**PONDS, POND FISH AND
POND FISH CULTURE**

DYCHE

Complements of
the Author.

to Mr. H. M. Smith.

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U. S. DEPARTMENT OF FISH AND GAME
KANSAS.

PONDS, POND FISH, AND POND FISH CULTURE.

BY

LEWIS LINDSAY DYCHE, A. M., M. S.,
State Fish and Game Warden,

*Professor of Systematic Zoölogy, and Curator of
Mammals, Birds and Fishes, in the
University of Kansas.*

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THIS BULLETIN

IS DEDICATED TO THE PEOPLE OF
THE STATE OF KANSAS
WHO ARE INTERESTED IN AND WHO LOVE
FISH AND FISHING.
YOU ARE URGENTLY REQUESTED
TO JOIN IN THE ORGANIZED EFFORTS
THAT ARE BEING MADE
BY THE STATE WARDEN AND HIS DEPUTIES
"TO PROMOTE THE CAUSE OF FISH CULTURE;
TO GATHER AND DIFFUSE INFORMATION
BEARING UPON ITS PRACTICAL SUCCESS, AND
UPON ALL MATTERS
RELATING TO THE FISHERIES;
THE UNITING AND ENCOURAGING
OF ALL INTERESTS
OF FISH CULTURE AND THE FISHERIES,
AND THE TREATMENT OF
ALL QUESTIONS REGARDING FISH,
OF A SCIENTIFIC AND ECONOMIC NATURE,"
AND TO ENFORCE
THE STATE FISH AND GAME LAWS
IN EVERY PART OF KANSAS.

LETTER OF TRANSMITTAL.

STATE FISH AND GAME DEPARTMENT.
PRATT, KAN., June 8, 1914.

To the Hon. George H. Hodges, Governor of Kansas:

SIR—I have the honor to submit to you for publication a bulletin on “Ponds, Pond Fish, and Pond Fish Culture.” Part I, on “Ponds,” was published in November, 1910. Part II, on “Pond Fish,” appeared in July, 1911. Part III, on “Pond Fish Culture,” is now in the hands of the state printer.

We have been delayed (for want of time) in the preparation of the third part of this bulletin. However, we desire to assure you that we did the best we could and at the same time attend to other duties of the department, which have been many and somewhat irregular during the past few years.

In the preparation of this bulletin we have endeavored to get together information based for the most part on our own studies, investigations and experiences. We have tried to give information that would be of use to Kansas people who may undertake to raise fish in ponds and streams for home use and home markets. While this bulletin is intended primarily for Kansas farmers, we hope that the information may be of some value to fish culturists in different parts of the country, as there seems to be a general demand for information of this kind. We are glad that the bulletin is finished, and take pleasure in dedicating it to the people of Kansas, for whom it was especially prepared.

Respectfully submitted.

L. L. DYCHE,
Fish and Game Warden.

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PART I.

PONDS, POND FISH, AND POND FISH CULTURE.

THE number of letters of inquiry that have been received by the Department of Fish and Game since the writer has been connected with it (December 1, 1909) concerning fish ponds, how to build them, what kind of fish to put in them, how to secure fish for stocking purposes, and numerous other questions, would indicate a very general and widespread interest in these subjects. These letters of inquiry have been received from nearly every county in Kansas and from several states as far east as Maine and Virginia and as far west as Washington and California. The number and variety of the questions in these letters were so great that it made it impracticable if not impossible for the department to undertake to answer them individually except by short notes referring to matter that was being prepared on these subjects with the hope that it could be published in the near future for free distribution.

One of the publications referred to as directly bearing upon these subjects was a bulletin on the subject of ponds, pond fish and pond fish culture that was being especially prepared to be issued at an early date. To a very considerable extent this bulletin has been so framed as to answer the various questions that have been propounded.

In putting the matter into a bulletin that will answer the numerous questions asked, an effort has been made to give simple and elementary information on the subjects treated and to make the information as nearly accurate as possible. No little pains and difficulty have been experienced in getting together the material which the author thought might be of interest and value to the readers of this bulletin.

The writer has been very much interested in the subjects of fish, fishing and good places to fish since he was a small boy. He made one of his first permanent collections of fishes during the spring of 1878, at Lawrence, Kan., and later, in the spring and summer of the same year, he made collections of the small fishes found in the Hackberry and Big creeks and other small streams near the headwaters of the Smoky Hill river in Gove, Logan and Wallace counties. Since that time he has studied fish more or less in connection with his work on mammals and birds, both in the field and at the University of Kansas in the

museum of natural history, and with his students in the zoölogical laboratories. He has always been interested in aquariums and fish hatcheries and has from time to time visited a number of them in different parts of the country. He has also for many years been especially interested in Kansas fish ponds and lakes, having had an interest for a period of twenty years in one of the best, if not the best, in the state of Kansas, at Lake View, near Lawrence.

In writing this bulletin the author has drawn very largely upon the experience and knowledge of his friends who have had practical experience in the building and in the management of ponds, especially as applied to conditions in the state of Kansas. He has also visited many ponds in the various parts of the state and has studied the methods of their construction and management and has talked with the people who built and cared for the ponds. He has also availed himself of as much information as could be secured from books, magazines and papers, and especially from government fisheries' reports and the valuable contributions of fish culturists whenever these latter were accessible.

This bulletin was written in his improvised office at the Kansas State Fish Hatchery building, which is located in Pratt county, Kansas, three miles east and one-half mile south of the city of pratt, and on the south branch of the Ninnescah river. As this location is over 200 miles distant from the larger state libraries, his only source of book reference was to that part of his own private library (about 300 books and pamphlets) relating to fish and kindred subjects, together with a few volumes that could be spared for temporary use from the State University library.

Much of the information in this bulletin has been compiled from original notes that have been made during the past thirty years, and no small part of it has been gathered from intelligent sportsmen and good citizens who have been interested in and are well informed on many subjects treated in these pages. In collecting material for this bulletin, he has sought in every direction within his reach and from every individual possible to obtain what he thought might be valuable and reliable information.

OFFICE BUILDING AT THE STATE FISH HATCHERY.
Dike and bottom of partly drained pond showing in the foreground.

NATIVE KANSAS FISHES.

To the majority of people fresh fish is not only a very acceptable article of food but a real luxury. As a rule fresh fish does not keep well except in cold weather, and must be packed in ice when shipped for any considerable distance. Even then most varieties of fresh fish lose more or less of their flavor when kept any length of time, and when prepared for the table are a disappointment, having a flat and insipid taste. If the people of Kansas want good fresh fish, they must secure them from the streams and ponds of our state.

Our native fishes—the black basses, the crappies, the sun-fishes and the catfishes—are among the best game and food fishes in the world; and when they have a shadow of a chance they do well in Kansas waters. Most of them thrive and do well in ponds that have been properly constructed and cared for. We hope in this bulletin to give instructions along lines that will make it possible to build ponds suitable for fish-culture purposes, such as are required for rearing fish on farms, and to give information that will enable a person of ordinary intelligence to manage such ponds for both pleasure and profit.

The German carp is also considered a very good food fish in many places in the world, and it is undoubtedly the best pond fish in the country when considered from the standpoint of the number of pounds that can be produced in an acre of water. The German carp feeds almost exclusively upon vegetable matter and converts a vast amount of worthless vegetable growths found in streams and ponds into fish flesh; and in all fairness to the carp, I want to say, strange as it may seem to some people, that this fish, when taken from good waters, is not only valuable in the markets of the world, but when properly handled and cooked is a good and nutritious food for human beings. A special bulletin on the German carp will be issued in the near future.

It is a well-known fact to many fish culturists and anglers that the young of the German carp serve very extensively as a food for game fishes. The carp is very prolific; the mature females are said to produce from 500,000 to 3,000,000 eggs each during the spawning season. It is safe to say that, owing to the fact that the carp lives on vegetable matter, which is usually abundant in streams and ponds, it is possible to produce in an acre of water from five to ten pounds of carp to one pound of native fish.

GO FISHING.

Most people are fond of fresh fish, and they enjoy the pleasure and the exciting sport of going fishing and of fishing. Show me a boy who is not delighted at an opportunity to go fishing. He will travel long distances, if need be, to visit some pond, lake or stream in the neighborhood where he can fish. As I look back, it seems to me that some of the happiest days

of my boyhood life were spent in Shawnee county south of Topeka on the banks of the Wakarusa, fishing. Hundreds of times I went fishing, and in those days almost always caught fish. Those were the happy days when the streams seemed to be full of fish and it was possible for almost any one with pole and line and a can of worms and a few live minnows to catch a good string of fish. It is one of my hopes, if I continue my relations with the state's fish business, that I can be of some service in helping in some way to bring back those good old days when an ordinary, everyday, "plain, plug, good citizen" can go fishing in Kansas streams and catch a good string of fish with a pole and line.

In those early days small-meshed seines and nets were not used to capture and destroy the young fish before they were large enough to spawn; neither was dynamite used.

THE BOY FISHERMAN.

It does boys good to go fishing. When fishing they are not doing anything else. Watch a bunch of boys fishing and you will usually find that the business not only takes all of their time and attention but that it is excellent recreation and sport for them. The same number of boys with small guns are a positive danger to themselves and a menace to the neighborhood where they operate. They not only shoot many birds that ought to be spared on account of their value as destroyers of insects injurious to agriculture and horticulture, but they are liable to shoot and kill or cripple any animals that may be running loose in the fields, or even each other. Since writing the above, my own cow, while feeding in a small pasture a few rods from the house, was accidentally shot in the knee by a small boy with a .22-caliber rifle. The small boy and the fishing pole may be considered a safe and harmless proposition; the small boy with a small gun is neither safe nor harmless. They—the small boy and the small gun—should be separated.

"GROWN-UPS" LIKE TO FISH.

Boys are not the only creatures that like to fish. I am not ashamed to confess the fact that I really like to "go a-fishing" occasionally, as much now and at times even more than when a boy; I like to fish the old-fashioned way, with pole and line; and I am not averse, when the fishing season comes and the signs are favorable, to digging bait, the old-fashioned grubworms and fishworms, for "catties" and "sunnies" to nibble at, and to catching a few minnows to tempt the rush of the crappie and the black bass. I like to sit on a grassy bank in the shade of a tree, watch the floating corks on two or three lines, and wait for a bite. How suddenly I would answer the "call of the wild" catfish or the bass that is pulling the cork out of sight! How I do like to feel that pull on the line made by a struggling cat or bass! Say, fellows, it's great! I have a good notion to

throw this paper and pencil away right now and go fishing! What a pity it is that a fellow who is naturally tired and especially hungry for fish has to work on a bright May morning like this when the signs are all favorable, the wind in the west, the very time when fish bite best! What you say, fellows? Let's all quit and go fishing; I am going. Well, what did you catch? is a question that has been asked in good faith and answered with questionable veracity since man and fish have known anything about each other.

Having caught some sunfish, a channel cat and one fair-sized bass, enough for a good mess, since the above sentences were written, I can assure you—for I am sure of it myself, and there are thousands of men and boys who will agree with me—that there is no better recreation or healthier sport for the young and the old than going fishing. Add to the pleasure and interest of *going* fishing the actual feat of catching a good mess of fish and you have a day's outing unsurpassed for pleasure and satisfaction.

HIGH PRICE OF MEATS AND THE VALUE OF FISH FLESH AS A FOOD PRODUCT.

