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THE MOLLUSCAN FAUNA OF THE BIG VERMILION RIVER, ILLINOIS

With Special Reference to its Modification as the Result of Pollution by Sewage and Manufacturing Wastes

WITH FIFTEEN PLATES

BY
FRANK COLLINS BAKER

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With Special Reference to its Modification as the Result of Pollution by Sewage and Manufacturing Wastes

WITH FIFTEEN PLATES AND ELEVEN TABLES

BY

FRANK COLLINS BAKER

Curator of the Museum of Natural History

University of Illinois

Contributions from the

Museum of Natural History of the University of Illinois

No. 22

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INTRODUCTION

The present paper embodies the result of investigations of the mollusk fauna of one of the smaller rivers of the State of Illinois, the Big Vermilion, carried on during the years 1918 to 1920. To this are added notes on another river, the Sangamon, for comparison. While all groups of mollusks were considered, special emphasis has been placed on the Unionidae or pearly fresh water mussels (Naiades), on account of their abundance, their significance in matters of geographic distribution, and their importance from an economic standpoint, as raw material from which pearl buttons are made.

For a number of years, the United States Bureau of Fisheries has been engaged in conducting a series of investigations of several rivers of Illinois and Indiana, for the purpose of ascertaining the mussel resources of these streams. In view of the rapid depletion of the supply in the larger rivers (Mississippi, Ohio, Illinois) it becomes necessary to search the smaller streams to replenish the older beds. The Maumee and the Kankakee (Wilson and Clark, 1912), as well as the Illinois (Danglade, 1914), have recently been rather carefully surveyed with interesting and important results.

It was thought that a somewhat similar investigation of the Big Vermilion River would be of value. The scope of the investigation included everything that appeared to affect the molluscan life of the river, physical characters, pollution, general relation and number of species. It was believed, also, that the Big Vermilion, as well as other smaller streams in the State, might provide good breeding stock with which to carry on artificial glochidial infection of fish, and the results seem to warrant the assumption. It will be necessary to make more or less detailed surveys of all of the smaller rivers and their tributaries, and the present paper may be considered a contribution toward this end, covering fully the Big Vermilion from its upper waters to the vicinity of Danville, a distance of about forty-five miles by stream. A portion of the Sangamon is considered, and this river may also prove a valuable source of mussel material.

Little has been done by field naturalists in the study of the distribution of the molluscan fauna of a stream from the headwaters to the larger portions of these rivers. Perhaps the most thorough and notable study of this character was carried on by Adams (1900, 1915), on the genus Io in which the Tennessee River and its tributaries (Powell, Clinch, Holston, French Broad, Nolichucky, etc.) were studied from sources to Chattanooga.

Ortmann has made a study of the distribution of the Naiades in the streams of Tennessee from this standpoint, using material collected by Adams (Ortmann, 1918); and Wilson and Clark (1912) have added greatly to our knowledge of the comparative distribution of the mussel faunas of the Kankakee and Maumee rivers.

Studies of this kind bring out the fact that certain species are characteristic of the upper reaches of a stream while others are found only in the lower part. Barriers, such as falls and polluted water, are also seen to have a large influence on the distribution of mollusks, especially river mussels. The same species may also vary in size or shape in different parts of the stream, as noted by Ortmann (1920). In fact, a true picture of the characteristics of the fauna of a river or smaller stream can be gained only by this method, which the present paper clearly shows.

The Salt Fork of the Big Vermilion is a striking example of the ill effect of sewage and other pollution on the fauna of a stream. It was carefully studied from this standpoint in order to determine accurately the distance that the polluted stream must flow before a normal fauna can establish itself, and to ascertain the relative effect of pollution on different species of mussels as well as on other aquatic animals. Mussels and crayfishes are considered good indicators of the measure of pollution in a stream and the absence of both of these groups of animals from the upper part of the Salt Fork is ample evidence of the septic condition of this stream.

The work was largely carried on during the months of August, September, and October, when the water was low. Collecting was done by wading in the stream as deep as hip rubber boots would permit. In the shallow water (up to two feet in depth) the entire bottom was gone over with the hands, and the mussels and other mollusks thus picked from the bottom of mud, gravel, and sand. Samples of all mollusks, as well as associated animals of the other groups, have been preserved in the Natural History Museum of the University of Illinois.

The different areas of the region studied are covered by three maps of the United States Geological Survey, the Mahomet, Champaign, and Danville Folios, and on these the stations recorded in this paper may easily be located.

ACKNOWLEDGMENTS

The writer is greatly indebted to Professor Frank Smith, not only for invaluable assistance in collecting much of the material upon which the paper is based, but also for many notes on the distribution of the Naiades and other mollusks in the two river systems. Professor Smith has studied the fauna of the Salt Fork and the Sangamon streams for many years, collecting from them at different times of the year. His classes in zoology have visited Homer Park yearly for a long period and thus the mollusk

fauna of this locality is better known than that of any other part of the stream.

To Professor Smith the writer is also indebted for the identification of the worms and crayfish, and the determination of the animal life in the samples of bottom sludge from the polluted part of Salt Fork. The sincere thanks of the writer are due to the persons noted below; the group of animals or plants which they have identified is indicated: Dr. Charles P. Alexander, *Coleoptera* and other insects; Dr. Edward Bartow; Dr. Stephen A. Forbes; Mr. Calvin Goodrich, *Goniobasis*; Dr. George M. Higgins; Mr. John Malloch, *Diptera*; Dr. J. Percy Moore, *Hirudinea*; Professor James E. Smith; Dr. E. N. Transeau, *Algae*; Dr. Victor Sterki, *Sphaeriidae*; Dr. Harley J. Van Cleave; Dr. Bryant Walker, *Ancylidae* and other mollusks.

PHYSICAL FEATURES OF THE BIG VERMILION BASIN

The Big Vermilion River drains about 1,500 square miles in Champaign, Ford, and Vermilion counties in Illinois and a small portion of Warren and Fountain counties, Indiana. The North Fork also drains from a small territory in the southeastern part of Iroquois County, Illinois. The main stream, known as Middle Fork, rises in the southern part of Ford County near the town of Melvin, in the Bloomington morainic system, at a height of 800 feet above sea level. Its course is southeastward, between the hills of the moraine known as the Roberts and Melvin ridges, passing through the latter and uniting with a tributary known as the West Branch of the Middle Fork, which also rises at an elevation of 800 feet in the Roberts ridge. At Potomac, the stream turns southward, cuts through the outer ridge of the Bloomington moraine and crosses the plain of the Champlain till sheet, uniting with the Salt Fork about six miles west of Danville.

The largest western tributary, known as the Salt Fork, rises in the till plain in the north-central part of Champaign County, near Thomasboro, at an elevation of about 740 feet above the sea. It drains the till plain lying between the Bloomington moraine on the north and the Champaign moraine on the south. It flows in a south and east direction for about 55 miles[1] and unites with the Middle Fork as described above. A large tributary of Salt Fork, known as Spoon River[2] rises in the northeastern part of Champaign County, in two branches, not far from the outer ridge of the Bloomington moraine. Its general course is southward for a distance of about ten miles, where it unites with the Salt Fork near St. Joseph.

Another large tributary is known as the North Fork, which rises in the southeastern corner of Iroquois County in the inner ridge of the Bloomington moraine. It flows southward, cutting through the middle and outer ridges of the moraine, crosses a part of the Champaign till plain and unites with the Big Vermilion at Danville. This tributary has a length of about 40 miles. From Danville the larger stream flows southeastward for about 20 miles, crossing a part of Vermilion County, Indiana, and empties into the Wabash River 10 miles from the Illinois State line.

The basin of the Big Vermilion River lies in or is surrounded by glacial moraines of the Early Wisconsin glaciation, the Bloomington moraine on

[1] Length of rivers designates total length including all meanders.

[2] Not to be confounded with Spoon River entering the Illinois River near Havana, Mason County.

the north and the Champaign moraine on the south. In its course it cuts through the Bloomington moraine in several places. The territory drained includes a small part of the Bloomington till plain and a considerable part of the Champaign till plain (Leverett, Illinois Glacial Lobe, plate VI.) As there are no outcroppings of rock in this area the streams have cut well defined, though meandering, channels. The upper, small, creek-like tributaries have sunk their beds but a few feet below the general level of the country, but lower down, the stream, after receiving several large tributaries, has cut its bed to a depth of ten or fifteen feet. In Middle Fork and North Fork, and in the Big Vermilion from above Middle Fork to the Wabash, the river has cut deep canyons upwards of 200 feet in depth, which produce some of the most picturesque scenery in the State of Illinois. This river valley varies from half a mile to a mile in width and in one place, about four miles below Danville, it widens to form a large amphitheater two miles wide and a mile long, with cliffs and hills rising on all sides to a height of over 150 feet.

Outside of the stream valleys the country is a flat till plain, largely devoted to crop purposes. Ridges, made up of the Champaign and Bloomington moraines and their branches, occur and have been largely instrumental in directing the course of some of the stream drainage. The Salt Fork turns to the north after leaving Urbana, and passes around Yankee ridge (a branch of the Champaign moraine) near the Brownfield woods, and spurs from the Champaign moraine occur in several places on the west and south banks of the Salt Fork, which are relatively high and the stream skirts their bases.

The bottom of the main stream and its tributaries varies greatly. The small tributaries mostly have mud bottoms. In Spoon River the bottom is of mud in most places and the water is of considerable depth, even in summer (three to four feet maximum in August). In places there are riffles where the water is very shallow (a foot or less) and the bottom here is of sand and fine gravel. The Salt Fork below St. Joseph is made up of stretches of stream where riffles with sand and gravel bottom alternate with deeper back water with mud bottom. Near Muncie there are outcrops of rock, a small tributary, Stony Creek, flowing over a stony bed. In the Middle Fork, shale rock outcrops in several places, notably below the interurban bridge, where the whole bottom is composed of a sheet of rock with a thin coating of sediment in spots. The same conditions are found in parts of the North Fork and in the Big Vermilion. These varying conditions provide the most favorable environment for the growth of river mussels, a fact made evident by the large naiad fauna found in the stream despite the unfavorable effects of sewage and waste pollution.

Natural dams occur in a few places in the Salt Fork, caused by the accumulation of débris which has lodged against the trunk of a tree that has fallen across the stream. At Homer Park, an artificial dam about five feet in height causes slack water for several miles up the stream. This dam markedly affects the mollusk fauna, the tumbling of the water over the dam mixing air with the polluted water and providing the dissolved oxygen so necessary to naiad life. It is probable that the large number of species of mussels found at some stations above this dam is due largely to the presence of sections of the stream where riffles provide the oxygenating agent. Mussels were usually found in or near such habitats. The mussel fauna below the Homer Park dam numbers 28 species while above the dam, as far up stream as Sidney, only 17 species occur, 10 species not passing the barrier, although the environment does not differ essentially. The current in the river is rapid over the riffles but rather sluggish in the deeper places. The difference between high and low water (spring and fall) is about six feet. The streams usually vary in width from ten to thirty feet.

In the late summer and fall the small tributary streams (creeks and rivulets) flowing into Salt Fork and other branches of the Big Vermilion are usually either dry or contain scattered pools of water throughout their length. They do not contribute any water, therefore, to the larger stream at this time of the year. The mollusks living in these tributaries bury themselves in the mud during this period of dry bottom and hibernate. Many die at this time.

The banks of the stream valleys, exclusive of the small tributaries, are for the most part high and well wooded especially where the valley floor is wide enough to permit meandering, in which cases the flat floodplains are abundantly wooded. These flat areas vary from a few hundred feet to a half mile in width. About two miles above Sidney an island has been formed by the forking of the stream, the area embraced being about 650 by 1200 feet. At this place the right bank is 20 feet high and the left bank quite low. The presence of fossil shells indicates that the island was probably the result of silt accumulation during a long period of time. The wooded banks of the stream alternate with farm lands, some in pasture and others in crops. Many of the crop lands have a fringe of timber bordering the stream. That the stream is high and powerful during the spring when it is in flood is evidenced by the tangled mass of logs and other woody débris which thickly cover the flood plain areas along the valley. Such conditions were especially noted between Sidney and Homer Park.

The current varies somewhat, being relatively sluggish in the backwater above dams and riffles, but quite swift over the shallow places. During the flood periods of spring and early summer the current is quite swift and in places becomes torrential. This condition is indicated by the large number of trees which have been thrown on the flood plains far above the margin of low water. As measured during the month of October the current in the Salt Fork at Urbana and a few miles down the stream had a velocity of from half a mile to a mile an hour. The water was very low when these measurements were taken by the State Water Survey. In its course of 90 miles to the Wabash River, the Big Vermilion River falls about 320 feet or 3½ feet per mile. It thus has a greater fall than either the Kankakee, which is 300 miles long and has a fall of 250 feet, or less than a foot per mile, or the Maumee River, which has a length of 150 miles and a fall of 154 feet, or about a foot per mile (Clark and Wilson, 1912).

The water in the normal parts of the stream is usually clear at depths of one to two and a half feet, especially on the riffles. This condition was noted in Salt Fork east of Sidney, and in the Middle Fork. Above Sidney, except where the water is very shallow, the stream is murky and laden with fine silt. During times of high water the stream is in this condition in all parts of the Big Vermilion. The upper part of Salt Fork, from Urbana to a point six or eight miles down stream is always more or less brownish in color from the large amount of sewage, equalling as much as a third of the total volume, and putrient matter as well as an oily scum is usually to be seen on the surface. The shore of the stream is rendered very unsightly by the mass of filth that is despoiled above the usual level by high water. At St. Joseph, ten miles from Urbana, much the same condition is found.

The upper part of the Salt Fork has been greatly modified by ditching and dredging. North of Urbana for the distance of a mile and a quarter above Crystal Lake Park a large ditch carries the surface drainage in a straight line to the park thus cutting off the tortuous windings of the original stream bed, which have been left as long, narrow, shallow ponds, reminding one of the 'ox-bows' so common in the valley of the Mississippi River. The bed of this ditch is about six feet below the general level of the surface. For several miles above this ditch the original stream has been deepened by dredging and the bed is now pretty generally five or six feet lower than that of the original stream.

From Crystal Lake Park, Urbana, to a point near St. Joseph, the stream has been ditched to straighten the bed, leaving numerous 'cut-offs' of the old stream bed. This canal permits a better flow of water for the disposal of the sewage. Where not ditched the stream bed has been deepened. The ditching has greatly modified the original stream bed, providing a new and different kind of environment for the mussels and other aquatic life. It is probable that all of the old fauna was exterminated during the ditching operations and the sewage pollution provides an unfavorable environment, which the aquatic bottom life does not seem able or inclined to enter. The effect of sewage pollution may be seen all the way down the stream from the source of contamination. At St. Joseph, where the stream bed has not been modified, conditions are very bad, the mud in the bottom being filled with gas forming bacteria which are constantly causing bubbles of gas to break at the surface of the water. Were it not for the sewage pollution, the stream at this place would be quite normal for the life of mussels and other bottom animals. (See the chapter on sewage pollution.)

Several other river systems have their beginning near Urbana and Champaign, on the southwest side of the Champaign moraine. These are the Embarras, which has tributaries rising south of Urbana; the Kaskaskia, which has its inception northwest of Champaign near the village of Rising; the Little Vermilion, which rises in the southeastern part of Champaign County; and the Sangamon, which rises in the extreme northwestern part of Champaign County not far from Gibson. Only the last stream has been examined for its mussel fauna for the purpose of making comparisons with the fauna of the Big Vermilion River.

The Sangamon River has a length of about 180 miles and a drainage basin of some 5670 square miles. It rises on the south side of the Bloomington moraine in McLean County, at an elevation of 850 feet above sea level, and cuts through two moraines in its course, the Champaign and the Shelbyville. The river channel is tortuous and meandering and the flood plain in many places very wide. The banks of the stream are low for the most part and wooded in spots. The stream has been examined carefully at only two points, Mahomet and west of White Heath, the first locality receiving the most attention. Near Mahomet the river is notably meandering, the banks are high, the Champaign moraine rising 90 feet above the water level near the village. The river bank is usually five or six feet above the stream, which has cut vertical cliff-like banks in many places. Below Mahomet the woodlands are abundant, extending well back from the river in some places. The river varies in width from 40 to 50 feet. The bottom alternates between riffles with sand and gravel bottom and deeper back water stretches with mud bottom. The former habitats are a foot or so in depth and the latter habitats two to four feet in depth in the summer. In the spring the river is ten to twelve feet deep and very swift, at times becoming torrential. The average fall of the stream is 2.3 feet per mile. Many logs and other débris thrown up on the flood plains attest the power of the river during spring floods.

West of White Heath, for a mile above the I. C. railroad bridge to two miles below, the river has been examined, though no systematic collecting comparable to that carried on at Mahomet has been done. The stream in the portion of the river valley examined is similar to that near Mahomet in its general physiographic features. The banks of the stream are on the whole lower than farther up the river near Mahomet. Studies of this stream similar to those carried on in the Big Vermilion and its tributaries would doubtless yield interesting and valuable results. The Sangamon is a characteristic mussel stream and should contain a much larger mussel fauna than at present known and listed.

GENERAL BIOLOGY OF THE BIG VERMILION RIVER

Although the chief purpose of the study of this stream was to ascertain the general conditions and distribution of the fresh water Mollusca, especially the Naiades or river mussels, such attention was given to other groups as came easily under observation. At least one of these groups bears an intimate relation to the Naiades in the matter of distribution as restricted by pollution, e.g., the crayfishes, and another, the fish, is closely related to the breeding habits of the mussels. Others, as some of the oligochaete worms, are especially characteristic of polluted waters. A few notes are given under each group.

The Protozoa and other microscopic groups are omitted because given little or no attention, except in the polluted part of Salt Fork. These are mentioned in the section on sewage pollution. The Big Vermilion and its tributaries present a wide field for the study of other kinds of aquatic life that are especially characteristic of the upper reaches of a river system

PLANTS

The larger aquatic plants were notably scarce in most parts of the Salt Fork. In several places in Salt Fork, especially near Sidney, between the cement and railroad bridges, the shores are lined with the spatterdock, *Nymphaea advena* Ait (see Fig. 11). The cat-tail, *Typha latifolia*, Linn., is common in various stretches of the stream, bordering the shore. The arrow-head, *Sagittaria latifolia* Willd., and the larger blue flag, *Iris versicolor*, Linn., were observed along the shore in many places. The water willow, *Dianthera americana* Linn., is abundant in the shallows in many parts of the Salt Fork below Homer Park. *Elodea canadensis* Michx., was abundant at Homer Park.

Filamentous algae occurs in many places, attached to submerged objects. Among these Cladophora and Spirogyra were noted. Septic algae growing in the polluted portion of Salt Fork are noted under the section on pollution of the stream.

WORMS

Nematoda. *Gordius robustus* Leidy, was collected in several places in Salt Fork between the first bridge below St. Joseph and the bridge above Sidney. It was found in mud bordering the shore, in shallow water. A number of minute nematodes were observed in the sludges of the bottom in Salt Fork between Urbana and St. Joseph. These were not identified.

Oligochaeta. These aquatic earthworms were abundant in places along the shore of Salt Fork. *Sparganophilus eiseni* Smith occurred in abundance in the mud on the margin of Salt Fork at Homer Park, and immature worm of this genus, as well as cocoons, were collected from near the bridge below St. Joseph to the bridge above Sidney. A single specimen of *Helodrilus chloroticus* (Savigny) was collected in the Salt Fork near St. Joseph. This species has not heretofore been recorded from Illinois and its occurrence at this locality adds another species of earthworm to the State list (see Smith, 1915:557). Limnodrilus was abundant in bottom sludges from the Salt Fork, from Urbana to near St. Joseph. Tubifex was also found, but not as abundantly.

Hirudinea. Two species of leeches occurred in several places in Salt Fork, below St. Joseph. They were nowhere abundant. The two species are: *Erpobdella punctata* (Leidy) Moore and *Placobdella rugosa* (Verrill) Moore.

CRUSTACEA

Three species of crayfish (Cambarus) were determined by Professor Smith from the material collected in Salt Fork and other parts of the Big Vermilion River. The most abundant was *Cambarus propinquus* Girard, which was found commonly from bench mark 655 to the Big Vermilion River below Middle Fork. It is especially abundant in the latter place where an individual may be found under every piece of stone. The same species was abundant in Stony Creek and in the Salt Fork near Muncie.

Cambarus blandingi acutus Girard, both young and adult, occurred in the upper parts of Salt Fork, but preferred a mud bottom rather than a rock bottom. *Cambarus immunis* Hagen was collected only at bench mark 655 where it was rare.

It will be noted that Cambarus is first met with about two miles below St. Joseph and twelve miles from Urbana. The only ones seen here were dead. Living crayfish begin to appear in abundance about six miles below St. Joseph or sixteen miles below Urbana. Crayfish and mussels both become common or abundant at about the same time, viz., fourteen and sixteen miles below the source of sewage pollution at Urbana. This agreement in distribution indicates the close relationship between these otherwise diverse groups of animals, as regards resistence to septic conditions, neither being able to thrive under pollutional conditions of the bottom.

AQUATIC INSECTS

Aquatic insects are doubtless abundant during spring and early summer in the lower parts of Salt Fork and in the Big Vermilion River. A few species were collected incidentally at some of the molluscan stations. These are listed in Table I, in the order of their occurrence in the stream.

It will be noted that the nymph and larval forms of most species appear coincident with the degree of sewage pollution. Chironomus and Libellula are, seemingly, able to accommodate themselves to the contaminated or polluted condition of the water in the neighborhood of St. Joseph. The adult beetles, breathers of free air, are not affected directly by these unfavorable conditions and occur in great abundance, even in the heavily polluted parts of Salt Fork above St. Joseph. The Ephemerids occur for the most part far down the stream where the water is at most only contaminated. The Neuroptera and Plecoptera are clean water forms and were found only in the Middle Fork which does not carry sewage. These are also to be found, probably, in the Big Vermilion below Middle Fork, but no attempt was made to discover these animals when that part of the stream was examined.

TABLE I. DISTRIBUTION OF INSECTS

	Old River bed	St. Joseph	Bridge below St. Joseph	Bench mark 655	Mile above iron bridge near Sidney	Iron bridge	Middle Fork
Diptera							
Chironomus decorus Joh., larva	x	x	x	....	x	....	....
Odonata							
Libellula pulchella Drury, nymph	x	x	....	....	....	....	....
Coleoptera							
Gyrinus analis Say, adult	....	x	....	....	....	....	....
Dineutes assimilis Aubé, adult	....	x	....	....	....	....	....
Cnemidotus 12-punctatus Say, adult	....	x	x	....	....	....	....
Laccophilus maculosus Say, adult	....	x	....	....	....	....	....
Copelatus glyphicus Say, adult	....	x	....	....	....	....	....
Hemiptera							
Corixa, nymph	....	....	x	....	....	x	....
Diptera							
Cricolopus trifasciatus F., larva (?)	....	....	x	....	....	....	....
Ephemerida							
Hexagenia bilineata Say, nymph	....	....	....	x	....	....	....
Heptagenia, nymph	....	....	....	....	x	....	....
Trichoptera, larva	....	....	....	....	....	x	....
Odonata							
Ophiogomphus, nymph	....	....	....	....	....	....	x
Neuroptera							
Corydalis, larva	....	....	....	....	....	....	x
Plecoptera							
Perla, nymph	....	....	....	....	....	....	x

HIGHER VERTEBRATES

Vertebrates characteristic of aquatic environments were fairly common in most parts of the Big Vermilion River valley. Three species of turtles were observed: the western painted terrapin (*Chrysemys cinerea* Bonnaterre), the snapping turtle (*Chelydra serpentina* Linn.) and the soft shelled turtle (*Platypeltis spinifera* LeSusur). The garter snake (*Thamnophis sirtalis* Linn.) was observed swimming across the stream in several places. The fox snake (*Elaphe vulpinus* Baird and Girard) was seen on several occasions near the margin of Salt Fork above St. Joseph. Frogs, among which the pickerel frog (*Rana palustris* LeConte) was noted, were abundant in many places, and tadpoles of all ages were abundant in both the Big Vermilion and Sangamon rivers.

Aquatic birds were occasionally seen in both river valleys. The little green heron (*Ardea virescens* Linn.) and the great blue heron (*Ardea herodias* Linn.), as well as the American bittern (*Botaurus lentiginosus* Montague) were seen repeatedly, especially in the old river cut-offs between Urbana and St. Joseph. Where high banks occur the kingfisher (*Ceryle alcyon* Linn.) made the woods resound with its rattle-like notes. These birds feed largely on young fish and in this way affect the mussel distribution by reducing the number of fish that may bear glochidia. Shore birds, among which were noted Wilson's snipe (*Gallinago delicata* Ord.), solitary sandpiper (*Helodromus solitarius* Wilson), yellowlegs (Totanus), sora rail (*Porzana carolina* Linn.), and killdeer (*Oxyechus vociferus* Linn.). The pied-billed grebe (*Podilymbus podiceps* Linn.) is seen frequently during spring and autumn on Crystal Lake and in the more pond-like reaches of the Salt Fork. Many of the shore birds feed on mollusks and insects which they find along the shores of the Big Vermilion River system. During migrations, the river valley and its tributaries are fairly alive with birds of all kinds, and at such times the region is well adapted for bird study.

The presence of the muskrat (*Ondatra zibethica* Linn.) is attested by the number of piles of opened mussel shells, the animals of which have provided this mammal with many a meal. In these muskrat piles have been found the shells of many species that are rare or difficult to find alive in the streams.

The abundance of all groups of animal life in the Big Vermilion system indicates that it is a favorable environment for an optimum biota. With the exception of the upper twenty miles more or less seriously affected by sewage pollution, the stream is one of the best collecting grounds in the State, a condition indicated by the very large mussel fauna of thirty-eight species and races, recorded in the following pages.

FISH FAUNA OF THE BIG VERMILION RIVER

The close relationship between the mussel fauna and the fish fauna, through the breeding habits of the former, render a knowledge of the fish fauna of the Big Vermilion necessary. As a large mussel fauna lives in the stream it follows as a corollary that there must also be a fish fauna of comparable size. Fortunately, Dr. S. A. Forbes, caused extensive collections to be made in 1901, and these are listed on the maps accompanying the work on the Fishes of Illinois, by Forbes and Richardson (1908). Fifty species are recorded from the Big Vermilion River and its tributaries (see Table II). It will be seen that at this date 28 species were found below Urbana, in that portion of the stream now heavily polluted.

Between the years 1908 and 1912, the Salt Fork between Urbana and St. Joseph was deepened and straightened and the bottom fauna was completely destroyed. In the canal thus formed, for the purpose of carrying off the sewage of the Twin-Cities, no living clams, crayfish, or other clean water animals have been found, and but one school of young fish (bullheads) was observed during several examinations of this part of the stream. It is possible that during periods of high water in the spring, some hardy fish may venture into this heavily polluted area. Below St. Joseph it is quite probable that some fish are found during high water periods. A few minnows were observed near the station called bench mark 655, about fifteen miles below Urbana. A farm boy reported that bullheads could be caught at high water on set lines.

Below bench mark 655, and for some distance above it, fish must resort in some numbers because of the presence of a fair sized mussel fauna (see Table III). Young mussels, however, were not seen in any number above the Homer Park dam, and it is possible that the upper stream is now little visited by fish suitable for glochidial infection. Below the dam, young mussels are plentiful at all points examined.

