STERKIANA 65-66, MARCH 1977

THE FRESHWATER NAIADS OF OHIO, PART I: ST. JOSEPH RIVER OF THE MAUMEE

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ACKNOWLEDGEMENTS

Acknowledgements are due Dr. Henry van der Schalie for his assistance in collecting some of the stations, his verification or identification of some of the specimens, and his encouragement to do the collecting and prepare this report; to Dr. Harold Harry for his help as a co-collector with Dr. van der Schalie, to Mr. Mercer Patriarche for providing data on fishes in the Michigan waters of the St. Joseph Basin, to Messrs. Clarence Miller and John Dobos for their assistance in the preparation of the tables and figures, and to Linda Southerland for her assistance in typing the manuscript.

INTRODUCTION

The lack of information on the fauna and flora of most of Ohio streams makes it difficult to evaluate the changes which have occurred in the past, and to postulate the effects of those in the future. Details pertaining to specific areas in Ohio are generally lacking in the literature but they seem to abound in the files of many Ohio scientists. The federal, state, and local governments, as well as environmental societies are alarmed at the changes which are taking and will take place with our present methods of advancing or improving our standard of living. Consequently, this paper attempts to make available data collected from the St. Joseph of the Maumee by the author and Henry van der Schalie, and to assemble scattered published and unpublished information on that river.

Although it lies in one of the crossroads by which two major molluscan faunas of the United States merge, the naiades (mussels) of this stream received only casual consideration.

This information was not the result of a planned study, but contains compilations of unscheduled collections as well as some made by Henry van der Schalie and Harold Harry serving to supplement those of the author.

GEOLOGY

As was clearly stated (Anon. 1964) 'The present land surface of the St. Joseph River basin is the product of intermittent continental glaciation which began about one million years ago, and ended only a few thousand years ago. Four invasions of ice separated by long interglacial periods occurred. The last glacier, the Wisconsin, is mainly responsible for the existing land forms. Evidence of pre-Wisconsin glaciation is found south of Hillsdale where logs reveal a layer of muck, a former land surface, about one hundred feet below the present surface.'

'The glacial land forms in the St. Joseph (Maumee) Basin, such as moraines formed when the ice front was pushing outward and dumping great masses of intermixed clays, sands, gravels and boulders; till plains, fairly level deposits of morainic materials laid down by the washing of stagnant ice; and outwash deposits of sand and gravel washed from the melting ice front--have all been altered by subsequent erosion and soil formation.'

The drainage area of the St. Joseph River is gently rolling to moderately hilly, due to the uneven deposition of a thick layer of glacial till. It has the rolling surface, smooth rounded slopes, sandy or gravelly plains, and nearly level clay plains characteristic of glacial origin. Marshes and bogs abound on the unmodified drift, especially in the upper portions of the drainage area. Extensive peat deposits and muck deposits occur throughout the basin, especially around the lakes, and numerous tamarack bogs are present. Hundreds of lakes, ranging up to acres in size are scattered throughout the upper reaches of the basin. Most of the headwater streams arise in the lakes or bogs and carry clear water. Their courses are varied in direction for, in general, they are governed by accidents of glacial deposition. Headwater streams of the St. Joseph Rivers (of the Maumee and Lake Michigan), such as Crooked Creek, Pigeon, Turkey, and Fish creeks occupy old glacial channels (Smith, Tharp, Bashnell, and Ulrich, 1940).

The divide between the Mississippi and the St. Lawrence drainages passes just west of Fort Wayne, Indiana and around the rather vague headwaters of the Eel River in eastern Noble County, Indiana. 'This divide is nowhere high and is not sharply defined. In places it is so indefinite that water near it at times goes either way, as in the old glacial water routes near Ft. Wayne and South Bend. During the flood of March, 1913, water from the St. Marys River passed over the broad flat divide immediately west of Ft. Wayne in a stream several feet deep and nearly one-half mile wide.'(Malott, 1922).

The indefinite nature of this drainage divide is illustrated in comments by Dyer (1892), 'The most important of these water gaps is the Pigeon-Fish Valley, which cuts through the entire moranic system from the St. Joseph of the Maumee to the St. Joseph of Lake Michigan. Its course across the moraines is thirty miles long, its average width about one mile, and its depression below the surface on either side within the limits of 150 feet.' (1892).

The lakes of the Pigeon River Chain are strung in a course 25 miles long, with Cedar Lake or bog at the head, from which the stream flows southward into Long Lake in the Pigeon-Fish Valley. A low divide exists between the waters of Pigeon Creek and Pleasant Lake, and those of Fish Creek and the St. Joseph of the Maumee (Dyer, 1892).

In a discussion of *Notropis heterodon* (Cope), Gerking (1947) evidently referred to this possible connection in the Pigeon-Fish Valley between the Pigeon River, a tributary of the St. Joseph River of Lake Michigan and Hamilton Lake which drains into Fish Creek and the St. Joseph of the Maumee. Gerking (1945) reported *Ericymba* from the St. Joseph of Lake Michigan as well as from Hamilton Lake. Wallace (1973) stated in reference to the above, 'Thus if *E. buccata* arrived too late to use the Maumee Outlet, it may have reached the Lake Erie drainage by crossing the watershed drainages in Indiana and Ohio. Possibly both of these means were utilized.'

PHYSIOGRAPHY

The St. Joseph of the Maumee arises in the uplands of Hillsdale County, Michigan. It flows in a southwest direction through Williams and Defiance Counties, Ohio and DeKalb and Allen Counties, Indiana to its junction with the St. Marys at Ft. Wayne to form the Maumee River. One major tributary, Fish Creek, extends from Ohio into the Indiana counties of Steuben and DeKalb.

This river is 100 miles long (Flynn & Flynn, 1904) of which approximately 35 miles of the main stream flows through Indiana, 39.5 miles in Ohio and 24.5 miles in Michigan. According to Brown (1944), 150 miles of tributary streams of the Maumee River (its tributary the St. Joseph River) drain the Michigan area of the basin. Sherman (1932) found the entire St. Joseph River Basin to include 1060 square miles. A map of Ohio showing the principal streams and their drainage areas (1964) indicates that 603 square miles of this area lies in Indiana, 238 in Ohio and 219 in Michigan.

The St. Joseph River arises as a small stream at an elevation of about 1050 feet above sea level, and falls 313 feet (an average of 3.1 feet per mile) throughout its course (Flynn & Flynn, 1904). Leverett (1897) estimated a fall of nearly two feet per mile. Sherman (1932) reported the same average for the Ohio portion. An average fall in feet per mile of 7.5 was reported for Fish Creek, 11.11 for Bear Creek, 10.7 in Eagle Creek, 7.74 in Nettle Creek, 8 for the West Branch of the St. Joseph River, 11.9 for the East Branch, and 12.3 for Silver Creek.

Leverett (1897) stated that the stream flowed throughout most of its course in a narrow plain between two moranic ridges and its descent was determined by that plain. He also reported that its valley cuts only 25 to 50 feet into the plain, and that its bottoms are narrow. In the Ohio Water Inventory Report (No. 11, 1960), the river is described as meandering widely as it, '.... follows the course of an old preglacial stream called Montpelier Creek' (Stout, Ver Steeg, and Lamb, 1943).

Soil types of the drainage area are reflected in water percolation and stream flow. The upper East Branch of the St. Joseph River drains an area of fairly light soils and has a stream flow constant and cool enough to maintain trout (Anon. 1964). The capacity of the drainage area to store and release water into the stream is illustrated by Kirsch's (1895) report of a flow of 55,000 gallons per minute in the entire six miles southwest of Hudson, Michigan, and a discharge of 2,000 gallons per minute from Fish Lake (Hamilton Lake, Indiana) into Fish Creek. The Michigan report on water conditions and usages (Anon. 1964) shows a wide variation in the stream flow near Hudson, from 3,360 c.f.s. in April, 1956 to no flow in August, 1964. The Ohio report on water pollution in the Lake Erie Basin (1966) listed maximum and minimum flows of 10,000 c.f.s. and 1.6 c.f.s. for the St. Joseph River.

Kirsch (1893) described the headwaters of the East Branch as having a gravel bottom in most places with some areas of mud. He also reported large drifts of wood. Farther downstream, the channel of bluish clay had eroded unevenly, leaving many projections and numerous holes, with long stretches of quiet water with depths up to four feet. Riffles were few, aquatic vegetation scarce, and the water not clear. The banks of the channel were six to eight feet high. Near Edgerton, he describes the main stream as 45 to 50 feet in width with almost perpendicular banks 8 to 10 feet high. Riffles were few and the stream was almost free of vegetation. He described Fish Creek as having the upper end dredged, but with the remainder crooked, swinging from side to side across the bottom land. Two miles from the source, its bed was mostly sand, at some places covered with coarse gravel; but in three woodland areas, it had largely a mud bottom. Many ditches and springs enter the creek increasing its volume rapidly. It was approximately 13 feet wide immediately below Fish Lake, but averaged only seven inches in depth. Everywhere in shallows, the channel was covered with water weeds and algae. Lizards tail was most common along the shore.

Near Edgerton, Fish Creek was 20 to 25 feet wide with clay banks about five feet high (Kirsch, 1893). 'The bottom of the channel is also clay and where not covered with sand or gravel is very slippery.' (Kirsch, 1893). He added that the stream was almost free of vegetation. He described Cedar Creek as having widths of 10 to 12 feet in the upper reaches, with depths of eight to 10 inches and a bottom mostly of mud, but gravelly on the riffles. It was dredged and straightened for two miles below Cedar Lake; but the remainder was very crooked with many deep holes and frequent gravelly shoals.

An anonymous author (1964) stated, 'The land use pattern of the Maumee Basin is today virtually what it was a century ago.' It continues, 'Because of the continuing stability of land use in the basin, traditional water resource demands and uses have not changed appreciably for many decades. Stream flow, as it is influenced by land use, appears to remain virtually unchanged.'

The St. Joseph River Basin is rather narrowly hemmed in between the Ft. Wayne moraine at the east and the Wabash moraine on the west. The morainic belt extends in a northeast-southwest direction from the junction of the St. Joseph and St. Marys Rivers at Ft. Wayne, Indiana into the headwaters in Hillsdale County, Michigan. The drainage basin of the St. Joseph lies almost wholly on its western bank.

WATER QUALITY

Water quality data were not obtained when the naiad collections were made, and can only be postulated from many isolated bits of data in a variety of reports. Gallagher (1941) described a fish kill on August 23, 1941. It was reported extending into Indiana. Fourteen species were identified, and local residents were amazed at the large population present. The kill started immediately below the point of discharge of tomato wastes from a cannery. The correspondence indicates that milk and other cannery wastes were present. It also revealed that a similar kill had occurred three years prior, at about the same time of year, and at the same location. A letter to the editor of the Record Harold, Butler, Indiana on July 23, 1942 reports cannery pollution from Edgerton, and the loss of fish downstream into Indiana. A letter dated November 18, 1941, from Thomas Gallagher to L. W. Lawton, Dayton, Ohio, is based on a fish kill at Edgerton which was correlated with the canneries. A reduction in cannery wastes followed the joint investigation of this fish kill by the Ohio Department of Health and Division of Conservation and Natural Resources, and no other fish kills were reported in a later letter (Gallagher, 1949).

Gerking (1945) reported Cedar Creek, Indiana, was polluted with cannery wastes and city sewage. He stated that near Auburn, sewage from both that city and Garrett entered the stream. He found only eight species of fish at his collection station four miles below Auburn, but 21 species above the city near Waterloo, even though some cannery wastes were seasonally deposited in the stream near that point. He reasoned that the sewage from Garrett and Auburn have been effective in limiting the fish population for a few miles downstream. He added, 'Experience in the field has led to the belief that the absence of darters .... from a stream, particularly the riffles, is a good indication of the presence of pollution.'

Table 6-2 (Anon. 1964) indicates that the section of the St. Joseph River from Montpelier to an area about one-half way through Defiance County contains industrial wastes including phenols, oil, cyanide, C.O.D., zinc, chromium and C.K. Below this area and to Ft. Wayne, the stream was found to contain phenol, oil, cyanide, zinc, copper, nickel, and high levels of carbon dioxide. This report estimated an annual runoff of 30,000 tons of calcium per year, 20,000 tons of sulfate, 9,000 tons of magnesium, 6,500 tons of chlorides, 3,700 of silicates, 4,100 sodium, 800 of potassium, 500 tons of total nitrogen, and 140 of phosphate. Table 6-1 of this report indicates that the combined municipal wastes of Montpelier, Ohio, Butler, Auburn, and Garrett, Indiana have a BOD of approximately 3,500 pounds per day.

The over-all water quality of the St. Joseph River was considered good (Anon. 1966); but a BOD of 764 pounds per day was reported for the Montpelier sewage treatment plant. Dissolved oxygen records of 2 mg/l were recorded several times in summer below Montpelier; and biological conditions of gross pollution were apparent at these times.

The stream receives plating wastes of rinse water of 30 gallons per minute containing cyanides, chromium, cadmium, and copper at Edgerton, Ohio (Anon., 1953). At low flow these wastes produce critical conditions. Cannery wastes below Edgerton must be controlled to maintain desirable water quality; and Edon has no public sewer system (Anon. 1953).

At Auburn, a gas manufacturing plant, located on a tributary ditch which empties into the St. Joseph River, has at times discharged wastes high in phenol content (Anon. 1953). This report also reveals that the city of Ft. Wayne, with its waterworks intake located approximately 23 miles below the point of discharge of these wastes, has frequently reported phenol problems.

Garrett, Waterloo, and Butler, all in Indiana and located on small tributaries, need to provide secondary treatment (85 to 95% reduction of BOD Anon., 1953). The report adds that Auburn, Indiana provides secondary treatment, but does not treat all sewage discharged into the stream. Adequate collection of sewage is needed in Avilla and Grabill, Indiana.

Water quality of the St. Joseph River at State Highway 30 near Blakeslee, Ohio was reported by Hubble and Collier (1960) as follows:

	10/5/55	4/25/56
Silica	7.40 ppm	3.10 ppm
Iron	.03	.03
Calcium	67.00	85.00
Magnesium	25.00	23.00
Sodium	10.00	6.10
Potassium	2.30	1.00
Sulfate	41.00	74.00
Chloride	7.05	12.00
Fluoride	.40	.30
Nitrite	1.60	1.80
Phosphate	.03	
Dissolved solids	350.00	305.00
Hardness, magnesium	270.00	307.00
Hardness, noncarbonate	34.00	90.00
pH	7.90	8.00
Color	12.00	15.00
Dissolved oxygen saturation	82.00%	79.00%
Dissolved oxygen	8.00 ppm	9.40 ppm

Allison (1965) described the West Branch of the St. Joseph River as having high water quality not influenced by pollution, with stable flow levels that support smallmouth and rockbass populations.