The present high prices that all the staple kinds of meat products command make it necessary for the great mass of the people to look not only for a cheaper meat food, but for more economic methods of producing it than have heretofore been devised. Even now men who are working for from \$1.35 to \$2 per day and who have families to support can scarce afford to eat beef, pork or mutton even once a day. As it takes the best of grass and hay and the best of grains to produce good meat, as the amount of land capable of producing this best of feed is limited, and as the number of people is constantly increasing, there is very little hope that good meat products will ever be any cheaper. Many people must have something that will in a measure take the place of, or at least answer in part as a substitute for, high-priced beef, pork and mutton. The possibility and value of fish as a good and wholesome food product for the people of Kansas should, I believe, receive more serious consideration than has heretofore been given to it. If each family in the state could have fish on an average of once a week it would not only be a most pleasing and satisfactory change in the regular bill of fare, but it would be an item of large economic importance. As there are over 300,000 families in the state it would mean that over 300,000 messes of fish would be consumed each week. The value of the fish thus consumed, allowing an average of twenty-five cents, or about one-half its actual value, for the mess of fish consumed by each family each week, would amount to \$75,000 for one week, and 52 times \$75,000, or \$3,900,000, for one year. If fish were eaten twice a week, the value of the amount consumed would be \$7,800,000 per year.

WITH STREAMS IMPROVED AND PONDS CONSTRUCTED.

It is not impossible, in connection with the future development of the state of Kansas, to bring about results even greater than those indicated above by improving our natural streams and ponds for fish-culture purposes, and more especially for the building of artificial ponds and reservoirs adapted especially for rearing food fishes. At the present time our rivers, streams and creeks are very much abused. Little or no care is given to them, and it is a most lamentable fact that many of them are used for sewerage purposes. At present all kinds of filth is either thrown into the streams or allowed unheeded to run into them.

As a people, we are skimming the cream from our fields, taking all we can get in corn, wheat and alfalfa, and returning nothing to the soil. The time will come when it will be necessary to put fertilizer on what are now known as our very best lands; the time will come when all the sewage and garbage that is now being poured into the streams will be badly needed as fertilizer for the impoverished farming lands; the time will come when every stream in the state will be badly needed by the people for various water supply and fish-culture purposes, and when it will be unlawful to pollute any public stream with sewage and garbage; the time will come, and it ought to be here now, when the sewage and garbage that now go into the streams will be converted into a fertilizer that will be indispensable for the production of crops. The ponds and streams of the state, instead of being foul mudholes and sewer channels, bearing all kinds of disease germs, will be improved and made to become a source of great pleasure and profit.

PONDS IN GENERAL.

The subject of ponds is one that the writer has been interested in for many years, and since his connection with the State Department of Fish and Game his interest has been increased and renewed, and he expects to give a considerable amount of attention to it in the future. He hopes to be able in different ways, and especially through publications issued by the department, to place before the people of Kansas all the information available on the subjects of construction, maintenance and use of ponds. Since the country has been occupied by civilized people the greatest activity and energy have been put forth to develop the lands for agricultural, horticultural and live-stock purposes. Improved and scientific methods have given better varieties of corn and wheat, better varieties of apples and strawberries and better varieties of potatoes and melons, but almost nothing has been done, particularly in America, to develop the streams, lakes and ponds and to improve the quality of food products that they do and could be made to produce.

The Chinese and Japanese are credited with having accomplished wonders, in the development of goldfish, in the production of rich shades of color and unique designs in form. The uncultivated wild goldfish is of a dull olivaceous green. The beautiful shades of red, gold, silver and black, and the various odd designs in shape found among these fishes, have been artificially produced and propagated by natural selection, the fish having been kept in ponds and handled and bred with as much care as any other stock that was to be improved under the influences of domestication. Nature has imposed no barrier, so far as I know, that would prevent the development of many of our own game and food fishes in quality, size and hardiness, provided they were subjected to the same intelligent care and oversight that has developed our best varieties of vegetable and animal forms of life. In Germany, and many other places in Europe, the rearing of fish and the various problems connected with fish culture have been in the past and are at the present time receiving a very considerable amount of attention. The rearing of fish for food purposes and for profit is looked upon much in the same light as the rearing of poultry and live stock in general. Not only are the streams utilized, but all natural ponds, lakes and sheets of water have been improved and are being used for fish-culture purposes.

In addition to this, I am told by some of our good American Germans who have recently visited the fatherland, that thousands of pieces of ground that were swampy or otherwise unprofitable have been converted into fish ponds and are now made to yield fish food products of great value to the masses of people.

NATURAL PONDS.

For the purpose of consideration, the subject of ponds naturally divides itself into two parts—natural and artificial.

Natural ponds in the state of Kansas are not very numerous. Most of them have been formed by rivers and creeks that have changed their channels and left bodies of water in their old beds. Some of these sheets of water make fairly good fish ponds, but as a rule they are more or less subject to overflow from the adjacent streams during periods of high water and are liable to lose most of their water, or even to go dry, during periods of drought. Such bodies of water are very unsatisfactory for fish-culture purposes.

There are other natural ponds formed by springs that run into natural basins, and still others that owe their existence to natural basins that catch the water from adjacent sloping grounds. These latter are called sky ponds by the Germans, as all the water that is drained into them comes directly, in rains and snows, from the sky. These natural ponds usually have muddy bottoms, with an accumulation of old leaves, weeds and various kinds of trash that have blown or have been

thrown or washed into their waters. Many of them have old logs, stumps, fallen trees, tree tops, brush and other similar rubbish in them. Some of these natural ponds also have heavy growths of vegetation, including grasses, weeds and mosses. Most of these natural ponds are more or less stocked with fish of one or more varieties; a pond of any size that has had water in it for six months or a year usually contains fish of some kind, more often catfish or sunfish. If the ponds are large, with some depth of water, carp, buffalo, shad, channel cat and, sometimes, crappie and bass, are found in them, as well as various kinds of minnows. Some of these natural ponds, where the water supply is not too irregular, produce and support a good many fish and are quite satisfactory. As a rule, however, they are hard to manage, most of them being too low to be drained, or if it is possible to drain them there is no water to refill them. Muddy bottomed ponds that cannot be drained and cleaned afford poor places for fish to spawn; and this is especially true of the larger game fishes. Natural ponds are usually well stocked with turtles, gars, bullfrogs, snakes, all of which are natural enemies of the fish. Owing to the various kinds of trash in such ponds it is usually very difficult to seine them and remove the natural enemies of the fish, including the larger fish themselves, which are not only enemies of the young and the small fish, but are a detriment to their growth and development.

Many of these natural ponds can be cleaned by removing the brush, logs and vegetable growths. This makes it possible to manage them in much better shape and puts them in a condition that seines can be used in removing the natural enemies of the fish as well as the large fish themselves. However, seining and netting in fish ponds may prove to be a dangerous business unless the operators understand something about fish culture.* Many of the natural ponds can be greatly improved for fish purposes by cleaning and developing them in certain places and by throwing up embankments to keep out flood waters. Sometimes these natural ponds can be fed by directing a small stream of fresh water into them through ditches or pipes from creeks or springs or even from windmill pumps. If this can be done their value as fish-producing bodies of water will be greatly increased.

These natural ponds are usually well supplied with fish food, especially the kinds of insects and plants that young fish and minnows feed upon; and young fish and minnows serve very extensively as food for the growing game fishes.

* See what is said about it under the heading of "Seining" in part III, or "Pond Fish Culture," in this bulletin.

ARTIFICIAL PONDS IN GENERAL.

The artificial pond is usually made by constructing a dike or dam across a draw or a piece of sloping ground, or across a small stream, or by inclosing a piece of ground that can be supplied with water. This ground that is to be used for pond purposes may be located on high lands or even near a hilltop as well as in the valleys and sloughs of low lands. It is to this class of pond that we desire to give our especial attention, for many of them have been constructed in the state of Kansas, and undoubtedly thousands more will be constructed in the near future.

The water supply of a pond is an all-important thing, and before the pond is built the source, permanency and possible amount of the water supply should be well considered. The water supply may be directly dependent upon the rain and snow fall. In such cases the water flows from natural drainage sheds into the pond basin and such ponds are usually called sky ponds. In other ponds the basin may be fed by springs, creeks or other bodies of water that may be turned into them by means of ditches or through pipe lines.

Good artificial ponds, constructed where they can be properly managed, can be made to serve a number of purposes, one of the chief of which is to be used as reservoirs for the storage of a vast amount of water that now runs out of the country. This water, flowing in swollen streams through and out of the state, does little if any good, and in many cases does a vast amount of damage.

WATER STORAGE POSSIBILITIES.

If there were a small pond or lake of the average size of an acre on each section of land in the state of Kansas, it would amount to over 80,000 acres of water. If the ponds could be made to average four acres in size, or an acre of water for each quarter section of land, it would amount to 320,000 acres of water. If these ponds and reservoirs could be made to average four acres of water to each quarter section of land, the number of acres of water would be 1,280,000—enough to cover 8000 quarter sections of land, or 2000 sections. In surface area this water, if combined in one body, would be equal to a lake 400 miles long and 5 miles wide—a body of water large enough to stretch across the state of Kansas from east to west.

Figure the volume of water that one acre would conserve at an average depth of three feet, and then it will be possible to estimate the vast quantity of water that could be held in the state if an average of from one to five acres of water could be stored on each quarter section of land. It does not seem unreasonable to consider this as among the possibilities of the future development of the state, particularly in the central and western parts, where the contour of the gradually sloping lands makes it possible to build ponds and reservoirs for holding sur-

face water at no great expense; and that too in a section of the state where the soil is very rich and productive and where the influence of permanent sheets of water would be an advantage to the country in various ways. If such an amount of water could be stored in ponds and reservoirs it would undoubtedly, in connection with the cultivation of the soil, do a great deal to modify and regulate both flood and temperature conditions. The evaporation from these bodies of water would surely exert a more or less beneficial influence on temperature and atmospheric conditions in general.

ADVANTAGES OF A FARM POND.

These small lakes and ponds would be of value in a number of ways to the farmer who, in a new country, is not only an agriculturist but frequently an horticulturist and stock raiser as well. Groves of trees, both forest and fruit-bearing, might be planted around them. These would serve various purposes, and while serving as windbreaks and for shade would grow into trees that would furnish wood, posts and even lumber. Groves of trees around bodies of water always attract flocks of song and insect-eating birds. Many of these birds would remain through the summer, not only enlivening the spot with their songs and bright plumage, but also rearing their young and waging a perpetual war on the injurious insects of the neighborhood.

Again, these ponds could be made to supply the stock of the farm with water, and in many places where the water supply is sufficient could be used to irrigate gardens, berry patches and even orchards.* The shady groves about the ponds, where song birds live and where the wild flowers bloom, might be made a source of much pleasure for family and neighborhood picnics. If the pond or lake were an acre or more in size there might be an ice house near the shore where a supply of ice sufficient to last through the summer season could be put up at small expense. A boat could be kept on the water, and a small building might be constructed in a grove near the shore where the boat and such articles as fishing tackle, bathing suits, skates, etc., could be housed for protection and safe-keeping. Such an arrangement would add much to the interest, enjoyment and value of everyday life on the farm and help very materially to solve a problem that we are all trying to work out.

ARTIFICIAL PONDS.

The Location of a Pond.

The location of the pond will depend principally upon two things: the lay of the ground in a suitable locality, and the possibility of supplying it with water. As no two pieces of ground are alike, the location and water supply of any pond

* See the account of the Sam Bailey pond, on page 33.

A view of one of Mr. Houchin's ponds north of Medicine Lodge. Ranch houses and groves of trees in background.
See account, page 31.

will be propositions that will have to be considered in their relation to surrounding conditions. It is always the part of wisdom to profit by the experience of others, so if you contemplate building a pond, it would be advisable to examine those of your neighborhood that have been built where water conditions and location are somewhat similar to those in the locality where the new pond is to be constructed.

How a Pond May Be Made.