Information concerning the species of fish that carry glochidia of the river mussels is still of a fragmentary character. Suber (1912), Howard (1914), and other workers of the U. S. Bureau of Fisheries have published considerable data on this subject, but much more is needed before one can fully understand the relation between mussels and fish.

Three species of mussels living in Salt Fork and other parts of the Big Vermilion River are known to have glochidia encysted on five species of fish, all of which have been reported from the Big Vermilion, viz.:

Mussels	Fish
Lampsilis anodontoides	*Lepomis humilis*
" *anodontoides*	*Pomoxis sparoides*
" *anodontoides*	" *annularis*
Quadrula metanevra	*Lepomis pallidus*
" *pustulosa*	*Pomoxis annularis*
" *pustulosa*	*Ictalurus punctatus*

The abundance of desirable species of mussels in the Big Vermilion indicates that it may serve as a reservoir for button material, the species being easily transported to laboratories anywhere in the state for artificial infection of fish.

TABLE II. DISTRIBUTION OF THE FISH FAUNA IN THE BIG VERMILION

	Above Urbana	Below Urbana	Spoon River	Below Spoon River	Near Sidney	Salt Fork Junction	Middle Fork	Danville	North Fork
Carpiodes diffiformis Cope. Blunt-nosed silver carp	...	x	...	...	x	x	x	x	...
Carpiodes velifer (Raf.). Quillback; Silver carp	...	...	x	x	x	...	x	...	...
Erimyzon sucetta oblongus (Mitchill). Chub-sucker	x	x	x	x	x	...	x	x	...
Minytrema melanops (Raf.). Spotted Sucker	x	x	...	x	x	...	x	...	...
Catostomus commersonii (Lac.). Common Sucker	x	x	x	x	x	x	x	...	...
Catostomus nigricans (Le Sueur). Hog sucker	...	...	...	...	x	x	x	x	...
Moxostoma aureolum (LeSueur). Common red-horse	...	x	...	x	x	x	x	x	...
Moxostoma breviceps (Cope). Short-headed red-horse	...	x	...	...	...	...	...	...	...
Campostoma anomalum (Raf.). Stone-roller	x	x	x	x	x	x	x	x	x
Hybognathus nucalis Agassiz. Silvery minnow	...	...	x	...	...	...	x	...	...
Pimephales notatus (Raf.). Blunt-nosed minnow	x	x	x	x	x	x	x	x	
Semotilus atromaculatus (Mitchill). Horned-dace	...	...	...	x	...	...	x	x	...
Abramis crysoleucas (Mitchill). Golden shiner	x	x	x	x	x	...	x	...	...
Cliola vigilax (B. & G.). Bullhead minnow	...	...	...	...	...	x	x	x	...
Notropis cayuga Meek. Cayuga minnow	...	...	...	x	...	...	...	...	x
Notropis blennius (Girard). Straw-colored minnow	x	x	x	x	x	x	x	x	x
Notropis illecebrosus (Girard). Minnow	...	...	...	...	...	...	x	x	x
Notropis whipplii (Girard). Steel-colored minnow	x	x	x	x	x	x	x	x	x
Notropis cornutus (Mitchill). Common shiner	...	x	...	...	...	x	x	x	x
Notropis atherinoides Raf. Shiner	...	...	...	x	x	x	x	x	...
Notropis umbratilis atripes (Jordan). Blackfin	...	...	x	...	x	x	x	...	x
Ericymba buccata Cope. Silver-mouthed minnow	x	x	x	x	x	x	x	x	x
Phenacobius mirabilis (Girard). Sucker-mouthed minnow	...	x	x	x	x	x	x	x	x
Hybopsis amblops (Raf.). Big-eyed chub	...	...	...	x	x	x	x	x	x
Hybopsis storerianus (Kirtland). Storer's chub	...	...	...	...	...	...	x	...	...
Hybopsis kentuckiensis (Raf.). River chub	...	...	...	...	...	...	x	x	x
Ictalurus punctatus (Raf.). Channel-cat	...	...	...	x	...	x	x	x	...
Ameiurus natalis (LeSueur). Yellow bullhead	x	...	x	...	...	...	...	...	x
Ameiurus melas (Raf.). Black bullhead	x	x	x	x	...	...	x	...	x
Noturus flavus Raf. Stonecat	...	...	...	...	...	..	x	..	x
Schilbeodes gyrinus (Mitchill). Tadpole cat	x	x	x	x	x	...	x	...	x
Schilbeodes murus (Jordan). Brindled stonecat	...	...	...	x	x	x	x	x	x
Esox vermicularis Le Sueur. Little pickerel	x	x	...	x	...	...	x	...	x
Fundulus notatus (Raf.). Top minnow	x	x	x	x	x	...	x	...	x
Labidesthes sicculus (Cope). Brook silversides	x	x	...	x	x	x	x	...	...

TABLE II—(continued)

	Above Urbana	Below Urbana	Spoon River	Below Spoon River	Near Sidney	Salt Fork Junction	Middle Fork	Danville	North Fork
Pomoxis annularis Raf. White crappie	...	x	...	...	...	...	...	...	...
Pomoxis sparoides (Lacepede). Black crappie	...	x	x	x	x	...	...	x	...
Lepomis megalotis (Raf.). Long-eared sunfish	x	x	x	x	x	x	x	x	x
Lepomis humilis (Girard). Orange-spotted sunfish	...	x	x	x	x	x	x	x	x
Lepomis pallidus (Mitchill). Blue gill	...	...	...	x	...	...	...	...	...
Micropterus dolomieu Lacepede. Small-mouthed black bass	...	...	...	...	x	x	...	...	...
Micropterus salmoides (Lac.). Large-mouthed black bass	x	...	x	x	x	...	...	x	...
Percina caprodes (Raf.). Log-perch	...	x	x	...	...	...	...	x	x
Hadropterus phoxocephalus (Nelson)	...	x	...	...	...	...	...	...	...
Hadropterus aspro (C. & J.). Black-sided darter	x	x	x	x	x	x	x	x	x
Diplesion blennoides (Raf.). Green-sided darter	...	x	x	x	x	x	...	x	x
Boleosoma nigrum (Raf.). Johnny darter	x	x	x	x	x	x	x	...	x
Etheostoma jessiae (Jordan & Brayton)	...	...	...	x	...	...	...	...	x
Etheostoma coeruleum Storer. Rainbow darter	...	x	x	...	x	x	x	x	x
Etheostoma flabellare Raf. Fan-tailed darter	...	x	x	...	...	x	...	x	x
Total species from each station	19	34	42	28	30	27	21	27	26

TABLE III. DISTRIBUTION OF THE UNIONIDAE IN THE BIG VERMILION RIVER

SYMBOLS
a, abundant
c, common
i, infrequent
1, 2, 3, specimens found
L, living
D, dead
g, gravel
m, mud
s, sand

	Upper Salt Fork	Drainage ditch	Old stream bed	Crystal Lake	Salt Fork, bridge 1	Salt Fork, bridge 2	Salt Fork, bridge 4	Salt Fork, bridge 7	Salt Fork, bridge 9	Spoon River, 1 mile	Spoon River, 2 miles	St. Joseph	Bridge below St. Joseph	Natural dam	Big bend	Below big bend	Bench mark 655	Mile north of iron bridge	Iron bridge, N. of Sidney	Cement bridge, E. of Sidney	Railroad bridge, E. of Sidney	4 miles above Homer dam	3½ miles above Homer dam	2 miles above Homer dam	Below Homer dam	Below Homer dam	South of Muncie	Stony Creek	Salt Fork junction	Middle Fork	Big Vermilion River	Near Danville
Station number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	25	26	27	28	29	30	31
Character of bottom	m	m	m	m	sg	sg	sg	sg	sg	m	m	m	m	m	m	m	m	sg	s	m	s	s	sg	s	m	sg	sg	sm	sg	sg	sg	....
Depth of water (inches)	18	12	15	36	12	10	15	12	12	18	18	18	20	18	18	20	16	18	18	20	16	15	12	15	20	15	10	10	10	12	10	....
	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D	L D
Carunculina parva	c ..		.. 1	c ..						i ..							.. 1	a ..	.. 1	c ..	.. c				c ..		1 ..					
Uniomerus tetralasmus	c ..		.. 1	c ..						1 ..					.. 2													c ..				
Anodontoides ferussacianus	c ..	c ..		c ..						i ..	i ..				1 1		.. 1		1 ..	1 ..					i ..		c ..	a ..		c ..	i ..	
Anodonta grandis		.. i	.. 1							c ..	1 ..					.. 2	i ..	i ..	.. 2	c ..	.. 1		i ..	i ..	a ..	c ..	.. 1					
Anodonta grandis gigantea				a ..																												
Anodonta corpulenta				a ..																												
Uniomerus tetralasmus sayi				i ..																												
Lampsilis luteola										c ..	i ..		.. c			.. 2	i ..	c ..		i ..	i ..	c ..	c ..	a ..	a ..	c ..	a ..	i ..	a ..	a ..	a ..	
Eurynia lienosa										i ..	1 ..		.. 1		.. 1		.. 2	.. 2	1 ..	i ..	.. 2		c ..	c ..	a ..	c ..	i ..	i ..	a ..	c ..	i ..	
Lasmigona complanata										c ..	.. 1		.. c	.. 3		i ..	i ..	a ..	c ..	a ..	a ..	a ..	a ..	a ..	a ..	a ..	.. 1		a ..	a ..	a ..	
Fusconaia rubiginosa										1 ..	.. 1		.. 3			.. 3	2 ..	1 ..	c ..	1 ..	.. c	i ..	i ..	i ..	a ..	a ..	c ..		a ..	c ..	c ..	
Amblema undulata										a ..	a ..		.. a	.. 3		.. 3	c ..	a ..	a ..	1 ..	a ..	c ..	a ..	a ..	a ..	a ..	a ..		a ..	c ..	a ..	
Quadrula pustulosa										1 ..					.. 1		i ..	i ..		.. 1	.. i		i ..	.. i	c ..	c ..	c ..		1 ..		c ..	
Carunculina glans										i ..					.. 1										i ..							
Strophitus edentulus pavonius										.. 1					.. 1		.. i				.. 1		i ..	i ..	c ..	i ..				.. 2	i ..	
Strophitus edentulus													.. 1				.. 1		.. i		.. 1	.. i	i ..	.. 1	c ..	i ..	i ..		.. 2		i ..	
Amygdalonaias elegans																.. 1																
Lasmigona costata																	.. 2	.. c	.. 1		.. 1	1 ..	c ..	c ..	c ..	c ..	c ..	i ..	c ..	c ..	c ..	
Alasmidonta marginata																	.. 1	.. 1			.. 2	1 i	i ..	i ..	c ..	i ..	c ..		1 1	i ..	c ..	
Pleurobema coccineum																	.. 1	.. 2			.. 1		c ..	i ..	c ..	c ..				.. 1	.. 2	
Lampsilis ventricosa																		a ..	.. 1		.. 2		c ..	c ..	a ..	a ..	a ..	c ..	a ..	a ..	a ..	
Anodonta imbecillis																				c ..	.. 2			.. i	c ..							
Lasmigona compressa																							i ..		i ..					2 ..		
Lampsilis anodontoides																									i ..				.. 1	c ..		
Lampsilis multiradiata																									2 ..		c ..			.. 2	c ..	
Actinonaias ellipsiformis																									i ..		i ..				1 ..	
Actinonaias ligamentina																									i ..	i ..	c ..		.. 1	c ..	a ..	
Quadrula lachrymosa																									i ..							
Quadrula metanevra																									i ..		i ..		2 ..	i ..	c ..	
Quadrula metanevra wardii																											1 ..			.. 1		
Rotundaria tuberculata																									i ..	1 ..	.. i				c ..	
Tritogonia tuberculata																									c ..	c ..	c ..			c ..	c ..	
Obovaria circulus																									i ..	i ..	i ..		c ..	a ..	c ..	
Pleurobema clava																									1 ..		a ..			1 ..		
Anodontoides buchanensis																											c ..	i ..			c ..	
Quadrula cylindrica																													1 ..	.. 1		
Eurynia iris																														.. 1		
Truncilla perplexa rangiana																																x ..
Total species	3 ..	1 1	.. 3	6 ..						11 1	5 2		.. 6	.. 2	1 6	1 5	6 8	8 4	5 5	9 1	3 12	6 1	14 0	11 3	28 0	17 0	20 3	7 0	12 3	16 6	20 1	....
Distance in miles from Urbana	....		....		1½	2½	4	6¼	8	10	10	10	12	14	14¼	14½	15¼	16½	17½	19¼	20	22¾	23¼	24¾	27	27	36	36	44	45	46	53
Hours given to collecting	5	10	10	3	5	5	5	5	5	3	4	6	3	4	1	1	5	3	1	2	2	3	2	2	[illegible]	1	2	1	3	4	4	....

TABLE IV. DISTRIBUTION OF SPHAERIIDAE, GASTROPODS, AND ASSOCIATED ANIMALS IN THE BIG VERMILION RIVER

SYMBOLS
a, abundant
c, common
i, infrequent
1, 2, 3, specimens found
L, living
D, dead
g, gravel
m, mud
s, sand

	Upper Salt Fork		Drainage ditch		Old stream bed		Crystal Lake		Salt Fork, bridge 1		Salt Fork, bridge 2		Salt Fork, bridge 4		Salt Fork, bridge 7		Salt Fork, bridge 9		Spoon River, 1 mile	
Station number	1		2		3		4		5		6		7		8		9		10	
Character of bottom	m		m		m		m		sg		sg		sg		sg		sg		m	
Depth of water (inches)	18		12		15		10		12		10		15		12		12		18	
Mollusca	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D
Galba caperata	a																			
Physa gyrina			a		a															
Planorbis pseudotrivolvis					a															
Musculium truncatum					a															
Physa crandalli			a				a													
Planorbis trivolvis			i		c															
Galba humilis modicella			i				c													
Sphaerium striatinum, var			a				c												i	
Sphaerium stamineum							c												i	
Sphaerium solidulum						c	c												a	
Musculium partumeium							i													
Musculium transversum							c													
Ferrissia tardus					x															
Gundlachia meekiana							x													
Campeloma rufum																				2
Ferrissia rivularis																				
Pisidium compressum																				
Pleurocera elevatum																				
Goniobasis livescens																				
Amnicola limosa																				
Galba parva																				
Planorbis antrosus																				
Pisidium kirklandi																				
Pisidium splendidulum																				
Sphaerium species																				
Total species of mollusks	1		5		5	1	8												3	1
Associated Animals																				
Helodrilus species									a											
Chironomus decorus, larva					c															
Libellula pulchella, nymph																				
Gyrinus analis; adult																				
Dineutes assimilis, adult													a		a		a		a	
Cnemidotus 12-punctatus, adult																				
Laccophilus maculosus, adult																				
Copelatus glyphicus, adult																				
Cricolopus trifasciatus, larva																				
Cambarus blandingi acutus																				
Sparganophilus eiseni																				
Tabanus atratus, larva																				
Corixidae nymph																			a	
Erpobdella punctata																				
Placobdella rugosa																				
Hexagenia nymph																				
Cambarus propinquus																			c	
Cambarus immunis																				
Corixa nymph																				
Gordius robustus																				
Trichoptera larva																				
Ophiogomphus nymph																				
Perla nymph																				
Corydalis larva																				
Benacus species																				

	Spoon River, 2 miles		St. Joseph		Bridge below St. Joseph		Natural dam		Below Natural dam		Big bend		Bench mark 655		1 mile north iron bridge		Iron bridge		Cement bridge	
Station number	11		12		13		14		15		16		17		18		19		20	
Character of bottom	m		m		m		m		m		m		m		m		s		m	
Depth of water (inches)	18		12		20		12		18		10		10		6		12		15	
Mollusca	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D
Galba caperata																				
Physa gyrina			2	2	c										c				c	
Planorbis pseudotrivolvis					1	1														
Musculium truncatum																				
Physa crandalli			2				c										3			
Planorbis trivolvis				1	c		c						i		i					
Galba humilis modicella				1												1	2			
Sphaerium striatinum, var														1			i			
Sphaerium stamineum													c		a		a			
Sphaerium solidulum						2							c		i		a			
Musculium partumeium							i										a			
Musculium transversum																				
Ferrissia tardus																				
Gundlachia meekiana																				
Campeloma rufum	i					2		3				3		5	1		1			
Ferrissia rivularis			3								a		i		1		a		a	
Pisidium compressum							i										a			
Pleurocera elevatum												1								
Goniobasis livescens													i							
Amnicola limosa															i		c		i	
Galba parva																		1		
Planorbis antrosus																				1
Pisidium kirklandi																		1		
Pisidium splendidulum																				
Sphaerium species																				
Total species of mollusks	1		3	2	3	2	4	1			1	2	5	2	7	1	10	2	3	1
Associated Animals																				
Helodrilus species																				
Chironomus decorus, larva			a		c		c								c					
Libellula pulchella, nymph			1																	
Gyrinus analis; adult			a																	
Dineutes assimilis, adult			a																	
Cnemidotus 12-punctatus, adult			1				1													
Laccophilus maculosus, adult			4																	
Copelatus glyphicus, adult			1																	
Cricolopus trifasciatus, larva					c		c													
Cambarus blandingi acutus						1									c					
Sparganophilus eiseni			1		1										1					
Tabanus atratus, larva							1													
Corixidae nymph							1													
Erpobdella punctata							c						c							
Placobdella rugosa							c						c							
Hexagenia nymph													2		4					
Cambarus propinquus													1		c				c	
Cambarus immunis													1							
Corixa nymph															1					
Gordius robustus					c												c		c	
Trichoptera larva																			1	
Ophiogomphus nymph																				
Perla nymph																				
Corydalis larva																				
Benacus species																				

	Railroad bridge		4 miles above Homer dam		3½ miles above Homer dam		2 miles above Homer dam		Homer dam (below)		Homer Park		South of Muncie		Stony Creek		Salt Fork junction		Middle Fork		Big Vermilion	
Station number	21		22		23		24		25		25		26		27		28		29		30	
Character of bottom	s		s		sg		s		sg		m		sg		s		sg		sg		sg	
Depth of water (inches)	16		15		12		15		8		18		8		10		10		12		10	
Mollusca	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D
Galba caperata																						
Physa gyrina									a												1	
Planorbis pseudotrivolvis																						
Musculium truncatum																						
Physa crandalli																					c	
Planorbis trivolvis																						
Galba humilis modicella																						
Sphaerium striatinum, var										1											c	
Sphaerium stamineum									i						i							
Sphaerium solidulum		1																				
Musculium partumeium																						
Musculium transversum																						
Ferrissia tardus																						
Gundlachia meekiana																						
Campeloma rufum		3				c					a											
Ferrissia rivularis			c																			
Pisidium compressum																						
Pleurocera elevatum																						
Goniobasis livescens									a				a								a	
Amnicola limosa																						
Galba parva																						
Planorbis antrosus																						
Pisidium kirklandi																						
Pisidium splendidulum													i									
Sphaerium species									a													
Total species of mollusks		2	1			1			4	1	1		2		1						4	
Associated Animals																						
Helodrilus species																						
Chironomus decorus, larva	c																					
Libellula pulchella, nymph																						
Gyrinus analis; adult																						
Dineutes assimilis, adult																						
Cnemidotus 12-punctatus, adult																						
Laccophilus maculosus, adult																						
Copelatus glyphicus, adult																						
Cricolopus trifasciatus, larva																						
Cambarus blandingi acutus																						
Sparganophilus eiseni									a													
Tabanus atratus, larva																						
Corixidae nymph																						
Erpobdella punctata																						
Placobdella rugosa																						
Hexagenia nymph	i																					
Cambarus propinquus	c												a		a				c		a	
Cambarus immunis																						
Corixa nymph																						
Gordius robustus																						
Trichoptera larva																						
Ophiogomphus nymph																			c			
Perla nymph																			c			
Corydalis larva															a				1			
Benacus species																						

GENERAL DISTRIBUTION OF THE MOLLUSK FAUNA

It will be noted in Table III that the mussels were found in greatest abundance in a bottom composed of sand or gravel, or both, and were fewer in number of species, as well as in individuals, on a mud bottom. As a rule the mussels were found in abundance on the shallow riffles and were often absent from the deeper places in which the bottom was composed of soft mud. A notable exception to this rule occurs at Homer Park where the largest mussel fauna is found in a mud bottom, and where this kind of a bottom produced eleven more species (28) than did the sand and gravel riffles a short distance below (17). This station has been used by Professor Frank Smith for many years as a field habitat for his zoology classes and the mussel fauna is, therefore, better known than that of any other locality on the stream. Although visited several times a year for nearly a score of years, there seems no diminution of the fauna in either species or individuals. A day spent at this station, during which two collectors examined the stream, yielded 24 of the 28 species. This indicates the great abundance of the fauna, which may be due in large measure to the aerating influence of the dam situated just above the collecting grounds.

The stream below the dam at Homer Park is an excellent place in which to study the ecological conditions governing the distribution of the mollusk fauna in a small stream. There is first a very shallow stream below the dam (Fig. 14) flowing over gravel and boulders, in which a few gastropods and small bivalves (Sphaerium) live in considerable abundance (Fig. 15). Mussels are rare. Then follows a comparatively deep area of the stream (2–3 feet) flowing over a bed of fine sand or mud in which mussels are abundant and gastropods rare (Fig. 13). This is followed by a moderately shallow stretch of the stream (1–2 feet) which flows over a bottom of coarse sand and gravel in which mussels are found in abundance, although not as numerous in species, as in the mud habitat. A few gastropods live here. These conditions are exceptional in Salt Fork and are not duplicated in any other part of the stream above Danville.

Some species of mussels, as Anodonta, Anodontoides, and Uniomerus, prefer a mud bottom and thrive only in such situations, but the great majority of the naiades prefer a sand or gravel bottom in water with considerable current, and this is the reason they are so abundant in the riffles of all streams. Among the smaller bivalves (Sphaerium and Pisidium), the majority of species prefer a mud or fine sand habitat. Of the snails or gastropods, Pleurocera and Goniobasis are usually found in a rocky (gravel) habitat while Campeloma prefers a mud or fine sand bottom. Physa lives in both mud and on rocks and Ancylus on vegetation or in empty shells of mussels. The ecological preferences of these species, as well as the associated animals, are shown in Table IV.

ECOLOGICAL VARIATION

The 35 species and varieties of Unionidae found in the Big Vermilion River west of Danville show an interesting distribution. Table III clearly indicates that there is a more or less gradual increase in the number of species as the stream increases in size. Taking into consideration both dead and living naiads and ignoring for the time the effect of sewage pollution on the distribution, the increase in species correlated with the increase in distance in miles from Urbana may be expressed in the following table:

Table Number V. Increase in Species with Distance

Station	*No. of Species*	*Distance from Urbana*
Big bend	6	14.25 miles
One mile north iron bridge	12	16.50 "
Railroad bridge	15	20.00 "
Two miles above Homer dam	14	24.75 "
Homer Park	28	27.00 "
South of Muncie	23	36.00 "
Salt Fork junction	15	44.00 "
Middle Fork	22	45.00 "
Big Vermilion	21	46.00 "

The sudden rise in number of species at Homer Park is noteworthy and is due to the exceptionally favorable environment, good depth of water, favorable bottom, plenty of food, and a fully normal supply of dissolved oxygen provided by the dam just above the Park. The dam appears to be an effective barrier to the migration of mussels, and it would also seem difficult for fish to pass the dam, except at very high water, and thus migration in the glochidial stage is rendered difficult or impossible. In the table it may be noted that 17 species occur at five stations, two to eight miles above the dam and 28 species occur below the dam. Seventeen species are common to both areas and 12 species are found below but not above the dam. This distribution is shown in Table VI.

A striking feature of naiad distribution, noted repeatedly in several species, is the conspicuous change in the shape of the shell as the distance from the headwaters of the stream increases. Species that normally have swollen or globose shells in the larger rivers, occur as flat or compressed forms in the headwaters of these streams. An increase in length of shell as correlated with decreased obesity is also noted, and also, a decrease in tuberosity. Ortmann (1920) has recently ably discussed this matter and shows that the rule holds good for many species in widely separated areas; the writer cannot fully agree with Ortmann in reducing so many species of Naiades to varieties on the basis of compression in the headwaters of streams. The *same* species varies in obesity, but it is the same species, whether thin or fat. Other characters are usually present which separate the allied species.

Table VI. Species of Unionidae Found Above and Below Homer Park Dam

Both Above and Below Dam	Below Dam Only
parva	*anodontoides*
ferussacianus	*ellipsiformis*
grandis	*ligamentina*
imbecillis	*multiradiata*
edentulus	*lachrymosa*
pavonius	*metanevra*
luteola	*wardii*
lienosa	*R. tuberculata*
complanata	*T. tuberculata*
rubiginosa	*circulus*
undulata	*clava*
pustulosa	*glans*
costata	
marginata	
coccineum	
ventricosa	
compressa	

In the Big Vermilion this variation in compression is marked in several species. Thus *Rotundaria tuberculata, Pleurobema coccineum,* and Amblema are more compressed than are individuals from the Wabash River below the junction of the Big Vermilion with that river. *Quadrula pustulosa* is smaller than the same species lower down in the Salt Fork, and the same may be said of *Alasmidonta marginata* and *Strophitus edentulus.* That the rule does not always hold good is shown by the variation of *Fusconia rubiginosa* which is abundant in most parts of the Big Vermilion and its tributaries. Measurements are given in Table VII, showing the length and breadth of several species in different parts of the Salt Fork from below Urbana to the Big Vermilion. The percentage of width to length is also shown.

It will be seen that the average index for the first lot is 42 per cent and for the last lot, 46 miles down stream, is almost the same, 45 per cent. These averages compare well with some of those given by Ortmann (1920: 283). It was observed, however, that in the Salt Fork and Big Vermilion the obese individuals occurred with the compressed specimens the former increasing in ratios as the distance down stream increased. The variety *wardii* of *Quadrula metanevra* occurred in two places in Salt Fork but always in company with the typical form. In the cases cited above ecological features cannot be called into account in locating the cause of the compression of the shell, for all live in the same section of the stream under identical conditions. The rule cited by Ortmann, however, seems to be applicable in most cases.

Several species increase in size toward the lower part of the river. This is especially true of *Anodonta grandis*, *Strophitus edentulus*, *Alasmidonta marginata*, *Eurynia lienosa*, *Lampsilis luteola*, *Amblema undulata*, and *Lampsilis ventricosa*. A few others show some increase at different stations. One species, *Uniomerus tetralasmus*, is apparently confined to the upper, smaller tributary streams of Salt Fork. It was common in the ditch north of Urbana; in Crystal Lake, Urbana, in Spoon River; and at Muncie in a small tributary. Two broken valves were found at the station called the natural dam, but these are believed to have been washed into this stream from a nearby tributary which was dry when this part of the Salt Fork was examined (September 25). *Tetralasmus* probably also occurs in the

TABLE VII. VARIATION OF *Fusconaia Rubiginosa*

Length	*Width*	*Per cent*	*Station No.*	*Distance from Urbana*
58	23	39	17	15¼ miles
62	26	42	..	....
61	31	50	..	....
68	27	39	..	....
79	33	42	..	....
86	33	38	24	24¾ miles
89	41	46	..	....
90	31	34	25	27 miles
82	35	42	..	....
89	47	52	..	....
71	30	42	26	36 miles
67	30	44	..	....
102	41	40	30	46 miles
65	30	46	..	....
86	43	50	..	....

upper part of Middle Fork and in North Fork, but the upper parts of these streams have not been examined. The majority of the other species occur at several stations along the Salt Fork and its tributaries and no particular variation in distribution was observed except as already noted.