The upper reaches of the St. Joseph River in Michigan includes the villages of Camden, Montgomery, and Reading with a total population of 1924 (Anon., 1964). This report indicated that Camden had no sewage collection or treatment at that time, and some untreated and treated sewage entered the stream from the other two communities. The area contains some silt and clay soils which together with bank and sheet erosion contribute substantial amounts of suspended solids to the flowing water.

Instances of pollution in tributaries probably had some adverse effects on the main stream below their mouths. Kills occurred in Brush Creek in 1953, 1954, 1956, 1962, and 1969. Dissolved oxygen was reduced to 1.2 ppm in 1956. In 1959, a kill in Bear Creek below Edon affected an area at least four miles downstream and thousands of fish, comprised of ten species, died when the oxygen dropped to 0.9 ppm on September 2.

FISHES OF THE ST. JOSEPH RIVER

Fish are credited as the means by which the Maumee and Lake Erie Basins were stocked with fresh water naiads. Their movements through the Wabash-Maumee outlet were described by Barney (1926), Greene (1935) and Hubbs and Lagler in 1947. The close association of mussel glochidia is well known; but the hosts or carriers of individual species is not well enough documented to theorize on the population of naiads to be expected in a stream on the basis of the fish population. The habitat or ecological conditions could probably be more closely correlated with naiad populations than fish species which may have been migrants or at best temporary visitants at the time they were captured. This supposition is also supported by the large number of fish in Nettle Lake as compared with the limited number of species of naiads in the lake (Table 1). This table also provides data on the fish population of the mainstream and major tributaries. These records may sometime be valuable in correlating information on the relation of fish and naiad distribution.

It is noted (Table 1) that 47 species of fish have been reported from Nettle Lake, 41 from the mainstream of the St. Joseph River in Ohio, 36 from the Ohio portion of Fish Creek and 36 fish species and one lamprey from the Michigan headwater tributaries, 27 from the Ohio waters of the West Branch, 21 from both Nettle and Silver Creeks, 16 from Bear and nine from Eagle Creeks in Ohio wwters. The bulk of the species recorded were provided by 1949 through 1955 stream surveys. The Ohio Division of Wildlife's records, in recent years, seldom list a dozen species of fish at any collecting site. These do not compare with the early records of the author which contained as many as 27 species taken during one seining survey at Nettle Lake, 27 at one site in the St. Joseph River, 24 in Fish Creek, as in the West Branch of the St. Joseph, 16 in Nettle and 15 in Silver Creeks in the years covered by this study (Table 1).

Table 1 reports 62 species and subspecies of fish taken from the Ohio waters of the St. Joseph River. These 62 species include representatives of the Ohio families of fish which are normally found in Ohio streams.

The well known runs of walleye and northern pike, white bass, and suckers may be nothing more than a movement upstream to the most desirable spawning areas. The large numbers of hatch-of-the-year smallmouth bass and suckers, and the adult minnows and darters found in headwater streams, which normally dry up in August, indicate that fish can and do move into the extreme headwaters as well as carry out the limited movements indicated by most fish movement studies.

A vast reservoir of information is available on the movements of fish; and it is generally comparable with the data presented by Funk (1955). He presented a concept of a sedentary and a mobile group within the population of most species. He found that the population of some species contains more of the sedentary group while other species include more of the adventurous, far roaming individuals, and that this adventurous group was often comprised of certain size or age groups.

Movements of minnows and darters, as well as larger species also occurs; but less information on them is available. Page and Smith (1971) reported annual migration patterns for both *Percina phoxocephala* and *P. sciera*, but could not determine the winter habitat. Page (1974) reported that after hatching, '.... young *Etheostoma squamiceps* dispersed throughout the Big Creek system, mostly moving downstream.' May (1969) reported a small number of *Etheostoma variatum* moved nearly three miles. Peckham and Dineen (1957) reported that Abbott (1970) had observed nearly ripe female mud minnows moving upstream.

Although the sedentary nature of some fish and homing of some others has definitely been proven (Gerking, 1950 and Larimore, 1952), the limited movements of large numbers of fish or the long distance travels of a few fish carrying sometimes hundreds of glochidia could result in a gradual expansion of the distribution of a mussel population, if habitat conditions were favorable.

THE NAIAD FAUNA OF THE ST. JOSEPH RIVER

Call (1896) called attention to the fact that several Ohio drainage mollusks are found in the Maumee River, close to the headwaters of the East Fork of the Aboite River near Ft. Wayne. He also called attention to the relation of the Wwbash and Erie Canal which had existed long enough to permit some interchange of faunas. He indicated that this relationship to distribution in terms of glaciation and its physiographic results already in an earlier paper of 1886.

Table 1. Fishes of the St. Joseph River and tributaries in Ohio

Species	Fish Creek	Bear Creek	Eagle Creek	Nettle Creek	Nettle Lake	W. Br. St. Joe	Silver Creek	St. Joe. River
Amia calva Linnaeus					X			X
Dorosoma cepedianum (Lesueur)		X	X		X			
Umbra limi (Kirtland)				X	X	X	X	X
Esox americanus vermiculatus Lesueur	X				X			
Esox lucius Linnaeus		X	X	X	X	X		X
Compostoma anomalum (Raf)				X	X			X
Cyprinus carpio Linnaeus	X			X	X	X	X	X
Ericymba buccata Cope	X	X				X	X	X
Hybopsis amblops (Raf)	X						X	X
Nocomis biguttatus (Kirtland)							X	X
Nocomis micropogon (Cope)	X	X		X	X			
Notemigonus crysoleucas (Mitchill)					X	X		
Notropis cornutus chrysocephalus (Raf)	X				X	X	X	X
Notropis cornutus frontalis (Agassiz)					X		X	X
Notropis emiliae (Hay)						X		X
Notropis photogenis (Cope)	X				X	X		X
Notropis rubellus (Agassiz)	X				X	X	X	X
Notropis spilopterus (Cope)	X				X	X		X
Notropis stramineus (Cope)	X	X			X	X	X	
Notropis umbratilis (Girard)	X	X		X		X		X
Notropis volucellus (Cope)	X					X		
Phenacobius mirabilis (Girard)		X						
Pimephales notatus (Raf)	X	X	X	X	X	X	X	X
Pimephales promelas Rafinesque	X	X	X	X		X	X	X
Rhinichthys atratulus (Hermann)	X							X
Semotilus atromaculatus (Mitchill)	X	X	X	X	X	X	X	X
Carpiodes cyprinus (Lesueur)		X			X	X	X	X
Catostomus commersoni (Lacepede)	X	X	X	X	X	X	X	X
Erimyzon oblongus (Mitchill)					X	X	X	X
Hypentelium nigricans (Lesueur)				X	X			
Minetrema melanops (Raf)				X	X			X
Moxostoma erythrurum (Raf)	X				X		X	X
Ictalurus melas (Raf)		X		X	X			X
Ictalurus natalis (Lesueur)	X			X	X			X
Ictalurus nebulosus (Lesueur)					X			X
Ictalurus punctatus (Raf)					X			X
Noturus flavus Rafinesque	X				X	X	X	X
Noturus gyrinus (Mitchill)					X	X		X
Noturus miurus Jordan	X				X	X	X	
Fundulus notatus (Raf)	X	X		X	X			
Labidesthes sicculus (Cope)					X			X
Ambloplites rupestris (Raf)	X				X	X		X
Lepomis cyanellus Rafinesque	X				X	X		
Lepomis gibbosus (Linnaeus)					X	X		X
Lepomis gulosus (Cuvier)					X	X		
Lepomis macrochirus Rafinesque				X	X	X		X
Lepomis megalotis Rafinesque	X				X			X
Lepomis humilis (Girard)	X				X			
Micropterus dolomieu Lacepede	X			X	X	X		
Micropterus salmoides (Lacepede)	X			X	X	X		
Pomoxis annularis Rafinesque	X			X	X			X
Pomoxis nigromaculatus (Lesueur)					X	X		X
Ammocrypta pellucida (Putnam)	X					X	X	X
Etheostoma blennioides Rafinesque	X		X	X		X		X
Etheostoma caeruleum Storer	X				X			
Etheostoma exile (Girard)					X	X	X	X
Etheostoma nigrum Rafinesque	X	X	X	X	X	X	X	
Etheostoma flabellare Rafinesque						X		
Etheostoma spectabile (Agassiz)	X	X	X		X			X
Perca flavescens (Mitchill)					X			
Percina caprodes (Raf)					X	X		
Percina maculata (Girard)	X				X	X	X	X
Stizostedion vitreum (Mitchill)					X			X
Cottus bairdi Girard	X					X	X	

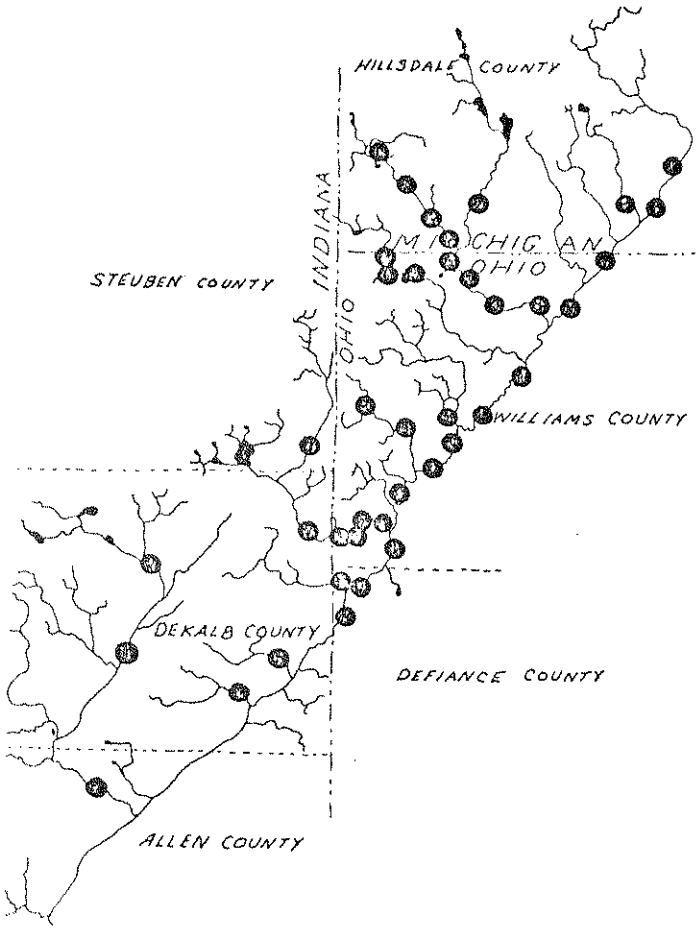


Fig. 1. Distribution of the collection stations of naiads which provide the basis for this report on the St. Joseph River.

According to Walker (1913), the preglacial fauna of the St. Lawrence system was exterminated during the glacial period. Later the naiad fauna of Lake Erie was established by fish carrying mussels into Lake Erie through the Maumee River during post-glacial Lake Maumee period. He gave *Alasmidonta marginata*, *Actinonaias carinata*, and *Lampsilis fasciola* as examples of mussels that entered which now have discontinuous distribution patterns in the Lake Erie Basin. Goodrich (1914) reported that the Little Wabash and St. Marys Rivers approach within three miles of each other southwest of Ft. Wayne, Indiana. The divide between the streams is not noticeable and flood waters connected them in 1913. Ortmann (1924) supported Walker's theories, but showed that invasion of the area could also have occurred during the Trent Outlet Stage when the Maumee River extended through the Lake Erie Basin which was then practically dry area (Ortmann, 1924). Henry van der Schalie (1939), in a discussion of facts presented by Walker (1913) and Ortmann (1924) stated, 'In these accounts there is ample evidence to show that mussels crossed these present divides only when rivers had formerly crossed them'

PRESENTATION OF SPECIES DATA

Amblema costata Rafinesque was reported by Kirsch from Cedar Creek near Waterloo, Indiana (1895) but it was not included in the naiads of the Maumee by Call (1900). It was considered by Clark and Wilson (1912) as second in abundance in the Maumee during their survey. They reported this species as abundant in the St. Joseph at Robinson Park and in the feeder canal at Ft. Wayne, and stated that they obtained large specimens at both places. Goodrich and van der Schalie (1944) noted that the 'three-ridge' was reported from the St. Joseph River northeast of Ft. Wayne. Goodrich collected specimens in the river about eight and one-half miles northeast of Ft. Wayne and in Silver Creek, Williams County, Ohio in 1941. Marsh collected it in the St. Joseph in Hillsdale County, Michigan, near Waldron, in 1941. These specimens are in the University of Michigan, Museum of Zoology. It was taken at 18 of the 40 sites collected during this study. Most specimens came from larger streams.

Fusconaia flava (Rafinesque). Call's 1896a and 1900 all inclusive comments on distribution of this species in Indiana would indicate it was found in the St. Joseph River. His statements are supported by Clark and Wilson (1912) who found it to be. '...

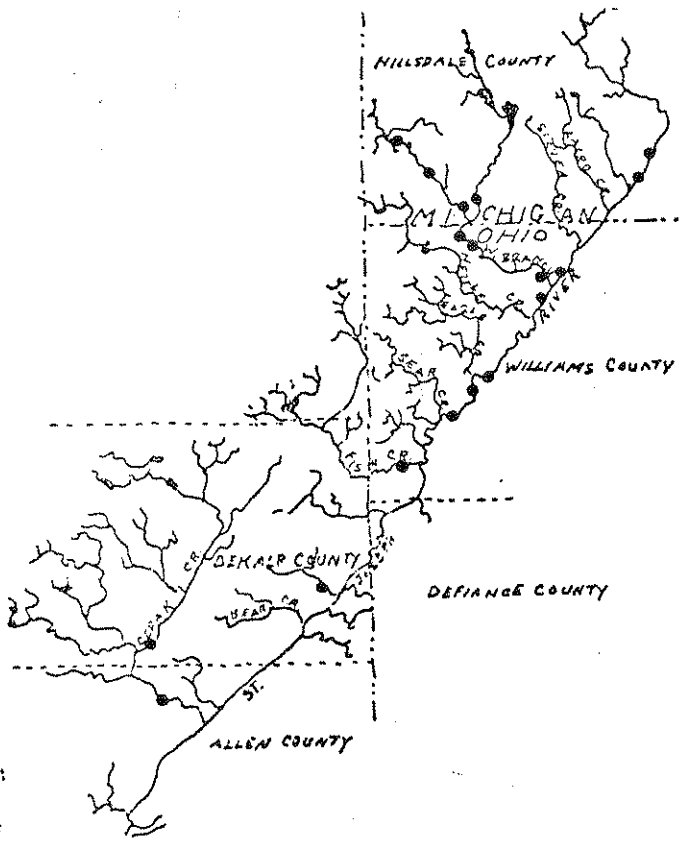


Fig. 2. Distribution of *Amblema costata* Rafinesque in the St. Joseph River Basin.

fairly common all along the Maumee and its tributaries ....' and, '...abundant in the feeder canal and reservoir at Ft. Wayne, Indiana.' Collections in the Museum of Zoology at Michigan indicate that it was found by most collectors in the drainage at most of their stations. Table 2 shows its wide distribution throughout the St. Joseph River basin with greater abundance in the tributaries rather than the main stream.