A pond such as it is possible to construct on a farm or ranch at the least possible expense is usually built by throwing up an earth embankment or dike across a draw or sloping piece of ground, thus forming a basin where it is possible to hold a few or many acres of water. Of course such ponds are dependent entirely upon the rain and snow fall of the country for their water supply, and the amount collected depends upon the rainfall and the area of the natural drainage slopes that shed their waters into these pond basins. This is the method usually employed in the central and western portions of the state for the construction of ponds where it is desired to collect surface water for pond purposes. Using this method, ponds that vary in size from one-fourth of an acre to that of five, ten, twenty-five or even several hundred acres in area may be constructed, depending on the lay of the country and the extent and nature of the watershed above the dam.

Sometimes ponds are formed by constructing dikes or dams across small streams or across draws where it is possible to hold the water that flows from springs; again it is sometimes possible to throw up embankments that will enclose low pieces of ground where water can be carried from near-by streams or other bodies of water through ditches or water pipes. The sole supply of some very good small ponds in the state is from water pumped by windmills.* A windmill with nothing to do except to run a pump that throws a two-, three- or four-inch stream of water will, under ordinary circumstances, furnish a quarter, half or even an acre pond with water.

The average depth of water in the many artificial ponds that I have visited ranges not far from three feet, with a maximum depth varying from six to sixteen feet.

To Build a Dike or Dam.

As a rule the most economical way to build a dike or dam for pond construction purposes is by the use of earth. The dirt that it is necessary to remove in shaping parts of the pond can in most cases be used to advantage in constructing the dam. The proper building of the earth embankment is all-important, as on its proper construction the existence of the water supply of the pond largely depends. The lay of the land,

* See Sam Bailey pond, on page 34.

the nature of the soil, and the possible amount of water to be held and the amount to be gotten rid of in times of high water and overflow, are propositions that vary so much for ponds in different localities that it is not possible to give definite instructions unless the particular location can be visited and studied. However, there are some general principles that will hold good for the construction of ponds in almost any locality.

The Foundation of a Dike or Dam.

The location of the pond should be well studied in its various relations to the dam that is to be built, and if possible the services of a civil engineer or a surveyor should be secured to lay it out properly and to give the various grades and to show not only exactly where the dam should be built but to give plans for its proper proportions. All the natural advantages of the location should be utilized.

It is very important that the ground for the foundation of the dike or dam should be properly prepared and that the foundation structure itself should be properly built, for upon these two things the success of the whole venture largely depends. Many of the dikes and dams that have been examined while visiting ponds in the different parts of the state have shown a lack of proper preparation and poor structural work in their foundations.

It is a difficult matter to retain water in a pond where there is a little seep or small underflow beneath or through the dike or dam. Most surface soil, even though it is apparently solid and free from holes made by small animals and insects, is more or less porous, due to various things, and especially to the decaying grass and plant roots that it contains. In its natural condition very little surface soil is in proper shape to serve as a good foundation for the bottom of a pond or for the embankments of a dike or dam to rest upon. If the ground where the dike is to be built is covered with grass, weeds or bushes, these should be removed, brush and trees being dug up by the roots and as far as possible the roots themselves removed. The ground for the foundation should be plowed, and when sod is present it should be removed at least for a space several feet wide through the entire center of the foundation. Where the sod is not removed it should at least be thoroughly torn to pieces by using a good harrow, and all the roots and light stuff that the harrow collects should be removed.* Then the ground should be plowed again, throwing the furrows from the center of the foundation. The harrowing and plowing should be continued until there is a good and well-formed ditch sloping from the sides to the center of a ditch, which should be several feet wide and from one to two feet deep.

* For the use of sods in riprapping the dam, see figure 5 and the account of the Ellis-Houchin ponds, pages 27 and 31.

(See figure 1.) If there are sand, loamy or gravel pockets or boggy spots in the ground chosen for the foundation, they should be scooped out.

FIG. 1. Foundation for dike or dam. This drawing shows excavation made by plowing and harrowing; the sod and surface soil has been removed and ground put in shape for permanent foundation.

I am told by those who have had experience that it is practically impossible to build an earth dam that will hold water on a natural stone foundation. The dam may be good, but the water will seep under it between the rocks and the earth or through the natural cracks and veins that exist in the rocks. If a dam is to be built in such a location, a trench should be dug through the rocks deep enough to reach a solid rock foundation. On this foundation that has been dug to and at least a few inches into the solid rocks, a reënforced cement wall should be constructed that would rise from one to two feet above the surface of the natural rock foundation. Over this cement wall an earth dam may be successfully built. In such

FIG. 2. In spongy or boggy soil and loose loam, before starting to build the dam, there should be a trench dug near the center and for the full length of the dam. This trench should be about six feet wide, and deep enough to extend into the clay or other impervious subsoil at least one foot. This ditch should then be carefully filled with good clay or loam, free from stumps, roots, twigs or other perishable material. In starting the dam on top of this be careful not to leave a seam between the dam and the material in the trench, but have the material thoroughly incorporated.

Another form of Fig. 2, showing ditches in any ground where dike or dam is to be built.

cases it is a good idea to remove the loose rocks for a distance of several yards or rods above the dam and cover the area from one to two feet in depth with well-packed clay or good hardpan soil.

I am also informed by men who have had experience that it is not a good idea to pile rocks in with the dirt that forms the dike or dam. Better keep the rocks if they are present to riprap the banks after the dam is finished. Good results have been secured where sandy or boggy places have been met with in foundations by digging one or two ditches from sixteen to twenty-four inches deep (or deeper if need be to get to and down six or eight inches into solid clay or hardpan) and from three to six feet wide through the entire length of the foundation of the dam. (See figure 2.) These ditches should be filled with good dirt, as free as possible from grass and plant roots. The dirt should be well packed in the ditches by being tramped by the animals that pull the scrapers.

Size and Width of Foundation.

As indicated above, all sand and gravel beds and all trash such as decaying vegetation, including plant roots, old logs and stumps, as well as loose rocks, should be removed and in no way get mixed up with the earth that forms the foundation of the dam. Chunks of sod that may be plowed up in shaping the bottom of the pond should not be used in the earthworks, at least of the lower half of the dam. They can better be placed near the top of the earth structure or for riprapping the sides of the dam or for sodding the completed structure. If the foundation of the dam is to be forty feet wide in the center when completed, it should by all means be started at that width. Never start a foundation at twenty feet and then allow the dirt to roll down the sides of the structure until it is forty feet wide. Such work leaves too much loose, unpacked earth on the outside of the embankment that is easily washed away by rains and waves.

While the dam is being built the dirt should be spread over the top or surface of the growing structure in such a way as to keep it comparatively level, and it should be tramped with the teams as evenly as possible to prevent uneven settling that would leave high and low places on the surface of the finished dam.

The width of the foundation or the base of the dike or dam depends, of course, upon the proposed height of the structure. For every foot in height there should be not less than from $1\frac{1}{2}$ to 2 feet of slope to the sides. For a dam 12 feet high and from 8 to 12 feet wide at the top—wide enough for a good wagon roadway—the following proportions should be observed (see cut, figure 3, showing cross-section of pond and dam): On the water side of the dam, the slope should be, as shown in figure 3, not less than 2 feet in width for every foot of height.

The dam being 12 feet in height this would give a width of 24 feet. On the land side the slope is also 2 feet to each foot in height. This would make a width of 24 feet. The dam is 8 feet wide on top, therefore 24 plus 24 plus 8, or 56 feet, should be the width of the base at the middle or widest part of the foundation of the dam.

By reference to the diagram and map (figs. 3 and 4) it will be seen that the earthworks of the dam gradually narrow up to a width not much greater than the eight-foot roadway at the ends. With the foundation well laid, the matter of the building of the embankment consists very largely of hauling and scraping in the dirt. To make headway, good teams and large scrapers should be used; and to insure solidity in every part of the structure as it gradually grows in its proportions of width and height, the dirt should, as we have said before, be spread evenly, and the surface of the embankment should be kept as nearly level as possible while it is being built. If high and low places appear on the surface, or if one side is built up while the other remains low, the tramping and packing of the dirt will not be even and the finished dam will, while settling, be liable to show irregularly high and low places on the surface. I make special mention of this because I have noticed that dams settling irregularly are more liable to leak than those that settle evenly.

Should a few rains fall on this structure while being built it would aid very materially in packing the ground. No difference, however, how much care is taken, it will take years for the embankment to settle thoroughly, but careful building may save trouble and expense by guaranteeing even and regular settling, especially during the dangerous period of the first two or three years after the dam has been completed.

The Overflow or Spillway.

Another all-important thing about the construction of a pond is to have a place where superfluous storm and flood waters can escape without injuring the dam. It is very difficult to give directions for the construction of spillways and overflows that will be applicable to all places, as the conditions in no two localities would be exactly the same. However, by observation and experience I have learned some general facts concerning overflows and spillways that may be helpful to those who are contemplating the building of ponds in places where it will be necessary to build such structures. Some knowledge of the amount of water that is liable to flow into the pond during and after heavy rains and snows would be necessary before the proper allowance of space could be made for its escape. No water should be allowed to run over the earthworks of the dam, as it would soon wash and wear away the embankment.

The overflow or spillway should be constructed at or near the

FIG. 3.

The dam should be not less than eight feet wide on top, and have a slope of two to one on each side. That is, for each foot in height it should have a width of two feet. A dam ten feet high and 8 feet wide on top would be 48 feet wide at the base. The spillway or overflow should be constructed at one end of the dam as indicated.

NOTE.—I am indebted to Prof. B. J. DALTON, of the University of Kansas, for drawings used in figs. 2, 3 and 4.

Other drawings and photos, except the Mary Best Ranch photo, by the author.

FIG. 4.

The figures in this contour map give the elevation of the contours in feet. Position of the spillway which conducts the surplus water around one end of and below the dam, is also shown. The screens on the pond side of the spillway are for retaining the fish.

end of the dam where the artificial embankment meets the solid earth. (See figures 3 and 4.) If the overflow water comes from heavy rainstorms, and occurs only a few times during the year, the natural ground near the end of the dam at one side of the pond may be made to answer the purpose. If such an arrangement is adopted, strong meshed wire fences fastened to heavy posts well set in the ground should be built to prevent the fish from escaping, and as the floating trash would soon choke up a small-meshed wire gate or fence, it will be necessary to build two or three wire fences with different sized meshes. The strong "hog wire" fence should be up stream; following this, there should be a three-inch mesh fence that would catch the stuff that slipped through the coarser fence; and beyond this, a quarter-inch mesh fence that would keep the small fish from escaping. In actual practice, I placed an inch-mesh wire screen between the three-inch mesh and the quarter-inch mesh screens. It helped very materially to prevent trash from stopping up the quarter-inch mesh screen. (See arrangement for cement spillway in figure 4.) These overflow places should be watched during periods of high water, and any accumulating material removed with pitchforks and rakes.

It may cost a little more to make it, but there is nothing safer and better (and perhaps cheaper in the long run) than a reënforced cement spillway or overflow varying in width from 5 to 50 feet and in height from 1 to 4 feet and large enough to accommodate the overflow that must be cared for in times of high water. The spillway should vary in length from a few feet to several rods, depending upon the lay of the ground at the end of the dam and along the side of the pond. If there is plenty of stone in the neighborhood, stone or a combination of stone and cement might be used to construct the spillway and retaining walls.

To Protect Ponds and Embankments.

In building ponds it is always advisable, when it is possible to do so, to have them so arranged that at times of inundation the flood waters will go around or be directed alongside and not through the ponds themselves. In many cases side ditches or spillways may be so constructed as to carry away the flood waters, and they work very well where the overflow is not too great and where the grade makes it possible to carry away the water in this manner. Water should always be carried far enough below the dam to prevent any running back or eddying that might do damage.

Protecting the New-made Dam.

For a few years, at least until the banks have become well settled and are covered with sod and bushes, it is frequently necessary to give some immediate special protection to the new-

made dam, especially on the side where the wind causes the waves to dash against it.