Three mussel species and varieties were found in Crystal Lake that are exotic as far as the Big Vermilion River is concerned. These are *Anodonta grandis gigantea*, *Anodonta corpulenta*, and *Uniomerus tetralasmus sayii*. These species were artificially introduced into this body of water about 1908 by a member of the zoological department of the University of Illinois. They originally came from a stream in western Indiana. That these mussels found a favorable environment and have thrived during these years is evidenced by the number of fine specimens recently collected when the lake was partly drained. Only the Uniomerus was rare, but one specimen being found. As Crystal Lake is not connected with the Salt Fork stream, these species have not been able to enter the Big Vermilion drainage.

As has been noted in the Illinois River (Forbes and Richardson, 1919), the mussel fauna gradually increases as the distance from the source of sewage pollution becomes greater. In the Salt Fork the fauna becomes normal at about 20 miles from the source of pollution at Urbana. In the Illinois River a normal fauna is not found within 80 miles (Hennepin) of the source of pollution indicating that the quantity of sewage is so great that the river must flow this distance before purifying itself sufficiently for the residence of normal aquatic life. That a normal fauna should be found within 20 miles of the source of pollution in the Salt Fork, though a much smaller stream carrying a smaller amount of sewage, is quite surprising when it is remembered that no large tributaries enter the stream above Spoon River, and indicates that self purification is active. The shallowness of the water (less than a foot on the average in fall and winter) probably provides a larger quantity of dissolved oxygen than would be possible in waters of a deeper stream. It was especially noted that *Amblema undulata* and *Lasmigona complanata*, of the larger species, withstood the absence of water better than any of the other comparable species. These mussels also resisted polluted conditions better than others and this fact is important in connection with mussel propagation for button shells.

COMPARISONS WITH OTHER RIVER SYSTEMS

It is of interest and value to compare the mussel fauna of the Big Vermilion River with that of some other rivers of comparable size and development. The United States Bureau of Fisheries has conducted mussel investigations of several of the rivers of Illinois and adjacent states and one of these, the Kankakee (Wilson and Clark, 1912), may well be compared with the Big Vermilion. The mussel fauna of the Sangamon River is also included, the data given being gathered from several sources, but principally from personal collections and from collections in the Museum of Natural History of the University of Illinois. Some species not listed by Wilson and Clark are included from Baker's Catalog of Illinois Mollusca (1906). These are indicated by an asterisk.

TABLE VIII. DISTRIBUTION OF UNIONIDAE IN THREE RIVER SYSTEMS

	Vermilion	Kankakee	Sangamon
Length of river in miles	90	300	150
Quadrula cylindrica	x	....	....
" *metanevra*	x	x	x
" *metanevra wardii*	x	....	x
" *pustulosa*	x	x	x
" *lachrymosa*	x	x	x
" *ebena*	....	x	x
Tritogonia tuberculata	x	*	x
Amblema undulata	x	x	x
" *peruviana (plicata)*	....	*	....

TABLE VIII—(continued)

	Vermilion	Kankakee	Sangamon
Fusconaia rubiginosa	x	x	x
" *trigona*	....	x	....
" *solida*	....	*	....
Rotundaria tuberculata	x	x	....
Pleurobema clava	x	x	....
" *coccineum*	x	x	x
Plethobasus aesopus	....	x	....
Elliptio gibbosus	....	x	x
Uniomerus tetralasmus	x	....	....
" *tetralasmus sayii*	x	....	....
Strophitus edentulus	x	x	x
" *edentulus pavonius*	x	....	x
Anodonta grandis	x	x	x
" *grandis gigantea*	x	....	....
" *corpulenta*	x	....	....
" *imbecillis*	x	x	....
Anodontoides ferussacianus	x	....	x
" *f. buchanensis*	x	x	....
Arcidens confragosus	....	....	x
Lasmigona compressa	x	x	....
" *costata*	x	x	x
" *complanata*	x	x	x
Alasmidonta marginata	x	x	x
" *calceola*	....	x	x
Ptychobranchus phaseolus	....	x	....
Obliquaria reflexa	....	*	....
Plagiola securis	....	*	....
Amygdalonaias elegans	x	*	....
" *donaciformis*	....	*	....
Proptera alata	....	x	....
Paraptera gracilis	....	*	....
Obovaria circulus	x	....	....
" *ellipsis*	....	x	....
Actinonaias ligamentina	x	x	x
" *ligamentina nigrescens*	....	x	....
" *ellipsiformis*	x	x	x
Carunculina parva	x	x	x
" *glans*	x	*	....
Eurynia recta	....	x	....
" *subrostrata*	....	x	....
" *iris*	x	x	....
" *fabalis*	....	x	....
" *lienosa*	x	x	....
Lampsilis fallaciosa	....	x	....
" *anodontoides*	x	....	....
" *ventricosa*	x	x	x
" *multiradiata*	x	x	....
" *capax*	....	....	x
" *luteola*	x	x	x
" *higginsi*	....	*	....
Truncilla sulcata	....	x	....
" *perplexa rangiana*	x	....	....
Total species in each river	38	48	25

It is noteworthy that with a length of 300 miles and with two tributaries of large size (Iroquois River, 100 miles in length, Yellow River, 65 miles long) the Kankakee River has a mussel fauna only 21 per cent greater than the Big Vermilion River with a length of 90 miles and no very long tributaries. Other species will proably be found in the Big Vermilion below Danville, which was not examined during this survey, and these may bring the total nearer to that of the Kankakee River. The Sangamon River undoubtedly contains many more species than listed in the table, and these will be found when additional collecting is carried on. The table shows that the mussel fauna of the Big Vermilion River is of large size as compared with other streams of similar character.

SYSTEMATIC DISCUSSION OF THE MOLLUSCA

In this chapter the species of mollusks, both Pelecypoda (mussels, clams) and Gastropoda (snails), are discussed in relation to their distribution in the Big Vermilion River, special emphasis being given the Unionidae or river mussels on account of their economic importance. The influence of sewage pollution of the stream on the mollusk fauna is also referred to. The species collected in the Sangamon River at Mahomet and elsewhere are included for purposes of comparison.

The classification followed for the Unionidae is that proposed by Simpson (1900, 1914) and extended by Ortmann (1912, 1918). The sequence of groups is that set forth in Walker's Synopsis recently published (1918). It will be noted that the newer classification necessitates the adoption of several new names, both generic and specific, but these seem, on the whole, justified by the rules of nomenclature and are a natural result of the advancement of knowledge on the subject.

For the purpose of providing reliable data on the particular characteristics of the mussels and other mollusks in this stream for comparison with similar features of this group of animals in other streams, a feature almost totally lacking in the literature, considerable space is devoted to descriptions of the minor variations and pathological conditions of each species in different environments. This has been done, more or less extensively, in several reports on the mussel faunas of three or four of our Illinois, Indiana, and other streams (Wilson and Clark, Danglade). It will be noted that there are certain features characteristic of the species in one stream not shared by the same species in other streams, as, for example, *Lampsilis ventricosa* which differs markedly in coloration and even in shape in the two river systems herein considered. Similar data on our other rivers would provide a body of facts of considerable importance.

FAMILY UNIONIDAE

1. Quadrula (Quadrula) cylindrica (Say). Rabbits-Foot.

This species was not found in the Salt Fork above a point about a mile west of its junction with the Middle Fork, 44 miles from Urbana. As it is not listed from the neighborhood of Muncie its westward extension in the stream lies somewhere between Muncie and Middle Fork. Even in this part of the river it is rare and the specimens obtained are small, of dark color and resemble the form called *strigillatus* by Wright. *Cylindrica* is not a widely distributed species in Illinois, if one may judge by the records at hand. Danglade (1914) did not find it in the Illinois River nor is it listed by other students. It has been reported by several conchologists from the Wabash River (Baker, 1906:79) and the Ohio River, in which streams it is common and of large size and fine color. The species probably would not thrive in polluted water. It was not found in the Sangamon River at the places visited. Owing to its peculiar shape it is not adapted for the cutting of button blanks and is considered worthless by the mussel fishermen.

2. **Quadrula (Quadrula) metanevra** Rafinesque. Monkey-Face.

This naiad is apparently a rare species in Salt Fork occurring sparingly from Homer Park to Middle Fork. It begins to increase in number of individuals near the Middle Fork, where the specimens are also larger and more brilliantly colored. All but one of the specimens collected are typical in form and coloring. Individuals from the Big Vermilion below Middle Fork are larger than those collected above this point. The species is also more abundant. It is found on both a mud and a gravel-sand bottom. Specimens from Homer Park are darker and less conspicuously rayed than those from Middle Fork, and are also less pustulose. *Metanevra* is rare in the Sangamon River, living on both a sand and gravel bottom.

2a. **Quadrula (Quadrula) metanevra wardii** (Lea).

Two specimens referable to this variety have been collected from the Big Vermilion; one near Muncie, in the Salt Fork, and one in the Middle Fork, above its entrance into the Vermilion River. These individuals are more elongated and compressed than the typical form and the tubercles are not as heavy, in fact are reduced to large pustules. Professor Smith has found the variety more common in the Sangamon River than the typical form, and until these two specimens were found in the Big Vermilion drainage, *wardii* was supposed to be the predominant form in the Sangamon while the typical form was believed to be the only form of this species found in the Big Vermilion, at least above Danville. *Wardii* is, as far as present material indicates, very rare in the Salt Fork and other tributaries of the Big Vermilion.

3. **Quadrula (Theliderma) pustulosa** (Lea). Warty-Back; Pimple-Back.

This is the most abundant Quadrula in both the Salt Fork and the Sangamon River, rivalling in number any other mussel species in the lower part of the Salt Fork. It does not occur in any abundance above the Homer Park dam, but below this point it is common, of large size, fine color, and good nacre. The sewage pollution has evidently affected this species as others and, with rare exceptions, only dead shells could be found above the Homer Park dam. Below the dam it occurs commonly and the increase in number of individuals is largely due to the aerating effect of the flow of water over the dam which provides the dissolved oxygen so necessary to these animals. The young shells (20mm. in length) are almost smooth with a broad dark green ray or stripe extending from the umbones to the ventral margin of the valve. No young shells were found in the stream above Homer Park dam and the species may not be breeding in this part of the stream at the present time.

The *pustulosa* from Salt Fork exhibit some variation in the pustulosity of the surface, but all are referable to typical *pustulosa*. A few specimens from Homer Park are more quadrate than the average but are otherwise typical. The individuals from the Sangamon River, however, show considerable variation in both form and pustulosity, ranging from nearly circular to quadrate and from almost smooth to quite pustulose. On an average, however, they are less pustulose than the species occurs in Salt Fork. Individuals might be picked out that could be referred to both *dorfeuillianus* Lea and *schoolcraftensis* Lea, but the range of variation is so great that they seem better referred to *pustulosa*. In the Sangamon River *pustulosa* occurs on a sand and gravel bottom but in the Big Vermilion River it is found most abundantly on a mud bottom. The individuals from Homer Park and the Sangamon River, especially the later, are of good size, 70 to 80mm. in length, and the thickness of the shell combined with the clear pearly luster would seem to make them good shells for the button trade. No evidences of parasitism were observed in the shells examined.

4. **Quadrula (Theliderma) lachrymosa** (Lea). Maple-Leaf.

This handsome shell is very rare in the Salt Fork and was not found at any of the localities in the Sangamon River. In the Salt Fork it has been found only at Homer Park below the dam, and only occasional specimens have been collected here. These are quite typical of the species.

5. **Tritogonia tuberculata** (Barnes). Buck-Horn; Pistol-Grip.

The buck-horn first makes its appearance in Salt Fork at Homer Park below the dam where it is of large size (female 145, male 115 mm.) and fine quality. The shells are densely covered with tear-like pustules which in a few individuals cover the entire surface, though usually confined to the middle and anterior end behind the posterior elevated ridge. Of the specimens collected 40 percent are males. Young specimens 46 mm. in length were found at Homer Park. Individuals from Homer Park are larger than those collected in the Sangamon River, the largest specimens being found on a mud bottom, although it also lives on a sand and gravel bottom. Both the Salt Fork and Sangamon specimens are of good quality from the button makers standpoint.

Abnormalities and pearly growths due to injuries or parasitism are rare in the specimens of this species examined. A few individuals from Homer Park had scattered pin-head pearls and a small patch of discolored blister formation near the anterior and posterior end, one in each end of two specimens.

6. Amblema undulata (Barnes). Blue-Point; Three-Ridge.

This characteristic mussel is the most abundant species in the Vermilion River, greatly exceeding (with the possible exception of *Lasmigona complanata*) in number of individuals all other species. It is also able to resist much of the ill effects of sewage pollution and is the first shell met with in the polluted waters of the Salt Fork. Living specimens, however, were not seen above the station called bench mark 655, a distance of over 15 miles from the source of pollution. Empty shells and odd valves occur more or less abundantly from St. Joseph, 10 miles below Urbana, to the station mentioned. As the species lives in fair abundance in the tributary known as Spoon River, for a distance of over two miles up stream from near the mouth of the stream, it is evident that at one time its distribution was equally continuous in the Salt Fork below the junction of Spoon River with Salt Fork, where now there is a break of nearly six miles. This break in the distribution is in all probability due to the sewage pollution, for the stream is admirably adapted by nature as a habitat for this species and has not been disturbed by dredging.

There is great variation in the form of the shell. Many specimens from the upper part of the stream, both Spoon River and Salt Fork as far down as the natural dam, are almost round with a broad 'wing' above the undulations, which may be reduced in number and form (Fig. 34). These shells may be inflated or rather compressed. Other shells are more quadrate and in occasional individuals the umbones are elevated simulating *Amblema peruviana* (*plicata* of authors). These shells have a black or dark brown epidermis in the adult condition. In Spoon River young shells 25 mm. long were common, but few young specimens were found in the Salt Fork above the Homer Park dam. Shells from the lower part of Salt Fork, below Sidney, are as a rule cleaner, the epidermis is of a brighter, lighter brown and are more uniformly quadrate than those from above Sidney. The largest specimen collected measured 140 mm. in length and this seems to be the maximum size for the *undulata* in this stream. Many of this size were seen.

In the Spoon River, and in the upper part of Salt Fork, injured shells are common. The injuries consist of breaks in the shells and subsequent repairs. In one specimen from the upper part of Spoon River, an injury had been received when the mussel was small which resulted in a deep channel across the right valve (Fig. 29) and a ridge, also slightly channelled, on the left valve (Fig. 30). Another shell had nearly a hundred blister pearls on the edge of the posterior margin of the left valve (Fig. 28) and a large blister pearl about midway of the pallial line in the right valve

(Fig. 27). Still another shell had covered a quantity of mud, which had gotten in between the mantel of the animal and the shell, with a thin layer of pearl, forming a large pad-like blister covering the greater part of the interior of the left valve (Fig. 26). The right valve was normal (Fig. 25). These blister pearls, as well as the more valuable free pearls, are believed to be caused by parasites, perhaps distomids. These injured shells are eagerly sought by the pearl hunters and mussel fishermen in the belief that they may contain pearls of value.

The *undulata* from the Sangamon River also exhibit a wide range of variation in the shape of the shell, but not to the degree seen in the material from the Spoon River and Salt Fork of the Big Vermilion River. In the Sangamon, *undulata* is very abundant on a gravel and sand bottom. In the branches of the Big Vermilion it occurs on both a mud and a sand-gravel bottom. As this species is very successful in resisting adverse conditions it is a valuable mussel for propagation in the streams subject to pollution. It is probably not much affected by a moderate amount of sewage in its environment. The button manufacturers consider it a good shell when the undulations are not too heavy to render the cutting of blanks difficult.

7. **Fuscunaia rubiginosa** (Lea). Wabash Pig-Toe.

This mussel is abundant in the lower part of the Salt Fork. It was not found in any abundance above the dam at Homer Park, where it is abundant, and the large number of dead, empty shells observed attest the presence of an unfavorable environment. As it is rare in Spoon River, where some other species are abundant, it is probable that this species requires fairly deep water and a large stream bed to attain good size and abundance in individuals. This characteristic of distribution was also noted by Wilson and Clark (1912:43) in the Kankakee River where *rubiginosa* was found to be more common in the lower part of the river.

There is considerable variation in the form of the shell; some examples are compressed, others quite inflated. Nearly all are distinctly quadrate, but in some examples the ventral margin is convex; in others it is somewhat concave; while in a few it is straight. The individuals from the upper part of the stream, above Homer Park dam, are usually dark brown with a satiny sheen to the epidermis and are almost rayless. Those from the lower part of the river, especially from Middle Fork, are light yellowish brown, quite distinctly rayed. The nacre varies from white to pink or salmon, but is white in the great majority of specimens collected. Young shells 28 mm. in length were common below the Homer Park dam, but were apparently rare above the dam. This may indicate adverse conditions due to sewage pollution and the species may not now be breeding freely, possibly for lack of suitable fish for the glochidia. Young specimens were also collected in the Big Vermilion River. One of the largest adult individuals found, below Homer Park dam, measured 95 mm. in length; another from the Big Vermilion River measured 103 mm. in length. The species occurs about equally on a mud or sand-gravel bottom.

A single example from Homer Park is worthy of special note. It is large, inflated, almost twice as wide as the average shell of the same size, and is elongate-quadrate in outline. When viewed from within, the valves are basin-shaped. All of the muscle scars are very heavily impressed and the pseudocardinal teeth are much modified and heavier than in normal *rubiginosa*. The lateral teeth are very high, wide and massive. The shell was dead when picked up and badly discolored and notes on the animal, which would have been very desirable, could not be made. The measurements of this shell, together with that of a normal shell of the species, from the same habitat, are given below:

Length, 90;	height, 59;	width, 50 mm.	Z11163 A, Variety.
" 82	" 58	" 36 mm.	Z11163 B, Normal.

This species also occurs in the Sangamon River, but does not, apparently, attain the dimensions of the Salt Fork specimens, nor does it occur as abunantly. There is but slight variation in form in the Sangamon shells. No pathological specimens were observed in individuals from either river. *Rubiginosa* is not much esteemed by either pearlers or mussel fishermen.

Rubiginosa frequently closely resembles *Pleurobema coccineum* in the form of the shell and specimens occur which seem difficult to place satisfactorily. The animals differ in that in *rubiginosa* all four of the gills are used as marsupia while in *coccineum* only the outer gills are so used. As far as the Salt Fork and Sangamon River shells are concerned there has been no difficulty in placing any individual. In this material *rubiginosa* is always quadrate with the umbones large and full, the posterior end of shell is almost sharply truncated and there is a more or less distinct ridge extending from the umbones to the posterior angle of the shell. In *coccineum* the outline is rather ovate, or rounded, there is no posterior ridge and the position of the umbones gives to the shell an oblique appearance which is very characteristic and is absent in *rubiginosa*. The ventral margin in *coccineum* is almost always convex and seldom straight or concave as in *rubiginosa*. The young shell in *coccineum* is also usually more distinctly rayed. The surface of the two species is also different, that of *coccineum* not being 'satiny' as is that of *rubiginosa*. The interior, and even the exterior, of *coccineum* is usually pinkish or salmon colored, although individuals occur with white nacre.

8. **Pleurobema clava** (Lamarck). Club-Shell.

This species is rare in most parts of the Big Vermilion examined, and was not found in the Sangamon. It occurs sparingly at Homer Park, abundantly in the Salt Fork near Muncie, and sparingly in the Middle Fork. At Muncie the largest specimen measured 90 mm. in length. The specimens from the Big Vermilion are beautifully marked with broad green rays on young individuals and on the umbonal half of older specimens. Large individuals are almost rayless.

This species has been previously known only from the Wabash River in Illinois (Baker, 1906:77) and the present records, although in the same drainage basin, extend the range of its distribution.

9. **Pleurobema coccineum** (Conrad). Thin Niggerhead.

The shell known as *coccineum* attains large size in certain parts of the Salt Fork. It is common, however, only at one place, below the dam at Homer Park. No shells of this species were observed above the station called bench mark 655, which is about 15 miles below Urbana. The shells from habitats above the dam at Homer Park exhibit evidence of an unfavorable environment, the shells having heavy lines of growth which on some specimens are raised to form ridges. These are especially marked at the rest periods (seasonal). The individuals from the upper part of the stream are also more or less pathologic, 50 per cent of the shells being abnormal in form or with pearly growths on the inside of the valves. *Coccineum* is found on both a mud and a sand-gravel bottom.

There is considerable variation in the outline and general shape of the shells from Salt Fork. The outline varies from quadrate to roundly ovate and the ventral margin from nearly straight to strongly convex. Young and half-grown shells seem more uniform than large adult shells. The quadrate individuals may easily be confounded with *Fusconaia rubiginosa*. In the last species, however, the shell is more inflated (*coccineum* is compressed), the umbones are directed upward and not backward, as in *coccineum*, and the posterior portion of the shell has a depressed area and a strong ridge which are absent in *coccineum*. The nacre of *coccineum* is pink of various shades, only two specimens from the Salt Fork having white nacre. In this respect the *coccineum* of the Big Vermilion drainage differ almost constantly from *rubiginosa* which has white nacre. The epidermis in specimens from the upper part of the stream (Homer Park and above) is usually very dark brown with faint evidences of rays. In some specimens, especially from the station three and a half miles above Homer Park dam, the whole shell, inside and outside, is of a delicate pink shade. Individuals from the Middle Fork and the Big Vermilion, where the species is rare, are lighter in color. The two largest specimens collected from the Big Vermilion drainage measure as follows:

Length, 96; height, 75 mm. Quadrate form above Homer dam, Z11114 A.
" 96 " 80 mm. Rounded form, Homer Park, Z11164 A.

In the Sangamon River *coccineum* is a most abundant and variable mussel, having a smooth, polished shell on which the rays are many and distinct. It also attains a large size, though not as large as specimens from the Big Vermilion drainage. The shape of the shell is more oblique and eliptical than is the species as it occurs in the Big Vermilion and the shell is a trifle more inflated on the average. So marked is the difference that it is comparatively easy to say from the shape of the shell and the surface markings what drainage a particular individual may have come from. The twelve sets of *coccineum* in this collection indicate in a marked degree the fact that species may differ conspicuously in both sculpture and form in different river systems. The nacre of the Sangamon River *coccineum* is more often white than in the Big Vermilion shells. Pearly secretions or pathologic malformations have not been observed in the specimens from the Sangamon River, indicating, without doubt, a more favorable environment than is provided by the waters of the Salt Fork. Young specimens (25–30 mm. long) are more abundant in the Sangamon River than in the Big Vermilion River, and these individuals are beautifully marked with dark green rays on a yellowish or light brown background. Occasional shells are pinkish. The beak markings on the umbones are especially well preserved in these young specimens.

A large right valve from Mahomet is very peculiar. In outline it is ovate, a trifle oblique. The posteroir portion of the valve is much elongated the hinge line is long and straight, and the posterior margin is sharply, obliquely truncated. The umbonal region is near the anterior margin of the valve. The lateral tooth is longer and straighter than in normal *coccineum*. The shell recalls *Pleurobema clava* but is much larger and differently shaped. The valve measures as follows: length 92, height 70 mm.

Ortmann (1918:549) considers *coccineum* a variety or race of *obliquum* (Conrad), together with *solidus*(=*catillus* Conrad), which is also rated as a variety of *obliquum*. To this disposition the writer cannot agree, the forms here listed as varieties being quite as much entitled to specific rank as are many other forms recognized as distinct species which have marked variation and a similar facies. The whole group of *obliquum-solidum-coccineum* are closely related, but I have seen no good reason after examining a large series in the Hinkley and other collections in the Museum collections, for lumping these species as varieties of *obliquum*. As far as Illinois specimens of *obliquum* and *coccineum* are concerned, the two species seem sufficiently distinct for recognition.

10. Rotundaria tuberculata Rafinesque. Purple Warty-Back.

This species was found at but two places in Salt Fork, at Homer Park and South of Muncie, and in the Big Vermilion below Middle Fork. At the first two places it is very rare, only a few individuals having been found by Professor Smith in a number of years. In a days search at Homer Park by two experienced collectors, only two living specimens and odd valves of two others were found. The largest specimen from Homer Park measures 72 mm. in length and 63 mm. in height. This species is one of the most abundant of shells in the Big Vermilion below Middle Fork, where specimens measuring 100 mm. in length are common. The distribution of this species is a good example of the progressive development of a species in the downward course of a stream, for in the course of about twenty miles the size nearly doubles. Beginning as a rare form at Homer Park it becomes one of the most common forms in the Big Vermilion, twenty miles downstream.

All of the Big Vermilion *tuberculata* are of the compressed type, and the shell is covered posteriorly and ventrally with large tear-like pustules. The anterior third of the valve is free from pustulation. The nacre of all shells seen is rich purple, which renders the species valueless for the button makers. *Tuberculata* does not occur in the portions of the Sangamon River examined.

11. **Elliptio gibbosus** (Barnes). Lady-Finger; Spike.

This mussel does not occur in Salt Fork, nor in any tributaries of the Big Vermilion above Danville that have been examined. It is fairly common in the Sangamon River at Mahomet on a sand and gravel bottom. Young and immature shells are distinctly rayed. The nacre of all specimens examined has been purple, no white-nacred individuals being seen. In the Kankakee River white-nacred specimens occur and become the dominant form in the lower part of the stream (Wilson and Clark, 1912:45). In the Illinois River beds of shells occur which have either a white or a purple interior. (Danglade, 1914:42). This familiar shell will probably have to be known as *dilatatus* (Rafinesque) if the original description is definite enough to identify it as the *gibbosus* of Barnes. *Dilatatus* was described in 1820. It is a pity that these names of Rafinesque could not have been applied earlier to these shells and thus saved the confusion which is now resulting from the changes of the old familiar names which zoologists in our universities have used for years in connection with their classes in systematic zoology.

12. **Uniomerus tetralasmus** (Say).

This species has been found living only in the upper waters of Salt Fork and in Stony Brook near Muncie. It occurs in fair numbers in the stream above Urbana and in Spoon River. Two broken valves were found in Salt Fork at the station called natural dam about 12 miles below Urbana. No living mussels could be found in the stream at this point and it is believed that the odd valves were washed into Salt Fork from a small tributary nearby which was dry at the time of our examination. *Tetralasmus* is a species of the small, mud-bottom tributaries and seems not to occur in the larger part of the stream with the larger and heavier mussels. The largest specimen collected measures 55 mm. in length. The colors of the shells are yellow, black, and greenish, the latter in indistinct ray-form.

12a. Uniomerus tetralasmus sayi (Ward).

Among the Anodontas collected in Crystal Lake is a specimen of the shell known as variety *sayi*. It is large for the species but seems otherwise typical. The dimensions are: length, 123; height, 58; breadth, 38 mm. (No. Z 11369). As only *tetralasmus* is found in the Salt Fork and its tributaries it is probable that this form was introduced with the Anodontas described on a subsequent page.