Quadrula cylindrica (Say) was not mentioned by Call in 1894, 1896, or 1900 as being found in the Maumee drainage of Indiana. Clark and Wilson (1912) found a few in the feeder canal at Ft. Wayne and two half shells in the mouth of the St. Joseph. They considered this the form *Q. c. strigillatus* since those taken from the quiet waters of the canal were beautifully marked with green triangles and fine capillary rays. Goodrich and van der Schalie (1944) indicate that this species crossed from the Ohio drainage over the low divide into the Maumee drainage. Live specimens were taken during this study in the main stream of the St. Joseph, Fish Creek and the West Branch of the St. Joseph. Not more than four were taken at any location. Dead shells were taken at two other sites in the main stream; but none was found in Indiana.

Cyclonaias tuberculata (Rafinesque) was not reported by Call (1900), but was recorded by Clark and Wilson (1912) as, '... not a common species of mussel ...' in the Maumee and its tributaries. They found it most abundant in the upper portion of the stream near Ft. Wayne. Specimens in the University of Michigan's collection were taken by Goodrich at two locations in the St. Joseph River in Allen County, Indiana in 1941. The collections here reported include specimens from the mainstream in Ohio almost to Montpelier, and from Fish Creek and the West Branch of the St. Joseph River. Its distribution in Fish Creek is spotty which probably indicates the lack of a uniform habitat. When found, they appear in fair numbers.

Elliptio dilatatus Rafinesque was reported from the Maumee Basin by Call (1896). Clark and Wilson (1912) found two in the St. Joseph near its mouth. Michigan Museum collections have specimens from the St. Joseph giving its distribution upstream throughout Allen and DeKalb Counties, Indiana; and Table 2 portrays its range in tributaries centered chiefly in Fish Creek and the St. Joseph near the mouth of Fish Creek, and in the West Branch of the St. Joseph River.

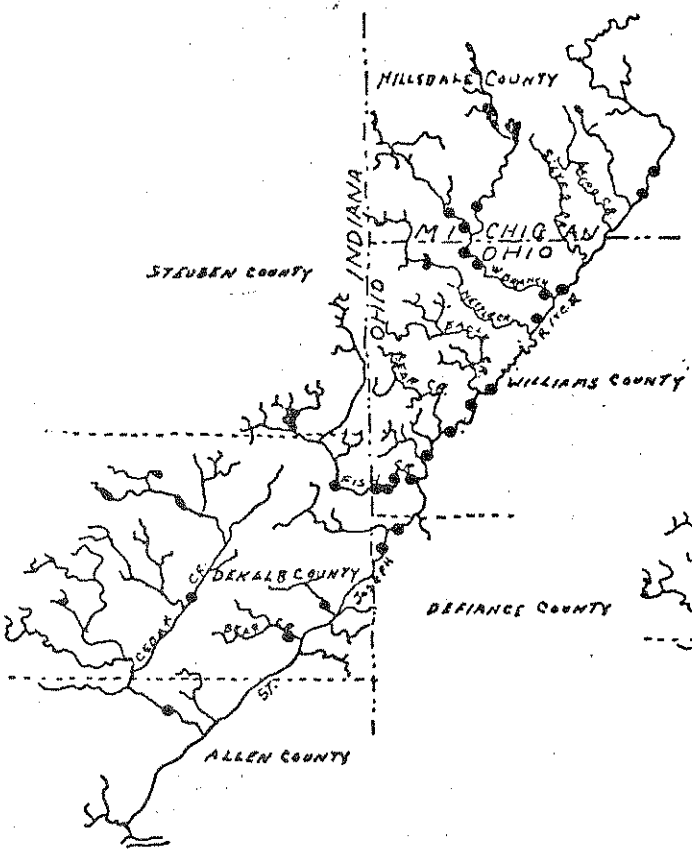


Fig. 3. Distribution of *Fusconaia flava* (Rafinesque) in the St. Joseph River Basin.

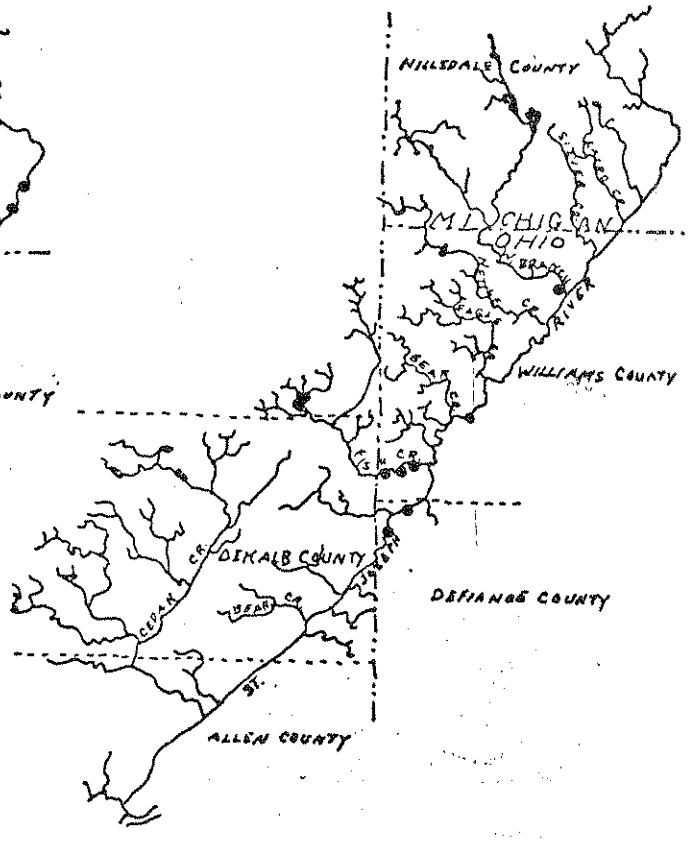


Fig. 4. Distribution of *Quadrula cylindrica* (Say) in the St. Joseph River Basin.

Table 2. The distribution of the freshwater naiads of the St. Joseph River (of the Maumee) drainage.

	Amblema costata Raf.	Fusconaia flava (Raf.)	Quadrula cylindrica (Say)	Cyclonaias tuberculata (Raf.)	Elliptio dilatata (Raf.)	Pleurobema clava (Lamarck)	Pleurobema cordatum coccineum (Conrad)	Alasmidonta calceolus (Lea)	Alasmidonta marginata Say	Anodonta grandis Say	Anodonta imbecillis Say	Anodontoides ferussacianus (Lea)	Lasmigona compressa (Lea)	Lasmigona costata (Raf.)	Strophitus rugosus (Swainson)	Actinonaias carinata (Barnes)	Caruncula glans (Lea)	Dysnomia sulcata (Lea)	Lampsilis fasciola (Raf.)	Lampsilis siliquoidea (Barnes)	Lampsilis ventricosa (Barnes)	Ligumia recta latissima (Raf.)	Obovaria subrotunda (Raf.)	Villosa fabilis (Lea)	Villosa iris (Lea)	Ptychobranchus fasciolare (Raf.)
Cedar Cr. Allen Co., Ind. S.R. 427	X	X			X				X						X	X				X	X					
Cedar Cr. Allen Co., Ind. S.R. 6 east of Auburn	X	X						X		X		X	X							X					X	
Cedar Cr. De Kalb Co., Ind. north of Waterloo		X						X				X			X	X			X	X	X					
Bear Cr. De Kalb Co., Ind. north of St. Joe		X										X														
Tributary in De Kalb Co., Ind. north of Newville	X	X		X		X										X			X				X			
St. Joe. R. Defiance Co., Ohio Milford Twp., Sec. 7		X	X													X			X			X				
Big Run Defiance Co., Ohio Milford Twp., Sec. 5																						X				
St. Joe. R. Defiance Co., Ohio Milford Twp., Sec. 5		X	X													X					X					
St. Joe R. Williams Co., Ohio St. Joe. Twp., Sec. 27				X	X									X		X						X				
Fish Cr. Williams Co., Ohio St. Joe. Twp., Sec. 16		X	X	X	X	X	X	X	X					X	X			X	X	X					X	
Fish Cr. Williams Co., Ohio St. Joe. Twp., Sec. 17	X	X							X					X						X					X	
Fish Cr. Williams Co., Ohio St. Joe. Twp., Sec. 20		X	X	X		X	X	X	X	X			X	X	X	X	X		X	X	X				X	X
Fish Cr. Williams Co., Ohio St. Joe. Twp., Sec. 19		X	X	X	X	X	X	X	X			X	X	X	X	X			X	X	X		X		X	X
Fish Cr. De Kalb Co., Ind. Troy Twp., Sec. 29		X		X	X	X	X	X	X				X	X	X				X	X	X				X	X
Fish Cr. Steuben Co., Ind. Richland Twp., Sec. 30	X	X						X		X		X	X						X	X					X	
St. Joe. R. Williams Co., Ohio St. Joe. Twp., Sec. 10		X		X	X	X	X			X					X	X					X					
Bear Cr. Williams Co., Ohio Florence Twp., Sec. 23										X																
Bear Cr. Williams Co., Ohio Florence Twp., Sec. 22									X	X																
St. Joe. R. Williams Co., Ohio Florence Twp., Sec. 36	X	X	X	X	X	X	X						X	X	X	X			X	X	X		X	X	X	X
St. Joe. R. Williams Co., Ohio Superior Twp., Sec. 30	X	X		X		X									X	X				X	X		X			
Eagle Cr. Williams Co., Ohio Superior Twp., Sec. 19										X										X						
St. Joe. R. Williams Co., Ohio Superior Twp., Sec. 16	X	X		X					X	X		X				X					X		X			
Nettle Lake Williams Co., Ohio Northwest Twp., Sec. 13										X	X									X						
Nettle Cr. Williams Co., Ohio Northwest Twp., Sec. 15								X				X														
Nettle Cr. Williams Co., Ohio Northwest Twp., Sec. 10										X		X								X						
St. Joe R. Williams Co., Ohio Madison Twp., Sec. 32	X	X					X	X		X		X			X						X					
W. Br. St. Joe. Williams Co. Ohio, Bridgewater Twp., Sec. 30	X	X	X				X						X	X	X	X				X	X		X		X	
W. Br. St. Joe. R. Williams Co. Ohio, Bridgewater Twp., Sec. 26										X					X					X						
W. Br. St. Joe. R. Williams Co. Ohio, Bridgewater Twp., Sec. 16	X	X					X	X	X				X	X	X	X			X	X	X				X	X
W. Br. St. Joe. R. Williams Co. Ohio, Bridgewater Twp., Sec. 17	X	X			X		X	X	X	X			X	X	X	X			X	X	X					X
W. Br. St. Joe. R. Hillsdale Co. Mich., Amboy Twp., Sec. 6		X			X		X	X	X	X		X	X	X	X				X	X	X				X	X
W. Br. St. Joe. R. Hillsdale Co. Mich., Camden Twp., Sec. 36	X	X			X		X	X	X	X			X	X	X				X	X	X				X	
W. Br. St. Joe. R. Hillsdale Co. Mich., Camden Twp., Sec. 23	X									X					X					X						
W. Br. St. Joe. R. Hillsdale Co. Michigan, Camden Twp., Sec. 8	X									X	X									X						
W. Br. St. Joe. R. Hillsdale Co. Mich., Woodbridge Twp., Sec. 28	X	X			X		X	X	X			X		X	X	X			X	X	X				X	X
St. Joe. R. Williams Co., Ohio Madison Twp., Sec. 21	X	X						X		X		X	X		X					X	X		X			
St. Joe. R. Williams Co., Ohio Madison Twp., Sec. 11												X	X							X						
Bird Cr. Hillsdale Co., Mich Ransom Twp., Sec. 24								X		X		X														
St. Joe. R. Hillsdale Co., Mich. Wright Twp., Sec. 31	X	X										X	X		X											
St. Joe. R. Hillsdale Co., Mich. Wright Twp., Sec. 20	X	X						X				X	X		X											

Pleurobema clava (Lamarck) is listed by Call (1896b) from the St. Joseph River, but no definite locations were given. Two empty shells were found by Clark and Wilson (1912) in the St. Joseph River, and only 20 in the entire Maumee Basin. Goodrich (1914) reported its range as far downstream as Defiance, Ohio in the Maumee, but did not mention that they were in the St. Joseph. However, specimens housed in the Museum of Zoology in Michigan indicate that he collected it from the St. Joseph at Newville, Indiana and at Edgerton, Ohio. He later (1932) reported a specimen taken by M. L. Winslow from the Maumee Basin in Hillsdale County, Michigan. It was taken at 11 of the 40 sites reported in this study: one in a small tributary in Indiana, four in Fish Creek, four in the West Branch and two in the main stream. Clark and Wilson (1912) rated it as fairly well distributed along the upper course of the Maumee, but nowhere abundant. This pattern may be true for it in the St. Joseph as shown by the 1939 to 1953 collections. However, the 1975 collections produced 56 in one area not more than 500 feet long, in two hours of collecting. More were available if continued collecting were undertaken.

Pleurobema cordatum coccineum (Lamarck). Goodrich and van der Schalie (1944) discuss the confusion existing in the taxonomy of the forms of this species. Call (1900) referred to it as *P. coccineus* Lea, and described it as common in all parts of Indiana, including the St. Joseph River. Clark and Wilson (1912) indicated that '*Quadrula coccinea* (Conrad)' was not as common as *Cyclonaias tuberculata* in the Maumee Basin. Specimens collected by Goodrich in the St. Joseph River, Allen County, Indiana, and by others from the West Branch of the St. Joseph in Hillsdale County, Michigan are in the Michigan Museum collections. Goodrich and van der Schalie (1944) include it as among the Maumee River fauna. Its distribution was rather spotty in the smaller portion of the main stream and in the tributaries. It centered around Fish Creek and the West Branch.

