom (Stations 28 and 29) though in this same region it was also found along a rather firm sand and gravel shore. In the upper reaches of the drainage it was collected on sand and gravel. My observations agree essentially with those of Isely (1925: 101) for the mussels of eastern Oklahoma. He learned that the mussel, in spite of its very fragile shell, occurred in a swift gravel-bottomed stream, as well as in mud banks in the bend of the stream and side channels where the water was sluggish.

Lasmigona compressa (Lea)

Distribution.—Wilson and Clark (1912*a*: 46) in their Kankakee survey state that this is a species belonging to small streams. The same authors in



MAP 7. Distribution of *Lasmigona compressa* and *Lasmigona costata* in the Huron River drainage. Note that *costata* is largely confined to the main stream and that *compressa* is partial to creeks and headwater conditions.

the survey of the Maumee River (p. 46) found only one specimen in that river, which expresses the same idea (i.e., that it is a creek form) in a negative way. Blatchley (1901: 250) reports finding several specimens in low water along the south shore of Lake Maxinkuckee. Beauchamp (1883: 433) in a note on the distribution of this species writes: "... I have also observed it sparingly in the Erie Canal at Syracuse, but never in lakes. It seems to prefer small streams with muddy bottoms, and there to form isolated colonies."

Map 7 shows that it is primarily found in brooks, creeks, and small-river areas, often going far into the headwaters. Two records indicate that it may be found in the larger parts of the river, but such occurrences are exceptional. This agrees with Wilson and Clark's results. I have never collected it in any of the lakes of this drainage, though it does occur in small streams below their outlets. Whereas *L. compressa* is primarily confined to the headwaters, *L. costata* inhabits the main course of the river and never has been found in the tributaries.

Ecology.—This species was found most commonly in pools above and below riffles. In such pools it was buried in compact sand and gravel or in mud patches close to shore. In the larger river it was taken from a soft mud bottom in a slow-moving current near the bank.

Lasmigona costata (Rafinesque)

Distribution.—In this drainage (Map 7) I have found *L. costata* only sparsely represented throughout the main course of the river. I have never found it in any of the lakes, or in the river tributaries. It is also absent in the backwater areas above the power dams. Ortmann (1919: 130) reports it from "large rivers as well as in very small creeks, although it is distinctly more abundant in the latter. There is hardly any small stream from which it is entirely absent, but in the large rivers, although present, it is decidedly rare." For the Huron River this statement is only partially true. It is sparingly distributed in the main stream, but does not occur in creeks and other tributaries. In the Clinton River, I found it confined to the main river—which repeats the findings in this drainage.

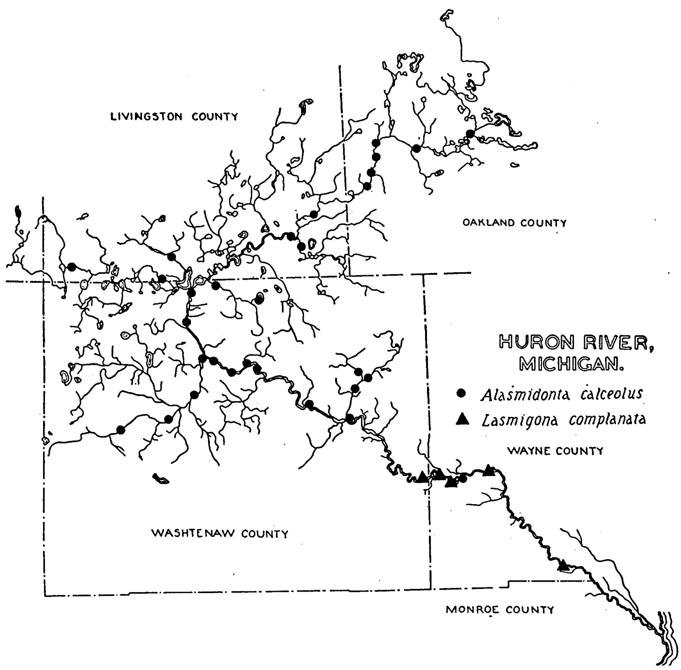
Ecology.—It is found mainly on a sand and gravel bottom, and usually occupies a situation where there is a noticeable current.

Lasmigona complanata (Barnes)

Distribution.—The occurrence of this species in this drainage came as somewhat of a surprise. Walker (1898: 6) in discussing the distribution of the Unionidae in Michigan wrote: "*Margaritana complanata* Barnes has not been found outside of the Saginaw-Grand Valley, except in one locality, the River Rouge, near Detroit." Recently, I have found it abundant in the lower reaches of the Clinton, Rouge, and Huron rivers. There are no records to indicate that it occurs in the River Raisin. It is, therefore, possible that this species is invading the Lake Erie tributaries either from the north or from the Maumee River on the south. The map (Map 8) shows that in this drainage *complanata* is definitely limited to the lower section of the river. I found this to be true also in the Rouge and Clinton rivers. Baker (1928: 150) finds it "equally abundant in both large and small rivers and creeks." This has not been found the case in the drainages of the southeastern part of

Michigan. Ortmann (1919: 135) in a monograph of the Naiades of Pennsylvania gives two very remarkable records on the occurrence in creeks at the outlets of two lakes of glacial origin. It has never been found anywhere else in that state, and Ortmann is at a loss to account for this discontinuous distribution, as well as for its presence under such unusual environmental conditions.

Ecology.—Utterback (1916: 100) says: "This species is very common in North Missouri where it grows very large in the lakes, but is uncommon and



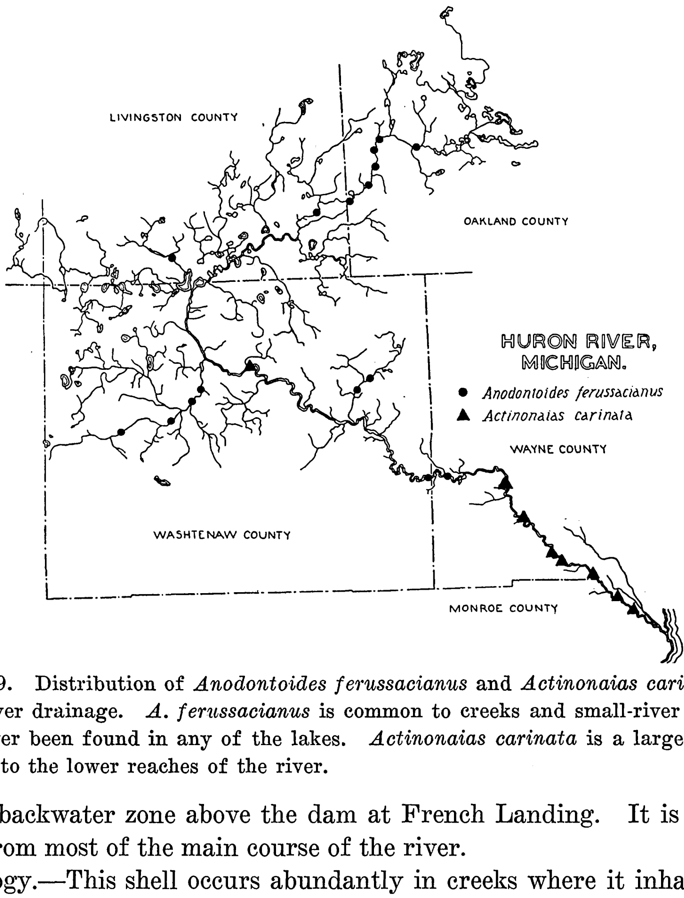
MAP 8. Distribution of *Alasmidonta calceolus* and *Lasmigona complanata* in the Huron River drainage. *Alasmidonta calceolus* is a species common to creeks and small-river conditions. *Lasmigona complanata* occurs only in the lower part of the river and in the ponded areas in this same region.

dwarfed in Central Missouri and is not found at all in the clear, swift-water streams of South Missouri." The lakes to which Utterback refers are segregated river oxbows rather than bodies of water that in the northern states are called lakes. I have never found it in any of the lakes of this drainage, though it is particularly abundant in the soft mud in the backwater area above the dam at French Landing (see Stations 28 and 29). It also occurred on the fine sand bottom below the Ford dam above Rawsonville (Station 27), and on a similar bottom one mile east of Willow (Station 31). At all these stations the water is normally rather deep and the current sluggish. In the

Rouge and Clinton rivers, it was found on sand and mud in a slow-moving current.

Anodontoides ferussacianus (Lea)

Distribution.—In the Huron River (Map 9) this species is most commonly found in creek and small-river conditions. Blatchley (1901: 251) reports it as rather common in the vicinity of the muck beds of Lake Maxinkuckee and in the lake outlet. It is also found in Lake Erie. However, I have never taken it from any of the lakes of this drainage, though it does occur in the



MAP 9. Distribution of *Anodontoides ferussacianus* and *Actinonaias carinata* in the Huron River drainage. *A. ferussacianus* is common to creeks and small-river conditions. It has never been found in any of the lakes. *Actinonaias carinata* is a large-river form restricted to the lower reaches of the river.

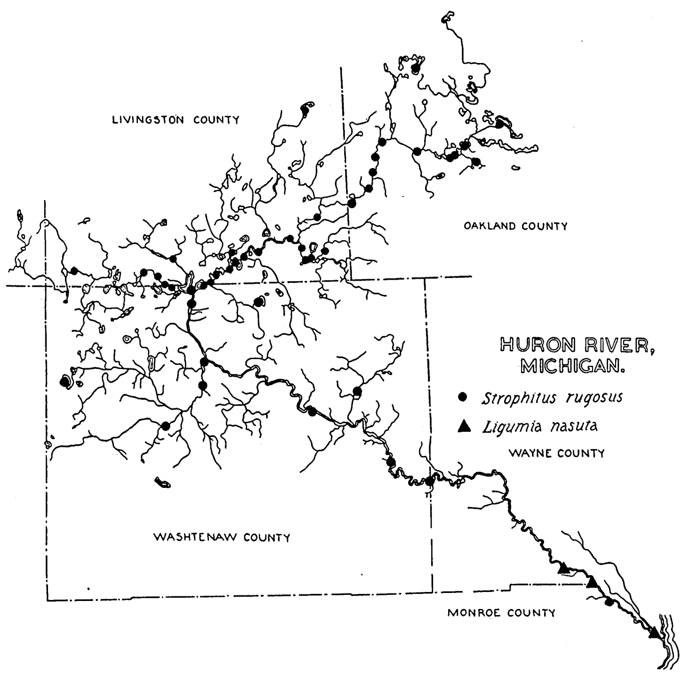
lakelike backwater zone above the dam at French Landing. It is scarce or absent from most of the main course of the river.

Ecology.—This shell occurs abundantly in creeks where it inhabits more or less quiet pools with a sand or gravel bottom. One of the best localities in this drainage is Fleming Creek at Station 35. Though usually found on sand and fine gravel, it may occur in mud. The records from the lower section of the river are of interest. A series of exceptionally large specimens was found on a fine sand bottom just below the Ford dam (Station 27). A similar series was found on the mud flats above Belleville (Station 28).

These specimens resemble the form called *buchanensis* Lea. I agree with Ortmann (1919: 170) in calling this a form rather than a species or subspecies. There is not a definite geographic range among these forms, and often a collection from a given locality will include specimens which are typical of both *buchanensis* and *ferussacianus*. At best, *buchanensis* is merely an ecological modification.