13. Strophitus edentulus (Say). Squaw-Foot.

This mussel once occurred in nearly all parts of the Big Vermilion River but it is now found in any number only below the dam at Homer Park. No living specimens were found above a point four miles above Homer Park dam or 22 miles below Urbana. It occurs, rarely, living, in Spoon River and its absence in a living state for a distance of 12 miles between this tributary and the first habitat in which it was found alive in Salt Fork is striking and suggestive of the harmful effect of sewage pollution. This species reaches its greatest perfection below the dam at Homer Park on a gravel bottom. *Edentulus* also occurs in the Sangamon River, but the individuals from that stream are not as large and are more compressed than the specimens from Salt Fork, which are as a rule quite corpulent. It is also not as abundant in the Sangamon as in the Big Vermilion. Measurements are given below of the largest specimens from the Salt Fork and the Sangamon.

Length, 90;	height, 54;	width, 41 mm.		Salt Fork, Z11174.
" 89	" 57	" 32 mm.		Sangamon, Z11227 A.

There is great variation among the shells referred to this species. Typical *edentulus* is rhomboid in form, rather inflated, with prominent, inflated umbones; the posterior margin of the shell is usually sharply, obliquely truncated, and the ventral margin is straight or even slightly convex. The color is usually black without rays. From this type the shell varies to an ovate or elliptical outline, a more or less compressed form, with a rounded, convex ventral margin and with an almost total absence of the strong posterior ridge so characteristic of the usual form. The variation is, as would be expected, toward the variety known as *pavonius*. The shells from Salt Fork are very thick and solid, much more so than in specimens from the Sangamon River. The nacre of the majority of specimens is yellowish in color.

13a. Strophitus edentulus pavonius (Lea).

This variety is described by Simpson (1914:348) as "Shell generally long elliptical; epidermis yellowish-green, more or less covered with green or brownish-green rays." In its typical form *pavonius* is easily separable from *edentulus*. The variety is almost as common in Salt Fork as is the typical form and there are many intermediate individuals. It is possible, however, to separate all of the *edentulus* from the different stations, 17 lots, into two groups; one with rhomboid or long-ovate outline and with black or brownish, rayless surface; and the other with long-elliptical outline, brownish surface, and many distinct rays. In *pavonius* the height is less as compared with the length than in *edentulus*. These two forms of *Strophitus* were almost always associated together, indicating their close relationship. On the whole *pavonius* is much less variable than typical *edentulus*. Specimens from the Sangamon River at Mahomet are brilliantly rayed with patches of bright green on the ventral margin of the shell.

Wilson and Clark (1912:48) state that the "question of rays appears to be closely related to clearness of water; in turbid streams mussels are usually dull colored, while in clear streams they are usually brightly rayed." This has been our observation in many cases, but the rayed *pavonius* in Salt Fork occurs with the rayless *edentulus* in quiet water on a mud bottom; both also occur in riffles on a sand-gravel bottom.

Pavonius is credited by Simpson to Ohio and Indiana; it is probably widely distributed in Illinois, but has most likely been listed under *edentulus* in most cases. It is known from Cook County, Will County, and the Wabash River (Baker, 1906:72). Its presence in the Sangamon River indicates that it is also an inhabitant of the Mississippi River drainage, as well as the Wabash and Ohio drainages. It is quite probable that the distribution of the variety is coincident with that of *edentulus*. The nacre of both *edentulus* and *pavonius* is usually yellowish or salmon colored although white-nacred specimens occur. Pearly growths are not as common among the shells of this species as found in the region under consideration as among the same species from other places. A few individuals had blister and pin-head pearls. A specimen each of the type and the variety had a peculiar pearl formation on the pallial line at or near the posterior end of the shell. These are somewhat dome-shaped, about 5 mm. in diameter and 4 mm. in height and evidently were caused by an effort on the part of the mollusk to cover some irritating object, possibly a nematode worm (Figs. 31, 32). As both shells were without the animal (*pavonius* had been alive very recently) this point could not be determined. The *edentulus* was from the railroad bridge east of Sidney (No. Z11098) and the *pavonius* from below Homer Park dam (No. Z11144 A).

14. **Anodonta grandis** Say. Floater.

The floater or paper-shell is more or less abundant in Salt Fork and other parts of the Big Vermilion drainage. In Spoon River it is common, living in the lower part of the stream. From this station to the station called bench mark 655, over five miles below, not a living Anodonta could be found, and the species does not become abundant until the cement bridge east of Sidney is reached, nine miles below Spoon River. This distribution is again indicative of the harmful influence of sewage on the bottom inhabiting animals. From the cement bridge to the Homer Park dam *grandis* is fairly common. It was very rare below the station at Homer Park, at which place it is common. The best habitat observed appears to be between the cement and railroad bridges east of Sidney, where the water is fairly deep in summer (three-four feet) and where there is a soft mud bottom and not much of a current in the stream. The species is typically a pond-inhabiting mussel. Gravid individuals were collected on September 13, 1918.

At Mahomet, on the Sangamon River, *grandis* is abundant and of large size, and occurs on a fine sand bottom. The Sangamon specimens are on the whole more cylindrical in form than those from the Big Vermilion and have a brown or brownish-green epidermis. The Big Vermilion specimens are mostly grass-green in color and are more elongate-ovate in form, the ventral margin being almost universally rounded while in the Sangamon shells this margin is nearly straight. The Sangamon River *grandis* are on the whole more solid than the same species from Salt Fork.

The nacre of the great majority of the Salt Fork specimens is bluish-white, while that of the Sangamon specimens is salmon-colored for the most part. A few individuals from both streams have salmon-colored patches and small pearl growths indicating that the animals had suffered from the attack of distomid worms, possibly the distomid of Osborn, which is known to infest this species in other places (Wilson and Clark, 1912). These shells, however, were rare and infection from this source seem uncommon among the *grandis* of these streams. No *Unionicola* (*Atax*) or other water-mites were observed in this species. These parasites are common in *grandis* inhabiting other streams (Wilson and Clark, 1912: 61–71).

An empty shell from the big bend in the Salt Fork showed evidences of distomid infection in the form of elongated blisters on the ventral margin of the valves, near the pallial line. In the right valve, near the anterior adductor muscle scar, there is a large blister, 8 by 12 mm. which evidently covered a distomid. The left valve of this specimen had suffered an injury when the animal was about two-thirds grown, which has caused a part of the antero-ventral margin to become folded inward, a part of the folded portion having the epidermis well preserved. The animal continued its shell formation so perfectly that from the outside no evidence of an injury is visible. This shell indicates plainly a case of a hard struggle for existence against both mechanical injury and heavy parasitism. The interior of the shell is spotted with grayish patches and salmon-colored streaks (No. Z11029–A). (Figs. 22,23.)

14a. Anodonta grandis gigantea Lea. Floater.

Specimens of an Anodonta from Crystal Lake, Urbana, are apparently referable to Lea's *gigantea*. Simpson (1914:420) diagnoses this variety as "Shell large, ovate or subrhomboid, a little higher in proportion to the length than the type; beaks full and high." The specimens from Crystal Lake agree with this diagnosis. The largest individual measures 152 mm. in length and 92 mm. in height. The umbonal region is more corpulent than in the *grandis* from the other parts of the Salt Fork. The color is brownish or greenish, the two colors frequently in alternating zones on the same specimen. Evidences of distomid infection are common in the form of salmon or pink discolorations and ridges. One individual has many long, thin, curved ridges on the interior of the shell, principally in the left valve. One of these ridges measures 93 mm. in length and 1.50 mm. in height (Fig. 24). Another individual has a round pearl attached to the posterior end of the shell, measuring 5 mm. in diameter. This variety has not been observed in any collections from the Big Vermilion or Sangamon rivers. Marsh has recorded *gigantea* from the Big Vermilion (Baker, 1906:73) but the exact location is not known, and must have been below the points examined by the writer.

15. Anodonta corpulenta Cooper. Floater.

The large Anodontas from Crystal Lake are divisible into two groups; one is the variety of *grandis* described above; the other seems to be the *corpulenta* of Cooper, although the shells are smaller than examples of this species from other rivers. The shells referred to *corpulenta* are subrhomboid, somewhat elongated in a few of the individuals. The umbonal swelling is very pronounced, extending well downward on the shell. The anterior end is broadly rounded and the posterior end is distinctly plow-shaped and rather strongly biangulate. The epidermis is olive or brownish. The surface is very rough, the growth lines in some specimens being elevated into longitudinal ridges. As in *gigantea*, the inner surface is ridged and salmon-colored in many specimens due to the presence of distomid worms. No specimens of this species were seen which did not in some degree show evidences of the work of this parasite. Characteristic measurements of this shell are given below (Z11368):

Length,	127;	height,	82;	breadth,	53 mm.
"	119	"	71	"	58 mm.
"	128	"	70	"	50 mm.
"	111	"	64	"	50 mm.

The large Anodontas in Crystal Lake are apparently not members of the original Salt Fork fauna. Neither *grandis gigantea* or *corpulenta* are found anywhere in the Big Vermilion drainage, at least above Middle Fork, 45 miles below Urbana. Since these shells were planted in the lake (see p. 27) they have evidently thrived and multiplied. *Anodonta grandis footiana* is parasitic in the glochidial stage on the Johnny Darters (*Boleosoma nigrum*, Hankinson, 1908:235) and as this fish also inhabits Crystal Lake it may have been the medium for the propagation of the alien fauna. That this fauna should have been so easily detected as alien is due to the method of examining a stream from its source to its mouth and the distinguishing of the foreign population is a striking recommendation of this mode of stream study.

16. Anodonta imbecillis Say. Paper-Shell.

This beautiful paper-shell occurs abundantly in but one place in the Salt Fork—near the cement bridge east of Sidney. Here it is of good size, grass-green in color, the rest periods showing as black longitudinal bands. The shell is easily known from all others in this State by the very flat umbonal region which is flush with the upper or dorsal margin of the shell. The largest specimen in the collection measures 75 mm. in length. *Imbecillis* was not collected or observed above the cement bridge, 19 miles down stream from Urbana. It was, also, not seen below the bed at Homer Park and it appears to inhabit only that portion of the stream between these points, a distance of about 8 miles. This mussel thrives best on a mud bottom in quiet water and it is not found, normally, on a sand or gravel bottom. It did not occur in our Sangamon River collections.

All of the individuals from Salt Fork bear evidences of distomid infection. In nearly all of the valves there are many small pearl-like blisters about the size of a pin head which are in all cases confined to the posterior two-thirds of the shell. None were noted near the anterior end.

The species is peculiar and almost unique among naiades in being hermaphroditic and in carrying the glochidia within the gills until they are ready for independent life, there being no parasitic stage encysted on fish as in the case of most Unionidae (Howard, 1914:353). It has an almost continuous breeding season, glochidia or embryos having been found in the gills during almost every month of the year. The Salt Fork specimens were gravid on August 26 and contained well formed glochidia. In this mode of reproduction *imbecillis* is parallelled by *Strophitus edentulus*, which also passes through its metamorphosis without parasitism.

17. Anodontoides ferussacianus (Lea). Paper-Shell.

This small naiad was found abundantly in but two places—the Middle Fork and Stony Creek near Muncie. It occurred infrequenty at all other stations. In the upper Salt Fork, north of Urbana, it was common at one time, near Lincoln Avenue, and in Crystal Lake. Two summers collecting failed to find it common at the present time at these places. Living specimens were not found in the Salt Fork betwen Spoon River and the big bend below the natural dam, a distance of over four miles, and it did not occur even infrequently above Homer Park dam, a distance of 17 miles.

All of the specimens collected are fresh, bright colored shells, greenish or olive with distinct grass-green rays. All but one specimen were normal in form and coloration. An individual from the cement bridge station was thicker than usual, had a short truncated posterior end and somewhat resembled small specimens of *Strophitus edentulus.* The beak sculpture was characteristic of Anodontoides. Pearly growths and abnormalities are rare in the shells collected. Gravid females were found September 26 and October 8. It seems to be rare in the Sangamon River, only a stray valve being found in this river near White Heath.

17a. Anodontoides ferussacianus buchanensis (Lea).

Specimens from the Salt Fork near Muncie and from the Big Vermilion are referable to this variety, long known under the name *subcylindracea* of Lea. The variety in the Big Vermilion drainage is more elongate, more cylindrical, and has a less height in comparison with the length than in the typical form. It is also decidedly biangulate behind, a characteristic lacking in the typical form. At the two localities it is associated with *ferussacianus*, but at Muncie it is the prevailing form.

18. Arcidens confragosus (Say). Rock-Shell.

This species is a rare inhabitant of the Sangamon River and is not found in the Big Vermilion River. It was reported from the Sangamon River at White Heath and Monticello by Mr. James Zetek, about ten years ago. Professor Smith has not found it at Mahomet during many years of collecting. Recently (September 1920) a single specimen, dead, was picked up by the writer in the Sangamon River at a point about four miles above Mahomet, thus establishing its presence above White Heath. It probably lives sparingly in the river and may inhabit water too deep for examination. It has been reported from the Sangamon at Springfield (Baker, 1906:74).

19. Lasmigona (Platynaias) compressa (Lea).

This characteristic species is rare in the Big Vermilion River. Several fine specimens were collected from the station three and a half miles above Homer Park in riffles on a sand-gravel bottom. One of these shells is pathologic, the umbones being almost in the center of the shell, the anterior end having a strong depression in front of the umbones. The posterior end is much shorter than usual and is rounded instead of broadly truncate. The interior shows distomid parasitism near the posterior end with a large elongated blister near the postero-ventral margin. The pseudocardinal in the right valve is elongated and thinner than in normal individuals and the lateral teeth in both valves are scarcely visible. In the left valve there is an abnormally high, long and narrow tooth under the beak. There is a pronounced lunule in front of the umbones which is absent in typical *compressa.* This species occurs infrequently in mud at Homer Park. In the Middle Fork a single dead and broken shell was found. No representatives of this species were found in the Sangamon River.

20. **Lasmigona (Lasmigona) costata** Rafinesque. Fluted Shell.

This characteristic mussel is fairly common at most stations visited from bench mark 655 (fifteen miles below Urbana) down the stream to Middle Fork. It probably inhabits the lower Big Vermilion to the Wabash River. Living specimens, however, were not seen above the station four miles above Homer Park dam, nearly 23 miles from Urbana. From Homer Park down stream it is a common mussel. The individuals are for the most part fine, large, heavy shells with good clean lustre. The shells from Homer Park have an olive epidermis beautifully marked with green rays. The largest individual collected measured 145 mm. in length and was found at the station three and a half miles above Homer Park dam (Z11116A).

The majority of the specimens of this species are colored light salmon on the interior of the shell. Pathological individuals are rare in the collections. One specimen from Salt Fork near Middle Fork, found on a sand bottom, has a large pearl blister on the posterior margin. A shell from Homer Park, taken from a gravel bottom, has an injury in the form of a crack in the shell on the outside which had been repaired on the inside by the addition of pearly matter forming a long, raised blister, 45 mm. long and 2 to 5 mm. wide (Fig. 33). This nodulous blister reaches almost to the center of the shell (Z11192 A). Gravid individuals were collected on October 8 and 13, 1920.

The *costata* from the Sangamon River, where the species is common, are somewhat heavier than those from the Big Vermilion River. The shell is also less high in comparison with its length. Young individuals of this species from either river drainage are very rare, judging by our collections.

21. **Lasmigona (Pterosygna) complanata** (Barnes). White Heel-Splitter.

This large, roundish, flat mussel is the most abundant species in the Big Vermilion River, occurring commonly or abundantly in all parts of the stream, excepting a small stretch of about five miles near St. Joseph, from Spoon River to the neighborhood of Danville. It also probably occurs in equal abundance below Danville. The abundance of this species in Spoon River and below the station bench mark 655, with the break of five miles between the beds of living mussels, is strong evidence of the effect of sewage pollution. In this barren area only empty shells and odd valves could be found after careful search; in one place, below the first bridge south of St. Joseph, dead, empty shells were abundant, but a careful search, conducted on two days, failed to discover a single living specimen. The largest and finest shells occur at Homer Park on a mud bottom in water from two to three feet deep. The largest shell from this station, a female, measured: length, 185; height, 130 mm. The species was observed to be gravid on the 6th of November, in 1918, and on October 8, in 1920.

The shells of *complanata* are very uniform in general shape, nacre, and condition. Pearly growths or pathological forms are rare. A few specimens contained small pin-head pearls and an occasional individual had suffered slight injury to the posterior part of the shell. The presence of many young and immature specimens indicates that the species is now breeding well and that the glochidia are finding suitable fish hosts. Young shells from the Sangamon River, where the species is abundant, are more of an olive color and not as green as those from the Salt Fork and other parts of the Big Vermilion River. Old shells from both drainages are dark brown or black.

22. **Alasmidonta (Pressodonta) calceola** (Lea).

This species has been recorded by Mr. Zetek from west of White Heath in the Sangamon River. No specimens were observed during the recent survey. As far as known it does not occur in the Big Vermilion River.

23. **Alasmidonta (Rugifera) marginata** Say. Elk-Toe.

In the big Vermilion River, this species is found, infrequently, at most stations from bench mark 655 as far down as the stream has been examined. It is not abundant anywhere and common at but three stations—below the dam at Homer Park, south of Muncie, and in the Big Vermilion. The first station where living specimens were found is four miles above the Homer Park dam. Individuals, both above and below the dam, are of good size and fine color, the characteristic green rays being very brilliant. Specimens from Middle Fork have many black spots on the shell. The largest specimen collected from the station two miles above the Homer dam, measured 80 mm. in length and 45 mm. in height; one from the Big Vermilion measured 96 mm. in length and 48 mm. in height.

Marginata exhibits little evidence of parasitism or abnormalities. One specimen collected from two miles above the Homer dam had several pearly growths and blisters indicating distomid infection. Gravid females were collected on October 8 and 13, 1920.

This species is rare in the Sangamon River, only one specimen being found at Mahomet during a days search. *Marginata* is a species more common in the upper waters of rivers and streams and is not, as a rule, found in any number in the larger rivers.

24. **Amygdalonaias elegans** (Lea). Deer-Toe.

But one specimen of this peculiar species was found. This individual was collected by Professor Smith at the big bend below the natural dam. The specimen was an empty shell, iron stained outside and inside, and apparently had not been living for a considerable time. It is typical in form but not as large as individuals from the larger rivers. The measurements of this specimen are: length, 57; height, 47; width, 27 mm. That but one specimen of this species should have been collected in this river drainage seems quite surprising, indicating, probably, that the species has not been able to become established. It is not found in the Sangamon River as far as known.

25. **Obovaria circulus** (Lea).

This nearly circular mussel was collected at but five stations in the Big Vermilion River; Homer Park below the dam, near Muncie, Salt Fork near Middle Fork, in Middle Fork, and in the Big Vermilion below Middle Fork. It is infrequent at the first place and abundant only in Middle Fork, near its junction with Salt Fork, on a gravel and sand bottom, in fairly shallow water (September) and in the Big Vermilion (October). In the Big Vermilion this species is very uniform in shape and size, the ratios of height to length ranging between 70 and 90 per cent. The shells are usually nearly circular and have a distinct light yellowish-brown zone at the posterior margin. The nacre is pearly and there are no evidences of discoloration from injury or parasitism. It has not been found in the Sangamon River.

As in the case of so many of our mussels whose names have become familiar, this species may have to be changed to that of *subrotunda* Rafinesque (1820).

26. **Actinonaias ligamentina** (Lamarck). Mucket.

This mussel was not found above the Homer Park dam. It occurred infrequently (almost rarely) below the dam on both a mud and a gravel bottom. In the Salt Fork near its junction with Middle Fork but one dead shell was found in half a days search for a distance of nearly a mile up stream. In Middle Fork, between the interurban bridge and the mouth of the stream, it was fairly common on a gravel and fine sand bottom in shallow water near riffles. In the Big Vermilion below Middle Fork it is the most abundant mussel, attaining a length of over 135 mm.

The individuals of this species are all normal specimens; the young and half-grown shells are greenish with many dark green rays of various width. Older shells are yellowish with few rays. In an old shell measuring 120 mm. in length and 75 mm. in height the rays showed but faintly (Z 11216). Evidences of distomid enfection were rare in this species in the Big Vermilion specimens. A long narrow pearly blister on the posterior margin of one specimen might have been due to the presence of the marginal distomid described by Kelly. Clark and Wilson (1912:62) found this distomid common as cysts in *ligamentina* from the Maumee River. A specimen from the Big Vermilion had a large pearl-like blister at the lower edge of the posterior adductor muscle scar. (Z 11482 A). An abnormal shell without the animal, was found in Middle Fork. The posterior end is sharply truncated and bent inward in the right valve and bent outward in the left valve. The hinge teeth are much more elevated and heavier than in normal specimens. This abnormality was due to an injury received when the shell was about three years old. It must have lived upward of two years after receiving the injury, judging by the rest marks on the shell. This individual measures length, 84, height, 52 mm. (Z11216A).

The Middle Fork and Big Vermilion shells are thick and of good, clear, pearly-white lustre. The mucket is one of the most valuable shells for the cutting of button blanks and the Middle Fork and Big Vermilion specimens appear to be of excellent quality for this purpose. The species from this stream could be used for glochidial infection of fish. Gravid females were collected on September 26. *Ligamentina* was not found in the Sangamon River.

27. Actinonaias ellipsiformis (Conrad).

This small naiad occurs rarely at three places in the Big Vermilion River; below the dam at Homer Park, in the Salt Fork south of Muncie, and in the Big Vermilion below Middle Fork. Whether this rarity is due to a real scarcity of the mussel or to the inability of the collectors to find it, is not known. Diligent search was made in the various places visited, and the fact that but few specimens have been found by Professor Smith after years of constant collecting at Homer Park, leads to the conclusion that the species is rare in this stream.

Ellipsiformis is common in the Sangamon River at Mahomet where it occurs on a sand and gravel bottom, more commonly on riffles, where the current is rather swift. The shells from this station are not large (maximum size, length, 63, height, 31 mm.) but are very thick, with pearly-white nacre. The shape is normal, the posterior end being sharply pointed with a narrow truncation. The color is yellowish or greenish with many dark green rays, often wavy. Rest periods show as elevated longitudinal ridges, especially near the ventral margin of the shell. A half-grown specimen, length 38, height 23 mm., resembles in outline young shells of *Actinonaias ligamentina* and if found with that species would probably be so identified. *Ligamentina,* however, is not found at Mahomet, and this specimen is doubtless referable to *ellipsiformis.* Utterbach's reference of the species to the genus Nephronaias (= Actinonaias) is strengthened by the similarity of these shell characters, which this author has also noted (1916: 142).

In the largest specimen of this species, from the Sangamon River, the right valve has a large blister parallel with the postero-ventral border, measuring 17 by 7 mm., and anterior to this blister a group of twenty of more 'pin-head' pearls. There are several of these small pearls in the center of the valve. The left valve has a number of 'pin-head' pearls bordering the pallial line and one larger (1 mm.) black pearl in the center of the valve. (Z11230 A). These may have been caused by distomid parasites, although none were observed in the animals of this species. Only one shell in a dozen were thus affected.

28. **Carunculina parva** (Barnes).

This diminutive mussel is characteristic of the smaller tributaries of the Big Vermilion River. It occurs commonly in the ditch above Urbana and also in Spoon River. No living specimens were found between the Spoon River tributary and the station one mile above iron bridge north of Sidney, a distance of over six miles. From this station to the railroad bridge east of Sidney, a distance of three miles, this species was abundant or common. It is infrequent at Homer Park and was not found in the Salt Fork below Muncie or in Middle Fork. Its normal habitat in the Salt Fork is on a mud bottom in quiet water. At Homer Park, however, it occurs sparingly on a gravel bottom in very shallow water.

The species as found in Salt Fork is normal in form but not of large size, the largest specimen observed, from the railroad bridge east of Sidney, measuring 30 mm. in length and 18 mm. in height (Z11096). The surface in the Salt Fork specimens is rayless, the color being brown from the umbones to the center of the valve, the balance of the shell being black. Specimens from Spoon River were smaller than those from farther down the stream.

Parva occurs infrequently in the Sangamon River at Mahomet on a mud or sand bottom.

29. **Carunculina glans** (Lea).

This small mussel, which is much higher in proportion to its length than *parva*, is very rare in Salt Fork, where it was found at but three stations, living individuals being collected only below the dam at Homer Park. Like *parva*, it is a species of the smaller tributaries and its normal habitat is on a mud bottom. It was not found in the Sangamon River at any station examined.

Frierson (1914: 7) has identified Lea's *glans* with the shell called *Unio* (*Toxolasma*) *lividus* of Rafinesque, changing the generic, name, accordingly, to Toxolasma Rafinesque. In this he is followed by Ortmann (1918:572, 573). Should these names be plainly identifiable from the original descriptions, these small shells will bear the names *Toxolasma parvum* (Barnes) and *T. lividum* Rafinesque. The writer wonders whether some of these Rafinesquean names have not been adopted too hastily and whether the fact of the identified specimens in the Poulson collection has not unduly influenced the references, which, without these identifications, are not as clear. The test must be, it would seem, a clear case of identification from the writings of Rafinesque alone.

30. Eurynia (Micromya) lienosa (Conrad).

The distribution of this small mussel seems to be coincident with that of *Lampsilis luteola* in the Big Vermilion and its tributaries. It occurred infrequently living in the Spoon River. It was not again collected in a living condition above the iron bridge north of Sidney, seven miles below Spoon River. At this place only one living specimen was found, and as far down as the cement bridge it is only infrequent. Between this point and the station three and a half miles above Homer Park dam no living specimens were found after diligent search in favorable habitats. It does not occur in any abundance above Homer Park dam; but below the dam the species is abundant and of large size. The largest specimens from Homer Park measure: length, 65; height, 31; breadth, 28 mm. (male); length, 55; height, 34; breadth, 25 mm. (female). In Salt Fork near its junction with Middle Fork it is abundant and in the Middle Fork it is common.

The species varies somewhat in coloration. From Homer Park upstream the color is black or dark brown with rarely faint indications of rays. Specimens from Middle Fork and Salt Fork near Middle Fork are more of a chestnut color, slightly reddish, often with quite distinct rays. By arranging the different lots by consecutive stations down the river it may be at once observed that there is a marked and striking increase in size, the increase being in some cases as much as 50 per cent between Spoon River and Homer Park. The Homer Park shells are on the average somewhat larger than those from farther down the stream and from Middle Fork.

The shells of many individuals of this species contain pearly growths in the form of blisters and 'pin-head' pearls. These occur near the margin of the valve, more frequently near the posterior end near the siphonal region. Gravid females were collected at Homer Park on July 30.

Lienosa was not collected from the Sangamon River and no records have been seen of its occurrence in that stream.

31. Eurynia (Micromya) iris (Lea).

A broken valve of this species was found in Middle Fork below the interurban bridge. The rays are distinct and the shell seems typical. It measures, length 37, height 21 mm. It appears to be a very rare shell in the parts of the Big Vermilion examined but may be more abundant below the stations examined where the river is larger. *Iris* has not been recorded from the Sangamon River.

32. Lampsilis luteola (Lamarck). Fat Mucket.

The mussel known among fishermen as the fat mucket is common or abundant almost everywhere in the Big Vermilion and Sangamon rivers. It has been killed by the sewage of the Salt Fork from St. Joseph to bench mark 655, a distance of five miles down the stream, but the number of dead and empty shells found almost everywhere between these points indicates that at one time, not very remote, it was common continuously from Spoon River, where it now lives in some abundance, to the Wabash River. Below the dam at Homer Park it is very common and of large size, and this abundance continues down the stream and was also noted in the tributary Middle Fork. At Mahomet on the Sangamon River it is also abundant.