One very good and economical way of doing this is to build a fence that would stand in the water from five to ten feet from the high-water line and parallel to the embankment. (See p. 22.) The posts of this fence should be well set. Drive them when possible. To make the fence strong, the posts should be heavy and of good wood and set not more than six feet apart. Some of the posts, those used along the central part of the fill, may need to be extra long, but none need to stand more than from twelve to twenty inches above the water at its highest stage in the pond. On the side of these posts next to the bank, a strong hog wire or some smaller meshed wire fence should be nailed. Between the bank and the fence brush should be thrown in and weighted down with chunks of sod, rocks, or logs. In a country where rocks or brush cannot be had, it would be wise to put an inch-mesh wire on the posts over the hog wire, and substitute hay, weeds, or some kind of trash for the brush, and then throw in sod and dirt on the trash material to hold it in place. Willows planted on this ground between the fence and the embankment would soon make such a growth that their roots would hold the banks though the fence should rust and rot away. This means some work, but it may prevent great damage to the dam or even save it from going out some night when a big storm is raging.

New Dams Should be Watched.

All new dams should be watched closely, as a small hole made by some burrowing animal, such as a ground squirrel or gopher, might in a short time cause serious trouble. Muskrats, gophers, and all other animals that are likely to dig and burrow in the dam embankments, should be shot or trapped as soon as possible after they enter upon the pond premises. Crayfish sometimes make small holes through dams, particularly when the embankments are narrow. In some localities, where dikes separate ponds from creeks and rivers in which the crayfish naturally live, they have been reported as causing trouble and doing considerable damage. Where game fishes, such as crappies, basses or the catfishes, are kept in ponds, "crawdads" do not have much of a chance to do mischief. They sometimes burrow in certain special places in dikes or dams. If the infested area is not too large their work can be stopped by embedding one-half or three-fourths inch mesh wire fencing or screening in the embankments.

Leaks in Dikes and Dams.

Should a leak appear in the dike or dam due to a crack in the ground or to the burrowing of some animal, or from any other cause, it can usually be temporarily stopped, if it is under the water where it cannot be easily reached, by throwing in

This illustration shows a fence that was built to protect an embankment. The space between the fence and the dike is being filled with brush, trash and dirt preparatory to planting willows.
See, also, page 28.

dirt, or dirt mixed with half-rotted stable manure. It will be necessary, in order to make permanent repairs, to make a cut in the dam, parallel to its edges, long enough, deep enough and wide enough to reach the water that is making its way through or under the dam. To stop a leak in an embankment here at the State Hatchery, it was necessary recently to dig holes from 6 to 10 feet deep, 4 to 6 feet wide and from 10 to 20 feet long, in order to reach a seepage that was going under a dike. After the leaky place has been found by digging into the embankment, it is frequently necessary to make a cut or to dig through the bank on the side away from the pond, to allow the water to drain out before permanent repairs can be made. The crack or hole where the water finds its way into the cut can sometimes be corked, temporarily at least, while the cut is being refilled by stuffing and driving rags or pieces of burlap or tow with a stick (we used a piece of 2 x 4 scantling) into the leaky places. By using a sledge hammer the packing material can be driven long distances and packed tightly.

If the ground is rather solid, wooden plugs from five to eight inches in diameter at the large end, and a foot or two in length, can sometimes be inserted and driven in so as to stop temporarily the flow of water.

A good supply of rather dry dirt, especially for the bottom of the fill, should be on hand, and as the excavation is refilled it should be thoroughly tamped and packed, a tamper being used in the region where the leak was found.

Ponds on Level Ground.

Ponds that receive their water supply from pipes or open ditches may be constructed on almost any piece of comparatively level ground where it is possible to lead water to them from rivers, creeks, lakes or other sources of supply. The instructions already given for building dikes and dams would apply for the embankments to be constructed for retaining water in these ponds. As the amount of water carried to the ponds can be controlled through the ditches and intake pipes, such ponds do not need overflows and spillways. Should there be superfluous water it can be easily handled and carried where needed through pipes. When the water supply is sufficient these are among the most satisfactory ponds that can be built. This class of pond includes many ponds or small lakes that are fed by springs. The dikes thrown around such bodies of water, once well built, as a rule cause very little trouble. There is no great water pressure on them such as sometimes comes to the banks of ponds that are quickly filled, even to overflowing at times, by the sudden influx of flood waters. Not much sediment is carried into such ponds as compared to sky ponds, and their bottoms are more nearly free from objectionable debris and mud. The stage of water in such ponds can easily be regulated.

Such ponds are especially satisfactory for the rearing of some of the more common varieties of fishes, such as the crappies, the sunfishes and the catfishes.

Grounds and Soils Suitable for Ponds.

Most of the ground in Kansas is well adapted for pond-building purposes and not much difficulty has been experienced in getting the soil to hold water. In some sandy localities it has been necessary to give some special treatments to the bottoms or basins of the ponds. If the soil on the bottom of the pond is very sandy it is a good idea to haul a few loads of clay or good soil, comparatively free from sand, and spread it over the ground. A bunch of cattle or other animals tramping over this when it is wet will greatly improve the condition of the bottom of the pond for holding water. I am told by those who have tried it that straw spread over a wet, sandy bottom and thoroughly tramped into the mud will also make a bottom that will hold water, and that a combination of clay and straw worked into the mud of the bottom of the pond by the hoofs of animals made a good, water-tight surface.

Another method is to sow the ground to grass or some kind of small grain, and then pasture it. The best of all methods, so far as I know from experience of my own and that of some of my friends who have built such ponds, is to use the ground for a feed yard for a few months. Although the soil may be very sandy, this kind of treatment will usually furnish a bottom that is practically impervious to water. The conditions and circumstances under which the pond is to be built will indicate which of these methods, or perhaps which combination of them, should be used for any particular locality.

After water has been turned into a pond, the ability of its ground surface to hold it seems to improve from year to year. This waterproofing, so to speak, of the bottom that comes with age is undoubtedly due to fine sediment that accumulates in the pond and is aided very materially by particles of decaying vegetable matter found in all ponds as soon as plants begin to grow in them.

SOME GENERAL NOTES ON PONDS.

Chain of Ponds.

In the building of ponds the lay of the ground frequently makes it advisable to construct two, three or more ponds rather than one. Moreover, two, three or four ponds, with from one to three acres of water each, can be managed to much better advantage for fish-culture purposes than one pond containing the same acreage of water as the combined ponds. The ponds can be connected with pipes that will allow the water to flow from one to the other, thus keeping up a circulation and sustaining the greatest number of ponds with the least possible

supply of water. This is particularly a fine arrangement where the ponds can be supplied by a small stream or spring of water that can be made to flow through them.

The Ideal Pond has Drain Pipes.

The ideal pond is the one that has pipes so arranged that it can be drained once a year or at pleasure. When the dam is constructed such pipes, from three to eight inches in diameter, depending upon the size of the pond, should be placed in the bottom of the dam at the deepest place to which the water in the pond naturally drains and at a place where the water can be run out through the pipe to the best advantage. One or more small pipes should be located higher up and at convenient places where they could be used for turning water into a tank for watering stock, or for irrigating garden patches, or for any other purposes needed.

Animals Should be Kept Out of Ponds.

No animals, not even ducks and geese, should be allowed to run loose in the ponds. They destroy the vegetation along the shore line and muddy the water; and in case of ducks, geese and pigs, they eat not only the food that belongs to the fish but the fish themselves, especially the young fish. By working the shores for food they also destroy the better part of the natural breeding and feeding grounds of the fish.

GROVES OF TREES ABOUT PONDS.

After the pond is built, groves of trees, if they are not already there, should be planted. The kinds to be planted depend upon the surrounding conditions and environment, but it is always safe to plant the varieties that naturally grow in the locality and others that have been tried and are known to do well in localities where conditions are somewhat similar. Cottonwoods, maples and willows usually do well near ponds even in the drier parts of the state. (See page 12.)

South of Wa Keeney, on the Saline river, there is a grove of ash trees with some hackberry trees growing with them. This grove is from 30 to 300 yards in width and extends along the river for two or three miles. It would seem that these varieties of trees might be grown in other localities in the western parts of the state. There are walnut trees growing on and near the Hatchery grounds that are loaded with fruit now (August, 1910). Walnut trees might be made to grow in other localities in this part of the country. Russian mulberries are good trees to plant about ponds. They bear an abundance of fruit that attracts many birds. While eating the mulberries, which have a long fruiting season, the birds as a rule do not disturb other kinds of small fruit to any great extent.

Groves of trees not only attract many birds but form wind-breaks which prevent the formation of waves that muddy the water, cut the banks and damage the earth embankments of the ponds. Groves of trees also provide shade for stock and may serve as camping and picnic places for pleasure-seeking parties. Groves of trees fringing bodies of water make the most pleasing and picturesque sights that can be found anywhere in the country, and that never fail to attract the attention of passers-by.

DIKES AND DAMS SHOULD BE SODDED.

While there should be groves of trees around the ponds, willows along the embankments and aquatic plants in the water, it is also very important that the dams and dikes should be well covered with a compact sod.* It is not always easy to find a grass that will do well for sodding purposes for the different localities of the state, especially for the central and western parts. It is usually possible to get some of the grasses native to the locality to grow. Foxtail and "sand bur" grasses do well on the dikes here at the Hatchery, but both are annual plants, and aside from the fact that they have objectionable qualities, they lack the mass of roots necessary for protecting the soil against wind and water.

BERMUDA GRASS.

Bermuda grass has been planted on some of the embankments of the State Hatchery grounds. It does well during the summer season, but if the weather gets very cold it seems to winterkill badly. This grass is a native of tropical climates, and I learn from Oklahoma Station Bulletin No. 85 that it can be grown as far north in that state as the Kansas line. This grass grows a foot or more in height at the Hatchery when not cut during the season. In the earlier stages of its growth, and later where it has been kept cut short or has been pastured, the general appearance of Bermuda grass, with its soft, velvety blades, is very much like buffalo grass. It is what one might expect would be produced if common blue grass and buffalo grass were crossed. It produces a thick, soft mat of fine blades, which are small and narrow, that completely cover the ground.† Bermuda grass grows much taller and ranker than buffalo grass, and the jointed runners it throws out are of much greater length. I have a specimen of one of these long jointed runners before me now, a growth of the year, and the longest one that my small boy George could find growing on the grounds. It measures eight feet and five inches in length, and has, in addition to any short branches, eleven additional runners that vary from twelve to thirty-

* See fig. 5.

† See page 28.

FIG. 5. Cross-section of a dam, showing terrace-like appearance of sides of embankments ripped with sods. The sods are from 12 to 14 inches in width and are laid up after the fashion of the steps of a stairway. The rise is about 4 inches (the thickness of the sods) and the steps vary from 5 to 6 inches in width.

A.—Cut end of piece of sod used in building the sod-wall terrace.

B.—Side of piece of sod exposed to the weather or water.

C.—Shows width of step or upper exposed surface of piece of sod.

This illustration shows a dike on the State Hatchery grounds that separates the Ninescaw river from a fish pond; it also shows a hog-wire fence that was built to prevent the river water from cutting and undermining the banks of the dike. A week after the fence was built it had caught moss and trash enough to turn the currents and cutting force of the water away from the banks. The top of this dike is covered with a dense growth of Bermuda grass.

seven inches in length. At each joint, and the joints are only a few inches apart, roots are given out from the growing plant, and from these roots new branches of grass are started. This grass also produces thick masses of roots that extend well into the ground; and on this account it is one of the very best of grasses, when properly grown, to prevent soil erosion on sloping grounds and on steep embankments. It grows best in the sunshine and shows great vitality during periods of drought. It makes good pasture. The horses here at the Hatchery seem to prefer it to any other grass that grows in the vicinity.* It is to be hoped that a hardy variety of this grass may be found for Kansas or that in time this variety may adapt itself to Kansas conditions. During the past winter (1909 and 1910) it killed out badly on the Hatchery grounds. However, it survived in spots, and especially on the south sides of the embankments. The live shoots in sods that were dug up in the spring and transplanted have grown well and the grass has spread very rapidly. In places bunches not more than six inches square have spread until spots five and six feet in diameter are covered with the fine, soft grass. This grass may be started by sowing seed, but those who raise it say that it should be propagated by planting small sods and root cuttings.