Strophitus rugosus (Swainson)

Distribution.—This species (Map 10) is especially common in the creeks and upper reaches of the river, i.e., in the smaller streams. In the main



MAP 10. Distribution of *Strophitus rugosus* and *Ligumia nasuta* in the Huron River drainage. *Strophitus rugosus* occurs commonly in small to medium-sized river conditions as well as in certain of the lakes. *Ligumia nasuta* has never been found anywhere except near the mouth of the river, where it is evidently a Lake Erie intrusion.

course of the river in Washtenaw, Wayne, and Monroe counties it is relatively scarce, which bears out Ortmann's (1919: 204) statement that it is averse to large rivers. It does occur in some of the lakes, but it is most common in those which have a marked river influence, such as one which has a sizable inlet or outlet, or both, or in a body of water of the river-lake type. I have never found it in a land-locked lake.

Ecology.—A species with very widespread distribution is likely to occur in a great variety of habitats. However, this species was found most commonly in creeks and small streams on a sand and gravel bottom, and occasionally on mud. It usually inhabits the pools and quiet-water areas and tends to avoid rapid-water zones. In the lakes it is found on several types of substrata, but only on nonshifting shoals, usually of sand and fine gravel. I have never found it on muck.

Variation.—Ortmann (1919: 205) considers *rugosus* to have possibly the widest range of any naiad in North America. A species which occupies so wide a range and which at the same time inhabits such diversified habitats can be expected to show a broad range of shell variation. Attempts have been made to name subspecies, and there are several such names now in use. The characters upon which these are founded do not consistently hold. In this drainage alone, I find a very wide range of variation, and I do not feel justified in referring any of these specimens to subspecific categories which have been artificially erected.

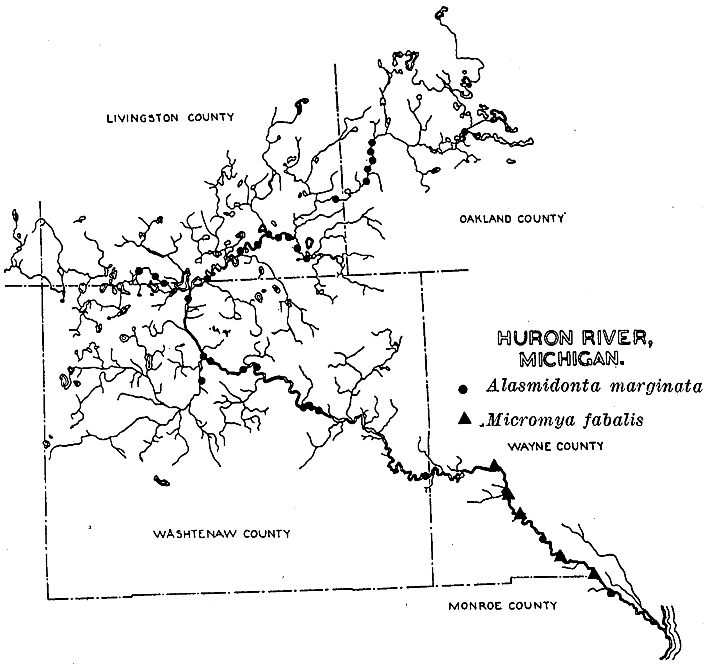
Alasmidonta calceolus (Lea)

Distribution.—This species (Map 8) is especially common in creeks and small-river conditions. Though it does occur in the main river above Ann Arbor, it is always rare there. Meek and Clark (1912: 16) report it as scarce in the Big Buffalo Fork of the White River. They indicate that it may have been overlooked, but the chances are that it was actually scarce. The only specimens taken in the Huron River below Ann Arbor were in the backwater area above Belleville (Station 28). Its occurrence here was rather unusual, and indicates how difficult it is to make any definite rules regarding distribution; yet, my records would indicate that its occurrence in lakes is the exception rather than the rule. I have never taken living specimens from any of the true lakes in this drainage.

Ecology.—In creeks, the usual habitat of this species, *calceolus* burrows down into the sand and gravel, locating itself either in the riffles or in the pools. Occasionally, it occurs in mud along the banks. In the larger parts of the river it occurs sparsely on sand and gravel. A few abnormally large specimens were taken from a sandy mud substratum in the ponded area above Belleville.

Variation.—F. C. Baker (1928: 184–189) has established two varieties of *calceolus,* which he names *c. danielsi* and *c. magnalacustris.* The basis for this distinction is a difference in relative obesity. This, expressed in percentages, is the product of the width of the shell divided by its length. Baker points out that *c. magnalacustris* is the lake form which is least obese; *c. danielsi* the creek form which is slightly more obese; while *calceolus,* itself, is the form common to the larger rivers and has a greater obesity than either of the others. Such a systematic scheme is of interest since it can be nicely tested in a drainage such as the Huron River which presents all three kinds of habitat. It should, however, be noted that since this species is primarily a creek form one may have difficulty in obtaining an adequate series from either a lake or a large river. With the material at hand, I was able to establish four stations in this drainage which yielded sufficient shells to obtain the results given in the accompanying table.

From Table VII it is evident that Baker is correct in his assumption that this species follows Ortmann's law—a law to the effect that certain species



MAP 11. Distribution of *Alasmidonta marginata* and *Micromya fabalis* in the Huron River drainage. *Alasmidonta marginata* is particularly common in small, and medium-sized river conditions. *Micromya fabalis* is rare in this drainage and has only been found in the lower reaches of the river.

tend to become more obese as the size of the stream in which they live increases. Baker admits (1928: 189) that mathematically the ratios he obtained are not reliable. Table VII also shows that the obesity in each of the collections greatly overlaps. To attempt to give names to such small differences is impracticable, though these differences might hold theoretically.

Alasmidonta marginata (Say)

Distribution.—In the Huron River this species is found mainly in the upper reaches of the drainage (Map 11). I have never found it in any of the lakes, nor in the small creeks, but, when a larger creek, such as Mill Creek,

TABLE VII

DATA ON THE OBESITY OF *ALASMIDONTA CALCEOLUS* IN THE HURON RIVER SYSTEM

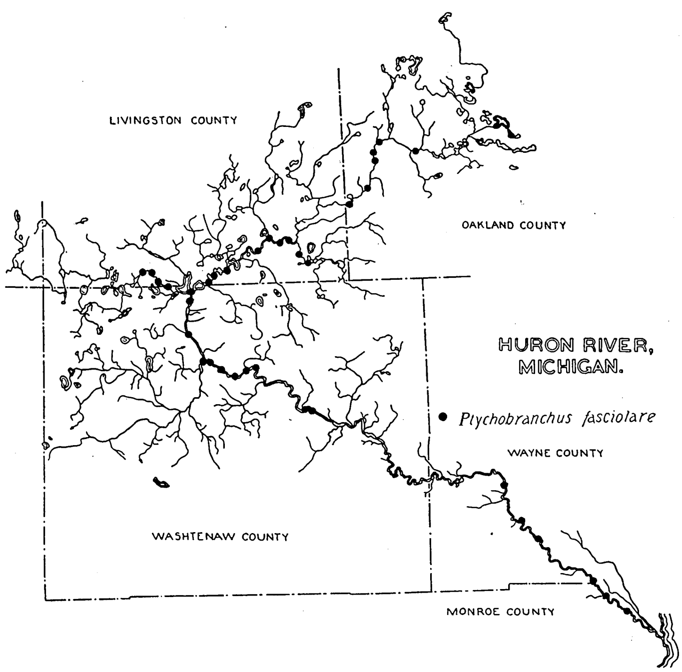
Locality	OBESITY EXPRESSED IN PER CENT																No. Spec.	Mean	P.E.M.
	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49			
I. Fleming Creek	...	1	1	1	3	2	1	4	1	...	1	...	...	...	1	...	16	39.87	0.52
II. Mill Creek	2	...	...	1	2	2	2	2	3	4	2	...	...	...	...	...	20	40.35	0.44
III. Huron River below Milford	...	...	...	1	3	5	2	2	8	3	3	2	1	...	1	...	31	41.58	0.31
IV. Huron River at Ann Arbor	...	...	...	...	...	1	...	4	2	...	2	...	...	2	...	1	12	43.17	0.57

STATISTICAL COMPARISONS OF THE MEANS FOR THE SEVERAL DIFFERENT LOCALITIES

Comparing:	Difference	Probable Error of Difference	Difference Divided by P.E. of Difference	Probability of Significance in Per Cent
I and II	0.47	.68	0.7	36
I and III	1.71	.61	2.8	94
I and IV	3.30	.77	4.3	99
II and III	1.23	.54	2.3	87
II and IV	2.82	.72	2.9	98
III and IV	1.59	.65	2.4	90

approaches a small-river condition, this species comes in. I found it throughout the main stream, but not in river-lakes and backwater areas. In the lower reaches of the river it is usually rare.

Ecology.—In the small-river areas of the upper part of this drainage it occurs on a sand and gravel bottom in a current. Stations 3, 4, and 33 are representative of this type of habitat. The species *marginata* was also found on gravel in the riffles below Delhi Mills, Washtenaw County, but the shells are not as abundant there as farther upstream. The Museum of Zoology has a series of twenty-eight specimens which were taken at Ann Arbor, indicating that the species was at one time well represented at this locality.



MAP 12. Distribution of *Ptychobranchus fasciolare* in the Huron River drainage.

Ptychobranchus fasciolare (Rafinesque)

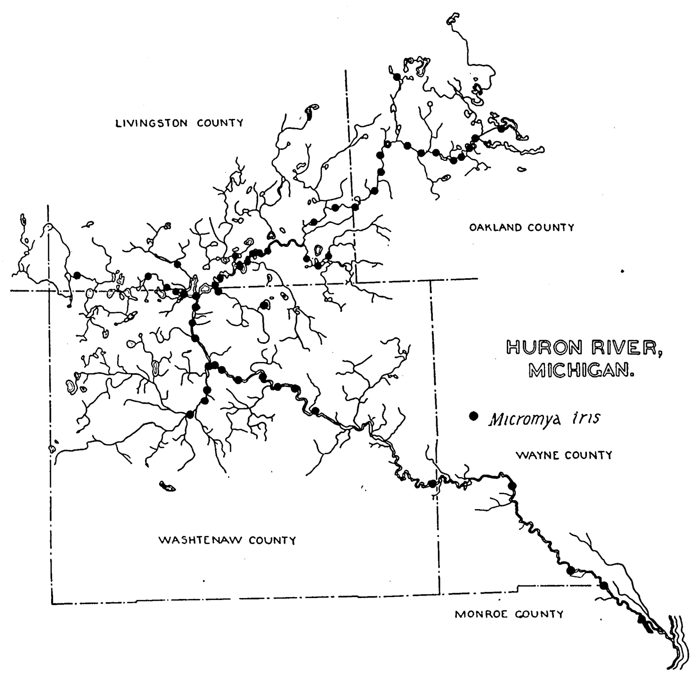
Distribution.—In this drainage (Map 12) *fasciolare* never occurs in any of the lakes or backwater areas above the various dams. It is usually absent from the creeks, such as Fleming, Mill, and Honey (of Livingston County). It is common in small-river conditions such as those of Portage River and the similar areas of the upper drainage. Below Ann Arbor there are only a few unpolluted stretches of river, and though this species is usually found in such places, it is never abundant there.