There is great variation both in form and coloration among the shells of this species in all of the habitats examined. The male shells are usually pointed at the posterior end and are elongated and somewhat compressed. From this form they vary by being quadrate in outline with a distinctly plow-shaped posterior end, corpulent and almost cylindrical, or flattened and oval, in this form greatly resembling *Actinonaias ligamentina*, from which they may be distinguished by the numerous double-looped ridges on the umbones. The female shells do not differ so greatly in shape, the post-basal swelling for the accommodation of the enlarged branchial marsupium giving more uniformity to the shell, the variation being principally in the width of the shell, which in old specimens is very pronounced. Male shells greatly predominate in the collections. In color there is every gradation between a bright yellow shell with distinct, narrow dark green rays, to a shell that is dark yellowish or brownish without rays or with the rays only faintly developed. A few specimens are dark brown or even pinkish with narrow, greenish rays. Young shells are very brightly rayed, the rays being dark grass-green on a light yellowish background, forming a beautiful surface ornamentation. The rays on the adult shells may be narrow or broad, or the broad rays may be made up of many fine rays, which may also be a trifle wavy. The nacre in all specimens examined from the two rivers here considered is pearly white, unmarked by color of any kind. The largest specimens seen occur at Homer Park; measurements of these are given below:

Length, 110;	height, 59;	breadth, 35	mm.	Male
" 116	" 68	" 40	mm.	Male
" 116	" 69	" 46	mm.	Female
" 100	" 65	" 48	mm.	Female

Pearly growths were observed in many of the specimens collected. Occasionally a few pin-head pearls occur in a valve but the greatest number of abnormalities consist of cyst-like pearly growths near the posterior end, in or near the adductor muscle and pallial line. These may occur in one or both valves. Occasionally the anterior adductor scar is almost wholly changed in character by these abnormal growths. In several shells the space between the pallial line and the margin of the valve is stained purple or brown, accompanied by few or many blisters of various sized. The posterior end of the shell may also be affected so that it ceases to grow, forming a blunt posterior end marked by blisters and discolorations. Whether this condition is due to distomid infection as mentioned by Wilson and Clark (1912 63) as occurring in *Actinonaias ligamentina* from the Maumee River is not known definitely, but the inference is strong that it is. It is noteworthy that the largest number of individuals affected by parasitism or other injurious agencies occurred in the upper part of the Salt Fork above Homer Park dam. Specimens collected from stations below the dam, including Middle Fork, were as a whole remarkably free from pearly growths or discolorations. Occasional individuals from Mahomet, on the Sangamon River, have round, pin-head pearls in the shell. Though no distomids were observed in the animals of *luteola* it is quite probable that these pearls and blisters, which were observed for the most part in empty shells, were caused by distomid larvae, possibly the marginal cyst described by Wilson and Clark (1912:62). Many young shells of *luteola* were collected and many more observed, indicating that the species is breeding freely from the Homer Park section of the stream downward. No young shells were seen above the Homer Park dam. Gravid females were observed at several places in September and October.

A specimen collected at Mahomet (Z11223 A) somewhat resembles *Actinonaias ligamentina* in the form of the shell, absence of strong umbonal markings and heavy hinge teeth; it seems to be one of those individuals which has led many students to say that "*ligamentina* runs into *luteola*." The shell is free of all abnormalities and has a clear pearly-white nacre. It measures, length 87, height 54, breadth 30 mm.

33. **Lampsilis ventricosa** (Barnes). Pocket-Book.

This large fine species was not collected in Salt Fork above the station about two miles north of Sidney, 16 miles below Urbana. As it does not occur in Spoon River (as far as known from our collections) it is probably a species that does not inhabit the smaller tributary streams. From the station mentioned as far down stream as the river has been examined, including Middle Fork, *ventricosa* is common or abundant in most places. Below Homer Park dam it is abundant and of large size, and more or less ponderous. The largest female shell was found at Homer Park and the largest male shell in Salt Fork near Middle Fork. These shells measure as follows:

Length, 138;	height, 60;	breadth.	56 mm.	Male
" 117	" 60	"	60 mm.	Female

Shells from the Sangamon River are equally large.

The shape of the shell is fairly constant and there is little variation except in the females, which are rounder posteriorly and have a large post-basal swelling for the enlarged marsupia. In color the Big Vermilion shells are all yellowish with dark green rays on the posterior slope. No specimen was seen in this river that was rayed all over. Very old specimens are entirely rayless. At Mahomet, on the Sangamon River, the yellow shell occurs and also another form in which the shell is yellowish-green with bright, grass-green rays, often of considerable width. One specimen is in outline like *Actinonaias ligamentina* and the surface is densely covered with dark green rays. Two other specimens have green rays on a pink background, have pink hinge teeth, and the whole interior of the shell is pinkish. These bright colored shells are the form called *occidens* by Lea.

These pink shells and the specimens with the numerous green rays are so strikingly different from the *ventricosa* as found in the Big Vermilion and also from the other shells found in the Sangamon, that the name *occidens* might be retained for these shells for ecological purposes. The color is not an age stage, for young yellow ventricosa were found associated with these distinctly rayed forms, and the rayed forms were collected at Mahomet and were not found at White Heath in the Sangamon. The river below Mahomet has not been carefully searched, however, and the *occidens* form may occur in some of this unexplored territory. It is also to be noted that, as far as the material from these two rivers is concerned, the beak sculpture of the *occidens* type of shell is very much larger and coarser than in the *ventricosa* type (Z11222). This form falls under the group of individuals called mutations by DeVries and others.

Ortmann (1918:583) makes *ventricosa* a variety or race of *ovata* (Say). As far as the authors' experience goes, this seems unwarranted, the two species being as easily separable as many other closely allied species. Individual specimens from Illinois localities approach *ovata* in that the posterior ridge is somewhat accentuated, but no specimens have been seen that could not be placed readily in one species or the other. *Ovata* is reported from the Ohio River in Illinois by Marsh but this species is more southern in its distribution, reaching its maximum development in Alabama and Tennessee. *Ventricosa* is a more northern species attaining its maximum development in the rivers of Illinois and Indiana.

Ventricosa is subject to the attack of distomid worms as well as to parasitism by mites (Unionicola) and the material of this species from the Big Vermilion have suffered more or less from this cause. Blisters, pin-head pearls and various abnormalities occur in many individuals. Among the shells collected at the station one mile above iron bridge north of Sidney there are several individuals of this sort. One has a large blister extending nearly the whole length of the ventral margin and covering the space between the margin and the pallial line. This was evidently formed by distomid parasites (Z11058 A). Another specime from the same lot (Z11058 B) has a large group of pearls (over 100) filling the space between the ventral margin and the pallial line over an area of about two inches. Other specimens have an abnormally thickened ventral margin in addition to blisters, indicating the presence of some irritating material between the shell and the mantle lobes, probably mud or sand (Z11149 A). A specimen from Mahomet had suffered a curious injury which had caused a large blister extending from the upper third of the posterior end to the center of the ventral margin, a distance of about three inches. This was plainly due to the presence of a quantity of mud getting in between the shell and the mantle, a small amount of this material being retained under the cylindrical blister on the ventral margin. The outside of the shell was so perfectly repaired that there was no evidence of the pathological condition within the shell (Z11202 A). Fig. 35. This injury was only in the left valve, the right valve being normal.

Nearly all of these pearly growths, blisters, and abnormalities have been noted to occur almost universally without the pallial line, between this muscle attachment and the ventral, anterior, and posterior margins of the shell. This limited area is easily understood when it is remembered that the adductor muscles and the pallial line form a barrier to the entrance of foreign material because the muscles at these points are firmly attached to the shell and parasites or foreign material cannot readily gain entrance to the interior of the animal between the mantle and the shell. This is true of all the shells of other species examined from these two river systems. It was noted that pearly growths and abnormalities were rarer in the shells from the Middle Fork and from Salt Fork near the Middle Fork than from Homer Park and up the stream from this habitat. The shells from the Sangamon River at Mahomet were much less subject to parasitism or abnormalities than those from the Big Vermilion River.

Young shells of *ventricosa* were common only in Middle Fork, in Salt Fork near Middle Fork, and in the Sangamon River at Mahomet. No young shells were collected from the stream above the dam at Homer Park.

Gravid females were observed on September 26 in the Salt Fork near Middle Fork in the act of spawning. The shells were buried in the sand, only the tips of the siphons showing above the general level of the bottom of the stream. The bright yellow siphon fringes, which are enlarged during the spawning period, were observed to wave about with graceful undulatory motion. The movements were more or less intermittent, a waving period being followed by a resting stage. These mussels had well formed glochidia and were evidently discharging the embryos from the marsupia. These glochidia are of the hookless type and develop in the mouth of fish and the undulatory motions possibly attract these fish which may be thus more easily infected with the glochidia, as suggested by Wilson and Clark (1912:13, 14). This undulatory motion of the siphon fringes is so striking that it at once attracts the attention of an observer,even if this person is not interested in the study of these creatures. Its habit of burying itself so deeply in the mud or sand of the bottom (four to seven inches) renders this species difficult to collect, especially if the sand be packed rather hard and the water is eighteen or more inches in depth, as frequently occurs. This condition was found in several of the Salt Fork habitats. Gravid females were also collected from other localities in October.

34. **Lampsilis multiradiata** (Lea).

This handsome mussel occurs rarely at but three stations, Homer Park, near Muncie, and in Middle Fork. It is common in the Big Vermilion below Middle Fork. The specimens from the Salt Fork Stations are all small for the species, being not over half the size of individuals from White River, near Muncie, Indiana, and the hinge teeth are much weaker than those from Indiana streams. This is especially true of the pseudocardinal teeth which are narrower and more elongated than the specimens examined from other streams. Individuals from Homer Park are brilliantly rayed, grass green on a yellowish ground. Middle Fork specimens are not as brilliantly rayed, the general color being yellowish with scanty rays. The largest specimens collected measure as follows, a specimen from Muncie, Indiana also being included for comparison:

Length, 34;	height, 22 mm.	Homer Park.			
" 43	" 31 mm.	Middle Fork.	Male		
" 69	" 55 mm.	Big Vermilion.	Female		
" 85	" 64 mm.	Muncie, Ind.	Female		

This species is rare in Illinois waters, judging by the few records available. These indicate, however, a wide range over the State, from Cook County to southern Illinois (Baker, 1906:64). Ortmann (1918:584, 1920:309) adopts the name *fasciola* of Rafinesque (1820) for this species, stating that the original description of Rafinesque is definite enough to indicate without much question a shell of the multiradiata type. If this be so, then Lea's very appropriate name must give place to the one used at an earlier date by Rafinesque. The species has not been recorded from the Sangamon River.

35. **Lampsilis anodontoides** (Lea). Yellow Sand Shell.

This fine shell, which is usually abundant throughout Illinois waters, was collected at only three stations in the Big Vermilion River, all of which were below the dam at Homer Park. The largest and finest individuals occur at Homer Park and the smallest were collected in Middle Fork. Specimens from the first named station have a yellowish shell with little or no indication of rays. Middle Fork specimens include yellowish shells without rays, as well as, more rarely, individuals with rather bright, wide rays, approaching in this respect the related species *fallaciosa* of Simpson. The largest specimens from the two localities measure as follows:

Length, 124;	height 57;	breadth 47 mm.	Male, Homer Park.
" 90	" 41	" 33 mm.	Female, Middle Fork.

The nacre is tinted with pinkish or salmon color. Pearly growths are not uncommon in specimens from the Big Vermilion. These are in the form of blisters and pin-head pearls, which are usually confined to the margin of the shell between the pallial line and the external margin of the valve. One individual from Homer Park had the entire area between the pallial line and the ventral margin of the shell abnormally enlarged and thickened, due possibly to the presence of distomid larvae and to some extent to the intrusion of small amounts of soil between the mantle and the animal (Z 11147A). Specimens from Middle Fork are, as a rule, free from pearls and abnormal growths. Gravid females were found on September 26 in Middle Fork, and on July 30 in Salt Fork at Homer Park. *Anodontoides* has not been recorded from the Sangamon River at Mahomet or in the other places examined.

The early writers, Say, Conrad, and others, have identified this species with the *Elliptio teres* of Rafinesque (1820) and if the shell is clearly identifiable from the description of Rafinesque the familiar name of Lea must become a synonym.

36. Truncilla (Pilea) perplexa rangiana (Lea).

Four specimens of this race of *perplexa* are in the naiad collection of the Museum of Natural History, University of Illinois, collected by Mr. A. A. Hinkley, in the Big Vermilion River at Danville. Three are females and one is a male. They are much smaller than specimens from Florence, Alabama, where the species attains its greatest development. The male and largest female shell measure as follows, corresponding measurements being also given for the Alabama shells.

Length, 41;	height, 29;	breadth, 22 mm.	Danville, male, Z3770.
" 44	" 34	" 20 mm.	Danville, female, Z3770.
" 55	" 43	" 32 mm.	Alabama male, Z3947.
" 73	" 53	" 35 mm.	Alabama female, Z3947.

As no specimens of *Truncilla* were found in the Big Vermilion or its tributaries as far down as Middle Fork, which is but a few miles west of Danville, this species evidently does not inhabit the stream above the locality from which Hinkley collected his shells. *Truncilla perplexa* as well as its variety *rangiana* is known in Illinois only from the Ohio and Wabash rivers. The small size of the Danville specimens may be due to the fact of their inhabiting the upper part of their distributional range, in a rather small river. Rafinesque's name *torulosa* has been used by Conrad, Agassiz, Reeve, and Ortmann for *Truncilla perplexa* and if the original description is clear enough to reasonably fix the shell as Lea's *perplexa* this form will stand as *Truncilla torulosa rangiana* (Lea). Neither *perplexa* or *rangiana* are known from the Sangamon River.

FAMILY SPHAERIIDAE

37. **Sphaerium striatinum** (Lamarck). Variety.

This finger-nail clam occurs abundantly only in the ditch north of Urbana. It also occurred infrequently in Spoon River, and near the iron bridge in Salt Fork north of Sidney. Dead specimens were found at bench mark 655 and below the Homer Park dam.

Sterki remarks of this form "possibly a form of *striatinum* Lam; apparently the same as a Sphaerium from Iowa and other places which for many years has been left unnamed, except in manuscript. It still seems impossible to say where the limits of *striatinum* are." The writer fully agrees with Dr. Sterki regarding the variation in this common species. This variety appears quite distinct from the ordinary specimens of the species and it is to be hoped that Dr. Sterki will give it a name. It is noteworthy that the form occurs commonly only in the drainage ditch above Urbana and was not found in any numbers below this place. A Sphaerium identified as *striatinum* by Zetek some years ago, occurring in Crystal Lake, was doubtless this form.

38. **Sphaerium stamineum** (Conrad).

This small mussel is abundant at several places in Salt Fork above Sidney. It occurs only infrequently at two other places. Reported by Zetek from Crystal Lake. Some of the shells are typical but others are similar to *straitinum* and it is difficult to separate some specimens from that species. At the station called bench mark 655 a form of this species occurs that is somewhat like the variety *forbesi* Baker, described from Mason County, Illinois.

39. **Sphaerium solidulum** (Prime).

An abundant species in the Spoon River and in the Salt Fork above Sidney. Occurs rarely at other places. Reported by Zetek from Crystal Lake. On the whole this species is quite uniform in characters.

40. **Sphaerium** species.

A Sphaerium occurs abundantly in Salt Fork below the Homer Park dam which is thought by Sterki to be possibly a new species. It is related to *solidulum* but is larger and more robust (mus. no. Z11383). It lives in shallow water on a more or less rocky bottom a short distance below the dam.

41. Musculium transversum (Say).

This fragile finger-nail clam is apparently rare in Salt Fork and its tributaries, occurring only in Salt Fork near Sidney. It has been reported from Crystal Lake by Zetek. The specimens are typical.

42. Musculium truncatum Linsley.

This very small clam was found only in the old river bed near the cemetery north of Urbana. Here it is common and typical.

43. Musculium partumeium (Say).

Reported by Zetek from Crystal Lake. It has not been found recently.

44. Pisidium compressum Prime.

This small clam occurs in abundance only at the iron bridge north of Sidney. A few specimens were found below the natural dam in Salt Fork. The individuals are quite typical.

45. Pisidium kirklandi Sterki.

A single specimen of this species was foumd at the iron bridge north of Sidney. It is apparently very rare.

46. Pisidium splendidulum Sterki.

A few specimens of this tiny species were found in the Salt Fork near Muncie. The individuals are young and not quite typical.

The distribution of the Sphaeriidae in Salt Fork is interesting and significant in connection with the sewage pollution of the stream. It will be noted that no Sphaeriidae were found in the Salt Fork between the Urbana ditch and the station called natural dam, 14 miles below Urbana. These mussels are characteristic mud dwellers and their absence from the intervening territory in the stream is striking evidence of the unfavorable conditions on the bottom. They were not found in abundance above bench mark 655. It will also be noted that Sphaerium appears, living, before Pisidium and is also found in abundance higher up the stream. This may mean that Sphaerium is better able to withstand these adverse conditions than Pisidium, which is more of a mud dweller. Pisidium is much less common everywhere in the stream and but one species occurs abundantly at one place (Table IV).

FAMILY PLEUROCERIDAE

47. Pleurocera elevatum (Say).

This long-spired snail is rare or wanting in most parts of the Big Vermilion River. Two white, weathered specimens of this species were found below the natural dam in Salt Fork. They may have been washed from a post-glacial fossil deposit. None were found either alive or dead in any other part of the Big Vermilion examined, excepting the two specimens mentioned above.

In the Sangamon River, at Mahomet, *elevatum* is very abundant on a sandy bottom in water a foot in depth (low water period). The specimens are large (maximum length 35 mm.) and vary in color from light yellowish to black or dark chestnut with a light zone below the suture. The characteristic peripheral keel is developed on the majority of specimens and ascends the spire just above the suture. In a few individuals this keel is absent and the body whorl is rounded. Many intermediate forms occur connecting these rounded shells with the more distinctly keeled forms. Usually there are from one to six spiral ridges on the base of the shell extending longitudinally parallel with the peripheral keel. The strongly carinate whorls of the young shell are six in number and these lose their sharpness more or less abruptly on the seventh whorl. No individuals were seen in which the protoconch or nucleus of the first whorl was preserved. Young and half-grown specimens have two brown bands on the spire whorls and four bands on the body whorl and base of the shell. This species also occurs in the Sangamon at White Heath, and it has been found in several Pleistocene deposits near Mahomet, the white shells of the fossils being washed out of the bank by periods of high water.

48. **Goniobasis livescens** Menke.

This river snail occurred in but four places in Salt Fork. It was infrequent at bench mark 655 and abundant just below the dam at Homer Park and near Muncie. It is abundant in the big Vermilion below Middle Fork. It has been identified by local naturalists as *Goniobasis pulchella* Anthony and has been reported as this species by other students as from the Big Vermilion River (Baker, 1906:98). Specimens were sent to Mr. Calvin Goodrich, who is making a study of this family, and were identified as *livescens*. I quite agree with Mr. Goodrich that they are *livescens* rather than *pulchella*. Young and immature specimens are banded like *Goniobasis depygis* Say.

Goniobasis semicarinata Say is reported from the Big Vermilion River by Marsh (Baker, 1906:98) but no specimens have been seen from this stream. The species may live in the river below Danville or the citation may be based on long-spired *livescens*.

FAMILY AMNICOLIDAE

49. **Pomatiopsis lapidaria** (Say).

This tiny snail is abundant in small, cold streams flowing into the Sangamon River. At one locality, about three-fourths of a mile below Mahomet, it was extremely abundant in a small brook about two feet wide and not exceeding six inches in depth. The bottom was of mud and fine sand. The largest specimen measures 7 mm. in length. This species was not collected from streams flowing into the Big Vermilion River.

50. Amnicola limosa (Say).

This common Amnicola occurred at three stations, only two of these yielding living specimens. At the station above the iron bridge north of Sidney, the shells were secured by sweeping the vegetation bordering the shore with the Walker dredge. The *limosa* from the Salt Fork are rather corpulent but are not as globular as the variety known as *porata* (Say). It is noteworthy that this species (and in fact the genus) should be found only in a stretch of the stream three miles in length, from 16 to 19 miles below Urbana. None were seen below the dam. Individuals were rare and difficult to find. Near the cement bridge east of Sidney, dead shells occurred among water plants (*Nymphaea advena*) but no living specimens could be found. *Limosa* was not collected at the stations in the Sangamon River.

51. Amnicola (Cincinnatia) cincinnatiensis (Anthony).

This *Amnicola* occurred rarely, but living, at but two stations in the Salt Fork, 16 and 17 miles below Urbana. The largest and only adult individual collected measures 6 mm. in length. Several half-grown shells were found. About two years ago Mr. James Zetek found *cincinnatiensis* near St. Joseph. A careful search of this region, both in the Salt Fork and in the small streams flowing into Salt Fork, failed to produce a single specimen of this species. During the intervening ten years the species appears to have died out, either from the effect of sewage pollution or from some other unknown cause.

FAMILY VIVIPARIDAE

52. Campeloma rufum (Haldeman).

The Campelomas of the Big Vermilion all appear to be referable to Haldeman's *rufum*. The shell is more or less pinkish, especially on the spire. One specimen from the iron bridge north of Sidney resembles Haldeman's figure 1 on plate 3 of the Monograph, which is the type of *rufum*. Specimens from Homer Park, below the dam, are strongly suggestive of *integrum* (Say), many of the individual shells being like Binney's figure 96 which represents Say's *integrum*. With these are short-spired shells recalling the *obesum* of Lewis as figured by Binney (figure 95). These are not quite like the figures of Lewis (1875, pl. 23, figs. 4–5) which are rather broader. Variation in *rufum* seems to parallel that of *integrum* in the length of the spire. Typical *integrum* has a white aperture and a bright green shell devoid of the peculiar pink tint of *rufum*.

The *rufum* from Homer Park have the spire whorls more or less gibbous, strongly shouldered, the first three whorls seeming to be telescoped into the later whorls. In this respect they resemble *integrum obesum* as suggested above. Measurements of a few of the Homer Park specimens are given below (Z11168):

Length,	37;	breadth,	24;	aperture length,	21;	breadth,	14	mm.
"	33	"	22	" "	19	"	13	mm.
"	30	"	21	" "	18	"	12	mm.

To this and other lots of Campelomae from the Big Vermilion River the statement of Lewis may be well applied: "These and many other forms in my collection, all part of a series, go far to show that it is unsafe to attempt to decide the limits of species from a few individuals" (1875:337).

The distribution of this species in Salt Fork is interesting and suggestive. Living specimens, small and few in number, were found over two miles upstream in Spoon River. Dead, mostly old and bleached shells, were collected at nearly all stations in the Salt Fork, but living shells of *rufum* were not seen above the station two miles north of Sidney. Here only one living specimen could be found. A mile farther down the stream another living specimen was collected. The presence of so many dead shells with so few living individuals above the Homer Park dam indicates clearly an unfavorable environment. There are many normal and favorable habitats for this mollusk in this stretch of nearly twenty miles in Salt Fork and the unfavorable agencies must be wholly those contributed by Man—the disposal of sewage and other wastes by means of this stream. Below Homer Park dam the species is abundant and as fine as can be found anywhere. *Rufum* is rare on a sand and gravel bottom and abundant on a mud bottom.

The Campelomae from the Sangamon River at Mahomet are also referable to *rufum*. The spire is longer and the shell narrower, however, than in the Salt Fork specimens, and there is no tendency to vary toward the *obesum* form of shell. The interior of the aperture is slightly pinkish. One specimen from Mahomet has a very heavy shell recalling the *subsolidum* of Anthony, a common species in most parts of Illinois but absent from either of the rivers under consideration. Reversed individuals are rare, only one specimen being found in the Sangamon River, a mile below Mahomet. This is a young individual.

The air-breathing snails, belonging to the genera Physa, Ferrissia, Planorbis, and Galba, are better able to withstand the ill effects of sewage and other stream pollution than are their relatives, the snails and clams that take their oxygen directly from the water (dissolved oxygen). They were therefore found in Salt Fork in places where the water breathers were entirely wanting, as at St. Joseph and the first stations below. It has been observed in other places, notably in the Genesee River, at Rochester, N. Y., where sewage pollution was at one time very severe, that these pulmonate water snails were the last to succumb to the toxic influences of pollution and they have been known to live in water that was filled with putrescent matter and also in water strongly impregnated with arsenic. When these snails begin to disappear, conditions must indeed be deplorable.

FAMILY ANCYLIDAE

53. **Ferrissia rivularis** (Say). River Limpet.

The tiny limpet-like shell known as *Ancylus* (*Ferrissia*) *rivularis* was very abundant in parts of Salt Fork, its usual habitat being the inside of empty valves of the naiades. The individuals are large (6.4 mm. in length) and fine and apparently normal in form. This species was found alive at St. Joseph where pollutional conditions are bad, and was also abundant at the stations lower down the stream where living mussels or pectinibranchiate snails were very rare or absent. Ancyli were not observed in Spoon River, in Middle Fork, or below the dam at Homer Park. Found by Mr. Zetek in the Sangamon River at White Heath.

54. **Ferrissia tardus** Say. River Limpet.

This Ancylus is in the author's collection from White Heath and Monticello, Sangamon River, and from the Salt Fork near Urbana, collected by Mr. Zetek and identified by Dr. Bryant Walker. No *tardus* were collected during the present survey.

55. **Gundlachia meekiana** Stimpson.

Specimens of this characteristic mollusk are in the author's collection from Crystal Lake, Urbana, collected by Mr. Zetek in August 1904, and identified by Dr. Walker. None were seen during the present survey.

In the catalogue of the Mollusca of Illinois (Baker, 1906: 101, 102) *Ancylus* (*Ferrissia*) *shimekii* Pilsbry is recorded from Salt Fork, Urbana, and *Ancylus* (*Laevapex*) *kirklandi* Walker from Crystal Lake, Urbana. These species were contained in the collection of the State Laboratory of Natural History. A recent examination of the material upon which these records are based indicates that there has been an error in the habitat given. None are from the Salt Fork or Crystal Lake. *Ancylus kirklandi*, identified by Walker, is in the laboratory collection from Havana, Illinois River (Nos. 13792, 13811, 24123) and Elizabethtown, Illinois (No. 24527). *Ancylus shimekii* (No. 24541) is in a bottle with *Ancylus rivularis*, both identified by Walker. The bottle is without locality and no record was found in the laboratory catalogs of the specimens bearing this number. It is evident, therefore, that these species of Ancylus must be eliminated from the list of the fauna of Salt Fork.

FAMILY PHYSIDAE

56. Physa gyrina Say. Tadpole Snail.

This snail is usually abundant wherever found. In the old cut-offs of the Salt Fork above Urbana, as well as in the ditch north of Urbana, it is abundant and quite typical with long, slender shell and spire, the immature individuals with a short, dome-shaped spire. Below St. Joseph, where it occurs sparingly, the shell is broader and even in adult specimens the spire is more or less dome-shaped. *Gyrina* is more common above than below the dam at Homer Park. The species is more characteristic of slow-moving, pond-like bodies of water than of larger streams. It occurs also in Stony Creek near Muncie, in a small pond near Middle Fork, and in the Big Vermilion below Middle Fork.