Alasmidonta calceolus (Lea) was reported from the Maumee Basin by Call (1896a). Records available include: specimens from Cedar Lake and Cedar Creek near Waterloo, DeKalb County, Indiana, the St. Joseph, Bird Lake and Bird Creek near Pittsford, Michigan, the West Branch of the St. Joseph in Wright Township, Hillsdale County, Michigan, and the St. Joseph River in Madison Township, Williams County, Ohio, all in the University of Michigan's collections. The collections forming the basis of this paper reveal it as found chiefly in the tributaries of the St. Joseph, but was never taken in large numbers. It is clearly a headwater or small stream species.

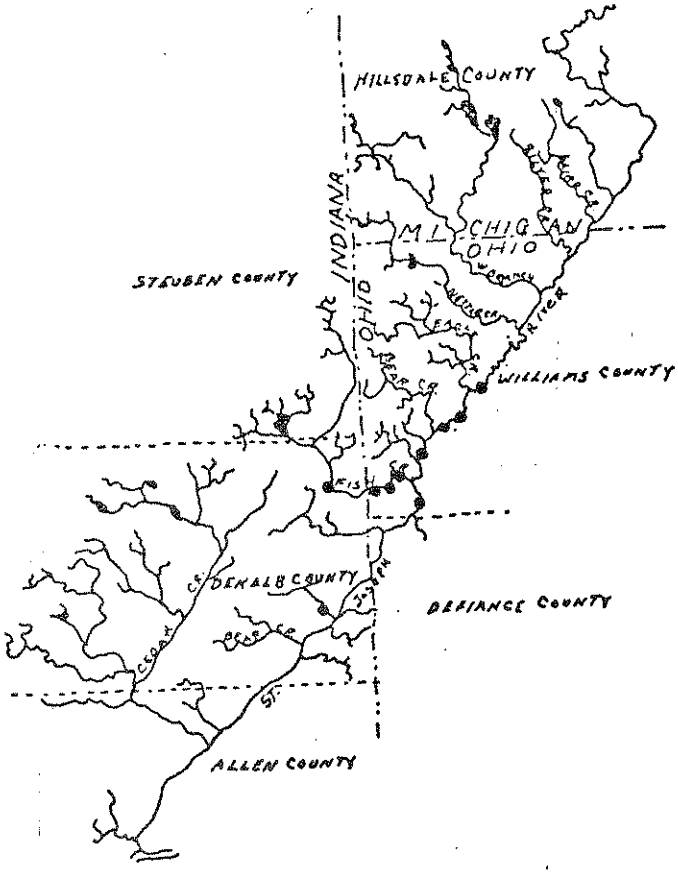


Fig. 5. Distribution of *Cyclonaias tuberculata* (Rafinesque) in the St. Joseph River Basin.

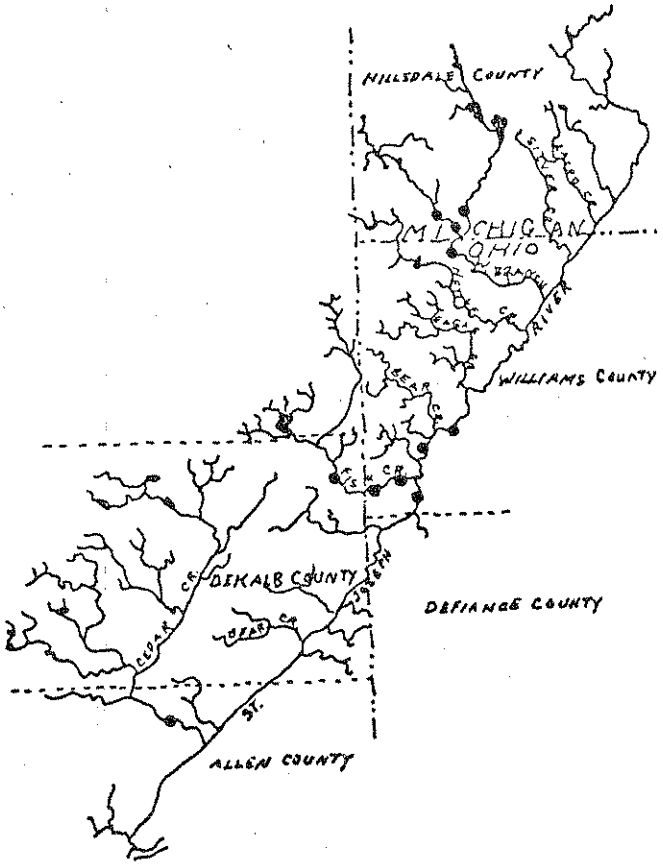
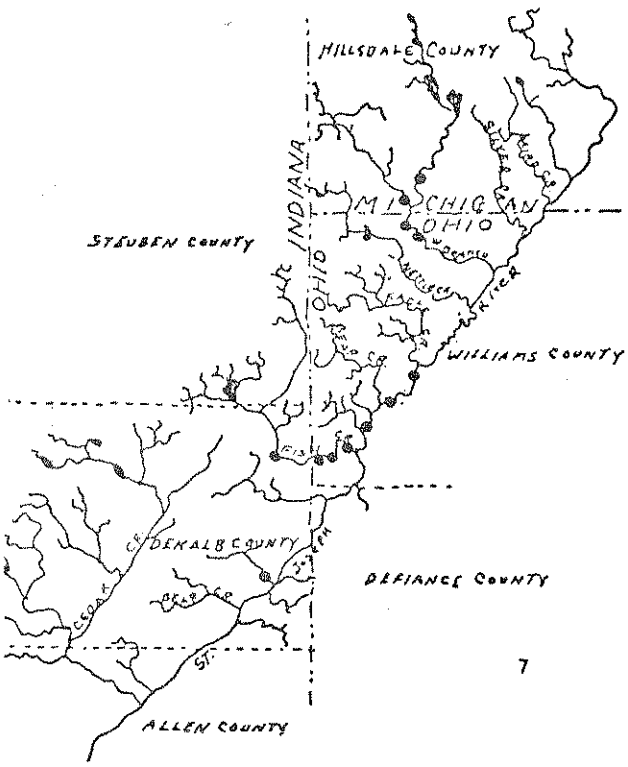
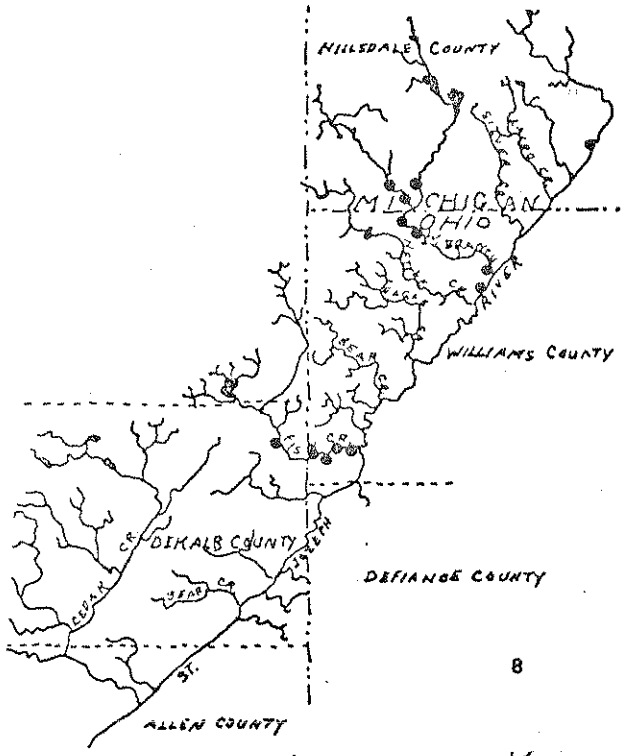
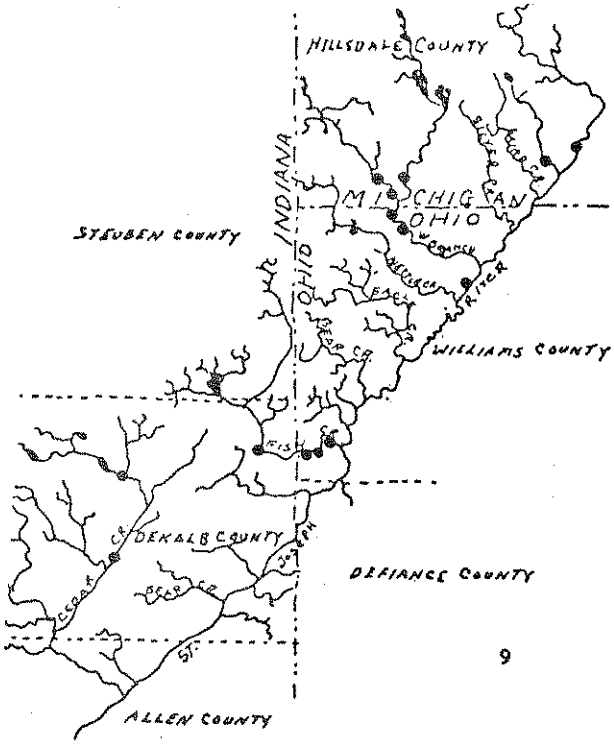


Fig. 6. Distribution of *Elliptio dilatata* (Rafinesque) in the St. Joseph River Basin.







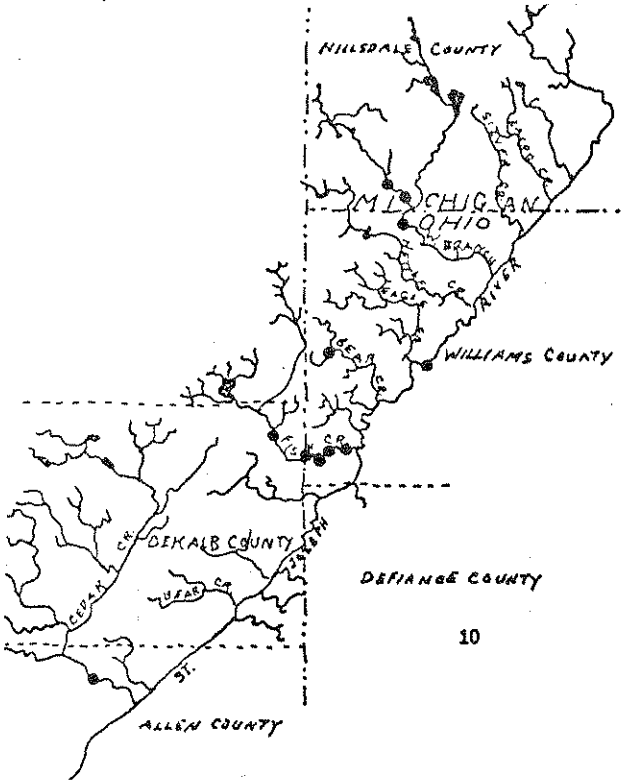


Fig. 7. Distribution of *Pleurobema clava* (Lamarck) in the St. Joseph River Basin.

Fig. 9. Distribution of *Alasmidonta calceolus* (Lea) in the St. Joseph River Basin.

Fig. 8. Distribution of *Pleurobema cordatum coccineum* (Conrad) in the St. Joseph River Basin.

Fig. 10. Distribution of *Alasmidonta marginata* Say in the St. Joseph River Basin.

Alasmidonta marginata Say was reported by Call (1896a) among the naiads of the Maumee Basin, and described by Clark and Wilson (1912) as, '....not especially common.' They record it from the St. Joseph River and the feeder canal at Ft. Wayne. It does not appear in the Michigan Museum collections nor in the literature on the St. Joseph River in lower Michigan. Ten of the 11 collections in this study were from tributary streams. Five was the largest number taken at any one collecting site.

Anodonta grandis (Say). Call (1896a) reported it from the Maumee Basin and Clark and Wilson (1912) from the St. Joseph River. It was collected throughout the basin by Goodrich and specimens are now in the Michigan Museum of Zoology collections. Table 2 shows its wide range throughout the St. Joseph Basin; but it was not found in the main stream below Edgerton, Ohio.

Anodonta imbecillis Say was first reported from the Maumee drainage by Clark and Wilson (1912) who report it from the St. MarysRiver at Ft. Wayne. It was not reported in the literature covering this area, since that date. Also the Michigan Museum collections have no specimens from the St. Joseph River prior to those taken by the author from Nettle Lake and those collected by van der Schalie from the West Branch of the St. Joseph in Hillsdale County, Michigan while assisting in this study. They were collected from only three locations, but not more than three at each.

Anodontoides ferussacianus (Lea) was included in Call's (1896a) list as from the Maumee Basin; but he did not specify its presence in the St. Joseph system. Clark and Wilson (1912) seven dead specimens in the Maumee drainage, all in Spy Run at Ft. Wayne. Specimens are recorded from Cedar Lake and Cedar Creek, Bear Creek in DeKalb County, Indiana, the West Branch in Michigan as well as the mainstream of the St. Joseph and deposited in the Museum of Zoology of the University of Michigan. La Rocque (1967) reported it from Silver Creek, Williams County, Ohio. It is a creek species and found throughout the St. Joseph Basin.

Lasmigona compressa (Lea) was included by Call (1896a) as found in the Maumee Basin. Kirsch (1895) reported it from Cedar Creek, a tributary of the St. Joseph River in DeKalb County, Indiana Clark and Wilson (1912) found only one specimen, at the mouth of the St. Joseph, in their Maumee River survey. Specimens in the University of Michigan collections establish its presence in Cedar Creek, DeKalb County, Indiana and in the St. Joseph in Hillsdale Coun-

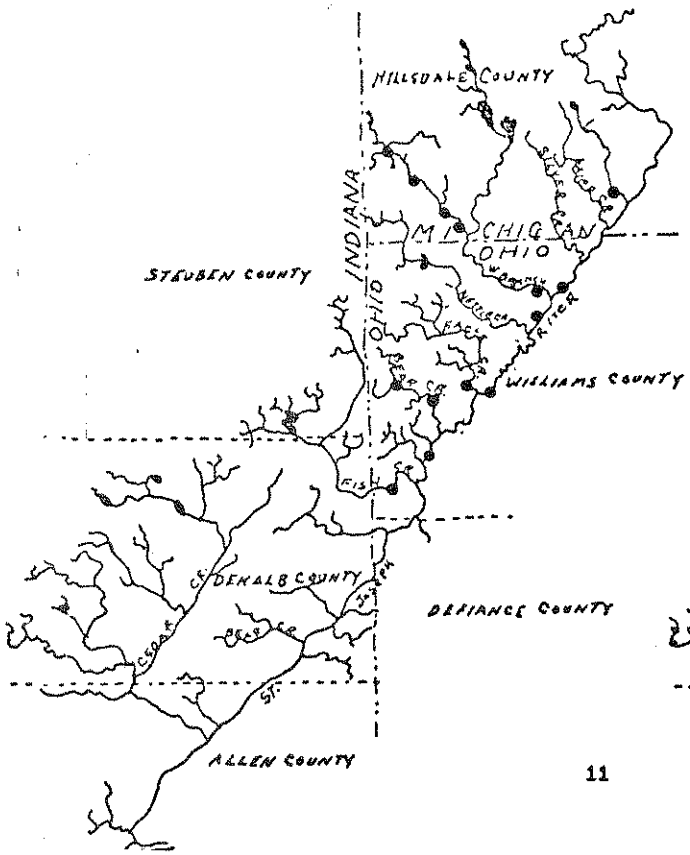


Fig. 11. Distribution of *Anodonta grandis* Say in the St. Joseph River Basin.