Ecology.—*P. fasciolare* is usually found buried deep in an unshifting sand

and gravel bottom in rapids and seems to show a definite aversion towards ponded or backwater conditions. This is of interest because in Lake Erie a form occurs which does live under lake conditions. Its associates are *Micromya iris, Lampsilis fasciola,* and *Elliptio dilatatus.*

Micromya iris (Lea)

Distribution.—This species (Map 13) is one of the most common in the headwaters. Occasionally it is found in lakes (Evermann and Clark, 1918: 254), though in this drainage it lives only in lakes of the river-lake type.



MAP 13. Distribution of *Micromya iris* in the Huron River drainage. It is common in large creeks and under small- to medium-sized river conditions. It rarely occurs in river-lakes.

Even in such lakes it is always very rare. Though found in some of the larger creeks, it is especially abundant under small- and medium-sized river conditions. Below Ann Arbor it becomes rare and occurs only where there are favorable river conditions, avoiding ponded areas, as well as the polluted zones.

Ecology.—Table VIII indicates its occurrence at the various stations from which it has been taken in the river. It thrives particularly well on a shoal of sand and gravel, where it occurs in the current.

Variation.—In the past, a northern race, known as *Micromya iris novi-*

TABLE VIII

BOTTOM PREFERENCE EXHIBITED BY *MICROMYA IRIS* IN DIFFERENT TYPES OF WATER IN THE HURON RIVER SYSTEM

The figures given represent average abundance, based on an arbitrary scale of 1 to 5: 1 = rare; 2 = average; 3 = common; 4 = abundant; 5 = very abundant.

	MUD	MARL	MUCK	SAND	GRAVEL	BOULDERS	CLAY
River-lakes	1.0	1.3	1.0	1.2	......	......	......
Small creeks	......	......	......	1.4	2.2	......	......
Large creeks	......	......	......	2.0	4.0	......	......
Small river	......	1.5	1.0	3.3	3.2	......	......
Medium-sized river	......	......	......	3.3	2.8	3.0	......
Large river	......	......	......	1.0	1.0	......	......

eboraci (Lea), has been generally recognized. The only clear-cut distinction which has been used to separate this race from the typical *iris* is the color pattern. In true *iris* the rays are supposed to be broader and interrupted at the growth-rests, so as to appear as blotches usually arranged in concentric bands; whereas the variety has finer and more continuous rays. At the present time, I am not in a position to pass on the validity of this distinction in other regions. However, in this drainage, I find too many intergrades to feel that such a distinction is valid. The color pattern is too variable a character in itself to be at all reliable for making such distinctions. My specimens not only intergrade, but a number of them are quite rayless.

Micromya fabalis (Lea)

Distribution.—Though there are records, such as those of Evermann and Clark (1918: 284), Call (1898: 459), and Headlee (1909: 306), which would establish this as a species common to lakes, I have never found it in any of the lakes of this drainage basin, nor has it been found in the headwaters of the Huron River. All records (Map 11) would indicate that this species is limited to the lower part of the river, which suggests that it has entered this drainage from Lake Erie, where it is sparsely represented. That it does occur in small streams is evident from the specimens recently taken in the headwaters of the Clinton River.

Ecology.—In the headwaters of the Clinton River this species was found imbedded in sand among the roots of aquatic vegetation in about four inches of water flowing about five miles an hour. The specimens found in the lower reaches of the Huron River were unfortunately not taken alive. Ecological conditions have been so altered there that it is now impossible to find adequate series of living mussels. Ortmann (1919: 264) found it among patches of aquatic vegetation in small streams of Pennsylvania. Evermann and Clark (1918: 284) took it in the Tippecanoe River of Indiana from a blue clay substratum near shore. Headlee (1906: 306) reports it from Winona Lake where it occurred on a sand and gravel bottom, going to a depth of four feet. He asserts (p. 313) that it can also live in a fine black mud with *Anodonta grandis* and *Strophitus rugosus.*

Ligumia nasuta (Say)

Distribution.—*Nasuta* has been found only in the lower reaches of the Huron River (Map 10). It has likewise been found at the mouth of the Clinton River. Calvin Goodrich has records to indicate that it is similarly distributed in the River Rouge. It is common to Lake Erie and has apparently entered these streams from Lakes Erie and Saint Clair. It has never been observed in any of the lakes of the Huron River drainage, though Goodrich (1932: 108) has shown that it is found in some of the inland lakes of Michigan: Douglas Lake, Cheboygan County; Valentine Lake, Montmorency County; and Sage Lake, Ogemaw County.

Ecology.—This species in the river is usually large and thick as compared with the small and thin specimens occurring in the lakes. In the river it occurs on a sandy bottom in more or less quiet pools, and even there must be counted as rare. In the lakes it is common in beach pools on a sand bottom.

Ligumia recta latissima (Rafinesque)

Distribution.—In the Huron River (Map 14) this species is confined to the main course of the river. It has never been found in any of the lakes or tributaries. It does, however, occur in the zone approaching small-river conditions below Kent Lake, Oakland County. In the river-lake area in Livingston County it occurs in the stretches of true river, but is absent in the backwater of lakelike river expansions. In the lower section of the river several young specimens were found in the ponded, backwater area above the dam at French Landing.

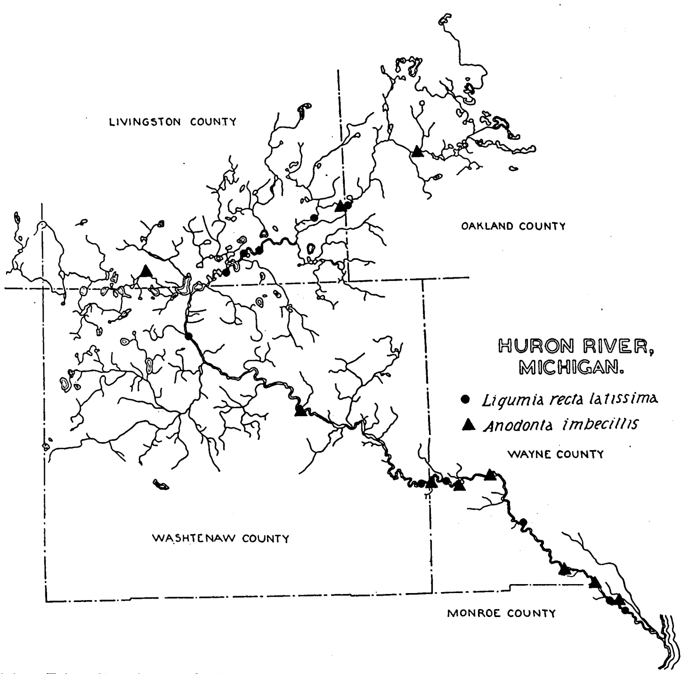
Ecology.—*L. recta latissima* is most common to large and medium-sized river conditions where it usually occurs on a sand and gravel bottom in the current (Stations 9, 13, and 32). The only exception to this is the record of young specimens found on a fine sand-mud bottom, in the backwater area two miles above Belleville (Station 28). Isely (1925: 109) describes the ecology of this species as similar to that of *Lampsilis anodontoides,* whose habitat is described as "a mud bank, in water 2 to 5 feet deep, generally along the stream margin and out of the main channel."

Variation.—It is of interest to note that Ortmann is not in favor of using the subspecific name *latissima* for the river form. In his monograph he (1919: 278) states:

> *Eurynia recta* is not very variable. The proportion of length and height varies slightly, and so does the color of the epidermis and of the nacre. In Lake Erie there is a

local form, which differs from the Ohio type by its smaller size, its paler epidermis (browner, inclined to russet), and the more regular growth lines. But, there are specimens in the lake, chiefly younger ones, which are indistinguishable from the specimens from the Ohio River. Therefore I do not think it advisable to separate the two forms by varietal names.

Under *Elliptio dilatatus* I have pointed out that Wilson and Clark (1912*a*: 45) and later Grier (1920) indicate that the nacre of this species also tends to become whiter in the lower reaches of the river. An examination of the specimens taken from the Huron River does not substantiate this. All the



MAP 14. Distribution of *Ligumia recta latissima* and *Anodonta imbecillis* in the Huron River drainage. *L. r. latissima* is found only in the main stream, under medium- to large-river conditions. *A. imbecillis* occurs under small- to large-river conditions, but unlike *A. grandis,* it has never been found in any of the lakes of this drainage.

material is predominantly white-nacred, and there is no evidence that those from the lower reaches of the river are whiter.

Ortmann (1920: 308) finds that this species "has a very wide distribution from the larger rivers well up into the headwaters, but is remarkably uniform in obesity." Grier and Mueller (1926: 20), however, come to the conclusion that the mollusk increases in obesity from a station above Lake Pepin of the Mississippi River to a station below this lake. The number of specimens examined was forty-seven. A study of Grier and Mueller's table reveals that the mean difference in obesity of the shells of the two stations amounted to one one-hundredth per cent. The conclusion appears to be a somewhat large one to draw from so small a numerical difference.

Carunculina parva (Barnes)

Distribution.—This species is restricted entirely to the lower reaches of the Huron River (Map 15). I have never taken it from any of the lakes, creeks, or headwaters, although Blatchley (1901: 251) found it in Lake Maxinkuckee, and F. C. Baker (1922: 50) reports it from small tributaries of the Big Vermilion River. It is abundant in the ponded backwater areas above the dam at French Landing. Below the dam there is a polluted zone in which *parva* is absent, but immediately below this it again appears, though less common than above this zone.

Ecology.—Above the dam at French Landing in the Huron River it was very abundant on the fine mud of this backwater area (see Stations 28 and 29); and in this same part of the river on sand and gravel close to shore (Stations 28*a* and 29*a*). It was also found thriving on a sand bottom one mile east of Willow (Station 31). In the vicinity of Rockwood, although a rare shell there, it occurred on a gravel bottom near shore (Station 32).

Lampsilis fasciola Rafinesque

Distribution.—In the Huron River this species was particularly common in the headwaters, having a distinct aversion for large-river conditions (Map 15). It was usually in large creeks and under small- to medium-sized river conditions. I have never discovered it in any of the lakes.

Ecology.—This species is usually on a more or less solid sand and gravel bottom in riffles and rapid waters. It does not occur in streams as small as Fleming Creek and the upper part of Mill Creek. It is rare in the Huron River below Ann Arbor. Wherever found, it tends to bury itself deeply so that usually only the siphons are to be seen. Table IX indicates its relative abundance on the various types of bottom in the river.

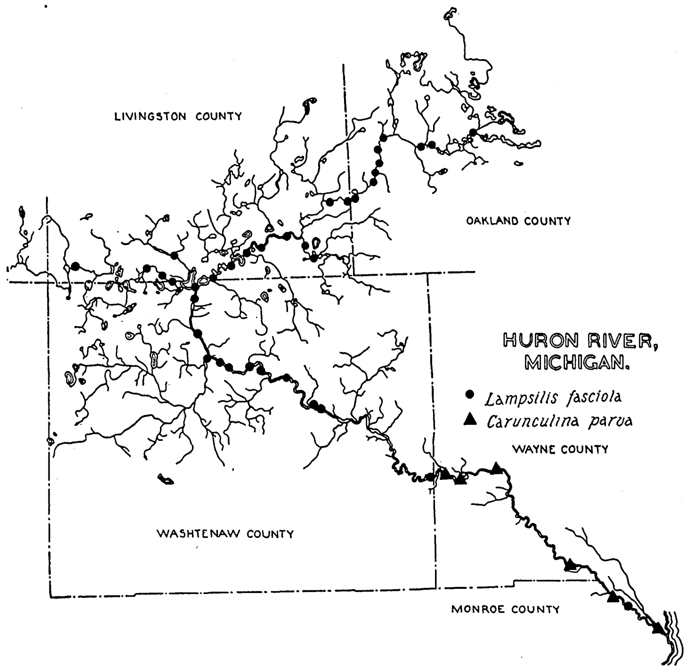
TABLE IX

BOTTOM PREFERENCE EXHIBITED BY *LAMPSILIS FASCIOLA* IN DIFFERENT TYPES OF WATER IN THE HURON RIVER SYSTEM

The figures given represent average abundance, based on an arbitrary scale of 1 to 5: 1 = rare; 2 = average; 3 = common; 4 = abundant; 5 = very abundant.