57. Physa crandalli Baker.

Specimens of a Physa with a shouldered whorls, a wide body whorl, the shell thick and heavy for the genus are referred to *crandalli*. This mollusk is abundant in the drainage ditch above Urbana associated with *gyrina*. None were found in the cut offs of the old stream and the species probably does not inhabit the pond-like habitats in which *gyrina* is usually found, preferring running water. The specimens referred to *sayii* Tappan, from Urbana (Baker, 1906:99) are also this species. It is noteworthy that living specimens of this species were collected at St. Joseph where polluted conditions are bad. None were found below the iron bridge one mile north of Sidney, or in any part of the Salt Fork below this point. Characteristic specimens were collected in the Big Vermilion below Middle Fork, on a stony bottom in riffles.

FAMILY PLANORBIDAE

58. Planorbis (Helisoma) trivolvis Say. Wheel Snail.

This species of wheel snail is apparently not common in Salt Fork, only scattering specimens being found along the stream. It occurred more abundantly in a small stream, dry in summer, which runs through low. swampy ground on the east bank of Salt Fork south of the interurban bridge at St. Joseph. Living *trivolvis* were not found in the stream above the first bridge below St. Joseph, twelve miles below Urbana. Even this air-breathing snail seems to be unable to live in any abundance in the polluted water of South Fork.

59. Planorbis (Helisoma) pseudotrivolvis Baker.

This recently described wheel snail (Baker, 1920:123) occurs abundantly in the old stream bed (cut-offs) of the Salt Fork near the Woodlawn cemetery, Urbana, and it is here the predominating species of the genus, true *trivolvis* being rare. The differences between this species and *trivolvis* have been clearly pointed out in the paper referred to above. Two specimens, one living, referable to this species were found in Salt Fork about two miles below St. Joseph, associated with typical *trivolvis.*

60. Planorbis (Helisoma) antrosus Conrad.

A single, small, bleached shell of this species was found near the cement bridge northeast of Sidney. It may have been washed from a Pleistocene fossil deposit near by. None were collected living.

61. Planorbis (Gyraulua) parvus Say.

This small species was found in limited number associated with *Planorbis trivolvis* and *Galba parva* in the low ground subject to spring overflow south of the interurban bridge at St. Joseph. It was typical in form as compared with authentic specimens collected near Philadelphia by Dr. H. A. Pilsbry. None were found in Salt Fork or in the Sangamon River.

FAMILY LYMNAEIDAE

62. Galba parva (Lea).

This tiny pond snail was found at but one place in the Salt Fork. A dead shell was obtained at the iron bridge, a mile north of Sidney. In the low ground south of the interurban bridge at St. Joseph before referred to, *parva* occurs abundantly in the bed of a small stream which has water in it only in spring and early summer. On the Sangamon River, this species was noted in abundance on wet mud flats bordering the margin of the stream. This locality was about three-fourths of a mile below Mahomet. The polluted water at St. Joseph appears to have little effect on this species or the other pulmoniferous mollusks associated with it. It is probable that at the times of high water so much oxygen is mixed with the upper layer which overflows these low places that the ill effect of sewage pollution, from decomposition of organic matter, is so reduced in quantity and quality as to be little noticed by these air-breathers.

63. Galba humilis modicella (Say).

This is usually a very common species where it occurs at all. It is rare, however, in the Big Vermilion, scattered specimens, mostly dead shells, being found at four stations. It was collected living in the drainage ditch above Urbana, in Crystal Lake (Zetek), and a large typical individual was found alive on the mud bordering the stream a short distance below the mouth of Spoon River in Salt Fork west of St. Joseph. The species occurs sparingly in the Sangamon River associated with *Galba parva* at the locality mentioned under that species. In a small pond in the gravel pit north of the interurban tracks west of the Middle Fork, *modicella* occurs living among cat-tails (*Typha*) associated with *Physa gyrina*.

64. Galba obrussa (Say).

Obrussa occurs in Stony Creek near Muncie, collected by Mr. John R. Malloch, May 29, 1919. The specimens are typical though small.

65. Galba caperata (Say).

This species occurs abundantly in swampy woodlands bordering the Salt Fork about three miles north of Urbana, the ground in dry weather being almost paved with the dead shells of this snail. Some of the snails escape the dry period by crawling into cracks and holes and there hibernating. This species has not been found in or near Salt Fork or the other tributaries of the Big Vermilion River. Because of its preference for small, summer-dry ponds and pools this *Galba* will not be found, probably, in any part of the streams herein considered.

POLLUTION OF SALT FORK BY SEWAGE AND MANUFACTURING WASTES

GENERAL NATURE OF STREAM POLLUTION

Stream pollution may be broadly divided into two main divisions: contamination by organic sewage from cities and towns and by chemical wastes from factories and mines. Both are inimical to life but the latter is especially fatal to animal life, causing wide stretches of otherwise fertile streams to become veritable deserts. Organic sewage, in a crude or highly concentrated form, is also very injurious, effectually eliminating most forms of life from the polluted body of water.

The importance and seriousness of the problem of stream pollution in its effect on the life of the rivers and streams into which the contaminating material is discharged has not until very recently been given the attention the subject demands. The diminishing fish supply, and in many places the very objectionable physical character of the polluted waters, have caused the authorities of several states to pass laws governing the discharge of these wastes into streams and the establishment of penalties for disregarding these laws. New York and Massachusetts have led in the framing of these laws and other states are following the good example set by these two older commonwealths, where the conditions seem to have reached a maximum of harmfulness (see Ward, 1918, 1919).

During recent years stream pollution has enormously increased and the problems arising from this condition have been investigated by many biologists and sanitary engineers. The former have studied the problem from the viewpoint of its effect on the useful animal life, especially fishes and river mussels, and this phase probably bears as close a relation to human welfare as any other. Of course, from the standpoint of health, the pollution problem is of paramount importance because of its bearing on such diseases as typhoid fever which may be caused by a polluted water supply.

Perhaps the worst effect of chemical pollution is to be found in the streams of western Pennsylvania, where water heavily loaded with oil or acid water from coal mines is permitted to flow into the rivers and streams of this part of the state. Studies by Ortmann (1909) show that whole stretches of the Allegheny, Ohio, and Monongahela rivers have been made into deserts, as far as the animal life is concerned, by the large amount of poisonous substances discharged into these streams by the mines, oil industries, and chemical and other factories that border these rivers. In the Susquehanna River the same condition prevails in many places (Leighton, 1904). Such pollution causes a complete extermination of the fauna (and largely of the flora) and leaves the streams in such condition that restocking by either natural or artificial means is practically impossible.

Pollution by sewage, when the polluting material is of small percentage as compared with the pure water of the stream (as 200 to 1), causes little inconvenience to the animal life and is doubtless of some benefit because of the additional food material that is added (Forbes and Richardson, 1919: 146). But the streams seldom remain long in this innoxious condition, the sewage becoming more and more concentrated until the whole stream may be supersaturated with noxious substances, the amount of oxygen in saturation reduced, and the biota finally driven out or killed.

The Illinois River is one of the most striking examples of the effect of sewage pollution on the life of a stream. Under the direction of Dr. S. A. Forbes, studies of this river have been carried on for more than forty-two years (since 1877) and a mass of reliable data has been gathered. The opening of the Chicago Drainage Canal in 1890 produced most revolutionary changes in the life of the Illinois river, by the discharge into it of the sewage of Chicago as well as commercial wastes from this city and other places along the river (Forbes and Richardson, 1913, 1919). The effect of this sewage pollution has been to cause the animal life to be almost excluded from the upper parts of the river. That the polluted condition is creeping down stream is shown by comparisons of collections made in 1911 with those made in 1918. In the earlier years a foul-water fungus disappeared from the river near Starved Rock; in 1918 it was found at Henry and Lacon, 35 and 41 miles farther down the river (Forbes and Richardson, 1919:145). At the present time (1919) optimum conditions and a normal river fauna are not encountered until Peoria is reached, a distance of about 120 miles from the chief source of pollution at Lockport. Sewage from the towns and cities along the river also contribute to the general septic condition.

A striking example of the deadly effect of sewage pollution on the mussel life of a stream is given by Wilson and Clark (1912:34) in their study of the Kankakee River mussel fauna. "The DesPlaines River, which joins the Kankakee to form the Illinois River, is simply an immense sewer bringing down the Chicago sewage. Both rivers, but especially the DesPlaines, are full of the characteristic algae and other vegetation which grow in such waters, and the combination of a copious vegetation with the sewage has effectually killed off all the mussels in the vicinity. Not a single living specimen could be found in either river; but there were hundreds of dead shells along the banks, most of these old and well bleached, but still capable of identification." This statement, of course, applies only to the lower part of the Kankakee River where the influence of the polluted DesPlaines has worked upstream for some distance. The Kankakee River for the most part is a highly productive stream with a high rate of dissolved oxygen, in fact, the water is supersaturated with this life-giving element.

In the Maumee River (Wilson and Clark:1912, 26, 28) shell beds were found which had probably been killed by the refuse from gas works near the junction of the St. Mary's and St. Joseph's rivers. "Spots of tar were found on dead mussels some distance below this point. The water was covered with an oily scum in places and a tarry odor was perceptible for several miles down the river." Lower down the river the mussels were showing the effect of increased pollution of the river by sewage.

The pollution is worst and usually the most deadly to animal life during periods of low water and in winter when the amount of water in the stream is small and the decomposing organic material has less water to deprive of its dissolved oxygen. During times of floods the putrescent material is also carried down the stream for many miles and contaminates areas not previously affected.

While all clean-water forms of animal life are more or less affected by sewage pollution, the decomposition of organic matter abstracting dissolved oxygen from the water and rendering it unsuitable for aquatic life, the fish, river mussels and crayfish are particularly affected, most fish being especially sensitive to contaminated water. Some fish (as the brook silversides, *Labidesthes sicculus*) are notably sensitive, while others (as the black bullhead, *Ameiurus melas*) will endure water that is badly polluted (Shelford, 1918:27; Wells, 1918:562–567). The young fish are relatively more sensitive than the adult fish. It is noteworthy that the more resistant species of fish are inhabitants of sluggish bodies of water, as ponds and shallow lakes, while the least resistant species live in running streams. It seems to be a question of the amount of oxygen necessary for the well being of the fish.

The ill effect of sewage pollution is most marked on the bottom of bodies of water, where a sludge is formed, often of great thickness (as much as ten feet in some instances), consisting of a mass of soft, black, sediment with a high content of organic matter, in which only a few organisms, normally inhabitants of polluted streams, can live (e.g., septic Protozoa and Rotifera, foul-water algae, and slime worms, Tubificidae). This effect on the bottom is perhaps the most serious phase of stream pollution because the septic condition of this area continues in operation long after the original source of contamination ceases to operate. This sludge formation renders the bottom unfit for clean-water life upon which many fish depend for food.

The effect of sewage pollution on the fish population of the upper Illinois River has been marked, many species, such as catfishes, red-horse, buffalo, and sheepshead, which were formerly very common and taken in quantity by the fishermen several years ago, are now either wanting, or greatly reduced in numbers. Other fish, not bottom feeders, such as sunfishes, crappies, and the basses, are reported to be decreasing in recent years as polluted conditions are creeping down the river (Forbes and Richardson, 1913:544). It has been observed that fish entering a polluted stream from a clean-water tributary soon die if unable to return to clean water. The fauna of a polluted stream also becomes gradually of greater size as the distance from the source of pollution increases. This has been observed by Forbes and Richardson in the Illinois River, by Ortmann in the Allegheny River, and by the author in the Big Vermilion River. The time necessary for the recovery of the normal biota of such a stream will in most cases be of long duration and in the case of a stream polluted by wastes from mines and chemical manufacturies, there may never be a return to the original condition.

In New York State, the Genesee River, at Rochester, has afforded a striking example of stream pollution, of the effect of this pollution on certain animal life in the river, and of the return of this life when the amount of pollution has been largely reduced. This stream has been under observation by the writer for a period of twenty-seven years (1892 to 1919) and collections of the molluscan life have been made from time to time, both before the period of maximum pollution and since that time. The portion of the river studied lies below the lower falls north of the city, and about a quarter of a mile below the outfall of several trunk sewers, the sewage being discharged into the river in a crude condition. Refuse and other waste matter, both liquid and solid, also enter the stream from gas works, tanneries, and manufacturing plants above the lower falls.

Collections made in 1892, before pollution became notably apparent, included nine species of gastropod mollusks, three being water breathers and six air breathers. These species included:

Musculium transversum
Musculium partumeium
Bythinia tentaculata
Planorbis trivolvis
Physa gyrina
Physa sayii
Physa oneida
Galba catascopium
Galba caperata

Individuals were notably abundant, thickly covering the rocks and the shore. In 1897, it was observed that the sewage was increasing in volume and pollution was becoming more noticable, the water appearing like very heavy, greasy dish water. The river was visited and examined at short intervals from 1898 to 1919. Each year it was noted that pollution was rapidly increasing. In 1907, the water-breathing mollusks, Musculium and Bythinia, had succumbed and none could be found. The air-breathers, Galba, Planorbis, and Physa, still held out, though reduced in number of individuals. An examination made in 1910 failed to discover a single living mollusk of any species. Apparently the water had reached such a state of concentrated pollution that even the air-breathing mollusks, which normally come to the surface to take free air, could not adapt themselves to this unfavorable environment and were either killed or compelled to migrate down the river to a point where pollution was less deadly. During the following years, 1910 to 1913, the river was visited but no mollusks were found.

During the summer of 1912, G. C. Whipple, made a study of the effect of the sewage pollution on certain animal and vegetal life in the Genesee River (Fisher, 1913:179–200). This study was made when pollution was at its maximum and during the period when molluscan life had disappeared from the lower part of the river. The dissolved oxygen in the lower river, below the trunk line sewer, in July and August, when the temperature was high and the water low, varied from 5 to 41 per cent of saturation. The water at the bottom of the river almost always contained less oxygen than that at the surface. On one day in August, the percentage of saturation in a distance of three miles did not exceed 5 per cent from the surface to the bottom of the stream, which has a depth of about twenty-six feet. The number of bacteria per cc for this period was 1,650,000 near the source of pollution and but 67,000 per cc near the mouth of the river where the influence of the pure water from Lake Ontario increased the amount of dissolved oxygen.

In 1917, a large part of the city sewage was diverted to a disposal plant situated near the shore of Lake Ontario. Here an average of 32 million gallons of sewage are treated daily and the treated sewage is discharged into Lake Ontario in deep water at some distance from shore. It is at once apparent that when this large amount of sewage was discharged into the Genesee River in a crude condition, it could not but render the water totally unfit for animal life and a menace even to the inhabitants who visited the beautiful parks bordering both sides of the lower Genesee River.

The result of the diminution in the amount and character of the sewage discharged into the river has been that the molluscan fauna, as well as other forms of aquatic animal life, have returned and are rapidly taking possession of the favorable environments which were in use previous to the maximum period of pollution. Collections made in September, 1919, contained six species, two being water-breathers and four air-breathers.

Musculium transversum	*Planorbis trivolvis*
Bythinia tentaculata	*Physa integra*
Galba catascopium	*Physa oneida*

It will be noted that of the returned species, one is different (*Physa integra*), while four are missing, *Galba caperata*, *Physa gyrina*, *Physa sayii*, and *Musculium partumeium*. It frequently happens that when a fauna returns to a habitat from which it has been driven by unfavorable conditions, it is made up of a different aggregation of species (see Ortmann, 1909, for additional notes on this subject).

The Genesee River is a striking example of the history of a polluted stream and its effect on one group of animal life. Previous to the stage of greatest pollution there is a varied fauna of mollusks very numerous in individuals. In the course of eleven years the gill-bearing species are forced out and after a lapse of fourteen years all molluscan life ceases to live in this part of the river. Seven years later the greater amount of sewage is diverted to another outlet. Two years after this change the mollusks have returned in as great numbers as before the maximum stage of pollution. The significance of all this lies in the fact of the early return of this life and strikingly indicates that streams may become restocked with life in a short period after pollution has ceased to be of an unfavorable character, provided, of course, the bottom of the stream has not been made permanently untenable by the deposition of poisonous substances that cannot be washed away by ordinary river currents. It is quite probable that the large fall of water, some 60 feet in height, immediately above the sewage outlet, has had a marked effect in the return of these favorable conditions.

No additional data are at hand indicating the changes in a polluted stream after septic conditions have ceased or become greatly modified. It is probable that similar beneficial results would be obtained in other streams if the sewage was diverted or treated to remove the large amount of organic matter. In the case of a stream like the Salt Fork, the septic condition of which will be discussed in the following pages, it would probably not require a very long time to reduce the septic conditions if the sewage from Urbana and Champaign were properly treated. While the putrescible matter at present covers everything, in some places to a considerable depth, the high water during the spring would in several seasons remove a large part of this material, and if no additional matter was permitted to flow into the stream, the lapse of a few years would enable nature to bring the stream back to a normal, healthy condition, and make it a place to seek for recreation instead of a place to avoid on account of its filth, as at present.

SEWAGE POLLUTION IN THE SALT FORK

The sewage and other wastes of the Twin Cities of Urbana and Champaign are discharged into the waters of the Salt Fork by separate systems, that of Urbana emptying into the Boneyard near the Big Four shops, while the sewer outlet of the Champaign system is situated on the Salt Fork about a mile below the Urbana outlet. There are two systems for each city, one for domestic wastes and the other for the care of storm water, the sanitary sewage. Septic tanks were installed with the systems, about the year 1894, to reduce the amount of putrescible matter, but at the present time the sewage receives little treatment and practically enters the Salt Fork in a crude condition.* The population in 1914 was estimated to be 13,750 for Champaign, and 9,252 for Urbana, or a total population of about 23,000 for the Twin Cities. At the present time, 1920, six years later, the increase has probably brought the total up to nearly 30,000. The sewage system, therefore, provides disposal for this population, and is all discharged into the waters of the Salt Fork. It is estimated by G. C. Habermeyer, that the total flow of sewage from the Urbana plant is about 500,000 gallons per day and from the Champaign plant about 1,000,000 gallons per day.**

The flow of the Salt Fork below the Champaign sewage disposal plant is 3,000,000 gallons per day. These figures indicate that the sewage forms one-half of the total water flowing down the Salt Fork. These data were taken in October, when the stream was low, and may be a trifle too high for those periods when there is a rise of water following a period of rainy weather. During a greater part of the year, however, the water is low and these figures will be approximately correct. The fresh water added to the sewage is derived from the stream north of Urbana which contributes 250,000 gallons per day, and the Boneyard, which adds 1,500,000 gallons per day, about two-thirds being clear water. "In October, 1917, the flow in the Boneyard below the Urbana tank was about one-third sewage and probably contained considerable other waste and sewage discharged above the Urbana sewage outlet. The flow in Salt Fork below the Champaign sewer outlet was probably one-half sewage."

H. E. Babbitt,*** thus describes the condition at the Champaign disposal plant at this date. "The appearance of the effluent from the Champaign septic tank is that of fresh sewage, having the typical color of sewage, and carrying fecal matter and paper. The appearance of the Salt Fork at the point of entrance of the sewage from the tank is good. It is about twenty

* New septic tanks have been installed at the Champaign sewage disposal plant on Salt Fork and a portion of the sewage is well treated before it enters the canal.

** Data for the sewage conditions, stream flow, chemical analyses, etc., of the Salt Fork are taken from an unpublished report of G. C. Habermeyer (assisted by S. D. Kirkpatrick, assistant chemist, and J. F. Schellbach, engineer) made for the State Water Survey Division of the Department of Registration and Education, of Illinois, and here used by permission of the late Chief of the Division, Dr. Edward Bartow.

*** From unpublished Report on the Champaign-Urbana Water Works System, prepared June 23, 1914. Extracts here published by permission of Edward Bartow.

feet wide, fifteen to eighteen inches deep, clear, colorless, and odorless. The stage of water at the time of inspection was low. No septic action was present except in the open ditch through which the sewage flows from the tank into the stream. There is a large sludge bank in the stream immediately below the outlet and a most obnoxious odor." Effluent from the Urbana tank appeared as typical fresh sewage, but was not representative of the ordinary effluent as the tank had been cleaned only the day previous to the visit (page 9).

The stream known under the name of the "Boneyard" carries both waste and sewage. This stream is about three and a half miles in length and rises about half a mile beyond the northern limits of the City of Champaign. The stream flows southward to near Third and Green streets, where it abruptly turns eastward, emptying into the Salt Fork near the Big Four shops in Urbana. This stream has a drainage area of about eight and a half square miles. Sewage enters the Boneyard near Goodwin Avenue and at the old high school on Stoughten Street, Urbana. Water bearing wastes, presumably from business houses near by, enters the stream north of Main Street. The banks close to the water line near Main Street culvert are slimy and green (data from G. C. Habermeyer, 1918).

The Boneyard is subject to great fluctuations of water level, due to the severe storms of spring and summer when heavy rains occur. At such times a rise of three or four feet in a few hours is not unusual and the waters overflow all adjacent low land. At one time (reported very bad in 1915) chemical wastes in the form of oil and tar were discharged into the stream from the gas works of the Champaign Street Railway, Gas and Electric Company, situated at the corner of Fifth and Hill streets, Champaign, east of the Illinois Central tracks. The oil at one period extended the entire length of the Boneyard, covering lawns, when the water was high, with an unsightly layer of heavy oil. The shores and bottom of the stream in many places were covered with tar, which has not subsequently been removed and also cannot be removed by the natural flow of water, but must be artificially taken from the stream bed.*

The oil discharged from the gas works, as well as from some other points along the Boneyard, is absolutely inimical to any life in the stream. The tar, if carried down stream, finally settles to the bottom and unless artificially removed, will remain there and render the stream unfit for bottom inhabiting life of any kind. Fortunately, such pollution is confined to the upper part of the Boneyard. Waters charged with sewage may become purified in a year or two after pollution ceases, but they will seldom or never recover from chemical pollution such as is produced by tar

* From Ralph Hilscher, Report on Contamination of the Boneyard in Champaign by Gas House Wastes August 28, 1915. Here published by permission of Edward Bartow.

and similar wastes. Ortmann's work on the rivers of western Pennsylvania clearly indicate the baneful results of such pollution (Ortmann, 1909).

The Boneyard is apparently now barren of all clean water life. Frequent examinations made during 1918 failed to supply any life of this character. Fresh water pulmonate mollusks, and *Cambarus* and other smaller Crustacea were once abundant, but appear to be wanting at the present time. A large snapping turtle was observed in the Boneyard near Lincoln Avenue, in 1918. The ditched portion of Salt Fork above Urbana, is a clean water stream, filled with aquatic life, which abruptly terminates at the junction of this stream with the Boneyard, with its load of sewage from Urbana. From here to a point fourteen miles below Urbana not a living mussel was found, and no air breathing snails were observed, except in one instance, believed to have been introduced from a near-by portion of the old river bed, which still retains clean water life, above St. Joseph, a distance of ten miles below Urbana. The large number of empty valves and paired shells of the river mussels below St. Joseph indicate an environment that has become, more or less recently, inimical to these creatures. Crayfish were also absent from the same area.

Habermeyer's report of Salt Fork, October 1, 1917, describes conditions as follows: "The stream below the Champaign outlet to the north line of section 10, one and a half miles below the outlet, was in very foul condition. At the east line of section 11, four miles below the Champaign sewer outlet, the stream appeared to be quite clear and there was no offensive odor noticeable. At the outlet of the west branch of Salt Fork, the water was clearer than that in the north branch (Spoon River). A resident near the junction of the two branches stated that at times when the creek flow increased, foul matter was washed down from above and there was considerable odor in the vicinity for a day or two."

The dredging of a new channel has been responsible for the water being clearer at times in Salt Fork than in Spoon River, providing a sand bottom which is hard and resistant and has not yet silted up to any degree. Spoon River has a mud bottom and the waters are turbid a large part of the time. In a photograph of the Salt Fork taken some eight miles below Urbana (two miles northwest of St. Joseph), the water was so clear that the ripple marks on the sandy bottom may be distinctly seen in the picture (Fig. 45) yet the stream at this point was totally barren of clean water life and the water was laden with masses of decomposing matter, made up of foul water algae and Protozoa, and the bottom was filled with slime worms (Limnodrilus). Below the junction of these two branches, bottom conditions are still very bad, and clean water life does not appear for a distance of several miles, as has already been shown.

The people mentioned in the report were interviewed in 1918. They reported that no trouble was experienced during periods of low water, but that after rains, when the stream rapidly rose, putrescible matter was washed down stream, cast on shore, and the odor was then very bad. This lasted until the water subsided. In the fall of 1920, the same people were again interviewed and conditions were reported to be much worse than previously, the unusually low stage of the water causing the putrescible matter to decay on the exposed sand bars in the river, from which some odor was noticed.

Stream measurements of the velocity of the current were made by the Water Survey at several points along the Salt Fork. These were made by Habermeyer on October 1, 1917, when the water was low in the stream. All data given in feet.

TABLE IX. MOUTH OF THE BONEYARD

Distance from east bank	1	2	3	
Depth of water	0.6	0.7	0.4	
Flow per hour	4608	4500	4320	
Salt Fork, Four Miles below Champaign Sewer Outlet				
Distance from bank	2.9	2.4	1.8	2.2
Flow per hour	3888	4320	4212	2412

These measurements indicate a very slow current, from about one half to nearly a mile an hour. At high water the rate of flow is undoubtedly several times as great. This slow rate of flow would cause much of the heavy matter in the sewage to be precipitated to the bottom and form sludge banks, and this has occurred at many places below both the Urbana and Champaign outlets. High water and more rapid current probably moves some of this sludge farther down stream, also carrying the fresh sewage farther down at such times. A recent examination made at very low water indicates that this has been the case, for hundreds of bars were observed out of water, each covered with a sludge formation of greater or less size.

Analyses of water from various places in the Salt Fork and tributary streams have been made by the Water Survey. The two tables that follow, taken from Habermeyer's report, indicate some of the conditions of the upper waters of Salt Fork (Tables X and XI).

In Table X the low percentage of dissolved oxygen (saturation) in the ditched stream above Lincoln Avenue is noteworthy as compared with the larger amount at Cunningham Avenue. At both localities, however, the water is relatively pure, there being little or no pollution. The sample from a mile and a quarter below the champaign outlet is striking because of the total absence of oxygen. The sudden rise in saturation at four and eight miles is also notable, and indicates that at these points on this date little decomposition was taking place. The sample from Salt Fork near Spoon River shows a marked fall in the amount of dissolved oxygen,

TABLE X. BACTERIOLOGICAL EXAMINATION, RELATIVE STABILITY, AND DISSOLVED OXYGEN IN SAMPLES FROM BONEYARD AND SALT FORK

Laboratory number	Total no. of bacteria per c c		Gas forming organisms in							Dissolved oxygen		Relative stability in percent	Temperature water F	Locality
	On gelatin 20°C	On agar 37°C	0.1	.01	.001	.0001	.00001	.000001	.0000001	p.p.m.	Percent of saturation			
38173	280	4,600	...	...	...	...	...	...	...	5.17	55 5	84	...	West of Lincoln Ave.
38174	1,400	2,220	*	...	...	...	...	...	...	7.75	84.5	84	68	Cunningham Avenue
38175	580,000	650,000	*	*	*	*	*	...	...	0.00	00.0	21	71	1¼ miles below Champaign sewer
38176	70,000	50,000	*	*	*	*	...	...	...	6.10	66.7	84	...	4 miles below Champaign sewer
38177	32,000	12,000	*	*	...	...	...	...	...	8.05	89.7	84	70	8 miles below Champaign sewer
38178	2,700	30,000	*	*	*	...	...	...	...	5.07	54.2	84	67	Mouth of Spoon River
38179	40,000	20,000	...	...	...	...	...	...	...	6.80	68.5	21	61	Up Spoon River
38180	600,000	500,000	*	*	*	*	*	...	...	2.45*	25.6*	21	64	Urbana sewage outlet
38181	81,000	95,000	*	...	...	...	...	...	...	1.00	10.7	11	...	Mouth of Boneyard

* Samples of dissolved oxygen and relative stability taken a short distance above number 38180.