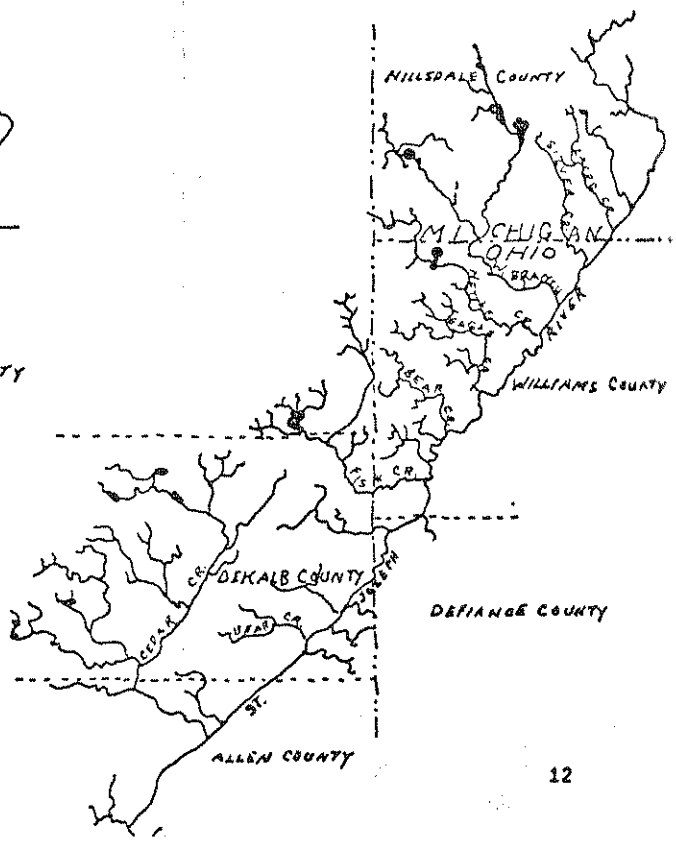


Fig. 12. Distribution of *Anodonta imbecillis* Say in the St. Joseph River Basin.

ty, Michigan. Table 2 indicates that it is mainly a creek species. It was taken in the upper reaches of the St. Joseph River and from its tributaries.

Lasmigona costata Rafinesque. Call's statement, 'This shell is found in every large stream and most smaller ones in Indiana.' seems to report it from the Maumee drainage in that state (Call, 1900). Although Clark and Wilson (1912) considered this naiad as fairly common in the Maumee River throughout most of its length, no mention was made of its presence in the St. Joseph River. In this study, it was found at 14 of the 40 stations included in this report. It is widespread throughout the drainage and occurs most often as a headwater species.

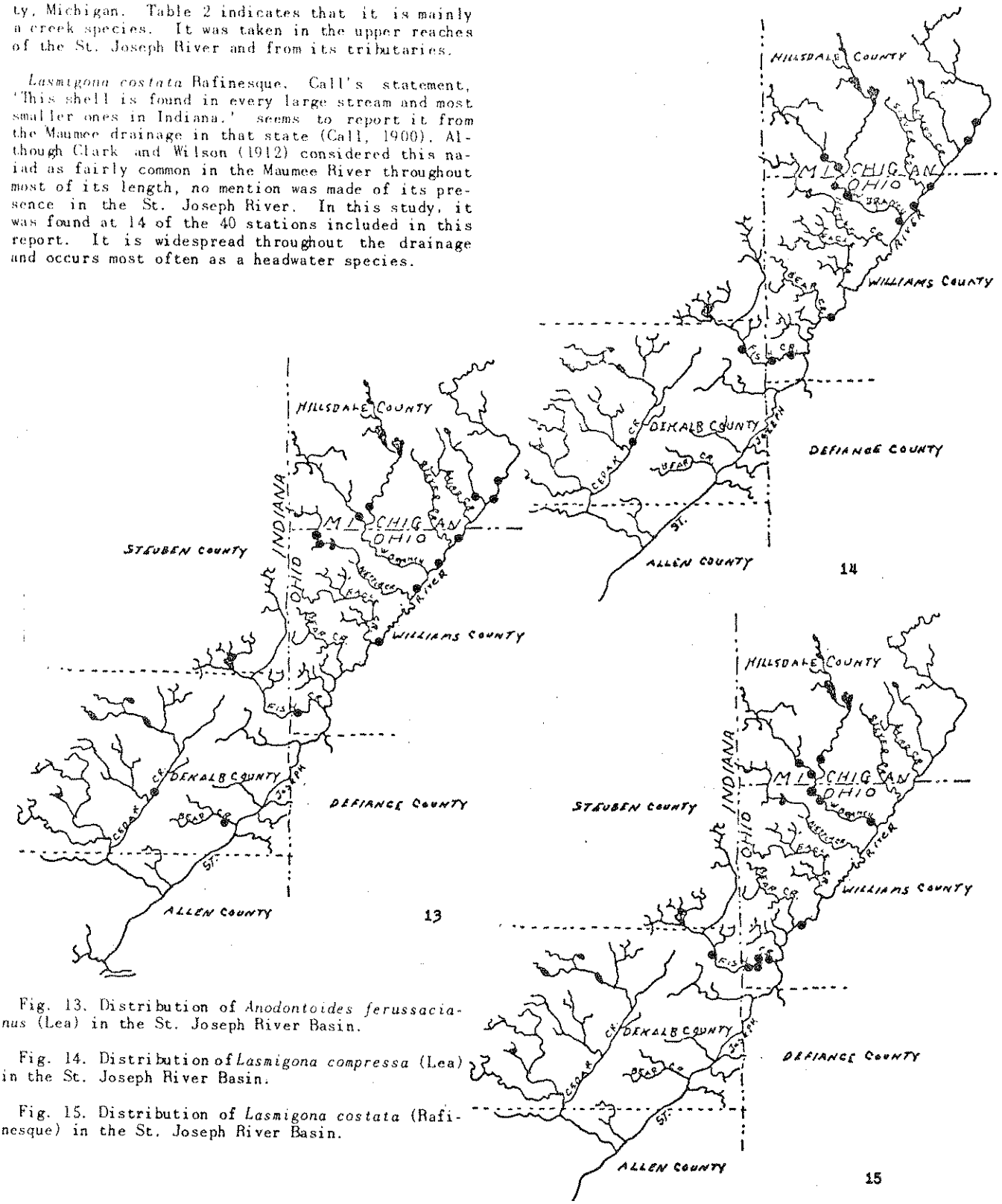


Fig. 13. Distribution of *Anodontoides ferussacianus* (Lea) in the St. Joseph River Basin.

Fig. 14. Distribution of *Lasmigona compressa* (Lea) in the St. Joseph River Basin.

Fig. 15. Distribution of *Lasmigona costata* (Rafinesque) in the St. Joseph River Basin.

Strophitus rugosus (Swainson) was collected by Kirsch (1895) from Cedar Creek near Waterloo, Indiana. Clark and Wilson (1912) found it as rather uncommon in the Maumee Basin, although widespread; and they took it from the St. Joseph River. This appraisal of its abundance was probably correct as indicated by their collections which were chiefly from the larger streams of the basin. According to Goodrich and van der Schalie (1944), it appears to be relatively rare in large rivers. Fifteen of the 19 collections of this species made during this study are from tributary streams. It ranges widely throughout the St. Joseph drainage, but its population in Fish Creek was large. Forty were taken at one site in that stream.

Actinonaias carinata (Barnes) was reported from the Maumee Basin by Call (1896a), but no locations were indicated. Clark and Wilson (1912) reported it as common in all three rivers (St. Marys, St. Joseph and Maumee), and also in the canal feeder. They stated that they were fine, large specimens. This mussel was estimated to comprise 90 percent of the shells of commercial value in the Maumee Basin (Clark & Wilson, 1912) as based on its value to the button industry of that day. Specimens in the Michigan Museum collection, taken by Goodrich, indicate that it occurred in the St. Joseph near Spencerville, Indiana, northeast of Fort Wayne, and near Cedarville in Allen County, Indiana. A specimen from Cedar Creek near Waterloo, Indiana is also in the Michigan collection. This species was found to be widely distributed in the St. Joseph Basin, but in relatively small numbers.

Carunculina glans (Lea) was first reported from the Maumee River by Call (1896a); but only six were found by Clark and Wilson (1912): one in the St. Joseph River near its mouth, four in the feeder canal, and one in the reservoir at the end of the canal. Half of a dead shell collected by Goodrich in the St. Joseph in Allen County, Indiana, is in the Michigan Museum's collection. He reported (1932) 'So far as the records of the Museum of Zoology indicate, *glans* occurs in the state (Michigan) only in Otter Creek, Monroe County.' Only one specimen was obtained during the collections on which this report is based. It was found in Fish Creek, Williams County, Ohio.

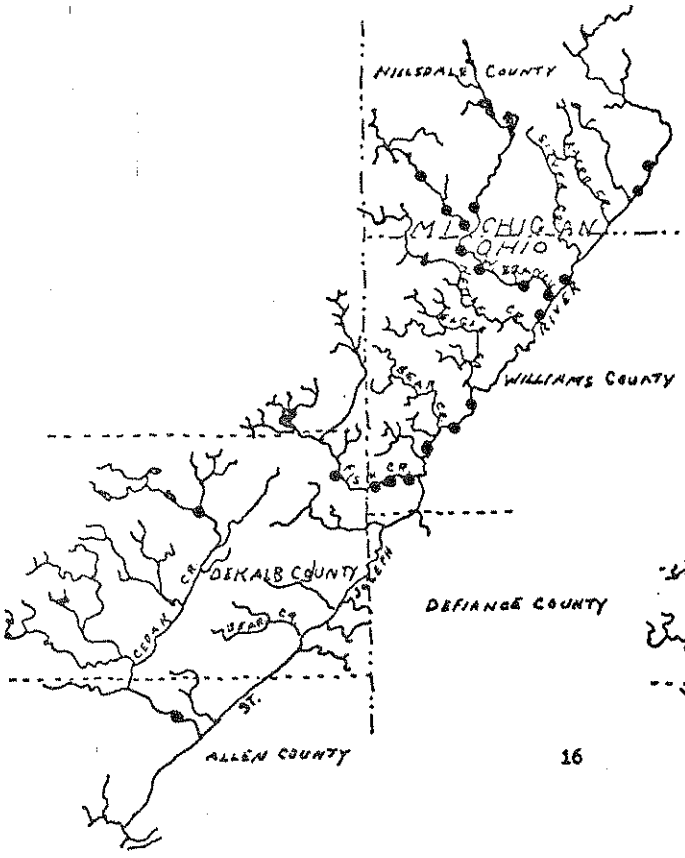


Fig. 16. Distribution of *Strophitus rugosus* (Swainson) in the St. Joseph River Basin.

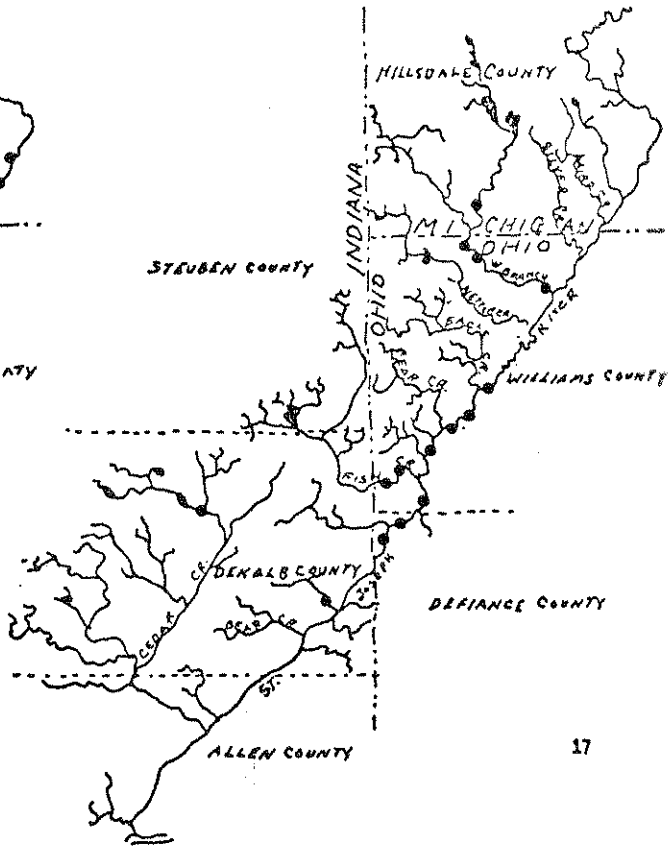


Fig. 17. Distribution of *Actinonaias carinata* (Barnes) in the St. Joseph River Basin.

Dysnomia sulcata (Lea). This species was reported by Call (1900) as, '... usually considered as being rare,' but he made no mention of its presence in the Maumee drainage. Clark and Wilson (1912) stated that it was, '... never very common, was not found below Defiance, Ohio.' They found it as dead shells along the mouth of the St. Joseph River. They took only one live specimen, in the Auglaize River, and only 15 shells were found in the Maumee Basin. Goodrich and van der Schalie (1944) reported *D. sulcata* from the Maumee Basin. Michigan Museum's collection contains a specimen taken from the St. Joseph in Ft. Wayne, Indiana.

Lampsilis fasciola Rafinesque was included in the mussel fauna of the Maumee by Call (1896a). It was considered as not common in the basin by Clark and Wilson (1912). They found it in the St. Joseph River and in the feeder canal at Ft. Wayne. Its Michigan distribution was plotted by van der Schalie (1944); but no records for the St. Joseph Basin were included. The Michigan Museum's collections as well as those forming the basis of this report (Table 2) indicate it has a 'not common' status as given by these early authors. They do indicate its wide and scattered distribution, especially in the tributaries. As many as 20 were taken in one hour from the West Branch of the St. Joseph River; but usually only one or two were taken from 14 of the 40 collecting sites.