	MUD	MARL	MUCK	SAND	GRAVEL	BOULDERS	CLAY
Small creeks	......	......	......	1.0	1.0	......	......
Large creeks	......	......	......	2.3	2.5	......	......
Small river	......	......	......	3.6	3.8	......	......
Medium-sized river	......	......	......	3.1	2.9	2.3	......
Large river	......	......	......	1.0	1.0	......	......

The nomenclature of *fasciola* has been somewhat confused. Winslow (1926: 23) lists it as a *Ligumia,* rather than a *Lampsilis,* supposedly on the authority of Ortmann. It is obviously a member of the *Lampsilis* group. In a recent letter to Goodrich, Stanley Brooks indicated that Ortmann recognized this as a *Lampsilis,* and that *Lampsilis* rather than *Ligumia* stands.



MAP 15. Distribution of *Lampsilis fasciola* and *Caruncculina parva* in the Huron River drainage. *Lampsilis fasciola* is common in small- and medium-sized river conditions, rare in the lower part of the river. *Carunculina parva* occurs only in large-river and ponded areas which occur in the lower reaches of the river.

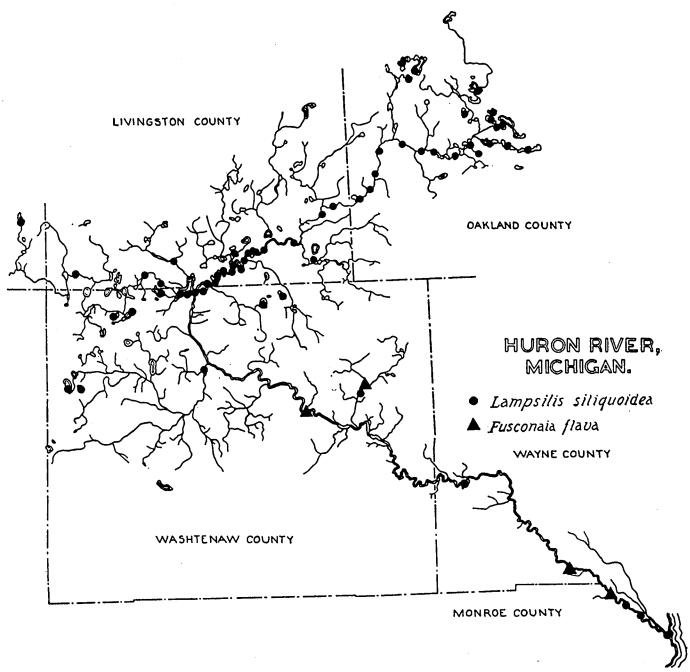
Lampsilis siliquoidea (Barnes)

Distribution.—The distribution map (Map 16) clearly indicates that in the Huron River drainage this species is primarily found in lakes of all kinds as well as under small- and medium-sized river conditions. It is rare in the creeks and larger parts of the river. It was only found at one station in the main river between the outlet of Portage Lake, Washtenaw County, and the region of influx of Lake Erie species below Flat Rock, Wayne County. In this impounded area it was decidedly rare. Its abundance in the region of the river-lakes in Livingston County will be referred to later.

Ecology.—Ortmann (1919: 288) wrote:

Ecologically this species is found under a number of conditions, but there is no doubt that it prefers rather quiet water and sandy-muddy bottoms. Strong currents and rough bottoms do not suit it, and although occasionally found in riffles, it probably has in such cases been washed out of the quieter pools. In the quiet water below riffles where there is more or less muddy bottom, or in slowly running water with fine gravel, sand, and mud, it is abundant.

This statement can hardly be improved upon. Where *siliquoidea* was found in the backwater area above Belleville, conditions were favorable, though it



MAP 16. Distribution of *Lampsilis siliquoidea* and *Fusconaia flava* in the Huron River drainage. *Lampsilis siliquoidea* is one of the most common species in this drainage. It occurs in most of the lakes as well as in the river; however, it becomes decidedly rare in most of the lower half of the drainage. *Fusconaia flava* is a rare species and is evidently restricted to the lower part of the river and its tributaries in that area.

was decidedly rare there (Station 28*a*). It occurs at the mouth of the river as an intrusion from Lake Erie, but it is rare in this zone where the substratum is composed of gravel and clay. Table X indicates its relative abundance on various types of bottom throughout the drainage.

Variation.—It is generally known that in certain lakes, particularly Lake Erie and in some land-locked lakes, this species is represented by a stunted form which is called *Lampsilis siliquoidea rosacea* (DeKay). Large series of specimens which might be referred to this form have been found in some of the lakes of this drainage. In river-lakes, as found in Livingston County,

TABLE X

BOTTOM PREFERENCE EXHIBITED BY *LAMPSILIS SILIQUOIDEA* IN DIFFERENT TYPES OF WATER IN THE HURON RIVER SYSTEM

The figures given represent average abundance, based on an arbitrary scale of 1 to 5: 1 = rare; 2 = average; 3 = common; 4 = abundant; 5 = very abundant.

	MUD	MARL	MUCK	SAND	GRAVEL	BOULDERS	CLAY
Land-locked lakes...	2.5	3.6	2.3	3.7	2.6	......	......
River-lakes	1.5	4.0	1.5	3.4	2.5	......	......
Small creeks	......	......	......	1.0	......	......	......
Large creeks	......	......	1.0	1.0	......	......	......
Small river	2.0	......	2.6	3.2	2.5	......	......
Medium-sized river	2.6	3.5	3.0	3.8	3.0	......	......
Large-sized river ...	1.0	......	......	1.0	1.0	......	......

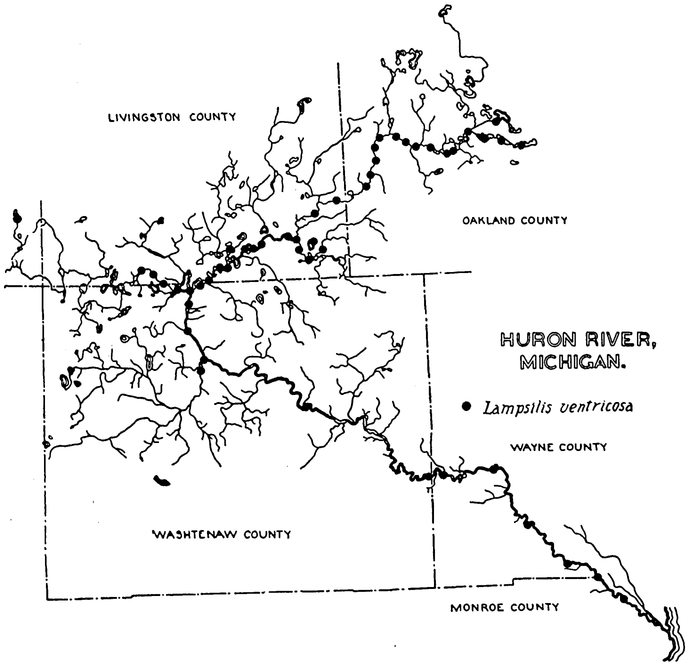
there are many forms which connect *rosacea* with true *siliquoidea*. Evermann and Clark (1918: 277) report: "*Lampsilis luteola* is represented in Lake Maxinkuckee and Lost Lake by two forms; although these forms are well connected by intergrades the extremes are pretty markedly distinct." Evidently, *rosacea* is nothing more than an environmental form. In this connection it is of interest to note Ortmann's (1919: 291) view on this matter: "I have the impression that *rosacea* is not so much a geographical, as an ecological race, produced by the environment of great lakes, and that it turns up wherever the proper conditions are offered."

Lampsilis ventricosa (Barnes)

Distribution.—This species is found throughout the main course of the Huron River (Map 17) and in its largest tributary, Portage River in Livingston County. It is especially common under small- and medium-sized river conditions on a sand and gravel bottom. In the river below Portage Lake near the Washtenaw-Livingston County line the bottom is coarse gravel and boulders, and in this rapid-water area *ventricosa* becomes rare. Below Ann Arbor pollution has eliminated it, but it again appears below the Ford dam above Rawsonville and continues to make its appearance on down to the mouth of the river. Yet, in this large-river zone it is not common because ecological conditions are less favorable to it. *L. ventricosa* is found in relatively few lakes in this drainage. In all such cases the lakes have a stream influence, either directly, as in the case of river-lakes, or indirectly, as in lakes which form a chain series, or those having a strong inlet or outlet, or both. It is only rarely found in true land-locked lakes, and there it probably has been introduced on parasitized fish bait.

Ecology.—In the Huron River, this species shows a decided preference for the less turbulent waters above and below riffles, where it occurs usually on sand and gravel. In the lakes, it is found mainly on solid shoals of sand, gravel, or marl. I have never found it on muck. In the lower reaches of the river a series was taken on a sand bottom (Station 27) below the new Ford dam above Rawsonville. Some of the handsomest specimens I have ever seen were found on the mud flats above the dam at French Landing (Stations 28 and 29). Table XI shows the types of conditions most favorable to it.

Variation.—As in the case of *Lampsilis siliquoidea,* this species also becomes stunted in a lake environment, the name *canadensis* being applied to



MAP 17. Distribution of *Lampsilis ventricosa* in the Huron River drainage. In contrast to *Lampsilis siliquoidea,* this species is scarce in most of the lakes and entirely absent in many. It is abundant under small- and medium-sized river conditions, becoming rare in the lower reaches of the drainage.

the dwarfed form. Here again we have river forms and lake forms that are bridged by a complete series of intergrades without any relation to the geographical distribution of the forms.

Actinonaias carinata (Barnes)

Distribution.—This species has a decidedly restricted distribution in the Huron River (Map 9). It has never been found in any of the lakes and creeks or under small or medium-sized river conditions, but only in the large-river area of the lower drainage. The farthest upstream it has ever been reported is at Ann Arbor. However, that record is an old one and is of

TABLE XI

BOTTOM PREFERENCE EXHIBITED BY *LAMPSILIS VENTRICOSA* IN DIFFERENT TYPES OF WATER IN THE HURON RIVER SYSTEM

The figures given represent average abundance, based on an arbitrary scale of 1 to 5: 1 = rare; 2 = average; 3 = common; 4 = abundant; 5 = very abundant.

	MUD	MARL	MUCK	SAND	GRAVEL	BOULDERS	CLAY
Large lakes (river influence)	....	1.5	....	2.0	....	....	....
River-lakes	1.0	1.3	....	2.0	2.0	....	....
Small creeks	....	....	....	....	....	....	....
Large creeks	....	....	....	....	....	....	....
Small river	....	....	....	3.2	3.4	....	....
Medium-sized river	....	....	....	3.1	3.3	....	....
Large river (backwater zone)	2.3	....	....	....	....	....	....
Large river (true river)	....	....	....	2.0	1.0	....	....

interest only in that its suggests that an investigation carried out about fifty years ago might have produced somewhat different results from those given at this time. At present this species is not found in the river at Ann Arbor and is present only beyond the dam at French Landing. In the portions of the river not effected by the pollution below French Landing, this species becomes relatively common.