TABLE XI. CHEMICAL ANALYSES OF SAMPLES FROM THE BONEYARD AND SALT FORK. PARTS PER MILLION

Laboratory number	Residue on evaporation		Loss on ignition. Dissolved residue	Chlorine in Chlorides	Oxygen consumed		Ammonia nitrogen	Albuminoid nitrogen		Nitrogen Nitrate Nitrogen	Nitrite Nitrogen	Alkalinity	Locality
	Total	Dis-solved			Total	Dis-solved		Total	Dis-solved				
38173	455	365	170	4	4.6	4.6	.112	.240	.240	.72	.025	252	West of Lincoln Ave.
38174	580	575	190	13	4.0	4.0	.048	.144	.240	.64	.020	240	Cunningham Ave.
38175	745	645	280	62	16.0	14.0	18.000	3.200	2.000	.20	.000	410	1¼ miles below Champaign sewer
38176	615	600	250	51	11.2	11.0	14.800	.720	.680	.48	.250	348	4 miles below Champaign sewer
38177	605	590	245	56	12.8	11.2	7.000	.752	.640	2.00	.300	338	8 miles below Champaign sewer
38178	630	585	245	59	10.0	9.2	23.000	.720	.480	2.20	.250	356	Mouth of Spoon River
38179	400	380	160	6	7.8	7.0	.080	.296	.360	.40	.002	248	Up Spoon River
38180	830	675	320	56	68.8	26.0	19.200	4.400	2.080	.48	.000	464	Urbana sewage outlet
38181	645	580	265	63	36.4	15.2	6.400	2.400	1.440	.36	.000	376	Mouth of Boneyard
38182	1460	825	360	85	38.8	31.2	32.000	6.400	1.600	.56	.000	482	Champaign sewage at manhole close to Urbana sewage tank.

which coincides with the absence of mollusks and crayfish from this part of the stream. The rise of the oxygen content 200 feet upstream in Spoon River shows the effect of the cleaner water, and this also coincides with the presence of clean water life in this part of Spoon River. The lower temperatures were probably responsible for the rise in oxygen content at the stations four and eight miles below Urbana. In the summer months, during low water and high temperature conditions, the percentage would probably be much lower. This difference was noted by Forbes and Richardson in their study of the Illinois River. The percentages of dissolved oxygen are relatively higher in these two stations of the Salt Fork, four and eight miles from the source of pollution, than in the Illinois River at Starved Rock, Hennepin, and Chillicothe, where samples taken in October showed smaller percentages, though many miles from the chief source of pollution at Lockport (Forbes and Richardson, 1913:565).

The rise and fall in the number of bacteria and the presence of many gas-forming organisms in the Salt Fork is well shown in the table. The sudden rise from Cunningham Avenue to the point one and a quarter miles below the Champaign sewer outlet is very striking and indicates in a graphic manner the difference between clean water and that heavily polluted by sewage wastes. The high number 200 feet up from the mouth of Spoon River indicates that there is some pollution in this stream, although not far above this point living mollusks (Naiades) were found in abundance.

In Table XI, the relative high amounts of albuminoid nitrogen, as well as ammonia nitrogen, supplied by the sewage material, in contrast with the small amounts in the purer water of the stream, are strikingly shown. All of these agencies are inimical to clean water life, especially fish, mussels, and crayfish, which by their relative abundance or absence, indicate in a most satisfactory manner the quality of the environment, and its fitness for the well-being of its inhabitants.

The sewage in the Salt Fork has greatly increased in recent years, following the increase in population, and, as in the case of the sewage from Chicago in the Illinois River, the polluted condition is gradually creeping down the stream below St. Joseph, changing the pure water inhabitants to those that can live under septic conditions. As no collections were made during previous years from the stream below St. Joseph it is not now possible to make comparisons of the present with previous conditions. Such lists as have been available have not indicated precisely the location from which they were collected (as in the neighborhood of St. Joseph, which might mean in the Salt Fork or in Spoon River) and they cannot be used for this reason. The value of exact local lists is emphasized in studies of this kind, showing that strictly technical (or pure science) information is often of the greatest value in the study of economic probems.

RECENT EXAMINATION OF THE POLLUTED PORTION OF SALT FORK

Figures 21, 36 to 45

During the fall, winter, and spring of 1919 and 1920 Salt Fork was carefully examined from Urbana to St. Joseph. All parts of the stream were searched for macroscopic life and samples of the bottom and of the water were taken for microscopic study, to determine the character and abundance of the foul-water organisms present. Examinations were made during the months of May, September, October, November, and December.

During the spring months the water is so high in the stream that collections can not be made and examination of the water is difficult. The great volume of water, laden with both sewage and silt, is of a dark lead color and polluted conditions are not apparent, although some putrescent matter was observed on several occasions. In the fall months conditions are much more favorable for critical examination, the water being so low that one may wade over any part of the stream. It is at this time, which extends from July through the fall and winter to the rainy period in March or April, that the polluted conditions are very apparent and the most satisfactory studies can be made. The general conditions of the stream at this period are summarized below.

The water in the Boneyard near the Big Four shops, below the Urbana sewage outlet is usually shallow, from a foot or less to two feet in places. The bottom is a mass of sludge with putrescent material covering all objects in the water and floating down the stream, which has an estimated flow of about half a mile an hour. Several large sludge banks are exposed and the odor is usually nauseating (Fig. 39). At the junction of the Boneyard with the Salt Fork the water varies from six inches to a foot in depth, there are several sludge banks and the putrescent matter covers all objects and lines the shores to a height of several feet, indicating former high water marks (Fig. 36). Samples of the sludge and green putrescent material from one of these sludge banks were examined by Professors Smith and Transeau and the following algae, Protozoa and other animals observed:

Blue-green algae

Pediastrum simplex, common.
Senedesmus abundans, rare.
Phormidium inundatum, abundant.

Diatoms

Navicula cryptocephala, common.
Synedea pulchella, not common.

Animals

Paramoecium, not common.
Euglena geniculata, very abundant.
Limnodrilus (sludge worm), very abundant.
Tubifex (sludge worm), one specimen.
Nematode worms, several.

Ciliate Protozoa were numerous, including Colpodium and a few hypotrichous and peritrichous species.

At the junction of the Boneyard with the Salt Fork the waters of the two streams usually formed two distinct bands, the clear water of the latter on the left or north bank and the murky, sewage-laden water of the Boneyard on the right or south bank, the line in the center of the stream dividing the two waters being clearly marked. (Fig. 21). The waters of these two streams do not fully mingle until they have flowed a distance of several hundred yards. All the way down the Salt Fork, however, as far as the first bridge, the right side is more discolored than the left side, indicating that the sewage-laden waters of the Boneyard and Champaign outlet flow mostly on this side of the stream.

At the Champaign sewage outlet, about half a mile below the Boneyard, there is usually a good flow of water from the discharge pipe into an open ditch, which empties into the Salt Fork a short distance away. At the point of entrance of the open ditch, the chocolate-colored water of the Champaign sewage is clearly marked as a dark band extending around the upstream end of a large sludge bank, similar to the one described in Habermeyer's report in 1917 (Fig. 41). Some fecal matter is generally present. The water in the Salt Fork at this point is usually less than a foot deep and the bottom is made up of a soft sludge which covers everything in the water. The odor is very bad, almost nauseating.

Below the Champaign outlet the stream is in very foul condition, as noted in Habermeyer's report. From the outlet to the first bridge, more than a mile down stream, the water is less than a foot deep, in most places but a few inches, and the bottom has much sludge, and putrescent matter covers every object in the water, as well as the shores and all objects on the shores to a height of several feet, indicating former stream levels. Fecal matter, in dark brown masses, as well as partly decomposed organic matter colored green by the presence of blue-green algae and the protozoan *Euglena*, are usually floating down the stream. The bottom substratum is of sand and gravel, and over this sludge banks have been formed of greater or less thickness. Bars of sand and gravel occur at irregular intervals and are covered with masses of putrescent matter forming long, alternating streaks of black and green. An oily scum resembling petroleum covers the surface in many places, and the bottom, when disturbed, emits an oily substance which spreads over the surface as an oily scum. This may represent some gas house wastes as well as heavy oil from other places along the Boneyard. The odor in this section of the stream is almost overpowering in many places, being distinctly a privy smell. In one place the observer was compelled to leave the vicinity of the stream, the odor was so strongly nauseating. In places, bubbles of gas may be seen to break at the surface from submerged sludge banks.

Samples of the bottom sludge and putrescent matter floating in the water were collected just above the bridge, about a mile and a quarter below the Champaign outlet. Algae and animal life were noted, but not as abundantly as in the sludge bank at the junction of the Salt Fork and Boneyard (Fig. 21).

Animals	Blue-green algae
Euglena geniculata, very few.	*Phormidium inundatum*, abundant.
Paramoecium, one specimen.	Diatoms
Vorticella, very few.	*Navicula salinarum*, abundant.

The scarcity of microscopic life and the total absence of clean-water life is paralleled by the chemical condition of the water at this station, where the examination of samples showed a total absence of dissolved oxygen and the presence of multitudes of bacteria and gas-forming organisms (see Tables X, XI).

From the first iron bridge to the Brownfield woods bridge, a distance of about a mile and a quarter, the stream is very shallow, less than a foot in depth on the average, the water grayish with a sloppy appearance, and the odor foul in places, though not as nauseating as below the first bridge. Putrescent masses of soft, grayish-black or greenish matter, ranging in size from a penny to a platter, may be seen floating down stream, held together by algal strands. Brown masses observed on shore resembled human excrement. The oily appearance of the surface of the water continues and oily matter ascends when the bottom is disturbed.

From the Brownfield bridge to the third (farmer's) bridge, a distance of about three-quarters of a mile, the conditions are the same as above this bridge (Fig. 38). Between the third bridge and the Cottonwoods road bridge, a distance of about a mile, the water is very shallow, scarcely exceeding six-inches in depth, with gravel or sand bottom. Sludge bars, of sand mixed with organic matter, are frequent, in many places occupying more than half the width of the stream, the channel, a few inches to a foot in depth, meandering over the bottom between these bars (Fig. 40).

These bars presented a striking appearance, the stones and sand being black from the decomposing organic matter, and the foul water algae being arranged in long streaks, presenting in combination a striped green and black design. The green algae is here very abundant, floating in the stream or covering the shores. In places the encrusting material on the shore margins is bright yellow. Everywhere along the stream the exposed surface of the bottom is black from the decomposing organic matter, which covers all objects and has been baked hard by the hot summer's sun. The vegetation bordering the shore also shows the effect of sewage action, being either black in color or having the dried pieces of polluted material attached to the lower part of the plants. The same conditions prevail from the Cottonwoods road to the Mayview road, a distance of about two miles.

Collections of materials made just below the third farmer's bridge, about three and a half miles below the Champaign outlet, contained the following organisms:

Blue-green algae	Animals
Phormidium inundatum, abundant.	Flagellate Protozoa, very minute.
Diatoms	*Euglena geniculata*, very abundant.
Navicula salinarum, abundant.	Many in stage of encystment.
	Dineutes assimilis, very abundant.
	On the surface of the water.

Collections at the Cottonwoods bridge (Fig. 42) contained a larger variety of animal life, which was rather meagerly represented above this bridge. This place is on the east line of section 11, about four miles below the Champaign outlet. The bottom here is of fine sand and mud.

Blue-green algae	Animals
Phormidium inundatum, abundant.	*Euglena geniculata*, very abundant.
Diatoms	Rotifer, illoricate, one specimen.
Navicula salinarum, abundant.	Limnodrilus, two specimens.
	Dineutes assimilis, a few examples.

Mussel shells or other mollusks were entirely absent in a living state and their shells were notably rare. About three quarters of a mile below the first bridge east of Urbana, a half valve of *Lampsilis luteola* was found on a sand bar (Fig. 37). Near the Brownfield woods bridge many broken pieces of mussel shells, as well as a few mutilated half valves, were observed. At a farmer's bridge half a mile below this bridge several broken valves of *Lampsilis luteola* and *Anodonta grandis* were collected, (Fig. 38) and from this point down stream to the Cottonwoods road bridge detached valves or broken pieces of shell were more or less common. From observations of this and other parts of the stream it seems evident that these mutilated shells were washed from the spoil banks on either side or from the bed of the old stream channel where it crosses the canal. At the junction of the Boneyard with the Salt Fork a layer of these shells was observed in the bank, about eighteen inches above the water line (the water being low), in a position that indicated the old bed of the Salt Fork before the canal was excavated. High water would wash this material way and provide the odd valves of mussels observed in different parts of this stream.

Below Mayview road bridge the conditions are much the same as in the neighborhood of the Cottonwoods bridge. The bottom is of sand and gravel, with some mud bordering the shore. The water is from a few inches to a foot in depth, the channel meandering among a continuous series of sand bars. The sand is ripple-marked in places and streaked with bands of dark green algae, with yellowish algae in spots. The surface of the flowing portion of the stream is thickly covered with patches of dark green putrescent matter, measuring in size from a peanut to a dish pan. Some of these masses are brownish, where the algae and Protozoa have not completely taken possession of them.

A large amount of oily scum may be observed on the surface and when disturbed the bottom emits quantities of oily matter, as is the case higher up the stream. On exposed bars and along shore the algae and putrescent matter have dried and caked, forming a pavement-like layer. The water is clearer here than in the portion of the stream previously examined, but no clean water life could be found; mussels, crayfish, and insects were entirely absent.

Samples of the bottom from the stream about 300 feet east of the Mayview road bridge, about six miles below the Champaign outlet were examined. The following life was present:

Blue-green algae	Animals
Pediastrum simplex, rare.	Ciliata, minute, abundant.
Phormidium inundatum, common.	Colpodium, several.
Diatoms	*Euglena geniculata*, very abundant.
Navicula salinarum, abundant.	Limnodrilus, common.
Fragilaria capucina, abundant.	Nematode worms, minute, abundant.

About a mile and a half below this locality additional samples were taken for examination. Conditions are similar but the water is not as clear, holding more sediment in suspension.

Blue-green algae	Animals
Pediastrum simplex, rare.	Ciliata, minute, abundant.
Phormidium inundatum, abundant.	Paramoecium, several.
Diatoms	*Euglena geniculata*, abundant.
Fragilaria capucina, abundant.	Limnodrilus, about a dozen.
	Nematode worms, minute, many.

At the last north and south farmer's bridge, the canal makes a wide sweep, in a southeasterly direction (Fig. 43) leaving the old stream bed to the west of the new channel, in the form of an 'ox-bow' almost half a mile in length, which, during the greater part of the year, forms a large elongated pond, that drains into Salt Fork canal by means of a small outlet at the south end which turns abruptly northeastward as it empties into the canal. At the time examined, the bed of this old stream was almost dry, following a period of very dry weather, and the fauna had retired to several small, shallow, muddy pools which remained in the deeper parts of the stream bed. An examination of these pools disclosed a number of bullheads (*Ameiurus melas*), many dragonfly larvae (*Libellula pulchella*), and a few mollusks (*Planorbis trivolvis*, *Physa gyrina*, and *Musculium transversum*).

It seems evident that this portion of the old stream forms a reservoir from which certain species of mollusks, as well as fish, are carried, or voluntarily migrate, through the outlet into Salt Fork. By this means only can the presence of these animals in the polluted water be accounted for, because none have been seen either above or far below the drain from the old stream channel. The specimens of *Planorbis trivolvis*, that have been observed in the Salt Fork canal below the east and west road bridge, were probably derived from this source.

Specimens of *Planorbis trivolvis* have been observed in the Salt Fork canal which probably came from this source. Near this locality a school of about fifty fingerling bullheads was observed on May 29, in a small part of the stream where a rather deep pool had developed. They were making frantic efforts to get out of the pool but the surrounding water was too shallow. The low water and general polluted condition of the stream evidently provided a very unfavorable environment. The source from which these fish came was quite likely the old cut off portion of the original Salt Fork from which place they had been carried or had voluntarily migrated, when the water was higher from the April rains.

From the east and west road bridge (Fig. 45) to the first farmer's bridge, a distance of about three-quarters of a mile, the conditions are the same as in the preceding portion of the canal. The water is clear but no living mollusks or other animals could be found. A half valve of *Anodonta grandis*, badly weathered, and a few bleached valves of *Sphaerium solidulum*, were the only evidences of molluscan life. These had evidently been washed from the old stream bed at some point where it was exposed by erosion in the canal walls. The same algae as previously observed was floating down the stream in large green patches. Samples of these green particles were examined by Professor Smith and found to contain such animals as *Euglena geniculata*, Paramoecium, and numerous ciliate Protozoa, mostly inhabitants of polluted water.

From the next farmer's bridge to the eastward turn of the stream the bottom conditions were also similar, except that the surface of the water was covered with an oily scum. Groups of greater or less size of gyrinid beetles (*Dineutes assimilis*) were seen at different places down stream for a mile or more. A single empty shell of *Planorbis trivolvis* was observed on the shore of the west bank below this bridge. No living clams were seen, nor any mutilated valves.

From the eastward turn of the stream to the mouth of Spoon River, the canal is in bad condition, the water being dirty and oily, with numerous bubbles of gas rising constantly from the bottom, which also gave off quantities of oily scum when disturbed (Fig. 44). The water is shallow and conditions as already described for the stream higher up. Green putrescent matter is not quite as abundant as higher up in the canal and the odor is not as bad.

Samples were collected from a point about a mile above the junction of Salt Fork with the Spoon River. Organisms were fewer in both species and individuals.

Blue-green algae

Phormidium inundatum, common.

Diatoms

Synedea pulchella, abundant.
Fragilaria capucina, abundant.

Animals

Ciliata, abundant.
Euglena geniculata.
Limnodrilus, a few individuals.

Below the mouth of Spoon River conditions are also bad. Where the current is strong, sand bars have been formed which cover the black mud beneath. Everywhere, except in the channel where it is sandy, the bottom is of soft mud, eight to fifteen inches deep, filled with ill-smelling gasses. Sewage conditions here are bad, the water having a foul smell. When wading in the water, the disturbed mud, which is black and oozy, constantly gives off bubbles of gasses that rise to the surface and break. This condition is uniform for the entire stretch of stream bed examined, about a third of a mile, from near the mouth of Spoon River to the middle of the big bend above St. Joseph. The surface of the water is usually covered with a film of oil resembling petroleum.

No living mussels could be found in this area. A single valve of *Amblema undulata* was seen near the mouth of Spoon River which was probably brought to its resting place from Spoon River during a period of flood. It is noteworthy that while no mussels or gill-bearing snails were observed in this part of Salt Fork, several species of fresh water pulmonates were seen in considerable numbers, indicating that here, as elsewhere, the pulmonates are able to live in water which is totally unfit for mussels and gill-bearing mollusks.

Examples of the bottom sediments and green masses floating in the water were taken from the stream about a hundred feet below the mouth of Spoon River. Algae was plentiful and included *Phormidium inundatum*, a blue-green species, in abundance. Two species of diatoms, *Navicula salinarum* and *Fragilaria capucina*, were also present. Of animals, Limnodrilus was well represented, but *Euglena geniculata* was not common, and ciliate Protozoa were much less numerous than in samples taken from stations higher up in the stream. Salt Fork here shows the influence of the added cleaner water from Spoon River.

At the mouth of Spoon River a bar has been formed, by natural or artificial agencies, which, except for a space about four feet wide, holds back the waters of that stream (Fig. 16). An examination was made of Spoon River about 400 feet above this bar. Here five species of mussels were found, in more or less abundance, and insects were also abundant. The water is low, two or three feet deep in the channel in the fall and the bottom is very muddy. A very small amount of green algae was noted on the surface, evidently brought up from Salt Fork. The mussels collected included:

Lasmigona complanata
Amblema undulata
Carunculina parva
Lampsilis luteola
Eurynia lienosa

A water boatman (*Corixa*, near *burmeisteri*) was very abundant, especially in the nymph stage, as were also numerous gyrinid beetles (*Dineutes assimilis*). Though the water was low, men were observed fishing for bullheads in this part of Spoon River. The contrast between this stream, with its abundance of clean water life, and the adjacent parts of Salt Fork, which is utterly devoid of clean water life, strikingly indicates the harmful effects of sewage pollution on the fauna of our streams.

Samples of the green matter floating on the water of the Spoon River were examined and found to contain *Euglena geniculata*, common, ciliate Protozoa, many. These masses seem to be made up almost entirely of these animals and low plants, of which three species were noted: *Phormidium inundatum* alga; *Navicula salinarum* and *Fragilaria capucina*, diatoms. A single pupa of *Chironomus decorus* was found at this place.

For a distance of several miles below St. Joseph unfavorable conditions seem to prevail, no living mussels being found for a distance of over four miles, and here they occur rarely. Living mussels are not found in any number for a distance of over five miles below St. Joseph. These animals are not abundant in species and individuals until a distance of twenty miles has been traversed below Urbana. Conditions for a distance of two miles below St. Joseph are similar to those described for the area just below Spoon River, the bottom consisting of black mud from which bubbles of ill-smelling gas rise when the bottom is disturbed. Below this point conditions begin to improve, though very gradually.

That conditions along the polluted portion of Salt Fork are often, if not always, highly objectionable was evidenced from conversations with farmers living near the stream. One farmer, who had built a small house within a few hundred feet of the stream, stated that the "stench was at times almost unbearable" and that people living half a mile away were strongly conscious of the odor. This was about five miles down the stream from Urbana. A gentleman driving along the road which parallels the Salt Fork east of Cottonwoods road, stated that the odor on September 10 was very obnoxious. People living a mile south and north of the stream do not suffer from these odors.

SUMMARY OF SALT FORK CONDITIONS

It has been shown in the previous pages that the sewage and other wastes that drain into the Salt Fork from the Twin Cities have driven out or killed all clean water life from the junction of the Boneyard with Salt Fork to a point about four miles below St. Joseph, or fourteen miles below Urbana. At this point a few living mussels are found and also a few crayfish. One must pass down the stream for a distance of twenty miles before encountering a normal river fauna, comparable to that found in Spoon River at a point less than a mile above the junction of that stream with Salt Fork. The abundance of clean-water life in Spoon River is in marked contrast with the total absence of this kind of life in Salt Fork, which normally would have, in suitable habitats, a similar fauna in the barren stretch of ten miles between the two localities compared. No better example is known of the total annihilation of a fauna from so great a distance as the result of polluted conditions.

Foul water algae and Protozoa, as well as some other animal life (slime worms) characteristic of polluted water, are abundant in that portion of the stream devoid of clean water life. The same relative conditions were observed by Forbes and Richardson in their study of the Illinois River.

Fish, especially young fish, have been made an index to the degree of pollution of streams. It would seem from observations made during the course of the present study, as well as from other occasions and in other places, that bottom-inhabiting animals, such as river mussels and crayfish, provide a better index for this purpose. Fish are able to migrate easily and swiftly from an unfavorable to a more favorable environment, but these more sedentary animals, especially the mussels, cannot change their environment so easily and must either adapt themselves to the more unfavorable conditions or perish. For example, young bullheads were observed in Salt Fork about three miles above St. Joseph in the spring when the water was comparatively high. But no mussels or crayfish have been seen within five miles of this point. This indicates clearly that fish are more flexible in this matter than the mussels and crayfish, which are not as mobile. Ortmann (1909:93–94) believes that crayfish are slightly more resistant than mussels to polluted conditions, and as scavengers (they have been observed eating dead mussels) they could naturally withstand a limited degree of unfavorable environment. Observations made on the Salt Fork, however, indicate that the two groups appear at about the same time.

Forbes and Richardson (1913:498) distinguish three stages of impurity of streams, which may apply equally well to either the stream itself or to the organisms living in the stream. These terms are "given in the order of diminishing impurity, namely, (1) septic or saprobic, (2) polluted or pollutional, and (3) contaminated or contaminate; and to these we will add 'clean-water' to indicate the conditions and organisms substantially equivalent to those of the natural, uncontaminated stream."

Judging Salt Fork by these standards of impurity, we would say that from the Urbana sewage outlet to the first bridge below the Champaign sewer outlet, a distance of about two miles, the stream is in a septic condition. From this point to about two miles below St. Joseph it is polluted. From this region to Homer Park, below the dam, it is contaminated. Below the dam there is probably some contamination at times, but the fauna is a clean water one and the stream would be classed as a clean water stream, being unmodified by sewage conditions. The lower part of Salt Fork near Middle Fork, and Middle Fork and the Big Vermilion as far as Danville are clean-water streams with a large and varied fauna of mussels, crayfish, and insect larvae. Below Danville there is sewage pollution, and conditions are again unfavorable.

SUMMARY AND CONCLUSIONS

The mussel fauna of the Big Vermilion River consists of at least 35 species and varieties. Ten species of small pelecypods and 15 species of gastropods also occur, making a total molluscan fauna of 60 species and varieties occurring in a distance of upwards of 50 miles. The mussel fauna of this stream compares well with that of two other Illinois streams of comparable size, the Sangamon, 150 miles long, with 25 species, and the Kankakee, 300 miles long, with 48 species. The total length of the Big Vermilion River is 90 miles, with 35 species. Seventeen species of Naiades occur in the Big Vermilion River that have not been found in the Sangamon River, while five species have been collected from the Sangamon that have not yet been detected in the Big Vermilion. The former stream belongs to the Mississippi drainage while the latter is a part of the Wabash drainage.

In the Big Vermilion it was noted that there was a progressive increase in number of species as the distance down stream increased, the headwaters containing but few species, which are usually smaller than the same species from lower down in the stream. It was also observed that the headwater inhabitants, as well as many naiads farther down the stream, were more compressed and of greater comparative length than the same species as it occurred in the larger part of the river.

The dam at Homer Park, 27 miles below Urbana, appears to form a barrier between the fauna above and below this obstruction. Above the dam, 19 species occur, while below the dam, 33 species have been observed. It is noteworthy that immediately above the dam the largest number of species found at one habitat was 14, while below the dam, at Homer Park, 28 species have been collected. It is probable that the fall of water over the dam aerates the stream and provides an especially favorable environment for the mussels.

UNFAVORABLE INFLUENCES

Sewage pollution has killed all clean water life for a distance of fourteen miles below Urbana and has made the stream an unfavorable environment for a distance of twenty miles. Below this point the fauna is normal and is not affected by sewage conditions. In the desert area between St. Joseph and Urbana, slime worms and septic Protozoa were observed among the animals and foul water algae among the plants. A few beetles, breathing free air, were observed in the stream near St. Joseph and for some distance above this locality. Many of the old pond-like bodies of water left on either side of the new drainage ditch are inhabited by clean water animals that occasionally get into the ditch during periods of high water. Fish, mollusks, and insects have been observed which doubtless came from this source.