Lampsilis siliquoidea (Barnes) was reported by Call (1896a) from Cedar Creek, Allen County, Indiana and from the Maumee and St. Marys Rivers at Ft. Wayne. Clark and Wilson (1912) found it in about the same locations as *Actinonaias carinata*, but not in as great abundance. The Michigan Museum's collections show it has wide distribution, as do the data presented in this report (Table 2). Its abundance varied greatly; but such finds as 32 in 45 minutes in Eagle Creek were not too unusual.

Lampsilis ventricosa (Barnes) was not reported from the Maumee drainage by Call's papers of 1896 or 1900. Clark and Wilson (1912) found it was not especially common, but stated that they found 18 at

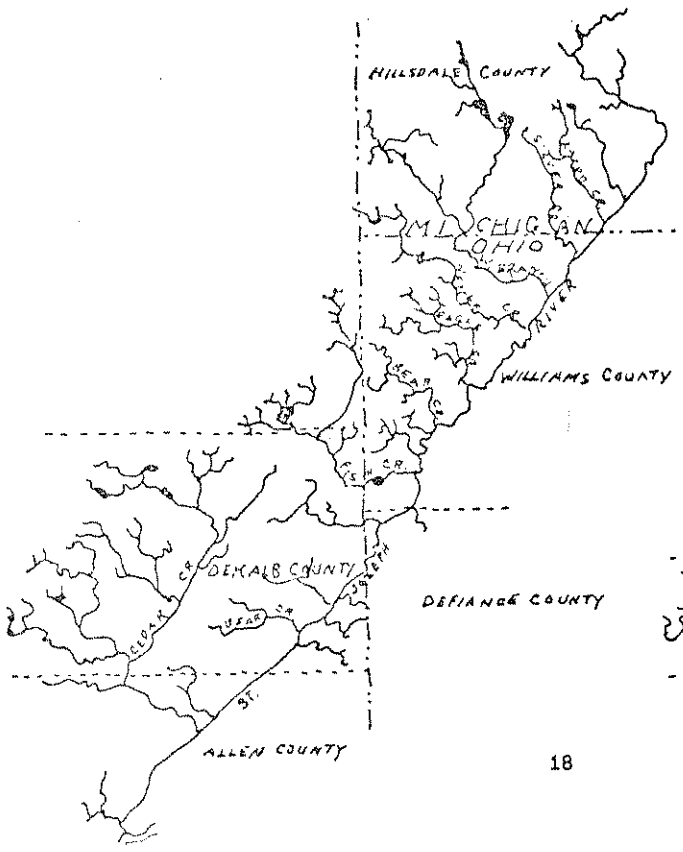


Fig. 18. Distribution of *Carunculina glans* (Lea) in the St. Joseph River Basin.

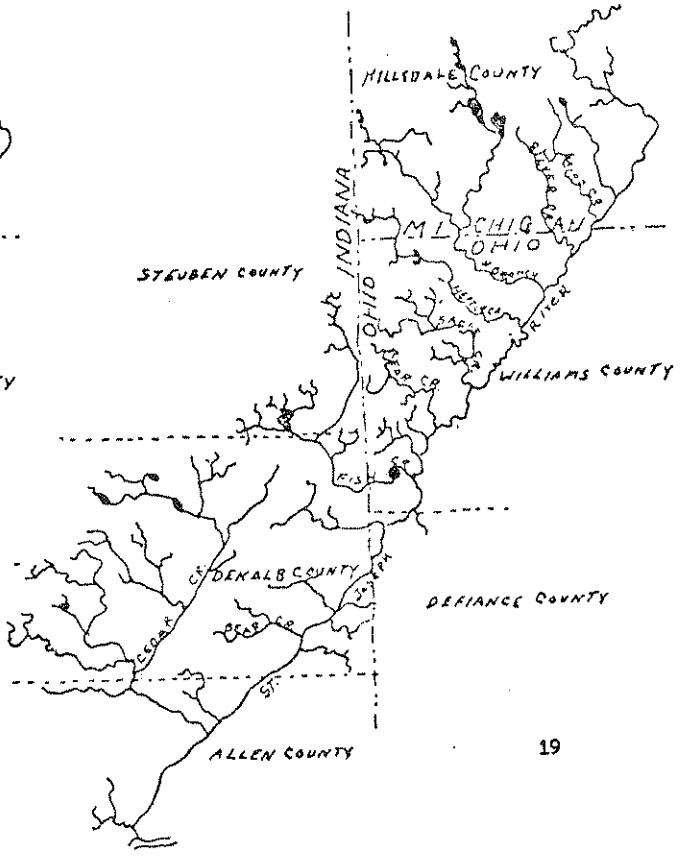


Fig. 19. Distribution of *Dysnomia sulcata* (Lea) in the St. Joseph River Basin.

the mouth of the St. Joseph River. They wrote, 'Although well-marked specimens of this species are easily recognized, it has many deviations from the typical form,' They found some specimens to approach *Proptera capax* (Green) and others *L. siliquoidea*; but that those from the Maumee Basin were well marked and fairly uniform. Several in the Michigan Museum collection are labeled *L. ventricosa* and some of those taken during the 1939 to 1953 period were tentatively identified as L. ovata. Goodrich and van der Schalie (1944) stated, '*L. ovata* is definitely a species that inhabits large rivers and there are transitions into the headwaters that connect *L. ovata* through the form *L. o. ventricosa* with *L. ventricosa*. The majority of the St. Joseph specimens probably best fit the *L. o. ventricosa* group, even though *L. ventricosa* is considered the northern form. Cvancara (1963) demonstrated a north-south cline and raised doubts concerning the taxonomic status of the *L. ventricosa* and *L. ovata* group. Table 2 indicates this mussel is found throughout the St. Joseph River Basin, but not in large numbers. The most taken at any one site during this study was some 17 from the West Branch of the St. Joseph River in Williams County, Ohio.

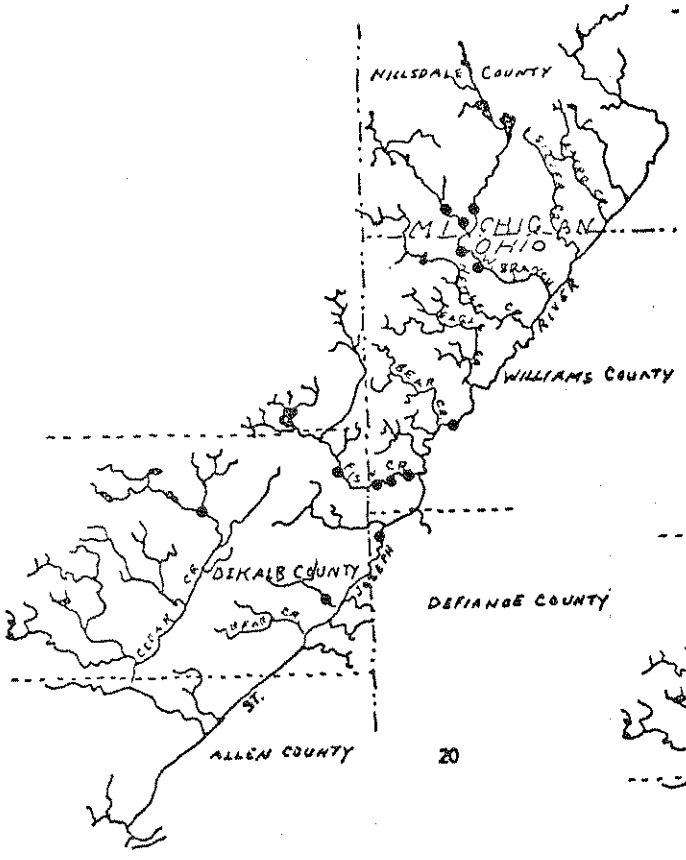


Fig. 20. Distribution of *Lampsilis fasciola*(Rafinesque) in the St. Joseph River Basin.

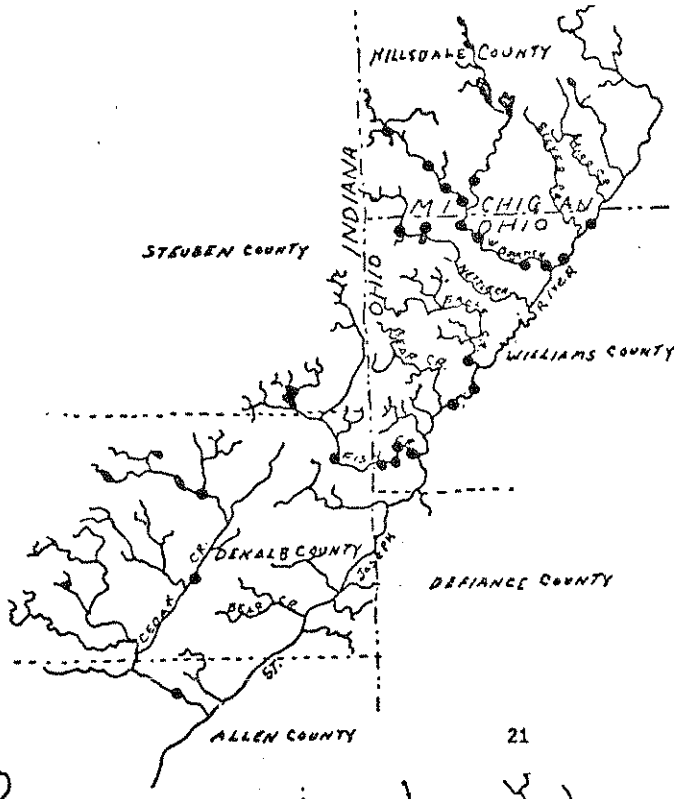


Fig. 21. Distribution of *Lampsilis siliquoidea* (Barnes) in the St. Joseph River Basin.

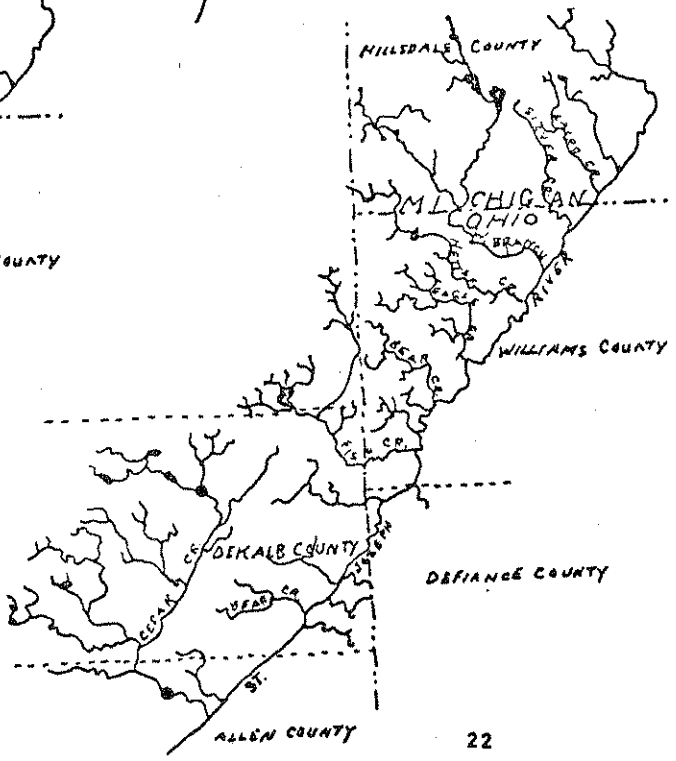


Fig. 22. Distribution of *Lampsilis ventricosa* (Barnes) in the St. Joseph River Basin.

Ligumia recta latissima (Rafinesque) was reported from the Maumee drainage by Call (1896a) and from the St. Joseph in 1900. It was fairly common and well distributed in the Maumee Basin, but not particularly abundant (Clark and Wilson, 1912). They found it in the feeder canal at Ft. Wayne and the St. Joseph River, but reported only 63 from the entire Maumee Basin. The 1939 through 1953 collections include 15 live and dead specimens taken at nine sites (Table 2).

Obovaria subrotunda (Rafinesque) was listed by Call (1896a) from the Maumee Basin, and from the St. Joseph River (1896a), but he does not indicate which of the two St. Joseph Rivers in Indiana. H. van der Schalie (1963) considered Call's listing as from the St. Joseph River of the Maumee. Clark and Wilson (1912) found it to be, '...fairly common in the feeder canal where 16 specimens were secured, and in the St. Joseph River near its mouth, where we obtained 10.' Goodrich 1932) intimated that it was not found in Michigan waters of the St. Joseph drainage, but specimens collected by him in 1941 from the main stream near Newville, DeKalb County, Indiana are deposited in the Michigan Museum. Table 2 indicates that this mussel was taken in four locations in the mainstream, three in Williams County, Ohio, two from two Williams County tributaries, and one from an Indiana tributary (Table 2).

Villosa fabalis (Lea) was considered by van der Schalie (1936) as reported from the Maumee drainage by Call (1900). Clark and Wilson (1912) considered this species as, '.... exceedingly abundant in the Feeder Canal ...,' where in 1909 several hundred were found. Goodrich took two specimens from the St. Joseph River northeast of Ft. Wayne in 1941. Goodrich did not report it from the St. Joseph drainage in Michigan (1932). One specimen was found in the mainstream in Williams County, Ohio during this study.

Villosa iris (Lea) was reported by Call (1896a) from the Maumee Basin. Clark and Wilson (1912) found four specimens in the St. Joseph River near its mouth, and two in the feeder canal. They qualified their shortage of specimens by stating, 'It is probably more common than collections would indicate, as it is frequently found in abundance late in the fall after muskrats have begun collectiong, where it is difficult to find in numbers before this.' The Michigan collections contain specimens from Cedar Creek, DeKalb County, Indiana, Lake Baw Bee, Hillsdale County, Michigan and the St. Joseph River at Edgerton, Ohio. It is a headwater species (Table 2)

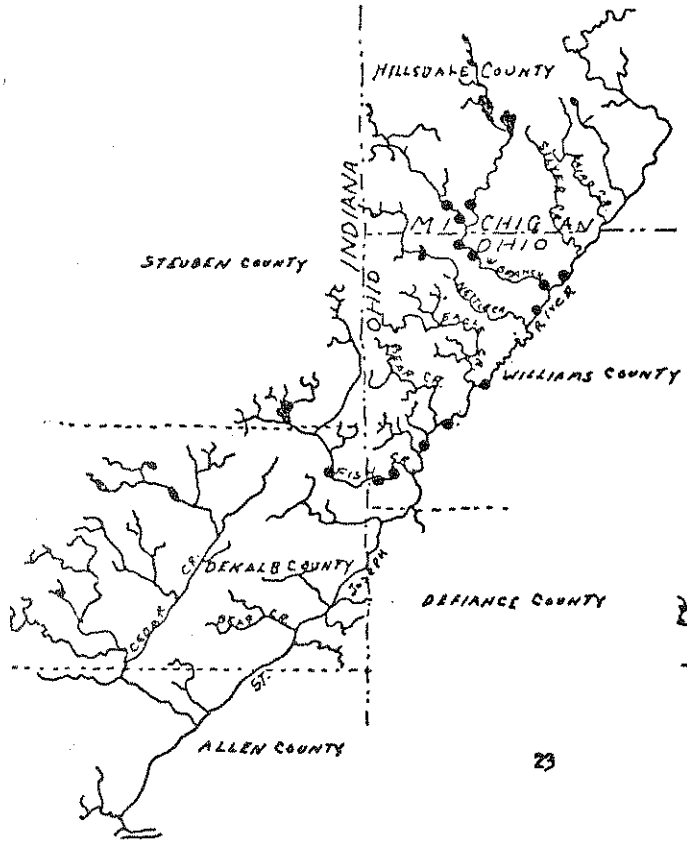


Fig. 23. Distribution of *Ligumia recta latissima* (Lamarck) in the St. Joseph River Basin.