Ecology.—In the Huron River drainage, *carinata* is common on a coarse gravel and sand bottom in water from two to five feet deep, flowing at three to four miles an hour (Stations 31 and 32). It distinctly avoids the backwater areas above the dam at Flat Rock.

Variation.—Wilson and Clark (1912*b* : 56) report that in a downstream direction in the Maumee River "*L. ligamentinus* decreased in number more than in size." If true, this would be an exception to Ortmann's law. F. C. Baker (1928 : 222), however, writes: "Though inhabiting all types of river and creek environment, this species shows little active variation. The creek forms are somewhat smaller and more compressed than the forms of the medium sized rivers, and these in turn are somewhat larger than specimens from the lower Ohio and Mississippi rivers." Furthermore, Ortmann (1920: 308), in his study of the correlation of shape and station in fresh-water mussels, finds that "although not going into the smallest headwaters, this species is found in smaller and larger rivers, but no change in obesity is observed."

Obovaria subrotunda (Rafinesque)

Distribution and ecology.—In this drainage I have been able to get only dead specimens of this species. They are all from the river below Flat Rock, where the species may occur with *Ligumia nasuta, Quadrula pustulosa,* and *Dysnomia triquetra,* as an influx from Lake Erie. In 1933 a large series of this species was collected in the Duck River, Tennessee, on a sand and gravel bar—the habitat in the Huron River, when discovered, will probably be of this character.

Truncilla truncata Rafinesque

Distribution and ecology.—This species is only rarely found in the Huron River and never occurs anywhere in the river except near its mouth. I have only two such records, and these would indicate that it hardly gets above Flat Rock. It occurs in Lake Erie. Both river records are of dead specimens, but these tend to show that the species undergoes the same modification which other species common to Lake Erie undergo when they are subjected to river conditions. Both are abnormally large, and not at all like the stunted forms which occur in the large lake. In Lake Erie *Truncilla donaciformis* is usually associated with this species.

Dysnomia triquetra (Rafinesque)

Distribution.—In the Huron River basin (Map 4) this species is confined largely to the main stream between Milford, Oakland County, and Dover, Washtenaw County, and to the tributary Portage River. It can thus be considered a small- and medium-sized river species. *Triquetra* does occur, though rarely, in the river-lakes of Livingston County, but significantly becomes common in true river conditions between the river-lakes. I have not found it in the creeks or the land-locked lakes, or in the river below the river-lake zone until Flat Rock, Wayne County, is reached. The appearance of the species there is in association with other mussels which represent invasions from Lake Erie.

Ecology.—In the Huron River drainage, I have taken one specimen of this species from a fine mud-sand bottom in Base Line Lake (Station 17), another actively moving on a mud bottom in Portage River (Station 33), and a few specimens from a sand bottom in a protected pool in midstream above Strawberry Lake. The species is found particularly abundant on a coarse sand and gravel bottom in the current at Stations 8 and 10.

BREEDING PERIODS OF THE NAIADES IN THE HURON RIVER SYSTEM

The material in Table XII is based largely on my own records, which give exact dates as to when the various species occur in a gravid or nongravid condition. Since in many instances there is a decided lack of information on this subject it was necessary to take into account such records as are furnished by Ortmann (1919), Utterback (1916), and others. The table is far from complete, yet from it may be noted:

TABLE XII

The Breeding Periods of the Naiades in the Huron River Drainage

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Cyclonaias tuberculata												
Quadrula pustulosa												
Amblema costata												
Elliptio dilatatus												
Fusconaia flava												
Pleurobema cordatum coccineum												
Anodonta grandis												
Anodonta imbecillis												
Lasmigona compressa												
Lasmigona costata												
Lasmigona complanata												
Anodontoides ferussacianus												
Strophitus rugosus												
Alasmidonta calceolus												
Alasmidonta marginata												
Ptychobranchus fasciolare												
Micromya iris												
Micromya fabalis												
Ligumia nasuta												
Ligumia recta latissima												
Carunculina parva												
Lampsilis fasciola												
Lampsilis siliquoidea												
Lampsilis ventricosa												
Actinonaias carinata												
Obovaria subrotunda												
Truncilla truncata												
Dysnomia triquetra												

The *Unioninae* are tachytictic (short-term breeders), among which the gravid period usually occurs some time during June and July.

The *Anodontinae* and *Lampsilinae* are bradytictic (long-term breeders). In the former the nongravid period (or interim) occurs more or less definitely in June and July; in the latter the interim is less clearly marked, so that there are several instances where the gravid period of one season tends to overlap that of the next.

FACTORS LIMITING THE ABUNDANCE OF THE NAIADES

As civilization advances in an area, the naiad fauna is often forced out. In the Huron River, social and industrial developments have brought about striking changes in the fauna, particularly from Ann Arbor to the mouth of the river below Rockwood. In some places within this area the fauna has been completely exterminated, and in others the ecological conditions have been so changed as to bring about a complete readjustment.

One of the greatest factors influencing the mussels in the river below the vicinity of Ann Arbor is the large number of dams. There are no less than seven of these within forty miles. They are located at the following places: Flat Rock, French Landing, above Rawsonville, Ypsilanti, Geddes, Ann Arbor, and just above Ann Arbor. These dams, though some are provided with fish-ladders, are without doubt obstacles to fish migration. Blocking the fish movements presumably interferes with the normal distribution of the Naiades throughout the area. However, granted that the fish could normally migrate, each of the dams forms a huge ponded area which replaces normal river conditions—an ecological change which involves a readjustment of the fauna independently of other factors. In fact, many river species of Naiades have been locally exterminated as a result of this change alone.

Below Ann Arbor, sewage has been very detrimental to the fauna. It is true that sewage may, if not too concentrated, increase the productivity of sections of a stream by increasing the dissolved organic compounds, but below Ann Arbor and as far as the backwaters of Geddes dam, pollution is so concentrated that it has killed all the Naiades. Furthermore, there is such a heavy deposit of sludge in this zone that it will be many years before bottom conditions will permit the re-establishment of a fauna even though the discharge of sewage into the river be discontinued. There is a garbage reduction plant below the dam at French Landing which has polluted the river for a number of years almost as far downstream as the backwaters of the dam at Flat Rock. In recent years, the discharge of wastes has been discontinued there, and gradually a fauna is re-establishing itself, though it has gone up only as far as about three miles below New Boston, leaving about seven miles of the river barren.

The only other area affected by a dam is the region below Milford. At times the water is very low in the river between the dam at Milford and the backwater of Kent Lake.

Only a relatively small amount of damage is done by man in gathering mussels for the pearl-button industry. This, together with the gathering of mussels for pearls in the region of Dexter, has been discussed in the section of this paper dealing with the economic status of the fauna.

Whereas man is the greatest enemy of the Naiades in the river below Ann Arbor, the muskrat and mink are most destructive to them in the river and lakes above Ann Arbor. Seton (1929: 574) points out that "wherever, on this continent, there is slow water with rushes and weeds, we find their child, the muskrat. And far from these, he is never found, except when seeking a new home." In this drainage there are many places where low marshy zones alternate with firm shoals and riffles which harbor many Naiades. This naturally greatly increases the devastating effects of these mammals. Great quantities of Naiades are consumed during the winter when mussels are the muskrats' main diet. It is of interest that they usually feed on the smaller forms. I have examined the "kitchen middens" near a large number of muskrat houses. The muskrats seldom if ever take the large thick-shelled species. The method usually employed by the muskrats for opening the mussels is to carry them out of the water, and to leave them exposed to the air until the mussel gapes. It is then an easy matter to remove the meat.

Many mussels harbor parasites of various kinds, but I have not observed any instance of such parasites having a lethal effect on their hosts.

WINTER HABITS OF CERTAIN LAKE-DWELLING NAIADES

A review of the literature dealing with the Naiades reveals that few definite observations have been published relative to their habits during the winter season. In the northern states, at least, this season is an unsuitable one for field work, because of ice and prevailing high-water level, and also because the Naiades are difficult to locate. Only a few papers could be found which give any information relating to their winter habits.

Von Hessling (1859: 102) was the first to give any definite information on the seasonal movements of Naiades. Hugh Smith (1898: 296), Simpson (1898: 284–85), and Isely (1925: 90) have contributed observational data on the winter habits of river mussels. I have found that the mussels of the Huron River behave essentially as Simpson and Isely have indicated. However, careful observations as to the influence of varying temperatures on the activities of mussels during the colder months are lacking.

Only two papers deal with the winter habits of lake-dwelling Naiades. Evermann and Clark (1918: 256) in their studies of the Unionidae of Lake Maxinkuckee state:

> . . . the mussels in shallow water near the shore move into greater depths at the approach of cold weather in late autumn or early winter and bury themselves more deeply in the sand. This movement is rather irregular and was not observed every year. It was strikingly manifest in the late autumn of 1913, when at one of the piers off Long Point a large number of furrows was observed heading into deeper water, with a mussel at the outer end of each. The return of the mussels to the shore during the spring and summer was not observed. . . .

Coker, Shira, Clark, and Howard (1921: 86) take cognizance of the above statement, but add:

> They do not generally migrate or bury themselves, however, but simply become benumbed so that they respond very slowly if at all to such stimuli as the touch of the clammer's hook.

In the fall of 1932 an experiment was undertaken to provide more information as to how and where lake-dwelling Naiades spend the winter. Previous attempts to find mussels on the shoals of lakes in early spring had been unsuccessful. Hence, it was necessary to devise a method whereby one could follow them from the fall through the winter to the time when they again appeared on the shoals in the spring.

The apparatus used in the experiment was very simple, consisting merely of a stake with the number of the specimen clearly marked on it, and with two staples near the top. A piece of copper wire with a metal tag bearing the number of the specimen was attached to one staple, while about five yards of a strong waxed thread was attached to the other. A hole was carefully drilled through the shell of the specimen just behind the hinge ligament. A small copper wire ring was inserted and to this the thread was attached. The thread was then loosely woven back and forth across the bottom so as to give the mussel freedom to move.

The locality selected for the work was Zukey Lake, which is tributary to Strawberry Lake, in Livingston County. This lake was of particular interest in that it had a fine sand shoal which harbored not only the two species common to lakes of this region, *Anodonta grandis* and *Lampsilis siliquoidea,* but in addition sustained three "river" species. This lake is clearly of the river-lake type, and afforded excellent facilities for the study. The specimens used in this work were as follows:

SPECIES	NUMBER USED
Lampsilis siliquoidea	7
Anodonta grandis footiana	5
Lampsilis ventricosa	4
Strophitus rugosus	2
Elliptio dilatatus	1
Total	19

Most of the specimens were returned to exactly the same places in which they were found after they were staked. On this shoal there were many other unstaked Naiades *serving as controls.*

Repeated observations were made of these specimens during the fall, winter, and spring. At each one of these times a bottom temperature reading and an air temperature reading were taken, and notes were made as to the condition and relative position of each specimen. A detailed account of the behavior of each specimen need not be given, but a summary of the conclusions which have tentatively been drawn from this set of observations, is as follows: Mussels on a lake shoal do *not* migrate out into the deeper water in the fall, remain there during the winter, and then return to the shoal in the spring. Observations on the staked specimens, as well as on the controls, fail to support any such theory. It was found that the mussels became active in the spring when the water reached a temperature of 10° C. (50° F.). At that time, if we assume the migration theory to be true, one should see tracks indicating that the individuals which so suddenly appear on the shoal had migrated shoreward. There was no evidence of this. In fact, several were observed to have moved toward deeper water soon after they had resumed activity. Actually, toward the end of November the mussels were observed to have burrowed down into the bottom (substratum) to about the level of the siphons. After this burrowing it was observed that at certain favorable times individuals may open their siphons and become slightly active, but rarely will they move from the position they have assumed preparatory to their winter dormant period. Once the ice has formed they remain quite inactive. With the ice-push and water movements in the early spring, small quantities of silt cover them completely, so that when one attempts to find them before they again resume activity, there is no clue as to where to look for them. When the water reaches a temperature which is favorable to the resumption of their activity (in this experiment it was about 10° C.), the shoal which on one day may not show a sign of a single mussel will have many hundreds of them the next day.