PRIVATE PONDS.

On many farms and ranches ponds have already been constructed. If you are contemplating building one it would be advisable to visit some that have already been built. By so doing you can investigate the methods that have been used for dam construction and for handling the water, and can compare them with the possible conditions that you will have to contend with in your own work of pond construction. By talking with the people who have built and who own and have charge of dams and ponds, and so getting their experience, much information might be secured that would be of undoubted value to you in the construction of the contemplated pond, whether it is to be a natural pond, an artificial pond, or a combination of the two.

If you are thinking of putting in a dam of any very considerable size and extent, or if the conditions are doubtful for one of even moderate size, it would be wise to consult an engineer. It would pay to secure the services of an engineer just as it always pays to secure the services of an architect when a house is to be built. The engineer could lay out the pond or ponds for you, giving grades, height and width of dam at various points and water levels; he could tell you how to take care of the water where overflows are to be constructed;

*October 21, 1910.—The Bermuda grass on the Hatchery grounds has made a fine growth this season and is still fresh and green, especially where it has been pastured.

how to manage the ditches and water pipes in cases where the water is to be received from adjacent springs, ponds or streams; and give much other information of value that would save much time and trouble, including an estimate of the cost of the structure. The Department of Fish and Game would be pleased to have you visit the State Hatchery grounds at Pratt. By so doing you could get many ideas about ponds, pond fish and pond fish culture, including any and all information that the department is able to furnish.

PONDS NEAR MEDICINE LODGE, BARBER COUNTY.

Early in the spring of 1910, while at Medicine Lodge, I had an opportunity to visit a number of small lakes and ponds in that part of the state. Some of these bodies of water were natural and some artificial, and others—found on the ranch of Miss Mary Best—were a combination of the two. What were originally natural ponds, supplied for the most part by overflow waters from the river, had been transformed by various improvements into what might be considered artificial bodies of water fed largely by springs.

Upon examining the ponds of this neighborhood I noticed, at least in one instance, what I had observed in other localities—that it is not wise to plow, scrape and remove dirt from the natural ground surface below the dam. This results in removing the surface soil, and in many localities such work

View of a section of a pond on the Mary Best Ranch, just west of Medicine Lodge. A natural pond that has been improved for fish culture and pleasure resort purposes.

will open up some of the lower strata of the ground that will allow the water that finds its way between them to seep away from the pond under the dam. Dirt for building the embankments should so far as possible be taken from the bottom of the pond itself while it is being shaped, or from grounds and adjoining places above the dam.

I also noticed in the neighborhood of Medicine Lodge another mistake that is sometimes made when dams are placed across small creeks, sloughs or ravines. This mistake is in the way the foundation of the dam was constructed. Some three or four dams were examined where brush had been thrown into wet, boggy places so that teams could get over the ground with scrapers. In another place poles and even logs had been used to make a sort of corduroy road for the team to travel over. Dirt had been hauled, scraped and tramped into and onto these artificially constructed foundations, but in every instance where these pole and brushlike roadway foundations had been used the water was either slowly seeping through them or was flowing in perceptible springlike rivulets.

THE ELLIS-HOUCHIN PONDS.

A series of private ponds about eight miles north of Medicine Lodge were especially examined. They had been constructed by Judge C. W. Ellis and Mr. A. M. Houchin, among the hills and smaller valleys that go to make up a considerable portion of that picturesque locality. As these ponds seemed to be well constructed and were built at a very reasonable cost, it might be well to give some account of one or two of them as examples of what can be done by one or two men with one or two teams and one or two plows and scrapers.

These ponds are so located that they catch a good supply of surface water, but some of them are also fed by springs of greater or less strength. The dams are constructed of earth scraped from adjoining banks or from the basin of the pond while it is being shaped.

An Economical Pond.

One pond put in by Judge Ellis and Mr. Houchin that looked particularly common-sense and practical in its general make-up, I desire to describe somewhat in detail. Its manner of construction and cost may serve as a guide in some respects for others who contemplate building ponds where circumstances and conditions are somewhat similar.

The dam that holds the water in this particular pond is 330 feet long. It is 12 feet wide on top and 16 feet high in its greatest depth; and for a distance of 100 feet where the deepest and greatest fill had been made, the average height is about 12 feet. A rather deep ravine and draw had been dammed. It held a body of water with a surface area of from two and one-half to three acres, varying in depth from 1 to 12 feet.

Just above the dam good posts had been set about six feet apart and hog-wire fence securely fastened to them. Between the embankment and the hog-wire fence brush had been thrown and tramped in, and in some instances quite large poles and even small logs had been thrown on the brush to hold it in place. This arrangement, as observation went to show, served well to keep the waves from cutting and wearing away the dam at the water's edge.

The dirt for building this dam had been taken for the most part from the rather high grounds near the ends of the dam. It was plowed up and moved by both large and small scrapers as the conditions of the case demanded. Men were hired by the day to construct this dam, and the total cost was \$105.

Another dam built by Judge Ellis was 135 feet long, 10 feet wide on top and 50 feet wide at its base for the greater part of its length. This dam was across a rather narrow valley in a ravine and averaged about 11 feet in height but was not more than 14 or 15 feet high in its deepest place. Its cost, together with the hog-wire fence and brush riprapping, was about twenty days' work for one man. However, this man used four horses hitched to a large scraper part of the time. The builders of the dam estimated that it would have taken five or ten days longer for a man with one team to have done the work. This dam held a beautiful little lake of from three to four acres of water. Its general shape was that of a fish hook or an old-fashioned crook-necked squash or gourd. The water in this pond was clean, as most of it came from springs. Water plants were growing near the shores, and groves of trees shaded the water in many places. As we walked along the banks we could see the wary fish, mostly black bass, dart from secluded little nooks where they had been feeding in shallow waters near the shore to safer retreats in the deeper water.

Some of the embankments built by Judge Ellis and Mr. Houchin have been riprapped, so to speak, with slabs of sod. The sods plowed up when the foundation of the dam was started and those taken from the basin of the pond cavity when it was formed were saved and used for building a sod wall on the sides of the embankment. This seems to make one of the very best finishings for the sides of the new embankments. This sod riprap wall not only protects the banks from water erosion but in many instances the growth of grass from the sods produces a permanent protection. If the erosion from waves and storm waters is not too great this sod-wall protection can be made to take the place of the wire-fence protection.

THE SAM BAILEY POND.

Mr. Samuel Bailey lives on the uplands north of the valley of the Ninnescah and about one-half mile northeast of the State Fish Hatchery grounds. He has built a pond almost on a hill-top and its sole supply of water is from a well. The water is

pumped by windmill power and carried into the pond through pipes.

I have visited this pond a number of times and have given it more than usual attention. It is such a complete success, considering the purpose for which it was constructed, that I desire to give special account of it, believing that the information may be of value to many persons who may be in position to build small ponds for irrigating and fish purposes. In size this pond covers an area less than one-fourth of an acre and is circular in shape. It was built by Mr. Bailey at an expense, allowing fair wages for labor, not to exceed a cost of \$25, or about five days' work for a man with a good team, a plow and a scraper. Of course this does not include the cost of a good pump and windmill. After the pond site had been definitely located, the excavation was made by plowing the ground and scraping the dirt until the pond cavity was about seven feet deep at the center and basin-shaped. The embankment walls, rising about four feet in height, are about six feet wide on top. The embankment surrounding the water represents the amount of dirt that was removed in making the excavation for the pond. After the work of digging and shaping the pond cavity had been finished, the ground surface of the pond basin was plowed and harrowed until the soil was thoroughly pulverized. The excavation was then ready for the water, which was allowed to run in until a pool formed in the center. Then a harrow was pulled through and around the pool a number of times. When the water had extended its surface two or three feet farther over the ground in the pond basin the harrowing was continued, half the harrow being in the water and the horses traveling on the dry ground. By the next day, when the water had extended its surface a few feet further, this operation was repeated, and so on until the pond area had filled within eighteen inches of the top of the earth embankment. This method of harrowing and puddling produced an excellent waterproof mud bottom that was quite hard and firm and held water from the very first.

The water for this pond is supplied by a good windmill that works a pump with an eight-inch stroke in a tubular well with three-inch casing and a two-inch point. The water is lifted about 35 feet from a well that is 70 feet deep. The water in the well usually stands within about 32 feet of the surface.

For five years Mr. Bailey has irrigated a three- or four-acre garden patch from this one pond. The water supply seems to be ample, for during a considerable portion of the time, even during a hot, dry summer like the present one (1910), the pond is full of water and the mill is running only a part of the time.

Mr. Bailey has started another pond just west of the one already built. This will give him two ponds with nearly half

THE SAM BAILEY POND.

A pond on a hilltop; supplied with water by the use of a pump and windmill power; water used for irrigation, fish and stock purposes.

an acre of water, which he expects to supply with one wind-mill and one pump. Of course the ponds can be filled during the winter and early spring and at other times when water is not needed on the garden, allowing a more liberal use of water when it is needed. Mr. Bailey runs a farm and gives only a small portion of his time to the garden business. However, he tried to impress upon my mind the fact that one could not have a good garden, even with an irrigating plant, unless considerable time was given to the care of it. Admitting that it takes some time to care for the garden, it surely pays to have one of the best vegetable gardens in the country, and that, too, in a country where little or no garden stuff can be raised without irrigation.

Unfortunately Mr. Bailey has not kept any account of the amount of the garden stuff raised and sold and its value. This spring, from March 28 to May 18, he sold over \$100 worth of rhubarb from a patch of five rows, each 230 feet long, and only a part—scarcely half—of the crop was gathered. Better and finer rhubarb I have never seen anywhere. The hills are from twelve to twenty inches in diameter and contained when examined from fifteen to forty good stalks each. Mr. Bailey gave me a half dozen stalks pulled from one of the first hills we came to. One of the stalks, stripped of its elephant-ear leaf, weighed fourteen ounces. There were other stalks in the patch that would undoubtedly have weighed a pound or more.

A bed of asparagus three times as large as the rhubarb patch furnishes an abundance of one of the best early vegetables that can be grown in any country, both for private table use and for the market.

In this garden I saw sweet potatoes growing at their best. Mr. Bailey dug a hill for me September 2 that contained 15 potatoes; another hill dug a week later contained 21 potatoes that weighed eleven pounds; another hill, dug about the middle of October, contained about 30 potatoes, a third of a bushel, that weighed eighteen pounds.

Grapevines, berry patches and fruit trees that had been planted around the edge of the garden in order that they too might be irrigated when water could be spared, were all doing well. I noticed a patch of the wonderful Burbank "wonder berry." It was surely a wonder to behold, bearing loads of fruit that weighted the vines to the ground. After tasting them, I wondered and wondered again and again that any one would care for them, as they are even more tasteless and insipid than frost-bitten, diaphoretic and aperient elderberries.

Judging from Mr. Bailey's experience with his garden, it is only reasonable to suppose that such an irrigated garden patch would easily make returns of from \$300 to \$500 per year if properly cared for, besides furnishing an abundance of fresh vegetables and fruits for family use. Such a garden is

possible for any one who can secure a good well near a piece of fertile ground that has grade sufficient to admit of irrigation.

Mr. Bailey has recently stocked his pond with crappie and bull pout—a yellow catfish. They are doing well, as several schools of hundreds of the young fish have recently been seen feeding near the shore.