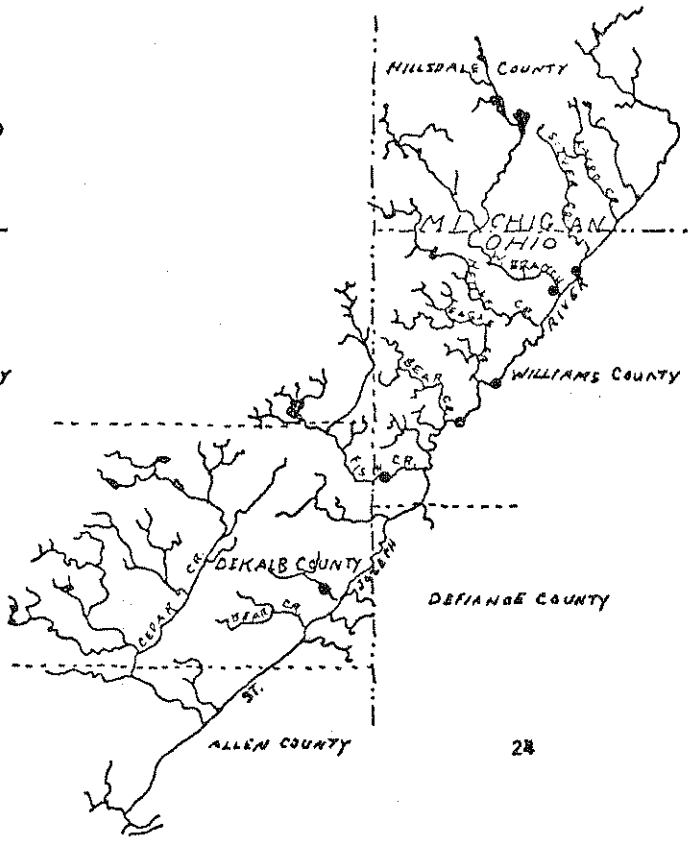


Fig. 24. Distribution of *Obovaria subrotunda* (Rafinesque) in the St. Joseph River Basin.

which was found most numerous in Fish Creek and the West Branch of the St. Joseph River. In general, only one to three specimens were taken at any location, but 94 were found at one station in Fish Creek in 1945 and 27 more found at another site in the stream in 1975.

Ptychobranchus fasciolaris (Rafinesque) was listed by Call (1896a) as found in the Maumee Basin, but was not mentioned as such in his 1900 illustrated catalogue. Clark and Wilson (1912) stated, 'This species was not abundant anywhere in the Maumee Basin, but was scattered along the length of the river. In the autumn of 1907 a fair number were obtained in the feeder canal. We found 16 good specimens in the St. Joseph River at Ft. Wayne ...' Goodrich and van der Schalie (1944) wrote, 'Apparently this species has gone northward by the Wabash-Miami route, entering Lake Erie and the tributary streams of the lake.' It was collected by Goodrich in 1941 northeast of Ft. Wayne, Indiana. Table 2 shows it inhabits the tributary streams, with one exception. It was taken at eight of the 40 collecting stations. The 1975 collections in Fish Creek produced from 44 to 62 specimens in about three hours of collecting at any one of the three sites examined.

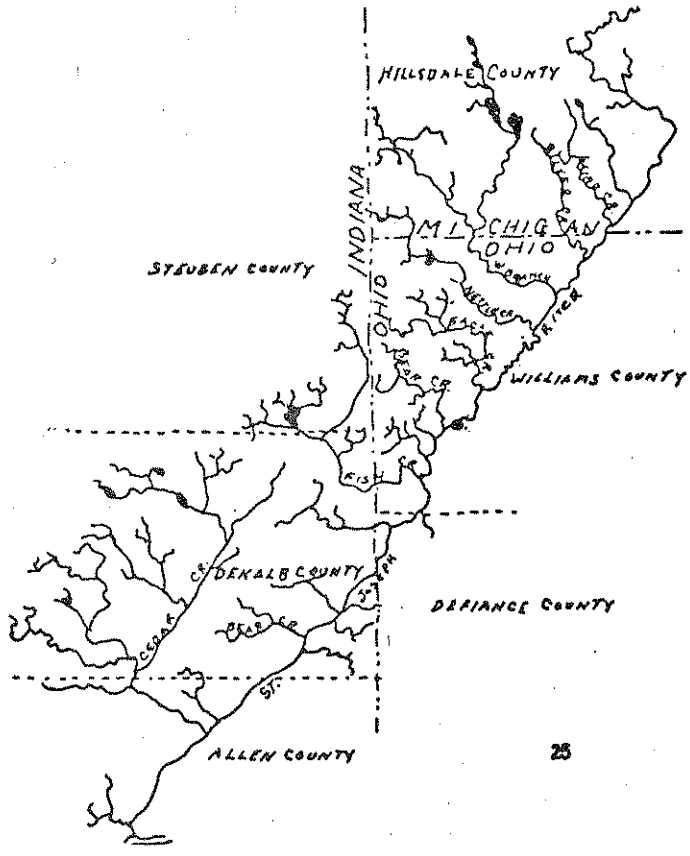
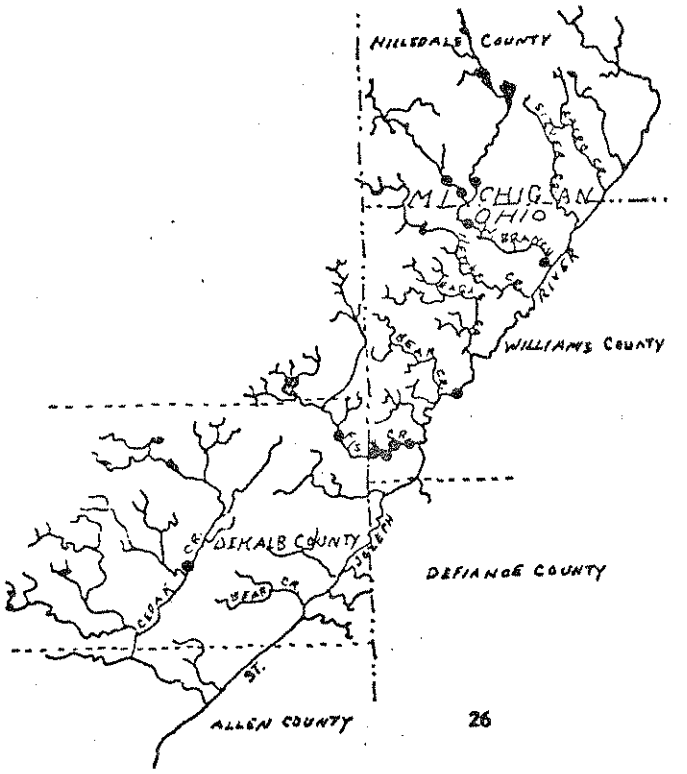


Fig. 25. Distribution of *Villosa fabalis* (Lea) in St. Joseph River Basin.



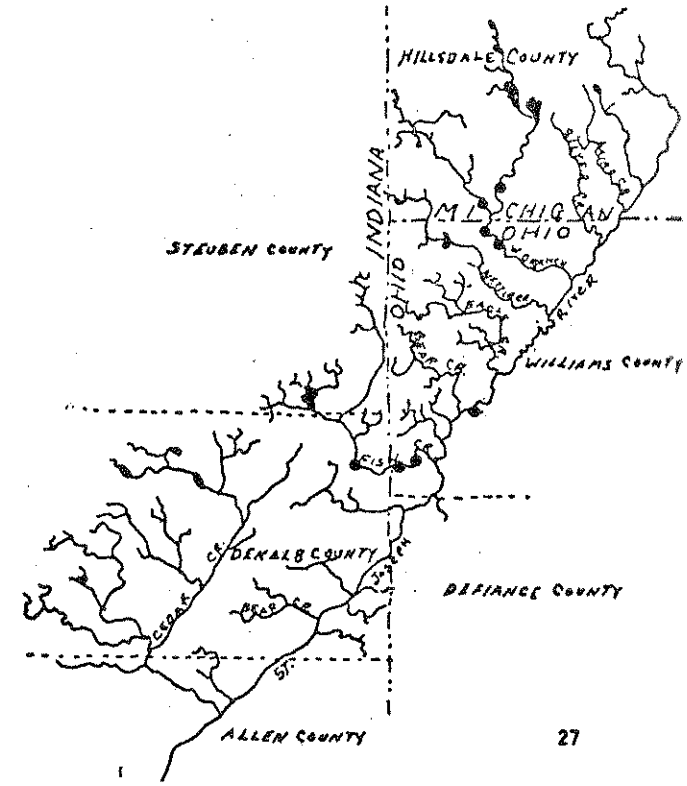


Fig. 26. Distribution of *Villosa iris* (Lea) in the St. Joseph River Basin.

Fig. 27. Distribution of *Ptychobranchus fasciolaris* (Rafinesque) in the St. Joseph River basin.

SPECIES NOT RECENTLY FOUND BUT REPORTED PREVIOUSLY

Quadrula pustulosa (Lea) was listed from the Maumee drainage by Call (1896b) and was found by Clark and Wilson (1912), '... throughout the length of the River (Maumee), but most abundantly in the central portion. A few ... were found at Ft. Wayne ....'

Quadrula quadrula (Rafinesque) was in the lower portion of the Maumee according to Clark and Wilson (1912), and reported from Lake Erie by van der Schalie (1941).

Megalonaias gigantea (Barnes). Call (1896a) reported it from the Maumee Basin; but no other author has indicated its presence here. It could have been a large *Amblema*.

Lasmigona complanata (Barnes) was reported from the Maumee Basin by Call (1896). Clark and Wilson (1912) found it common near Ft. Wayne. They took five from the mouth of the St. Joseph River. Goodrich (1914) did not mention a location from which it was taken, but stated that it was one of the species which crossed the Wabash-Maumee divide. He did not mention it from the St. Joseph in Michigan (1932).

Actinonaias ellipsiformis (Conrad). The Michigan distribution by Goodrich included, '... and St. Joseph River of the Maumee, Hillsdale County,' but this record was accepted by van der Schalie and van der Schalie (1963). Its distribution does not include southeast Michigan.

Carunculina parva (Barnes) was listed among the Maumee River species of naiads, but has not been reported by later authors.

Dysnomia perplexa (Lea), '... has crossed over from the Wabash drainage into the Maumee River system and has gotten into Lake Erie where an occasional specimen is found.' (Goodrich and van der Schalie, 1944).

Dysnomia triquetra (Rafinesque), ',,, is found in the Wabash, White, St. Joseph and Maumee drainages' (Goodrich and van der Schalie, 1944).

Leptodea fragilis (Rafinesque), '... has crossed over into the Maumee drainage.' (Goodrich and vander Schalie, 1944).

Ligumia nasuta (Say) is another species considered by van der Schalie (1936) to have been mistakenly reported by Call (1900) from the St. Joseph of Lake Michigan rather than the St. Joseph of the Maumee.

Obovaria olivaria (Rafinesque) was reported by Call (1900) as present in the St. Joseph River in Indiana. Call's report was considered to be in error by van der Schalie (1936) who believed that Call was referring to the St. Joseph of the Maumee.

Obovaria retusa (Lamarck). Goodrich (1914) states, 'Call records *Obovaria retusa* (Lamarck) from the St. Joseph ...,' and, 'It is highly probable that he had before him specimens of *Quadrula pustulosa*, much produced forward, free of tubercles and suggestive of *retusa*.'

Proptera alata (Say). Clark and Wilson wrote, 'This species is of occasional occurrence in the Maumee Basin but not abundant. Along the upper parts of the basin they were rather rare. Three were obtained in the St. Joseph River at Ft. Wayne ...'

Truncilla donaciformis (Lea) was taken in the Auglaize River by Clark and Wilson (1912), but not in the Maumee above Grand Rapids, Ohio.

Truncilla truncata Rafinesque was found in the Maumee at Defiance, Ohio by Clark and Wilson (1912).

Obliquaria reflexa Rafinesque was not found in the Maumee River above Defiance, Ohio, but was fairly common below that point (Clark and Wilson, 1912).

DISCUSSION OF DATA

Unfortunately the lower portion of the St. Joseph River was not collected as thoroughly as the upper two-thirds of the stream. Recent efforts to collect the lower area were thwarted by high water. The presence of dams which raised the water level and water quality such as earlier presented were also hampering factors. As expected, a river some 100 miles long, and its tributaries provides a wide variety of habitats, especially when the drainage area includes glacial till. Yet among the 26 species taken from the basin, 14 or more were found at 10 of the 40 collecting stations. *Fusconaia flava* came from 27 of the 40 sites, *Lampsilis siliquoidea* from 26, *Strophitus rugosus* from 21, and *Amblema costata* and *Lampsilis ventricosa* were taken at 19 and 18 stations respectively. Although the stream bed varied greatly, sets of conditions combined in these many locations to produce similar populations of naiads.

Only four species were taken at less than five stations, and only eight at less than 10 sites of the 40 sampled. Only one *Villosa fabalis* was taken among the 40 sites; but it was collected together with 18 other species. One *Dysnomia sulcata* and one-half of an extremely fresh shell were found together with 13 other species. *Carunculina glans* was found only once but with 19 other species. It thus appears that habitats, unless they were essentially microhabitats, were not the determining factors in the maintenance of these species.

A haphazard pattern of distribution of most species is apparent from both Table 2 and the species distribution maps. This difference is probably a result of uneven distribution of habitat conditions throughout the drainage basin; or it may also indicate that each area collected was a composite of habitats, some more favorable to some species than to others, and collectively capable of supporting up to 27 species at once. Except for a paper by Van Cleave (1940), the study of habitat niches or micro-

habitats of naiad species has received little attention; but it seems that *Pleurobema clava* would provide an excellent species, in Fish Creek, for such a study. During the three days of collecting in 1975, the author walked a couple of miles of stream and postulated the presence of this species from the type of bottom. In nearly every instance, they were buried in patches of pea to hickory-nut size gravel, in fairly clean broad riffles, in 3 to 10 inches of water at the low water and fall period of the year.