The autumn season often finds the water level of a lake lower than usual. It is known that Naiades have the ability to adjust themselves to the water levels which are most favorable to them. I believe that in instances where the mussels on a shoal move towards deeper water, it is rather an adjustment to the lowering of the water level than a seasonal migration preparatory to a dormant or quiescent condition.

SUMMARY

On the basis of their fauna, the Raisin, Huron, and Clinton rivers have apparently had a connection with the Maumee River during glacial times; on the same basis the River Rouge appears to have originated in postglacial times and does not appear to have had such a direct connection with the Maumee River.

The naiad fauna of the Huron River consists of twenty-five species, not counting three doubtful ones.

Two species, *Lasmigona complanata* and *Carunculina parva,* are reported in this river system for the first time.

Some species have a very definite distribution, as *Cyclonaias tuberculata, Lasmigona complanata,* and *Actinonaias carinata*; others a less definite one, as *Lampsilis siliquoidea* and *Anodonta grandis.* Generally, the distribution is correlated with definite ecological preferences.

Though certain species, as *Alasmidonta calceolus,* show an increase in obesity in a downstream direction, in accordance with Ortmann's law, such differences as occur are usually minute, and do not warrant subspecific separation.

The physical and chemical conditions in the drainage basin above Ann Arbor are favorable for the propagation of Naiades.

The various types of lakes and various types of river habitats harbor definite naiad faunal associations. In all, fourteen type habitats are listed, each with a distinct fauna.

Not only the size of the lake but also the amount of fluvial influence decidedly affects the number of species which occur in lakes.

In certain areas below Ann Arbor, power dams and pollution have proved detrimental to the Unione fauna.

Man and the muskrat are the most destructive forces for the Naiades of this drainage.

With the approach of winter, lake-dwelling Naiades do not, as has been supposed, migrate into deeper water to remain there during that season. On the contrary, they remain on their shoals throughout the winter, imbedded and inactive.

The mussels of the Huron River do not have any great economic importance, and no large mussel fishery can be anticipated.

BIBLIOGRAPHY

The earliest mention of the Huron River Naiades in scientific literature that I have seen is in a "List of Land and Fresh-Water Shells Found Within a Circuit of Four Miles about Ann Arbor." This paper, by Bryant Walker and C. E. Beecher, was published in 1876. Nine Naiades are mentioned therein, and an estimate is given of their relative abundance. A paper by Ortmann, "Distributional Features of Naiades in Tributaries of Lake Erie," deals in general with some of the lake tributaries in Michigan, but not directly with the Huron River. An article by F. C. Baker in *Ecology,* in 1926, is concerned with mollusks of White Lake, Oakland County. Beyond these three publications, there is no work of a scientific nature that deals with the distribution and ecology of the molluscan fauna of this drainage basin.

ALLEN, WILLIAM RAY

1923 Studies of the Biology of Freshwater Mussels. II. The Nature and Degree of Response to Certain Physical and Chemical Stimuli. Ohio Journ. Sci., 23, 2: 57–82.

ALTNÖDER, K.

1926 Beobachtungen über die Biologie von *Margaritana margaritifera* und über die ökologie ihres Wohnorts. Archiv. f. Hydrobiol., 17: 423–91, Figs. 1–10.

AMERICAN PUBLIC HEALTH ASSOCIATION, AMERICAN WATER WORKS ASSOCIATION, AMERICAN CHEMICAL SOCIETY, COMMITTEES OF

1925 Standard Methods for the Examination of Water and Sewage. (6th ed.) New York: Amer. Pub. Health Assoc., xi, 119 pp., fig.

BAKER, FRANK COLLINS

1898 The Mollusca of the Chicago Area. The Pelecypoda. Bull. Chi. Acad. Sci., 3, Pt. 1: 46–110.

1922 The Molluscan Fauna of the Big Vermilion River, Illinois. Ill. Biol. Monogr., 7, 2: 1–126, Pls. 1–15.

1926 Fresh-water Mollusca from White Lake, Oakland County, Michigan. Naut., 40: 49–52.

1927*a* The Naiad Fauna of the Rock River System: A Study of the Law of Stream Distribution. Trans. Ill. St. Acad. Sci., 19: 103–12.

1927*b* Molluscan Associations of White Lake, Michigan: A Study of a Small Inland Lake from an Ecological and Systematic Viewpoint. Ecol., 8, 3: 353–70, Pl. 4, Figs. 1–3.

1928 The Fresh-water Mollusca of Wisconsin. Pt. II. Pelecypoda. Bull. Univ. Wis., No. 1527: 1–485, Pls. 29–105, Figs. 203–99.

BAKER, F. C., AND A. R. CAHN

1931 Freshwater Mollusca from Central Ontario. Ann. Rept. Nat. Mus. Can., 1929: 41–64, Pl. 2.

BALL, GORDON H.

1922 Variation in Fresh-water Mussels. Journ. Ecol., 3, 2: 93–121, Figs. 1–6.

BEAUCHAMP, W. M.

1883 Distribution of *Unio pressus* Lea. Amer. Nat., 17: 433–34.

BLATCHLEY, W. S.

1901 A List of the Mollusca Known to Occur in Lake Maxinkuckee. 25th Ann. Rept. Ind. Dept. Geol. and Nat. Resources, 1900: 248–51.

BLATCHLEY, W. S., AND L. E. DANIELS

1903 On Some Mollusca Known to Occur in Indiana. 27th Ann. Rept. Ind. Dept. Geol. and Nat. Resources, 1901: 577–680, Pls. 1–3, Figs. 1–42.

BUTLER, AMOS W.

1885 Observations on the Muskrat. Amer. Nat., 19: 1044–55.

CALL, RICHARD ELLSWORTH

1900 A Descriptive Illustrated Catalogue of the Mollusca of Indiana. 24th Ann. Rept. Ind. Dept. Geol. and Nat. Resources, 1899: 335–1017, Pls. 1–78, Figs. 1–11.

COKER, ROBERT E.

1914 Water-Power Development in Relation to Fishes and Mussels of the Mississippi. Rept. U. S. Comm. Fish., 1913, App. 8: 1–28, Pls. 1–6.

1915 The Common and Scientific Names of Fresh-Water Mussels. U. S. Bur. Fish. Econ. Circ., 15: 1–4.

COKER, ROBERT E., AND JOHN B. SOUTHALL

1915 Mussel Resources in Tributaries of the Upper Missouri River. Rept. U. S. Comm. Fish., 1914, App. 4: 1–17, Pl. 1, map.

COKER, R. E., A. F. SHIRA, H. W. CLARK, AND A. D. HOWARD

1921 Natural History and Propagation of Fresh-Water Mussels. U. S. Bur. Fish. Bull., 37 (1919–20): 77–181, Pls. 5–21, Figs. 1–14.

CONRAD, T. A.

1836 Monography of the Family Unionidae . . . of North America. Philadelphia: J. Dobson, 118 pp., Pls. 1–65.

CURRIER, A. C.

1868 List of the Shell-Bearing Mollusca of Michigan, Especially of Kent and Adjoining Counties. Kent Sci. Inst. Misc. Publ., 1: 1–12.

EVERMANN, BARTON WARREN, AND HOWARD WALTON CLARK

1917 The Unionidae of Lake Maxinkuckee. Proc. Ind. Acad. Sci., 1917: 251–85.

FORBES, STEPHEN A., AND R. E. RICHARDSON

1913 Studies on the Biology of the Upper Illinois River. Bull. Ill. St. Lab. Nat. Hist., 9, Art. 10: 481–574, Pls. 65–85.

GOODRICH, CALVIN

1914 Union of the Wabash and Maumee Drainage Systems. Naut., 27: 131–32.

1932 The Mollusca of Michigan. Univ. Mus. Univ. Mich., Mich. Handbook Ser., 5: 83–113, 22 figs.

GOODRICH, CALVIN, AND HENRY VAN DER SCHALIE

1932 II. The Naiad Species of the Great Lakes. Occ. Papers Mus. Zool. Univ. Mich., 238: 8–14.

GRIER, NORMAN MCDOWELL

1919 Morphological Features of Certain Mussel-Shells Found in Lake Erie, Compared with Those of the Corresponding Species Found in the Drainage of the Upper Ohio. Ann. Carn. Mus., 13, 1–2: 145–82, Pls. 2–3.

1920 Variation in Nacreous Color of Certain Species of Naiades Inhabiting the Upper Ohio Drainage and Their Corresponding Ones in Lake Erie. Amer. Mid. Nat., 6: 211–43, Pls. 1–3.

GRIER, N. M., AND J. F. MUELLER

1926 Further Studies in Correlation of Shape and Station in Fresh Water Mussels. Bull. Wagner Free Inst. Sci. Phila., 1: 11–28, 2 figs., map.

HEADLEE, THOMAS J.

1906 Ecological Notes on the Mussels of Winona, Pike, and Center Lakes of Kosciusko County, Indiana. Biol. Bull., 11, 6: 305–18, Pl. 12, Figs. 1–2.

HEADLEE, T. J., AND JAMES SIMONTON

1904 Ecological Notes on the Mussels of Winona Lake. Proc. Ind. Acad. Sci., 1903: 173–79, Pls. 1–2, map.

HOWARD, ARTHUR DAY

1914 A Second Case of Metamorphosis Without Parasitism in the Unionidae. Sci., 51, 1330: 353–55.

1922 Experiments in the Culture of Fresh-water Mussels. U. S. Bur. Fish. Bull., 38: 63–89, Figs. 58–75.

ISELY, F. B.

1925 The Fresh-water Mussel Fauna of Eastern Oklahoma. Okla. Acad. Sci. Proc., 322: 43–118, Figs. 1–3, 2 tables.

LEFEVRE, GEORGE, AND WINTERTON C. CURTIS
1910 Reproduction and Parasitism in the Unionidae. Journ. Exper. Zool., 9: 79–115, Pls. 1–5, Fig. 1.
1911 Metamorphosis without Parasitism in the Unionidae. Sci., 33, 857: 863–65.
1912 Studies on the Reproduction and Artificial Propagation of Fresh-water Mussels. U. S. Bur. Fish. Bull., 30: 105–201, Pls. 6–17, Figs. 1–4.

LINDAHL, JOSHUA
1906 Orthography of the Names of the Naiades. Journ. Cincinnati Soc. Nat. Hist., 20, 2: 235–43.

MARSHALL, WILLIAM B.
1890 Beaks of the Unionidae Inhabiting the Vicinity of Albany, N. Y. Bull. N. Y. St. Mus., 2, 9: 169–89.

MEEK, S. E., AND H. WALTON CLARK
1912 The Mussels of the Big Buffalo Fork of White River, Arkansas. U. S. Comm. Fish. Rept., 1911: 1–20.