PART II.

POND FISH: DESIRABLE KINDS, HABITS AND FOOD VALUES.

STOCKING THE POND WITH FISH.

AFTER the water has been turned into the pond basin and all expectations about having a pond or lake have actually been realized, there comes an "anxious time" about getting the pond stocked with fish. One of the very first questions that naturally comes up is, What kind of fish should it be stocked with? This question naturally involves the discussion of a number of subjects more or less related to each other. Some of these will be considered in this, the second part of the Bulletin, and others at various places in the third part, which will deal mainly with the subject of "Pond Fish Culture."

KIND OF FISH DEPENDS LARGELY UPON THE WATER CONDITIONS.

Before some of these questions that naturally come up for consideration can be answered at all satisfactorily it will be necessary to know a number of things about the conditions and environment of the ponds to be considered; the size of the pond or lake, and the nature of the surrounding grounds; the size and depth of the deepest places; the amount and depth of the shallow water that can be used for feeding grounds; and the amount and nature of the food supply that the pond is capable of producing. These are things that must be taken into consideration. The minimum and maximum amount of water and its temperature at different seasons of the year, especially during the hot summer season, are also important things to know.

TEMPERATURE CONDITIONS OF THE WATER.

The temperature can be taken at 7 A. M. and at 7 P. M. on the surface and on the bottom, in places of average depth and at the *deepest* places in the pond. By placing a thermometer in an open bottle or fruit jar, lowering it to the bottom of the pond and leaving it for an hour or two, then quickly pulling it up and reading the thermometer, the temperature of the water in the bottom of the pond can be easily ascertained. A fish pole can be planted in the pond and the string that is tied to the thermometer bottle can be fastened to it thus making it possible to raise the thermometer and read it at pleasure. If

the water is too deep for a fish pole, a cork or light float may be attached to the string holding the thermometer bottle, so that it can be found and raised for bottom temperature readings when desired. Ponds that are fed by springs or from underground sheets of water, and those that are filled by pumps, have a lower temperature (other conditions being equal) than those that are supplied directly from creeks, open ditches or from surface drainage. The average temperature of shallow ponds is higher than that of deeper ones under similar conditions.*

READY TO FILL THE POND.

After the dam or dike has been finished and the bottom of the pond has been put in proper condition to be filled with water, the owners are usually anxious to see the new pond area fill up with water either from natural drainage or such other sources of water supply as the locality may afford. It would really be better in many cases to allow the new dam and pond area to stand and settle for a few months or even a year. However, this is not necessary, as it is possible to fill new-made pond basins as soon as they are finished.† Before the water is turned onto the ground that is to serve as the bottom of the newly-made pond it should be carefully examined for sandy, gravelly or porous places. Just what special thing should be done to put the bottom in proper shape to hold water depends upon the nature of the material that goes to make up the bottom. Some instructions and a number of suggestions have already been given (in Part I) regarding the special treatments of pond basins in getting them ready to serve as good water-tight bottoms.

FILLING THE POND.

When the time to fill the pond with water actually comes it is always advisable, when it is possible to do so, to allow the pond to fill slowly and gradually. In the case of the so-called sky ponds that are filled with storm and flood waters this matter cannot be so well regulated and the pond may fill up in a few hours' time. Under such circumstances the filling process should be carefully watched and the overflow, or spillway, kept open so that any sudden accumulation of superfluous water could escape without doing damage to any part of the pond structure. The writer happens to know of a few instances where this matter of the first filling of ponds with flood waters was not watched as it should have been. The overflow, or spillway, became clogged with trash and the water was forced over the new-made dams, which were eaten away by the uncontrolled waters in an incredibly short period of time.

* Actual temperatures will be discussed in Part III of this Bulletin.

† See how Bailly pond was filled as soon as the earthworks were completed. Page 33, Part I.

THERE SHOULD BE DEEP RESTING AND BEDDING PLACES.

There should be natural or scooped-out places in every fish pond not less than six feet in depth (8 or 10 feet would be better); water on the bottom of a pond remains more even in temperature than that on the surface. The deeper holes in a pond provide cool places for fish to rest in during the hot summer weather. It also furnishes them places of retreat where they can bed with more safety when the weather is cool and when the pond is covered with ice in the dead of winter. Unless the fish are surrounded by plenty of water at such times they may die for want of air. For many years we have noticed that many fish that have been bedded either from necessity or by accident in shallow water—water that was not more than from one to two feet in depth—have died during the winter. They seem to become very numb and nearly frozen, so to speak, and apparently die for the want of air; or, in this weakened condition they seem to be more susceptible to the attacks of the white fungus disease* which, under such conditions, sometimes kills off great numbers of fish.

KIND AND CONDITION OF WATER FOR FISH.

While spring water is usually considered to be very fine for fish it is perhaps the poorest of all waters when it comes to furnishing the fish with food supplies. It contains practically no fish-food material, and when it first comes from the ground is poorly supplied with air. It can be much improved and supplied with both food and air by carrying it for greater or less distances through open ditches, ravines or creeks, where there is more or less plant and animal life growing. Artesian water and water pumped from wells are as destitute of fish-food as spring water, but the quality of such water for fish purposes may be improved by running it into ponds that are well supplied with water plants and insect life.

Fish live in the water and breathe the air that is held in small bubbles in mechanical mixture with the water. They do not live on water any more than human beings live on air. We live *in* the air and breathe it; fish live *in* the water and breathe by passing the water through the gills (their lungs) and by this operation get or gather the oxygen from the particles of air that the water contains in the shape of minute bubbles. Hence, running water, or water that is agitated into waves by the wind is always better for fish as it contains more minute air-bubbles for them to breathe.

When fish are placed in a small tank, tub or any vessel they will live but a short time, as the air supply is soon exhausted. The same fish placed in the shade and kept moist with damp leaves or some such material as grass, will frequently live much longer, as they can subsist for a certain length of time

* This disease (*saprolognia ferox*) will be discussed in Part III of this Bulletin.

in real air if they are kept moist. Fish frequently die in shallow ponds during the hot summer time for the want of air during periods when the wind does not blow; during such times the water is not agitated and the air supply of the water becomes exhausted.

The condition of the water, whether clear, muddy or tainted with some chemical or deleterious substance, and the changes to which it may be subjected during the year, should be considered in its relation to any particular kind of fish that is to be reared in it.

FOOD SUPPLY SHOULD BE KNOWN.

Another all-important thing that should be known in connection with the fish-culture business is the amount of food supply that the water contains for any given kind of fish. Of course, much depends upon the kind of fish placed in the pond, whether they are vegetable feeders, whether they live upon both vegetable and animal life, or for the most part or wholly upon animal life. The food supply for fishes will be discussed in Part III (Pond Fish Culture), where this subject in its relation to the rearing of fishes will be considered.

When the ponds and lakes are being stocked, the purpose for which the fish are being reared must also be taken into account: whether for sport—the pleasure of angling being one of the chief objects—or whether for food, the family table and the market value of the fish being the chief factors under consideration. The pond owner may have both ideas in mind, desiring to produce fish for both the pleasure and the profit of the business. Just what one may be able to do will depend upon a number of things, some of which we hope to explain in this Bulletin.

POND FISH FOR KANSAS WATERS.

It is very doubtful if any fish will ever be found that are more satisfactory and better adapted to the conditions and environments of Kansas waters than some of the kinds native to our own state. With few exceptions, the Kansas Department of Fish and Game will recommend for the stocking of Kansas streams and ponds some of the well-known species and varieties of Catfishes, Basses, Crappies and Sunfishes, types known to be indigenous to the waters of this part of the country. It is hoped that most of these, at least the best varieties of them, can with some intelligent care be made to adapt themselves to the conditions of Kansas pond fish life. The different kinds recommended for pond fish culture will be treated separately.

We hope in the near future to carry on some experiments here at the Hatchery in order to determine more exactly just what can be done with certain kinds and varieties of fish in ponds, and to find out something more than seems to be at

present known in reference to their relations to each other and their surroundings when reared together in the same body of water. These experiments will apply not only to our native Kansas fishes, but to others that have been or may be introduced in the future. However, the Department will be very cautious about introducing any new varieties of fish or game, at least until it has thoroughly satisfied itself that the newcomer has qualities and characteristics that would make it a desirable "good citizen" addition to our fauna. The Department considers that some of our native fishes, such as the basses, crappies, sunfishes and catfishes, and some of our native wild game birds, such as the quail and prairie chicken, the mallard and teal ducks, are to be ranked among the very best in the world both for food and sporting purposes, and, all conditions considered, the very best for Kansas.

LARGE-MOUTH BLACK BASS (*Micropterus salmoides*).

Common in most of the waters of Kansas and one of the best known and most highly prized fish in the state: Not a good fish for small ponds, on account of its food habits.

SMALL-MOUTH BLACK BASS (*Micropterus dolomieu*)

Rare in Kansas streams, and has not done well when introduced in this state, where it has had to compete for its living and existence with the large-mouth variety.

ROCK BASS (*Ambloplites rupestris*).

A large and fine looking fish belonging to the Sunfish family. When grown weighs from 8 to 24 ounces. Rare in Kansas streams, but seems to do well at the Hatchery. It may prove to be a good pond fish and a good fish for Kansas streams. A good pan-fish when taken from good water.

*The Black Bass.**

GENERAL HABITS AND HABITAT.

The BLACK BASS is a great favorite among sportsmen, and is undoubtedly the most popular game fish in Kansas, if not in the United States. Many anglers and fishermen have told the writer that they had rather take the Black bass on a hook than any fish that swims in the inland waters. The Black bass is one of the original native Kansas fishes, and at one time, in the early history of the country when settlements were few and far between, it was rather common in the smaller and the middle-sized streams of the state. But few are found in the large streams as most of these are too roily and muddy during parts of the year, especially during the months of May and June—the chief spawning season for the Black bass. These fish are seldom taken in the Kansas river between Manhattan and Kansas City. However, many of the tributaries of this part of the river furnish suitable homes for them. It is not the muddy bottoms of the larger streams that are objected to by the Black bass so much, perhaps, as the muddy water. Bass are frequently found in ponds and streams with muddy bottoms where the water is comparatively clean, but they undoubtedly prefer gravelly and stony bottoms as they always seem to choose such places when possible. They also seek places in the ponds, lakes and streams where there are plenty of aquatic plants growing; they also like to stay around old tree tops, logs or brush piles that may be in the water.

Plants growing in water from one to three feet deep furnish places of retreat where the bass can find shade and food. At Lake View, where we had an opportunity to make studies and observations on the Black bass for a period of more than twenty-five years, they always, so far as we could learn, chose flat sandy or gravelly places where the water was from sixteen inches to three feet deep, and where there were little open places among the lily pads, for their spawning grounds.

A GREAT GAME FISH.

The writer has been fishing and angling for Black bass in the state of Kansas for more than forty years, and is free to confess that no fish in Kansas or any other state or country (and he has fished in a good many waters and for a good many kinds of fish from Mexico to Central Alaska, and from Florida

* In this article the Large-mouth Black Bass is referred to and is the one the author has studied in Kansas. The Small-mouth variety has been introduced into Kansas waters but thus far has not made much progress.

to North Greenland) has ever given him so much satisfactory sport and real pleasure as this wary and game warrior.

SIZE OF SPECIMENS.