PARASITES AND PATHOLOGIC AGENCIES

As a rule, parasites, either distomids or Unionicola (Atax) were rare in the naiads collected in the Big Vermilion and Sangamon rivers. Some of the Anodontas had marginal cists of distomids and many shells of this genus were discolored from this cause. Clark and Wilson (1912:61), in their study of the Maumee River fauna, observed distomids in various mussels which were believed to be the distomids described by Osborn and Kelly. The affected mussels were *Actinonaias ligamentina*, *Obovaria circulus*, *Elliptio gibbosus*, *Lampsilis ventricosa*, *Amblema undulata*, *Lasmigona costata* (thought to be the distomid of Kelly), and *Anodonta grandis* (thought to be the distomid of Osborn). It is probable that these flat-worms also infest many of the mussels of the rivers investigated, but they were not observed in the specimens collected. *Cotylaspis insignis* and forms of *Unionicola* were also found by Clark and Wilson, but these parasites were not seen in the mussels examined from the area under consideration.

Pearls, usually of small size, were frequently seen attached to the shells of mussels, and many pearly growths cause by injuries were also observed. A large round pearl was found in a shell of *Anodonta grandis gigantea* from Crystal Lake, which measured almost a quarter of an inch in diameter (5 mm.). It has been suggested that many of these pearls and pearly growths attached to the mussels may have been caused by parasites, such as the distomids before mentioned. The same is also true of the round pearls found in the animal tissues of the mussels.

Crippled shells, those individuals have abnormal valves, were not common in either of the rivers examined. Mud was found to cause trouble in many cases, getting in between the mantle and the shell below the pallial line and causing large blisters.

ECONOMIC CONSIDERATIONS

The shells known as river mussels or Naiades are used in the manufacture of pearl buttons. As this industry, the making of pearl buttons, has reached large proportions it is imperative that the raw material be conserved for the maintenance of the industry. The continued fishing of the mussel beds in the larger rivers has greatly depleted the amount of available raw material—the mussel beds—, and the whole industry, shell collecting and button making, is threatened with disaster if means are not found to restock the depleted beds (see Coker; 1919:44). The United States Bureau of Fisheries has conducted many interesting experiments on the propagation of mussels by the artificial infection of fish with mussel glochidia and the means and methods for restocking these cleaned-out areas are at hand. It only remains for proper laws to be passed and enforced, by the states or federal government, or both, regulating the time and place in which shelling operations may be carried on. Reasonable time must be given, at least three years, for the recovery of a depleted mussel bed.

In this connection it would seem that the mussel fauna of such a stream as the Big Vermilion River might form a reservoir from which the depleted beds farther down the stream might be restocked by fish which had been infected with glochidia from the commercial species living in the smaller stream. The Big Vermilion contains eleven species that are used for cutting button blanks and are considered valuable for this purpose by the button manufacturers. These are:

Amblema undulata Blue point
Lampsilis luteola Fat mucket
Lampsilis anodontoides Yellow sand-shell
Lampsilis ventricosa Pocket-book
Tritogonia tuberculata Buckhorn
Quadrula pustulosa Warty-back
Quadrula lachrymosa Maple-leaf
Actinonaias ligamentina Mucket
Fusconaia rubiginoas Wabash pig-toe
Lasmigona complanata White heel-splitter
Lasmigona costata Fluted shell

Several of the smaller shells are also used when shells are scarce, as *Lampsilis compressa*, *Quadrula metanevra*, *Obovaria circulus*, and *Strophitus edentulus*. In the Sangamon River about the same number of species suitable for the button industry occur and these are usually of fine quality.

In their survey of the mussel fauna of the Kankakee basin, Wilson and Clark (1912:35) recognize the value of these smaller streams, with a fauna too small in individuals to be used by the shell fishermen, but containing many of the essential species from which good button blanks may be cut. These authors say: "The most valuable species are all good breeders throughout the basin. This, taken in connection with the excellent quality of the shells they produce and the good railroad facilities everywhere available, makes this basin one of the best yet examined for the supply of glochidia to be used in artificial mussel propagation." This statement might apply with almost equal force to the Big Vermilion, which may sometime be needed for a reservoir from which to propagate the mussels in the larger rivers.

Whether all of the fishes which have proved the most satisfactory hosts for glochidia are abundant here is not known, but as young of nearly all the commercial shells were observed, it follows that the fishes carrying the glochidia must also be present.

The Big Vermilion River is seen, therefore, to be a valuable asset to the State, containing a fauna of both biologic and economic importance, which should be conserved for possible use as a restocking reservoir for the larger rivers. Pollution should be reduced to a minimum and the timber along the banks, especially of the headwaters, should be conserved in order that the water may be held in the ground and gradually flow into the streams, instead of running off in floods, causing excessive high water in the spring and extremely low water in the fall and winter. It would be possible to reforest many parts of the upper branches of the streams, where they are low or irregular places unfit for farming operations.

BIBLIOGRAPHY

Adams, C. C.

1900. Variation in Io. Proc. Amer. Assoc. Adv. Sci., 49:208–225.

1915. The Variations and Ecological Distribution of the Snails of the Genus Io. Memoir Nat. Acad. Sci., 12, 184, pp. 61 pl.

Baker, F. C.

1906. A Catalogue of the Mollusca of Illinois. Bull. State Lab. Nat. Hist., 7:53–136.

1920. Animal Life and Sewage in the Genesee River, New York. Amer. Nat., 54: 152–161.

1920. A New Planorbis from Illinois. Nautilus, 33:123–125.

Binney, W. G.

1865. Land and Fresh Water Shells of North America. Part II, 161 pp., 261 figs.; part III, 120 pp., 232 figs.

Clark, H., and Wilson, C. B.

1912. The Mussel Fauna of the Maumee River. Bureau Fish., Doc. 757, 72 pp., 2 pl.

Coker, Robert E.

1914. The Protection of Fresh-water Mussels. Bureau Fish., Doc. 793, 23 pages, 2 pl.

1919. Fresh-water Mussels and Mussel Industries of the United States. Bull. Bur. Fish., 36:11–89, 46 pl.

Danglade, Ernest.

1914. The Mussel Resources of the Illinois River. Bureau Fish., Doc. 804, 48 pp., 5 pl.

Eldridge, John A.

1914. The Mussel Fishery of the Fox River. op. cit., 8 pp.

Forbes, S. A., and Richardson, R. E.

1908. The Fishes of Illinois. Nat. Hist. Surv. Ill., Vol. III, Ichthyology. 357 pp. Many plates and an Atlas of maps.

1913. Studies on the Biology of the Upper Illinois River. Bull. Ill. State Lab. Nat. Hist. 9:481–574, 21 pl.

1919. Some Recent Changes in Illinois Biology. Bull. Ill. State Lab. Nat. Hist., 13: 137–156.

Haldeman, S. S.

1842–1844. A Monograph of the Fresh-water Univalve Mollusca of the United States. Philadelphia. Many colored plates.

Howard, Arthur D.

1914. Experiments in the Propagation of Fresh-water Mussels of the Quadrula group. Bur. Fish., Doc. 801. 52 pp., 6 pl.

1914. A Second Case of Metamorphosis without Parasitism in the Unionidae. Science, 40:353–355.

Iseley, Frederick B.

1911. Preliminary Note on the Ecology of the Early Juvenile Life of the Unionidae. Biol. Bull., 20:79–115.

1914. Experimental Study of the Growth and Migration of Fresh-water Mussels. Bur. Fish., Doc. 792, 24 pp., 3 pl.

LeFevre, Geo., and Curtis, Winterton C.

1908. Experiments in the Artificial Propagation of Fresh-water Mussels. Bull. Bur. Fish., 28:615–626.

1910. Reproduction and Parasitism in the Unionidae. Journ. Exper. Zool., 9:79–115, pl. 1–5.

LEIGHTON, MARSHALL O.

1904. Quality of Water in the Susquehanna River Drainage Basin. Water Supply and Irrigation Paper No. 108, U. S. Geol. Surv., 76 pp.

LEVERETT, FRANK.

1899. The Illinois Glacial Lobe. U. S. Geol. Surv. Mon. 38.

MARSH, M. C.

1908. Notes on the Dissolved Content of Water in its Effect upon Fishes. Bull. Bur. Fish., 28:891–906.

ORTMANN, A. E.

1909. The Destruction of the Fresh-water Fauna in Western Pennsylvania. Proc. Amer. Phil. Soc., 48:90–110, 1 pl.

1912. Notes on the Families and Genera of the Najades. Ann. Carnegie Mus., 8:222–365.

1918. The Nayades (Fresh-water Mussels) of the Upper Tennessee Drainage, with Notes on Synonymy and Distribution. Proc. Amer. Phil. Soc., 57:521–626.

1920. Correlation of Shape and Station in Fresh-water Mussels (Naiades). Proc. Am. Phil. Soc., 59: pp. 267–312.

1920a. A Monograph of the Naiades of Pennsylvania. Part III. Systematic Account of the Genera and Species. Mem. Carnegie Mus., 8:1–384, 21 pl.

PENNSYLVANIA.

1918. Industrial Waste Survey of the Clarion River Basin. Ann. Rept. Commis. Health, Penn., 10:1279–1316.

SHELFORD, V. E.

1917. An Experimental Study of the Effects of Gas Waste upon Fishes, with Especial Reference to Stream Pollution. Bull. State Lab. Nat. Hist., 11:378–425.

1918. Ways and Means of Measuring the Dangers of Pollution to Fisheries. Bull. Ill. Nat. Hist. Surv., 13:23–42.

SIMPSON, C. T.

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

SMITH, FRANK.

1915. Two New Varieties of Earthworms with a Key to Described Species in Illinois. Bull. State Lab. Nat. Hist. 10:551–559, 1 pl.

SURBER, THADDEUS.

1912. Identification of the Glochidia of Fresh-water Mussels. Bur. Fish. Doc., 771, 10 pp. 3, pl.

1913. Notes on the Natural Hosts of Fresh-water Mussels. Bull. Bur. Fish., 32: 101–116, 3 pl.

1915. Identification of the Glochidia of Fresh-water Mussels. Bur. Fish. Doc., 813, 9 pp. 1 pl.

UTTERBACH, W. I.

1916. The Naiades of Missouri. Amer. Midland Nat., 4, nos. 1–10, 200 pp., 29 pl.

1916. Breeding Record of Missouri Mussels. Privately printed, 8 pp.

WALKER, BRYANT.

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., no. 6. 213 pp., many cuts.

WARD, H. B.

1918. The Elimination of Stream Pollution in New York State. Trans. Amer. Fish. Soc., 48:25 pp.

1919. Stream Pollution. Jour. Amer. Water Works Assoc., 6:823–831.

1919. Stream Pollution in New York State. A Preliminary Investigation of the Problem from the Standpoint of the Biologist. New York Conserv. Comm., 79 pp., 3 pl.

Wells, M.

1918. The Reactions and Resistance of Fishes to Carbon Dioxide and Carbon Monoxide. Bull. Ill. State Lab. Nat. Hist., 11:557–571.

Wells, W. F.

1920. Conservation of the Quality of Water of New York State as a Natural Resource. Science, 52:279–284.

Wilson, C. B. and Clark, H. W.

1912. The Mussel Fauna of the Kankakee Basin. Bur. Fish. Doc., 758, 52 pp., pl. and map.

1914. The Mussels of the Cumberland River and its Tributaries. Bur. Fish. Doc., 781, 63 pp., 1 pl.

PLATE I

EXPLANATION OF PLATE

FIG. 1. Drainage ditch above Urbana, east of cemetery. Station 2.

FIG. 2. Salt Fork south of Muncie. Note water willow in center of stream bed; also numerous bare portions of stream bed, the river appearing as a series of pools. October, 1919. Station 26.


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PLATE II

EXPLANATION OF PLATE

FIG. 3. Old stream bed of Salt Fork in Busey woods, north of Crystal Lake, Urbana. Original habitat for *Planorbis pseudotrivolvis*. Station 3.

FIG. 4. Junction of Middle Fork with Salt Fork to form the Big Vermilion River. Looking south from road bridge crossing Middle Fork. September 26, 1920.

Fig. 5. Middle Fork a fourth of a mile above junction with Salt Fork. Bed of river exposed in foreground. Station 29. September 26, 1920.


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PLATE III

EXPLANATION OF PLATE

Fig. 6. Spoon River, seven-tenths of a mile above Salt Fork. Station 10. September 28, 1918.

Fig. 7. Spoon River, riffles below bridge, same locality as Fig. 6.


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PLATE IV

EXPLANATION OF PLATE

Fig. 8. Bench mark 655, Salt Fork, above road bridge. Station 17. September 13, 1918.

Fig. 9. Salt Fork two and a half miles north of Sidney, looking north, the Champaign moraine on the left, a flood plain on the right. Station 18. September 13, 1918.

BAKER FAUNA OF BIG VERMILION RIVER PLATE IV

PLATE V

EXPLANATION OF PLATE

FIG. 10. Iron bridge one mile north of Sidney. Station 19. August 26, 1918.

FIG. 11. Cement bridge northeast of Sidney. Note large area of water lily, *Nymphaea advena*. Station 20, August 26, 1918.

PLATE VI

EXPLANATION OF PLATE

FIG. 12. Salt Fork three and a half miles above Homer Park, Station 23. October 4, 1918.

FIG. 13. Salt Fork. Deep pool below dam and rapids. Professor Smith's field laboratory during a period of twenty years. Station 25. November 4, 1920.


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PLATE VII

EXPLANATION OF PLATE

Fig. 14. Dam in Salt Fork at Homer Park. The dam is just below the interurban bridge and is five feet high. November 4, 1920.

Fig. 15. Salt Fork below dam at Homer Park. Shallow water and rocky bottom. November 4, 1920. Part of Station 25.


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PLATE VIII

EXPLANATION OF PLATE

FIG. 16. Salt Fork and mouth of Spoon River. Rowboat marks outlet of Spoon River through bar. September 24, 1920.

FIG. 17. Valley of Big Vermilion River from crest of bank at Gray's Siding. October 8, 1920.

FIG. 18. Cutting through shale rock covered with glacial deposits. Big Vermilion River one mile below mouth of Middle Fork. Station 30. October 8, 1920.

PLATE IX

EXPLANATION OF PLATE

Fig. 19. Rock bed of Big Vermilion River one mile below Middle Fork. Station 30. October 8, 1920.

Fig. 20. Sandbar in center of riverbed, several hundred feet below fig. 1. Station 30. October 8, 1920.

Fig. 21. Junction of Boneyard with Salt Fork. Boneyard on right above ice. December 20, 1919.


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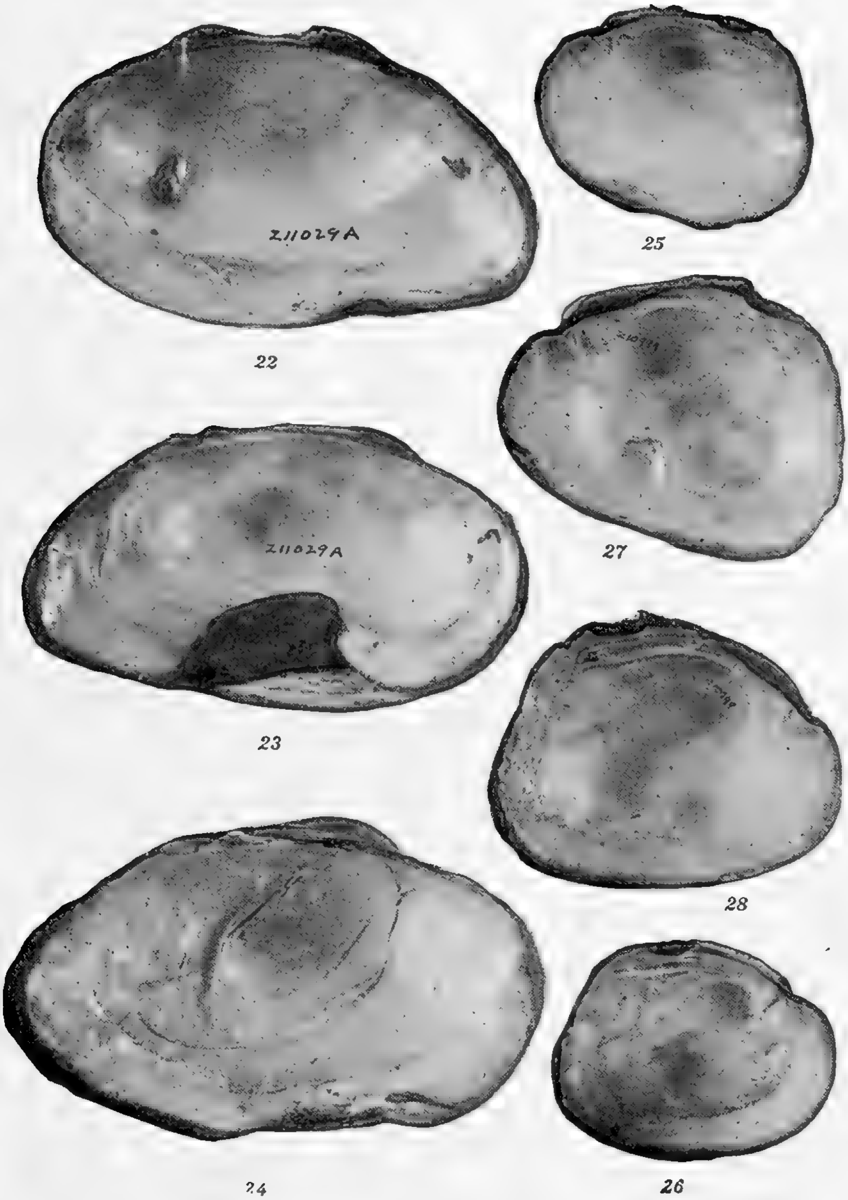
PLATE X

EXPLANATION OF PLATE

Fig. 22. *Anodonta grandis.* Right valve with pearly growths at anterior end.
Fig. 23. *Anodonta grandis.* Left valve with injured portion folded inward.
Fig. 24. *Anodonta grandis.* Pearly formation in left valve.
Fig. 25. *Amblema undulata.* Right valve uninjured.
Fig. 26. *Amblema undulata.* Left valve with large blister inside pallial line.
Fig. 27. *Amblema undulata.* Left valve with abnormal pallial line.
Fig. 28. *Amblema undulata.* Left valve with pin-head pearls between pallial line and margin of shell.

Pathologic mussels from Salt Fork.

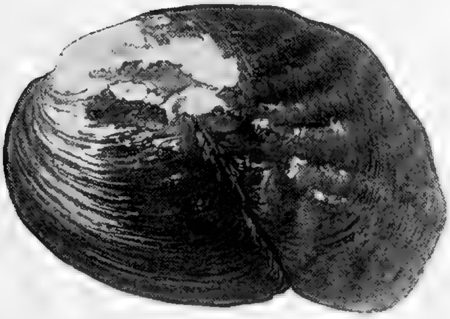


BAKER FAUNA OF BIG VERMILION RIVER PLATE X

PLATE XI

EXPLANATION OF PLATE

Fig. 29. *Amblema undulata.* Left valve with channel due to injury.
Fig. 30. *Amblema undulata.* Right valve with ridge due to same injury.
Fig. 31. *Strophitus edentulus.* Right valve with pearl near posterior end.
Fig. 32. *Strophitus edentulus.* Left valve with distomid discoloration.
Fig. 33. *Lasmigona costata.* Right valve with repaired injury near posterior end.
Fig. 34. *Amblema undulata.* Spoon River form with rounded shell.
Fig. 35. *Lampsilis ventricosa.* Left valve with injured postero-ventral margin.
Pathologic mussels from Salt Fork.



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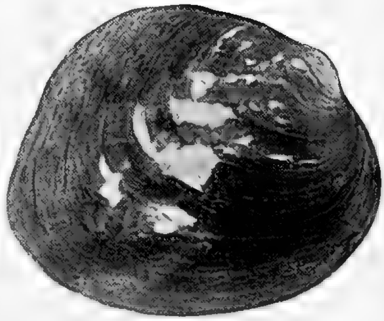

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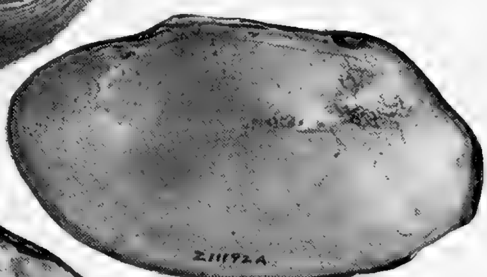

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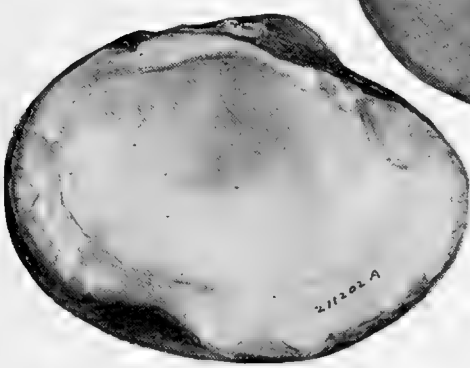

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PLATE XII

EXPLANATION OF PLATE

Fig. 36. Junction of Boneyard with Salt Fork canal, looking west. Note high bank on left where mussel shells were found, indicating bottom of bed of Salt Fork stream before the canal was dug. Sludge bank in foreground. September 14, 1920.

Fig. 37. Salt Fork canal three-fourths of a mile below first iron bridge east of Urbana. December 31, 1919.

Fig. 38. Farmer's bridge across Salt Fork canal, one-half mile below Brownfield Woods bridge. December 31, 1919.


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PLATE XIII

EXPLANATION OF PLATE

FIG. 39. Boneyard just below Urbana septic tank outlet. September 14, 1920.

FIG. 40. Salt Fork canal west of Cottonwood's road bridge. Note bare sand bars with stream meandering between. Bars are covered with green putrescent matter dried by the sun. September 14, 1920.

FIG. 41. Salt Fork canal at entrance of small ditch from Champaign outfall pipe. Note sludge bank in foreground and sewage indicated by dark color of water in center of picture. September 14, 1920.

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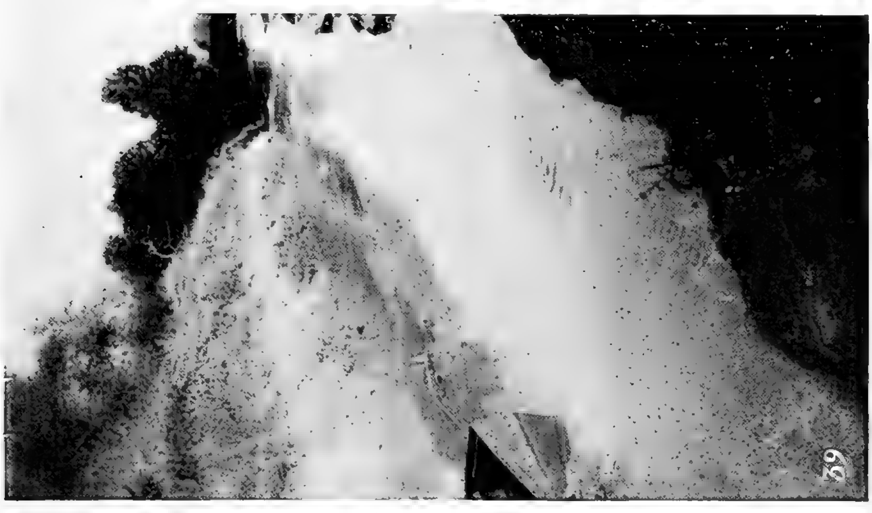

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PLATE XIV

EXPLANATION OF PLATE

Fig. 42. Salt Fork canal looking east from Cottonwood's road bridge. Note bare patches of bottom. September 14, 1920.

Fig. 43. Salt Fork canal looking southeast from last north and south road bridge. September 24, 1920.

Fig. 44. Salt Fork canal looking west from last farmer's bridge above St. Joseph. September 24, 1920.

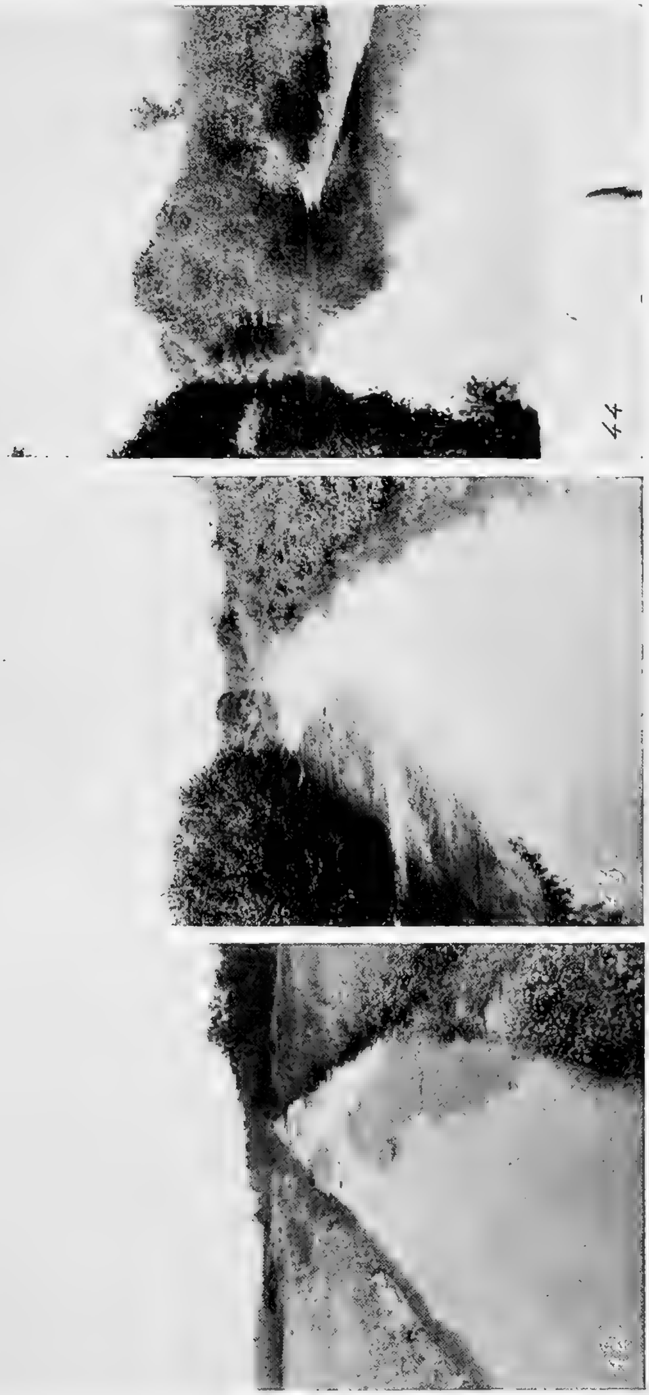
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PLATE XV

EXPLANATION OF PLATE

FIG. 45. Salt Fork canal looking south from last east and west road bridge west of St. Joseph. September 28, 1918.

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