ORTMANN, ARNOLD E.
1909 The Destruction of the Fresh-water Fauna in Western Pennsylvania. Proc. Amer. Phil. Soc., 48, 191: 90–110, Pl. 6.
1911 A Monograph of the Najades of Pennsylvania. Mem. Carn. Mus., 4, 6: 279–347, Pls. 86–89, Figs. 1–8.
1912*a* Notes upon the Families and Genera of the Najades. Ann. Carn. Mus., 8, 2: 222–365, Pls. 18–20, Figs. 1–28.
1912*b* The Geological Origin of the Freshwater Fauna of Pennsylvania. Top. Geol. Surv. Pa., 1910–12: 130–49, Fig. 1.
1918 The Nayades (Freshwater Mussels) of the Upper Tennessee Drainage, with Notes on Synonymy and Distribution. Proc. Amer. Phil. Soc., 57: 521–626, map.
1919 A Monograph of the Naiades of Pennsylvania. Part III. Mem. Carn. Mus., 8, 1: 1–384, Pls. 1–21, Figs. 1–34.
1920 Correlation of Shape and Station in Fresh-water Mussels (Naiades). Proc. Amer. Phil. Soc., 19, 4: 269–312, map.
1924*a* Distributional Features of Naiades in Tributaries of Lake Erie. Amer. Mid. Nat., 9, 3: 101–17, Figs. 1–2.
1924*b* The Naiad-fauna of Duck River in Tennessee. *Ibid.*, 9, 1: 3–47.
1925 The Naiad-fauna of the Tennessee River System below Waldon Gorge. *Ibid.*, 9, 8: 321–71, map.
1926 V. The Naiades of the Green River Drainage in Kentucky. Ann. Carn. Mus., 17, 1: 167–88, Pl. 8.

ORTMANN, A. E., AND BRYANT WALKER
1922 On the Nomenclature of Certain North American Naiades. Occ. Papers Mus. Zool. Univ. Mich., 112: 1–75.

RAFINESQUE, C. S.
1820 Monograph des coquilles bivalves et fluviatiles de la rivière Ohio. Ann. Gen. Sci. Phys. Bruxelles, 5: 287–322.

RUSSELL, I. C., AND FRANK LEVERETT
1915 Geological Atlas of the United States. Ann Arbor Folio Michigan. U. S. Geol. Surv., Ann Arbor Fol., Reprint No. 155: 12–15, Figs. 1–8.

SAY, THOMAS
1858 The Complete Writings of Thomas Say on the Conchology of the United States.

Ed. W. G. Binney. Descriptions of Terrestrial Shells of North America. New York: H. Bailliere, 252 + 44 pp., Pls. 1–72 + 3.

SCAMMON, RICHARD E.

1906 The Unionidae of Kansas, Part I. Kans. Univ. Sci. Bull., 3, 9: 279–373.

SETON, ERNEST THOMPSON

1929 Lives of Game Animals. Garden City, N. Y.: Doubleday, Doran and Co. 4, Pt. 2: 567–601, Pls. 70–73, fig.

SIMPSON, CHARLES TORREY

1896*a* On the Mississippi Valley Unionidae Found in the St. Lawrence and Atlantic Drainage Areas. Amer. Nat., 30: 379–84.

1896*b* The Classification and Geographical Distribution of the Pearly Fresh-water Mussels. Proc. U. S. Nat. Mus., 18: 295–343.

1899 The Pearly Fresh-water Mussels of the United States; Their Habits, Enemies, and Diseases; with Suggestions for Their Protection. U. S. Fish. Comm. Bull., 1898: 279–88, Figs. 1–8.

1900 Synopsis of the Naiades, or Pearly Fresh-water Mussels. Proc. U. S. Nat. Mus., 22: iii–viii, 501–1044, Pl. 18.

1914 A Descriptive Catalogue of the Naiades, or Pearly Fresh-water Mussels. Detroit: Bryant Walker, 1540 pp.

SURBER, THADDEUS

1912 Identification of the Glochidia of Freshwater Mussels. U. S. Bur. Fish. Doc., 771: 1–10, Pls. 1–3.

1913 Notes on the Natural Hosts of Fresh-water Mussels. U. S. Bur. Fish. Bull., 32: 103–15, Pls. 19–21, fig.

1915 Identification of the Glochidia of Fresh-water Mussels. U. S. Comm. Fish. Rept., 1914, App. 5: 1–9, Pl. 1.

TAYLOR, FRANK B.

1913 The Glacial and Postglacial Lakes of the Great Lakes Region. Smithson. Rept., 1912: 291–327, Figs. 1–10.

TRANSEAU, EDGAR NELSON

1905 The Bogs and Bog Flora of the Huron River Valley. Bot. Gaz., 40: 351–55, Figs. 1–2.

TUCKER, MARY ELIZABETH

1927 Morphology of the Glochidium and Juvenile of the Mussel *Anodonta imbecillis*. Trans. Amer. Micro. Soc., 46, 4: 286–93, Pl. 10.

1928 Studies on the Life Cycles of Two Species of Fresh-water Mussels Belonging to the Genus *Anodonta*. Biol. Bull., 54: 117–27.

UTTERBACK, WILLIAM I.

1916 The Naiades of Missouri. Amer. Mid. Nat., 4, 1–10: 1–200, Pls. 1–29, Frontis., Figs. 1–9.

WALKER, BRYANT

1898 The Distribution of the Unionidae in Michigan. [Privately printed by the author], 23 pp., Pls. 1–3.

1913 The Unione Fauna of the Great Lakes. Naut., 27, 2–5: 18–23, 29–34, 40–47, 56–59.

1918 A Synopsis of the Classification of the Fresh-water Mollusca of North America, North of Mexico, and a Catalogue of the More Recently Described Species, with Notes. Univ. Mich. Mus. Zool. Misc. Publ., 6: 1–213, Figs. 1–233, pl.

WALKER, BRYANT, AND CHAS. E. BEECHER

1876 List of Land and Fresh-water Shells Found within a Circuit of Four Miles about Ann Arbor, Mich. Const. By-laws Ann. Arbor Sci. Assoc. with Proc., App., pp. 43–46.

WHITE, CHARLES A.

1905 The Ancestral Origin of the North American Unionidae, or Fresh-water Mussels. Smithson. Misc. Coll., 48, Pt. 1: 75–88, Pls. 26–31.

WILSON, CHARLES B., AND H. WALTON CLARK

1912*a* The Mussel Fauna of the Kankakee Basin. U. S. Bur. Fish. Doc., 758: 1–52, Pl. 1, map.

1912*b* The Mussel Fauna of the Maumee River. *Ibid.*, 757: 1–72, Pls. 1–2.

1914 The Mussels of the Cumberland River and Its Tributaries. *Ibid.*, 781: 1–63, Pl. 1.

WILSON, CHARLES B., AND ERNEST DANGLADE

1914 The Mussel Fauna of Central and Northern Minnesota. U. S. Comm. Fish Rept., 1913, App. 5: 1–26, map.

WINSLOW, MINA L.

1926 A Revised Check List of Michigan Mollusca. Occ. Papers Mus. Zool. Univ. Mich., 181: 1–28.

PLATE I

FIGS. 1–3. Stations 1, 2, and 3 in the Huron River. Headwater conditions of the main stream between the outlet of Commerce Lake and Milford, Oakland County.

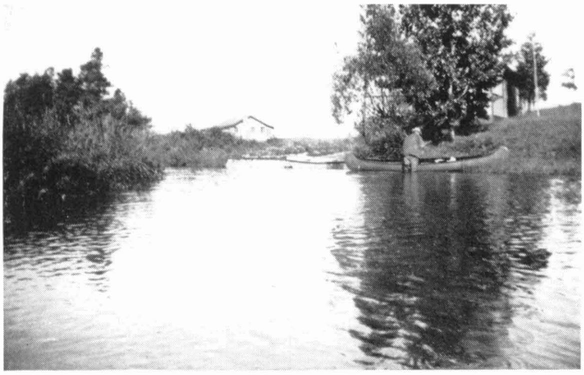


FIG. 1

FIG. 2

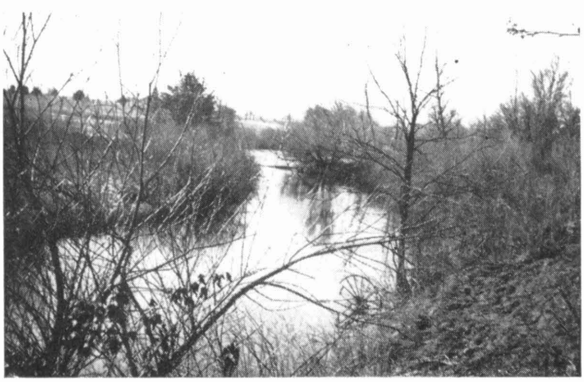


FIG. 3

PLATE II

FIGS. 1–3. Stations 4, 5, and 6 in the Huron River. The transition between small and medium-sized river conditions as found northwest of New Hudson, Oakland County, to south of Woodruff Lake, Livingston County.

Fig. 1

Fig. 2

Fig. 3

PLATE III

FIGS. 1–3. Stations 8, 9, and 10. Medium-sized river conditions as found east of Ore Lake downstream to east of Buck Lake, Livingston County.

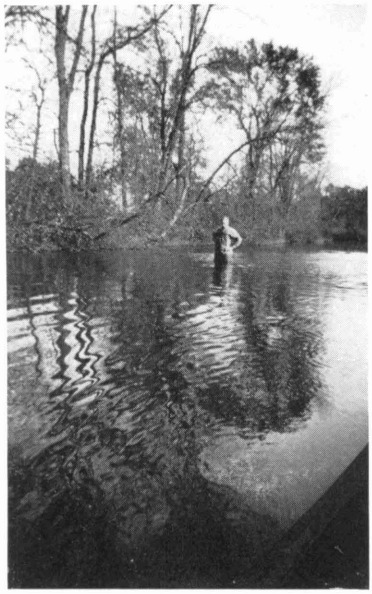


FIG. 1

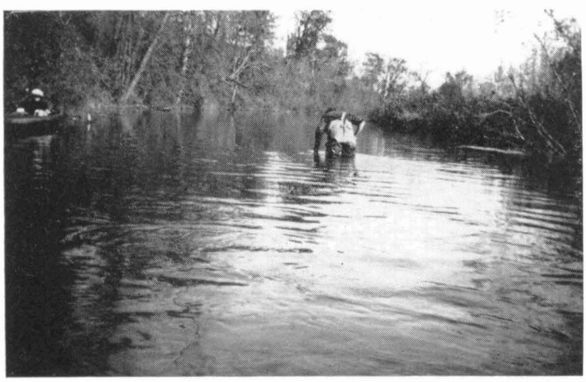


FIG. 2

FIG. 3

PLATE IV

FIGS. 1–3. Conditions shown here represent the transition from medium-sized river conditions (Station 11) to impounded river water above Strawberry Lake (Station 11*a*) to the outlet of Strawberry Lake (Station 12), where a characteristic mass of dead shells covers the bottom of the stream.

FIG. 1

FIG. 2

FIG. 3

PLATE V

FIGS. 1–3. The river-lake region of the Huron drainage is shown here with typical river conditions between the lakes (Station 13) and the shores of two river-lakes: Gallagher Lake (Station 14) and Whitewood Lake (Station 15).