The Black basses caught in the streams and lakes of Kansas usually vary from nine to twenty inches in length and from six ounces to six pounds in weight. The largest the writer ever captured at Lake View was in the spring of 1904. The fish was a little over twenty inches in length and weighed a fraction over six pounds. So far as I know, Mr. George A. Clark, of Topeka, Kan., holds the record of the state for the largest native born "Jayhawker" Black bass. In the spring of 1905 Mr. Clark, while casting with a light rod and line, hooked a real jumbo and in due course of time landed him without injury by using a hand landing net. This splendid fish was between twenty-two and twenty-three inches in length and weighed seven pounds and nine ounces. Both of the above fish, after being measured and weighed, were returned to their homes in the lake. So far as I know the above fish taken by Mr. Clark holds the record as the largest Black bass that has been taken in this part of the country in waters as far north as Lake View, which place is near the Kansas river five miles northwest of Lawrence.

A HARDY FISH.

As a rule the bass is a hardy fish, and when once established in its habitat, adapts itself fairly well to the surrounding conditions, whether in creek, river, pond or lake. However, if the water is muddy and there are no deep places for the fish to retreat to in hot and cold weather they will not do so well; spring freshets also interfere with the spawning season, and under such conditions these fish usually become reduced in numbers, or in a few years disappear altogether.

There is little use to stock bodies of water with Black bass where the above unfavorable conditions have to be contended with.

FOOD HABITS OF FISH GENERALLY.

The food habits of any variety of fish ought to be well studied and understood before that fish is placed in any particular body of water; otherwise it will not be possible to know what its relations would be to that body of water and to the other fish in the same waters. In other words, if two kinds of fish are to be reared in the same pond or lake, their respective food habits and their general life histories, including their relations one to the other, ought to be well known.

All kinds of fishes consume more or less animal matter, but the proportion eaten by those belonging to the sucker or small-mouthed groups or families is rather small and belongs to the lower orders of animal life, as compared with the amount and kinds taken by the groups having large mouths, such as

those that belong to the bass, catfish and other predatory families.

FOOD AND FOOD HABITS OF THE BLACK BASS.

While the Black basses are notorious and voracious feeders, yet they do not possess such all-devouring, omniverous appetites as some of the catfishes. An old Black bass is very finical in his tastes and affectedly over-particular about his menu and the way the various courses are served. The varieties and kinds of food that he takes are limited and he wants these special courses served not only alive, but moving.

The chief part of a bass's food consists of fish. All kinds of live minnows and young fish in size up to one-half pound in weight are devoured, including, in some instances, young bass themselves, for the Black bass is a veritable cannibal. This cannibalistic tendency is not confined to the well-grown and old bass, but applies also to the young fish; the young, even those that have been hatched but a few weeks, if other food is not plentiful, feed upon each other. It is not a rare thing for fish culturists who study and have the care of young Black bass to find the larger and stronger specimens of a "brood" or school swallowing, or at least attempting to swallow (for they sometimes fail and even choke to death in their efforts), the weaker and smaller unfortunates of their own kind.*

Yesterday, while loading the fish-car, we examined over a dozen young bass that had swallowed smaller members of their own family. An average-sized specimen of these young cannibal basses measured three and one-eighth inches in length, and it had in its stomach another bass that measured one and seven-eighths inches. To-day (October 26, 1910), while the fish are being transported on the car, we have noticed that some of the small bass about three inches in length are swallowing other bass about two-thirds their equal in size. The unfortunates have been seized by the head and while the heads and shoulders are in the stomachs of the larger fish, the tails are protruding from the captors' mouths; and in some instances the protruding tails are wiggling, showing that the captives are still alive. It takes from one to two hours for a captor to get its captive down and out of sight. Thus are the pleasant, friendly relations between "kin" ever kept up and continually renewed in the Black bass family.

The writer has been studying the food habits of the Black bass for at least forty years. When a boy it was his custom to examine the stomachs of the fish he dressed in order to find out what they had been feeding upon. This operation gave him valuable knowledge when it came to solving the problem of "what to use for bait"—a profound secret never

* Notes taken from "Fish and Fishing for Fishermen," a book being prepared by the author.

before completely divulged. For many years we do not remember of having dressed a fish of any size that we did not cut its stomach open to see what it had been feeding upon, and for many years past notes have been written upon the subject of "The food habits of fishes." Hundred and hundreds of Black bass's stomachs have been opened and written notes of over three hundred specimens kept, and as a result of this investigation we believe that it can be said with a reasonable amount of certainty that the major part of the food of the Black bass, at least in Kansas, is made up of fish—both minnows and young fish of nearly every variety entering into the food mass.

Crayfish and frogs are eaten quite extensively under certain conditions and in certain localities. But few insects have been found except in the stomachs of the smaller specimens of basses, those ranging in size from one to nine or ten inches in length. In the larger specimens, minnows and young fish constitute at least seventy-five per cent of the food mass, while crayfish, frogs and all other material constitute about twenty-five per cent. Specimens taken from small lakes and ponds show a much larger percentage of fish food than those taken from creeks and small rivers.* Twenty-seven specimens taken just as they came, in the month of May, 1904, at Lake View, showed absolutely nothing but fish food, while an equal number of specimens taken in the spring months from the Wakarusa river years before showed only about sixty-five per cent fish food—crayfish in that particular instance making up about twenty-five per cent of the total mass, frogs and other material the other ten per cent; yet there were an abundance of minnows and young fish in the Wakarusa. This would indicate that the Black bass likes crayfish food and takes it quite freely even when fish food is quite common and accessible.

Frogs are eaten to a very considerable extent, but the supply is never great at any one time, at least in bodies of water where Black bass live, and they enter into the bass's regular bill of fare only as a morsel that is sometimes taken as a delicious dessert.

KIND AND QUANTITY OF FOOD EATEN.

The Black basses are voracious eaters from the time they first begin to feed, and the older and larger the specimens the more they consume. While fish and crayfish, when they are present, constitute the great bulk of their food, many other living and moving things are sometimes taken, and we are not sure—looked at from the standpoint of the bass—whether these things are taken on account of hunger or just to vary the regular routine of diet.

* The author is speaking of the Large-mouth Black basses that he has studied in the state of Kansas.

At the Kansas State University Natural History Museum the writer has a German carp that weighed over eight ounces that he took from the stomach of a Large-mouth Black bass that he caught at Lake View, in May, 1907. The bass weighed over five pounds and the carp's tail fin was still to be seen in the mouth of the bass when caught, the carp being so long that it could not be completely swallowed by the bass.

From the dissected specimens we learned that it takes two or three large crayfish and as many as a dozen small ones for one meal for a two- or three-pound bass. Young catfish, mostly bullheads, from a few inches in length to a half pound in weight have also been found in the capacious stomachs of these greedy fish feeders. Snakes as long or even twice the length of the fish themselves have not infrequently been taken from their stomachs; and birds, especially young ones, are sometimes found in the stomachs of the bass. From a specimen taken at Lake View in June, 1904, the writer took a young and almost full-grown robin. While visiting Mr. C. L. Davidson (mayor of the city of Wichita), a few years ago, he showed me a fine specimen of Large-mouth Black bass that weighed about five pounds that was being kept alive in a small cement pond in his yard. This fish was semi-domesticated and would frequently seize and swallow pieces of meat that were thrown on the surface of the water. It would also catch birds that happened to light on the edge of the pool to drink. Just a few days previous to my visit at Mr. Davidson's, this sly old bass had seized a blue jay that happened to alight near the edge of the pond to quench its thirst. After swallowing the bird, the bass swam around for two or three hours with the ends of the tail feathers of the unfortunate jay protruding from his mouth. The bird, like the carp before mentioned, was so long that it could not be entirely swallowed. Mr. Davidson recently informed me that this same fish captured two more blue jays after my visit to his house. It was necessary for the fish to jump from the water in order to catch the birds.

BLACK BASS A GREAT FAVORITE.

Judging from the applications for fish that come to the Department of Fish and Game, nearly every owner of a pond wants it stocked with Black bass. This is due for the most part to the following reasons: The Black bass is a well-known, much-talked-about, and much-praised fish; it not only grows to a fair size, but attains its size in a reasonable length of time; it is considered to be one of the best food fishes, having a good flavor, flaky meat, and not so many bones as some other fishes. However, one of the principal reasons, if not the chief of them all, that makes the Black bass such a prime favorite and puts it in such great demand, is the fact that it is such a splendid game fish—one of the very best in the world to catch with a hook and line. That "pull" that it makes

on the rod and line is something great! Did you ever watch a bunch of Black bass fishermen while in action? They are for the time being totally oblivious to everything else about them; they seem to lose themselves in a mental exhilaration, and to enjoy an indescribable enthusiasm—a something unknown to common mortals—that causes them to labor incessantly and patiently for hours and hours—even days—waiting every second for that glorious moment of excitement, that entrancing magnetic “pull” that has so many thousands of time “*de-lighted*” the minds and hearts of many of the keenest sportsmen the country has ever produced.

BLACK BASS IN PONDS.

However, when it comes to placing Black bass in ponds several things connected with their life history should be taken into consideration. The great size of the fish’s capacious mouth which opens into a very capacious stomach should not be lost sight of. The possible food supply of any body of water, and particularly a pond, is an all-important thing that must always be taken into consideration before the water is stocked with any kind of fish. The subject of food supply in waters and ponds will be discussed more at length elsewhere in this Bulletin, and particularly in the third division under the head of “Pond Fish Culture.”

OBJECTIONS TO BLACK BASS AS A POND FISH.

Consider for a moment the possibility of having one hundred good-sized Black bass in an acre pond. If each Black bass took four ounces of fish food, which is a little over one-half the amount actually found at times in the stomachs of large bass, the total amount consumed in one day would equal twenty-five pounds. If each bass took only one ounce a day for thirty days, the amount eaten would equal one hundred eighty-seven and one-half pounds of fish. It is not possible for an acre pond to produce and spare such an amount of minnows and young fish each month of the growing and feeding season. The chief objection to raising Black bass in ponds is the fact that the ponds can not be made to produce food enough to support a sufficient number of bass to make the rearing of them profitable even for angling purposes. But few can be raised per acre of water unless an extra amount of food is supplied. As soon as the food supply becomes scarce the bass turn cannibal and each one eats up everything of its own kind that it can catch and swallow.

If there were two one-acre ponds, one of which was well stocked with German carp, gizzard shad and other vegetable eating fish, and the other with bass, and these ponds were separated by gates of large and small meshed wire screening so placed that the young of the carp and other vegetable eating fish could pass into the bass pond and the young bass into the carp pond, the chances for rearing and feeding a supply of

bass would be greatly increased. Such an arrangement would allow the young bass to go where they pleased and to feed upon the young of the other fish, and would allow the young of the vegetable-eating food-fish to go into the bass pond and serve as food for the bass.

When hungry, old Black bass are not over-particular about the kind of fish they consume. The dissection of the stomachs of pond specimens where food was none too plenty has shown time and again that they are not averse to eating their own kind, taking young specimens that varied in length from two and one-half to six and seven, and even ten or more inches in length.

Judging from what is known of the nature and food habits of the Black bass, it would not seem advisable to place these fish in ponds, even though these bodies of water are of considerable size, unless some special provision can be made to supply them with food and to protect the young bass from the cannibalistic appetites of each other and of the old parent specimens.

In a Bulletin which is being prepared on "German Carp," the feasibility of raising young carp and other fish for bass food will be discussed. For stocking small ponds we would recommend such fishes as the crappies, some of the sunfishes and certain varieties of the catfishes. These will be discussed in their respective places in this Bulletin.

WHITE CRAPPIE (*Pomoxys annularis*).

It does well in ponds and was formerly more or less common in many of the streams of Kansas. Where the Black crappie has been introduced, the white form seems to disappear. The crappie are among the very best pan fishes.

BLACK CRAPPIE (*Pomoxys sparoides*).

In some localities known as the "calico" or "strawberry" bass. Rare in Kansas waters except where it has been introduced. No fish does better in the State Hatchery ponds, and there is no better fish for its size (one to three pounds) in the state. It should be in every stream and pond where it can live.

The Crappies.

A NATIVE KANSAS FISH.