The mainstream of the St. Joseph River included only one of the sites at which 14 or more species of naiads were collected, as compared with nine in the tributaries. Seven of the collection sites from which nine or more species were taken were located in the river as compared with eight in the tributaries. No live specimens were taken from the river below Edgerton, or in the tributary stream at Newville, Indiana about nine miles below Edgerton. Yet in spite of a reported BOD of 764 pounds per day from the Montpelier sewage disposal plant, and oxygen levels of 2 mgl in the stream below during the 1960s (Anon., 1966), it would appear that the water quality prior to that time must have been better since naiads were present at two and four miles below the village in 1938 and 1948. In 1948, the site about 11 river miles downstream from this village produced the best collection of naiads taken in the mainstream of the St. Joseph River. If pollution were present in 1960, it must have been in the 1938 through 1948 period when this area was collected. Yet, no fish-kill reports are available in the Ohio Division of Wildlife's files for that period.

Bear Creek has had several fish kills in recent years; but in general the tributary waters in the larger tributary waters are relatively free of extensive pollution. Domestic pollution enters the extreme headwaters of the West Branch of the St. Joseph and in Lairds Creek. No specimens were found in the latter stream. The reported fall of from 100 to 200 feet from the source of the branches of the St. Joseph in Michigan (Anon., 1964) would indicate that the cleansing ability would normally be high, a fact borne out by Allison's (1965) statement of the high water quality of the West Branch.

We are prone to believe that a direct relationship exists between water quality and the loss of many of our rarer species. *Quadrula cylindrica* was found only as shells at the two stations about three and five miles below Edgerton in 1948. This is the area in which pollution has been reported as a problem for many years, and in which Gallagher (1949) stated that no fish kills had been reported since the big one of 1941. The empty shells were in such condition as to indicate that they could not have lain in that stream for seven years, nor did they indicate that they were eroded by being washed downstream for four or five miles from water of better quality above the village. If they were introduced after the 1941 fish kill, their growth per year was greater than the shell growth lines would indicate to have reached their size when collected. The author has observed survival of fish during several fish kills in isolated unusual sets of conditions which provide a habitat in which a few specimens can survive. The many springs in the area could produce such conditions in a small section of the stream bed, in which these *Quadrula* could have survived. More live specimens were taken in Fish Creek in 1975 than had formerly been taken in the entire stream during the years 1939 through 1953. Four were taken at one station in three hours of collecting. Two half shells, which were not in advanced stages of erosion, were also taken at the same site.

The live specimens of *Dysnomia sulcata*, and the half shell found in excellent condition at a muskrat midden, represent the second report of this species since the work of Clark and Wilson (1912). Another specimen number 91,409 in the Michigan Museum collection was found at Ft. Wayne.

The third reported rare and endangered species (Stansbery, 1970) in the St. Joseph River collections is *Pleurobema clava*. It was taken at 12 sites, most of which were in the tributaries, and eight were in Fish Creek and the West Branch of the St. Joseph. It would appear that it requires very clean water since only one specimen was taken about nine miles below Montpelier; but 11 were taken about two miles farther downstream where the largest number of species and specimens were taken from the main stream. The diversification and large size of the naiad population at this point, above Beaber Creek, would indicate that the St. Joseph River's rapid ability to recover its water quality in this area. The specimen taken from the tributary near Newville, Indiana was dead. Otherwise, four of the collections contained one specimen each, one three specimens and the others ranged from 11 to 33 from each station. The follow-up collection in 1975 produced 1, 18, and 46 specimens at three sites in Fish Creek.

It is unfortunate that a type of 'index of abundance' has not accompanied collecting information to permit some comparisons of abundance. It is noted that Clark and Wilson (1912) stated that *Ligumia recta* was fairly common in the Maumee Basin, and yet they took only 63 specimens at 28 stations scattered throughout the entire basin. They considered *Leptodea fragilis* as rather abundant below the dam at Defiance, Ohio where they found 19 specimens; but they reported it as abundant at Grand Rapids where only 16 were found. Can one assume from the 15 *Dysnomia sulcata* by Clark and Wilson (1912) that this species was twice as abundant as *Strophitus rugosus* because only eight of the latter were taken in the basin? Can we make a direct comparison with the collections listed in Table 2? If so, the collecting time was approximately the same. One could not consider that *Pleurobema clava* was absent when the 1948 collections were made or that it is three times as abundant today than it was in 1953. In the days when water quality was not considered a major problem, before harvest was considered as depleting the population, and when malacologists thought of pristine populations, Call (1894) stated, 'The habits of our mollusks are so peculiar that certain seasons present sometimes many forms which fail to appear again for several years.' Clark (1976) discussed the incongruities of sampling which indicate that the entire stream bottom needs to be checked before positive statements on the populations can be made, and that the experience of the collectors in the areas being collected is important. Krumholz, Bingham and Meyer

(1970) illustrate the difference in harvest from the same area by the same method in two consecutive years. The behavior of naiads also may be involved in the estimates of abundance. All four *Quadrula cylindrica* and the *Dysnomia sulcata* collected in 1975 in Fish Creek were lying on the surface of the gravel bottom, completely exposed. Yet, all the *Pleurobema clava* were buried and were found only by raking the locations.

Fish Creek contained 24 of the 26 species found in the St. Joseph drainage, including the rare and endangered species. The numbers of each species found in this creek are probably equal to or exceeded those found at other collecting sites in the St. Joseph Basin. The naiad information available (Table 2) presents the naiad population of the St. Joseph River under its best habitat conditions.

The West Branch contained 22 of the 26 species found in the St. Joseph Basin, but included only *Pleurobema clava* and *Quadrula cylindrica* of the rare and endangered species (Table 2). The numbers of individuals of each species were not equal to those of Fish Creek, except for *Lampsilis fasciola* which was more abundant in this stream. *Anodonta imbecillis* was found only in the upper end of the West Branch and in Nettle Lake, but not elsewhere in the entire drainage. The desirability of small, clear water streams as locations for stream impoundments is a possible threat to the habitat of both smallmouth bass and some naiads. However, the effects of the construction of small reservoirs on such streams has not been documented for Ohio. Collections by the author would indicate a tremendous increase in numbers of *Amblema costata* and *Quadrula quadrula* in the Auglaize River above the power dam at Defiance, Ohio, as compared with the findings of Clark and Wilson (1912) before the dam was built. Yet, there is little question that some species would be adversely affected, at least in a limited area. Such development has already been started on the West Branch.

The list of species previously reported from the St. Joseph River which have not been recently found is impressive. It again raises the question of taxonomy and of methods and conditions of collecting, as well as to true changes in the population, and or habitat. The actual presence of some of these species in the St. Joseph River is subject to question, based on their present and past distribution.

As previously mentioned, fish are generally accepted as the carriers or hosts necessary for the development of glochidia, and they provide distribution in water areas. However, according to the list of hosts of naiad glochidia published by Parmalee (1967), but taken from Baker (1928), it appears that relatively little is known of the specificity of hosts except for a few species. The work of Stein (1973), which more than doubled the known hosts of *Amblema costata* (Say), indicates the same possibility for other species. Parmalee (1967) listed as unknown the hosts of 15 of the species of naiads found in the St. Joseph River.

The maximum number of species of naiads were taken in Fish Creek, which contained all but *Anodonta imbecillis* and *Villosa fabalis* (Table 2) of the 26 species found in the St. Joseph Basin. Yet, only 36 species of fish are known from Fish Creek (Table 1) as compared with 48 species from Nettle Lake, 41 from the mainstream of the St. Joseph and 37 from the West Branch. Even though 48 species of fish were taken from Nettle Lake, only three species of naiads were collected from the lake. Nettle Lake contained seven species of fish not found at other sites in the St. Joseph Basin, and Bear Creek contained one not found elsewhere. Although Fish Creek and the West Branch, in general, produced the best collections from the Basin, they did not contain any species of fish not found in the other streams. One collecting site in the mainstream of the St. Joseph River and two in Fish Creek produced the greatest numbers of species of naiads, but only one fish, *Rhinichthys stratulus* (Hermann) was found with them and not elsewhere. Three species of fish, *Notropis photogenis* (Cope), *N. volucellus* (Cope), and *Ammocrypta pellucida* (Putnam) were found in Fish Creek, West Branch, and the St. Joseph River, but not at other sites sampled in the drainage area. The author's memory for many years has carried an association between the fish *Ammocrypta pellucida* and the naiad *Obovaria subrotunda*. Original field collection data for fish are available in the author's files for six of the seven sites at which *Obovaria subrotunda* was taken in the stream system. The darter and the naiad were found together at five of the six naiad collecting sites, and the naiad was found at only five sites at which the darter was taken. These correlations may be superficial, but appear to be the only ones which are apparent.

Interesting and supporting information on the habitat preferences or stream size can be made with the data reported from the Huron River in southeastern Michigan (1938) and the distribution of the naiads collected for this report. Stream size appears to be correlated with certain sets of conditions which result in rather distinctive populations which can, in general, be predicted prior to collecting the area.

SUMMARY AND CONCLUSIONS

Between 1938 and 1953, the author, aided by Drs. Henry van der Schalie and Harold Harry collected naiads in 39 stations of the St. Joseph River of the Maumee. Twenty-six species were found. The author also collected fish from 63 Ohio stations in the drainage area and took 64 species of fish. Recent concern about rare and endangered species prompted a recheck of some of these early collection sites. Fish Creek was selected for this purpose because it appears to have been least affected by changes occurring throughout the St. Joseph River Basin. Three locations were visited in October 1975 to make collections which might be correlated with the data collected earlier.

The naiad population of the St. Joseph portrays

the invasion of the Mississippi fauna into the St. Lawrence assemblage. The spotty distribution of many species seems to indicate considerable variation in habitat in the St. Joseph; but concentrations of certain species might also be interpreted as suggesting that small but similar habitat conditions are also scattered throughout the basin. It does not appear that the less frequently found species required specific habitats for they were usually taken in sites which produced the large numbers of species, or species which were widely distributed throughout the stream system. A microhabitat approach might reveal the reasons for their occurrence.

TABLE 3. Comparison of collections from Fish Creek for the years 1948, 1953, and 1975, Williams County, Ohio, St, Joseph Township.

Date	10/3/48	7/4/53	10/15/75
Location, Section	19	19	19
Species list			
Fusconaia flava	10	9	7
Quadrula cylindrica	--	--	1
Cyclonaias tuberculata	--	--	14
Elliptio dilatata	--	--	3
Pleurobema clava	--	14	46
Pleurobema cordatum coccineum	--	--	1
Alasmidonta calceolus	--	--	1
Alasmidonta marginata	4	4	2
Anodonta grandis	1	--	7
Anodontoides ferussacianus	1	1	--
Lasmigona compressa	1	1	11
Lasmigona costata	--	8	8
Strophitus rugosus	2	2	17
Actinonaias carinata	6	--	3
Lampsilis fasciola	--	2	2
Lampsilis siliquoidea	3	5	23
Lampsilis ventricosa	10	5	17
Villosa iris	3	9	15
Ptychobranchus fasciolaris	--	--	62
Total specimens	41	60	228

Although the main stream was severely polluted below Edgerton in the early period prior to 1941, it appears that conditions must have improved for a few years to permit the appearance of some dead shells found there during the late 1940s. These data seem to indicate that the water quality below Montpelier was poor, but improved rapidly before it was affected by the wastes from Edgerton. It would appear that little or no naiad population was present in the mainstream below Edgerton. Dead shells collected in this area in 1948 suggest the possibility of some specimens surviving the periods of acute pollution under very limited habitat conditions, possibly springs in the stream bottom. However, the large populations, both in species and numbers, were found in the tributaries having high water quality.

There appears to be no direct correlation between the fish found in the streams and the naiads collected in them. Nettle Lake contained the largest number of naiad species and individual fish per acre; but it had the smallest number of naiad species. The only correlation, which may be tenuous, appeared to exist between *Obovaria subrotunda* and *Ammocrypta pellucida*. Those water areas containing the larger numbers of fish species did contain maximum numbers of species of naiads and vice versa.

Abundance, as reported in the literature, seems to have little meaning because of the conflicting reports and the lack of indices which would permit comparisons. Even the present data are not comparable because of variations in collecting, and conditions under which they were made. Although the collecting time for the naiads taken in 1948, 1953, and 1975 (Table 3) was approximately the same, the species taken and numbers varied greatly. One of the species considered as rare and endangered was 'three times as abundant' in 1975 as in 1953, and none was taken at that location in 1948. It would seem that a variety of physical, chemical, and climatic conditions, as well as collecting methods and experience of the collector, produces discrepancies in the findings of the same collector. There are apparent variations in abundance of both species and abundance in populations at the same location when collections over a period of years are compared, but these may be more superficial than real.

The Fish Creek Basin provides an excellent example of an area in which land use has varied little over the past century and will probably continue much the same for some time. The naiad populations are probably as representative of the early inhabitants of the stream of the St. Joseph Basin as can be found today. The protection of this stream and its aquatic communities *now* offers the chance to preserve a 'relic' of the past for future comparisons with the then existing habitats and populations. Scenic Rivers, Wild Rivers, and other programs have been initiated to preserve a unique situation for a definite purpose; why not a stream for its unique aquatic habitat and aquatic communities?

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Accepted for publication December, 1976

AMU MEETING PLANNED JULY 11-15 AT NAPLES, FLA.

A symposium on the Evolution of Mollusca will highlight the 43rd annual meeting of the American Malacological Union, Inc. (AMU) July 11-15 at Naples, Florida.

Dr. George M. Davis, AMU president, said the Naples Shell Club will be host for the meeting, with virtually all activities to be at the Naples Beach Club Hotel.

Costs per room will range from $19 per day per single to $22 for a couple (European Plan). The hotel is on 135 acres with 1,000 feet of beach frontage. Facilities include an Olympic size swimming pool, tennis courts, a golf course and seven meeting rooms.

The symposium will be held jointly with the Systematics Association of Great Britain. Papers on other aspects of malacology will also be read during the meeting.

Those wishing to present papers should write to Dr. Davis, Academy of Natural Sciences, Mollusk Department, 19th and Parkway, Philadelphia, Pa. 19103.

Those wishing information on other aspects of the program and accommodations should contact Jerome M. Bijur, 135 Seventh Ave. N., Naples, FL 33940. Information on meeting details will be sent to AMU members as it becomes available.