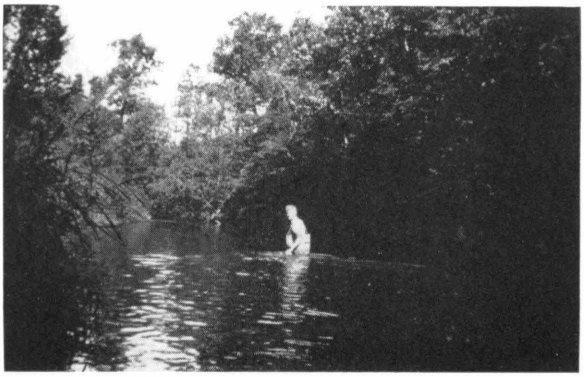


FIG. 1

FIG. 2

FIG. 3

PLATE VI

FIGS. 1–3. Illustrating the transition from river-lake conditions at Base Line Lake (Station 17) to fairly large-river conditions as shown below Base Line Lake (Stations 18 and 20).

FIG. 1

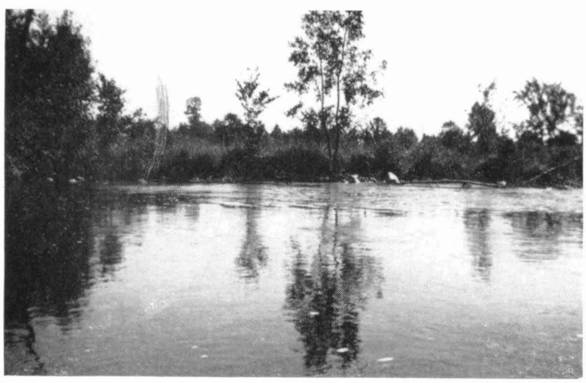


FIG. 2

FIG. 3

PLATE VII

FIGS. 1–3. Typical conditions are shown in fairly large-river environment at Stations 21 and 22 at Dexter, as well as at Station 23, Ann Arbor, Washtenaw County.

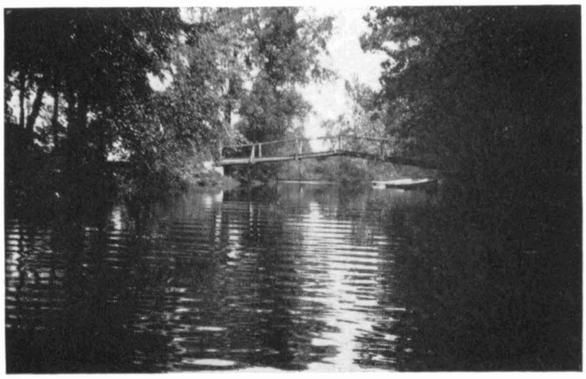


Fig. 1

Fig. 2

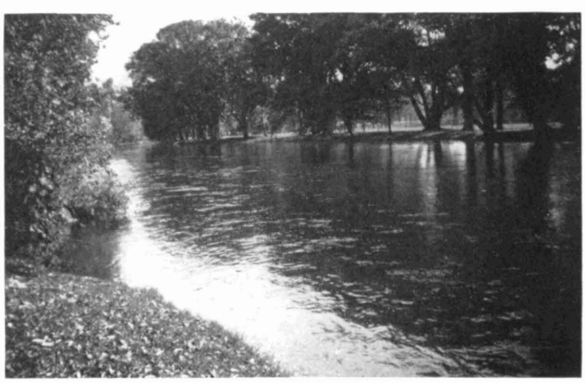


Fig. 3

PLATE VIII

FIGS. 1–3. The polluted zones of the river just below Ann Arbor (Station 24) and the polluted ponded region above the Geddes Dam (Stations 25 and 26).

FIG. 1

FIG. 2

FIG. 3

PLATE IX

FIGS. 1–3. Impounded waters above artificial dams as shown below the new Ford dam (Station 27), which, in withholding water, is exposing mud flats (Station 28) and shoals (Station 28*a*) above the dam at Belleville.

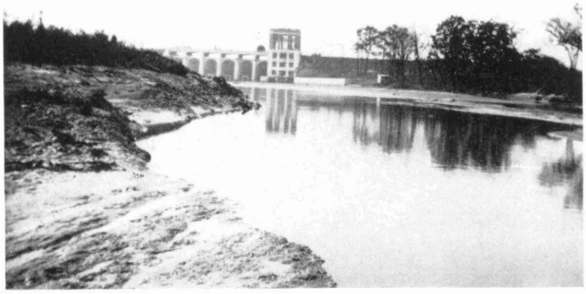


FIG. 1

FIG. 2

FIG. 3

PLATE X

FIGS. 1–2. A similar exposure as seen above the dam at Belleville (Plate IX) is shown above the dam at French Landing, Wayne County (Stations 29 and 29*a*).

FIG. 3. Large-river conditions in the heavily polluted zone below the sewage disposal plant at French Landing (Station 30).

FIG. 1

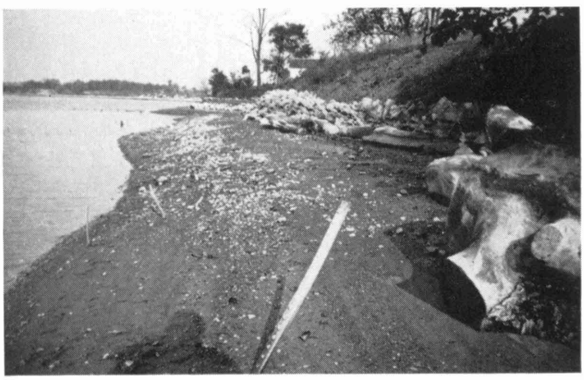


FIG. 2

FIG. 3

PLATE XI

FIG. 1. A polluted region in the river east of Willow at Station 31.

FIG. 2. At Station 32, where mussels are numerous and where there is an invasion of several species common to Lake Erie.

FIG. 3. Typical small-river conditions as seen at Station 33 in the Little Portage River, Livingston County.

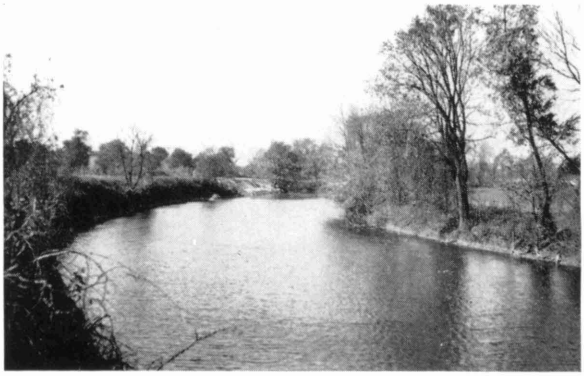


FIG. 1

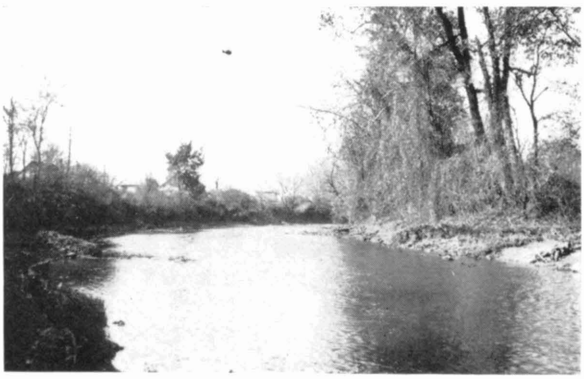


FIG. 2

FIG. 3

PLATE XII

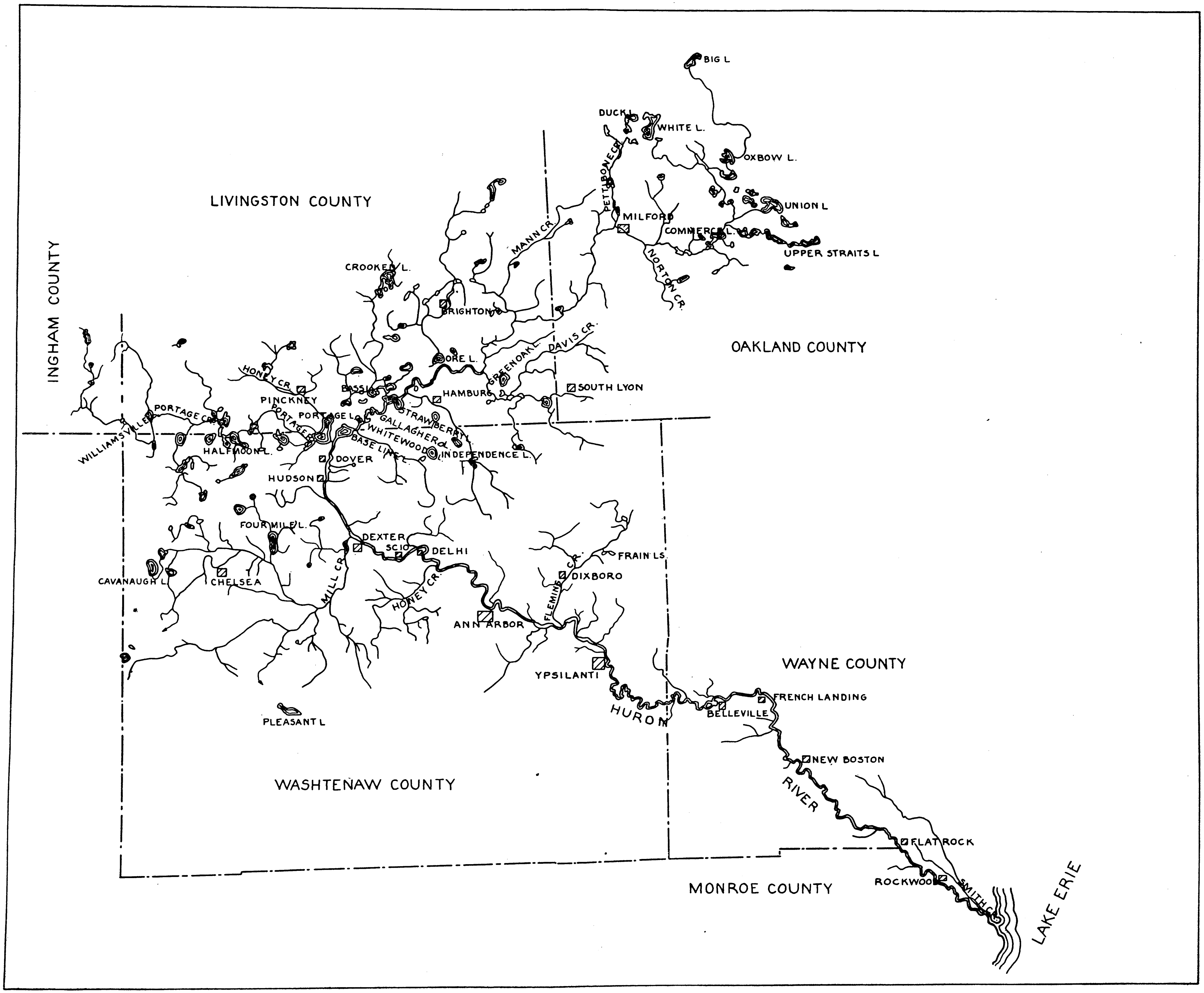
Figs. 1–2. Creek conditions as seen in the outlet of Loch Alpine (Station 34) and Fleming Creek (Station 35).

Fig. 3. A shoal of Whitmore Lake, Washtenaw County, representing a typical land-locked lake in the Huron River drainage.

Fig. 1

Fig. 2

Fig. 3



MAP 18. Huron River basin.

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