The Crappie is a native Kansas fish. As early as 1867, '68, '69 and '70, the writer caught strings of them in the Wakarusa river and its tributaries. In 1871 and '72 he took them in Mill creek, Mission creek, the Marais des Cygnes, Dragoon and One Hundred Ten Mile creek. In 1873 he caught them in all the larger streams between Topeka and Wichita, including the Neosho, the Cottonwood and the Walnut. So it is fair to presume that when the country was first settled the crappies were well distributed in all the waters of the state where conditions were favorable for their living.

TWO SPECIES OF CRAPPIES.

There are two species or kinds of crappie; however, they are very near cousins and are so much alike and have so many things in common that it is difficult for one to distinguish them unless a special study of the two kinds has been made. Both varieties usually go by the name of crappie, or "croppie." They have several common names, depending for the most part upon the locality in which they are found. Much of the literature that has been published referring to these fish does not designate the particular variety.

THE WHITE CRAPPIE.

The White or River crappie (*Pomoxis annularis*) is also known as the common or Large-mouthed crappie, and is sometimes called the Southern crappie. It grows to a length of from twelve to fourteen inches and attains a weight of from one to one and one-half pounds, and very rarely exceeds this weight in Kansas. Of late years I have not seen any very large specimens of this species—none to exceed one and three-quarters pounds in weight.

COLOR OF WHITE CRAPPIE.

The general ground color of the body of this species of crappie is a silvery white flecked with small blotches of dark or olive green. The dark green mottling is to be found chiefly on the upper half of the body, and in some specimens shows a tendency to arrange itself in the form of narrow vertical bands, ordinarily from seven to ten in number, showing in some specimens taken in states east of Kansas quite distinctly. This banded condition is not very apparent in Kansas specimens, and unless the fish are examined when taken from the water may not be noticed at all.

HOW TO DISTINGUISH WHITE CRAPPIE.

However, the best way for the novice to distinguish the White crappie from the Black crappie is by the number of sharp spines in the dorsal fin. In the White crappie the number of sharp dorsal spines is typically six, very rarely five or seven. In the dark colored, or Black crappie, which will be the next one described, the typical number of sharp dorsal spines is seven and sometimes eight, but rarely nine and very rarely ten or six. The White crappie is longer and thinner in proportion to its weight than the Black crappie and is lighter in its general color on its sides and back.

HABITAT OF WHITE CRAPPIE.

The White crappie has for its habitat most of the bodies of water from the Great Lakes region southward through the Mississippi valley to the Southern states, and westward including Kansas and Nebraska. So far as we have been able to ascertain this crappie makes itself at home in nearly all the Kansas streams, and in all ponds and lakes where it has been planted, or which have been in the past in any way connected with the streams.

OLD RIVER-BED PONDS.

When Kansas rivers are swollen with storm and flood waters, many sloughs and old deserted creek and river-bed ponds are filled with over-flow waters. The crappie, together with many other kinds of fish, such as carp, shad, buffalo, and the catfishes, go into these over-flow ponds seeking new feeding grounds, and many of them are left there when the waters recede. Some of these ponds hold water from year to year unless the season is quite dry, and many fish live and spawn in them. If the ponds dry up, as they sometimes do, many fish perish. During periods of low water we have seen thousands of young crappies in some of these over-flow ponds, and have, at different times, helped to move them to bodies of water where they could live until they might meet with better water conditions.

THE BLACK CRAPPIE (OR CALICO BASS).

The Black crappie (*Pomoxis sparoides*) is also known as the Small-mouthed crappie. It has a variety of local names, depending upon the locality where it is found, such as Strawberry bass, Grass bass and Calico bass. This last name was undoubtedly suggested by the beautiful calico patterns of color delineated on the body of this species.

In Kansas the Black crappie is frequently called the Giant crappie by fishermen, owing to the fact that a very considerable number of fish weighing from one to two pounds each are caught. This crappie does well at Lake View and is highly prized by fishermen not only as a very fine food fish, but as being worthy of the attention of the sportsman who

has a light rod, fine line, a small hook and the real skill, feelings and sentiments of an angler.

Comparative Size.

The White crappie has always done well in Kansas waters but is apparently being supplanted by the dark variety. It seldom attains a weight of more than one and a quarter pounds in Kansas waters where the writer has examined it. However, the White crappie is usually considered throughout its range to be as large a fish, or even larger in certain localities, than the Black crappie. My personal acquaintance with these two fish in different parts of the country would indicate that both species grow to about the same length, from twelve to sixteen inches, when well-developed or full grown; but the Black crappie is somewhat deeper and thicker in proportion to its length and weighs a little more on that account.

The respective measurements of two specimens, each twelve inches in length, one representing each variety, go to show that the Black crappie is a good half-inch deeper in the body, measuring four and one-half inches, (measured with calipers just in front of the dorsal fin) than the White crappie, and more than one-quarter of an inch greater in width, measuring good two inches through the center of the body. The weight of the Black crappie was nineteen ounces and that of the White crappie was fifteen and one-half ounces, the fishes as stated above being of the same length.

COLOR OF THE BLACK CRAPPIE.

The ground or general body color is silvery white, the same as in the white species, but there are a very considerable more of dark olivaceous blotches in the Black crappie, especially on the upper half of the body. This colored mottling shows no tendency to form in transverse bands as it sometimes does in the White crappie. The mottling or spots on the fins are also more distinct than on the light-colored variety, and their color, while apparently tinged with dark green when looked at in good light, usually looked sooty black in most specimens examined by the author.

HABITAT OF THE BLACK CRAPPIE.

This species is found inhabiting about the same waters as the White crappie, but ranges somewhat farther north. It is reported as abundant in all the ponds and lakes of the Great Lakes region, and as far north as the Ottawa river, Canada, and the Lake of the Woods country, where the author found these fish in 1890.

The crappies that the author caught in Kansas some forty years ago were, as he remembers them, of the white variety. All specimens collected some thirty years ago and preserved for the State University Museum are of the light-colored or

white species. The first Black crappies that the author remembers having seen in Kansas were taken at Lake View, being propagated from stock that the United States Fish Commission had planted there nearly twenty years ago.

Spawning Habits.

The writer has never had much success either in finding or in having the opportunity of examining the spawning beds of the crappie. The White crappie seems to prefer roily water for its spawning grounds, even when clear water is accessible. That they can spawn and propagate their kind in roily or even muddy water is plainly shown from what takes place in some of the over-flow ponds along the Kansas river. These ponds have muddy bottoms, are shallow—generally from one to five feet deep—and the water is warm; yet the crappies seem to thrive in them, and under what would seem to be adverse conditions they produce thousands of young which are from two to four inches in length in the fall of the year.

The writer has been able at times, and in certain places, to locate the spawning grounds of the crappie, and in some instances to locate the fish near the spawning beds, which were made in little sandy or gravelly open places more or less surrounded by water plants and mosses. In these instances the water was from fourteen inches to four feet deep, and being slightly roily it was impossible to get any very correct observations. He knew that the bed was there, and judging from the way the old fish guarded the spot and bristled up its spines and chased every living creature that came near that particular preserve, he knew that there were eggs or very young fry (fish less than one inch long) in that particular spot.

Fourteen thousand and six hundred were raised in an acre pond at the Hatchery during the summer of 1910, but the water was too roily in this pond to see the nests, though several schools of very small and almost transparent fish were observed during the summer and fall.

Food Habits.

The crappie has rather a large mouth, the lower jaw protruding in a way that gives it a slight bulldog or puglike appearance. However, the crappies are not given to the destruction of other fishes to any great extent. The author has looked into the stomachs of over five hundred specimens and has a fair idea of their food habits, at least in the localities where he has examined them.

A large series of specimens that were examined from Lake View show between twenty and thirty per cent of fish food. Most of this fish food, however, was small minnows.* At

* Minnows are *minnows*, and when full grown they are still small, ranging in length from two to five or six inches for most of the species.

times when minnows were scarce small young sunfish were taken quite extensively. We have never found a young crappie in the stomach of any of the specimens of crappie examined. So far as I know they are not cannibalistic in their nature and it is fair to presume that they will not eat their own kind, at least in waters where it is possible for them to get other food.

Specimens taken from creeks and small rivers show a still smaller percentage of fish food, the amount scarcely reaching ten per cent of the total mass of food consumed.

The crappies eat great numbers of crustaceans and insects of both land and water varieties. The amount of vegetable food taken is small, except with some of the young fish. In examining a lot of over one hundred young fish from three to five inches in length in the zoölogical laboratory at the State University, a considerable amount of vegetable matter was found mixed with the insect and crustacean food materials, and occasionally, even in these small specimens, a little minnow was found in the food mass.

THE CRAPPIE AS A GAME FISH.

The crappie is scarcely classed as a game fish among real anglers, yet it makes rather a quick move when it takes the hook but does not put up fight enough to free itself from the hook and get away to suit the sportsmen, at least those who have been accustomed to fish for trout and Black bass. Yet the crappie is a fine fish to take with a light tackle, and what it lacks in dash and splash is in a good measure made up by the beautiful picture of silver and green that is presented to the fisherman as soon as the captive is lifted from the water. There are hundreds of fishermen, and "anglers" too, who enjoy fishing for crappie. The crappie will frequently take an artificial lure, rising to a fly or dashing after a small spoon when these tricks are skillfully handled and properly cast upon the water. However, the best bait for a novice or unskilled crappie fisherman is a grasshopper, a young crayfish, or a small minnow from one to three inches long. Such expert crappie fishermen as George A. Clark, of Topeka, and W. I. Hoadley, of Lawrence, catch crappies with artificial lures such as flies and small spoons; however, with these gentlemen the lure or bait does not count for so much as the skill displayed in handling the rod and line combined with a knowledge of the habits of the fish.

When a minnow is used for bait it should be carefully strung under the back fin on a small, thin, stout hook so that it will hang in a horizontal position when dropped into the water. By a small hook I mean one that measures not over two- three- or four-eighths of an inch from the point straight across to the shank. The wire of the hook should be fine, the strength being furnished by the quality of the material.

WHERE FISHERMEN FIND CRAPPIES.

Crappie like to stay near old logs, brush heaps and tree tops, and it is around such places that the wise crappie fishermen seek for them. At Lake View some of the more enthusiastic piscatorial artists spend considerable time and patience (combined with some labor) in building what they are pleased to call "crappie blinds." Posts are driven one, two or three rods from the shore to which logs, limbs of trees and piles of brush are anchored. Around these improvised, deceivable, would-be shelters many half-witted, unsuspecting and unwary crappie are actually frustrated, deluded and caught by certain semi-professional, somewhat-tricky and none-too-sportsman-like methods that are sometimes employed in cases of emergency by the none-too-partriotic and none-too-scientific fisherman.

Many times at Lake View the crappie fishermen have their best luck when they fish in the water made more or less roily where buffalo and carp are feeding on the bottom. We have often tried to discover why crappies were found in such places; whether they sought shelter in the turbid water, naturally liked that kind of water, or visited such places for the food that other fish were stirring up. The latter reason seems plausible.

CRAPPIE AS FOOD FISHES.

I think that most fishermen and lovers of fish will agree with me that the crappies are to be classed among our best food fishes. When taken from decently pure and clean waters there is nothing in the state of Kansas that equals them, with the possible exception of the Wall-eyed pike, medium-sized Black bass and Channel cats. The flesh of the crappie is white, firm and clean, being free from certain parasites that are frequently found in other fishes. The bones are not troublesome if the fish has been properly dressed, with fin bones and rays removed and nothing left in the flesh except the back-bone and a few ribs. When properly cooked the white, flaky, juicy flesh can be removed from the bones with a fork, and it has an exceptionally fine and delicate flavor, suited to please the most fastidious palate.

CRAPPIES GOOD POND FISH.

In view of what has been stated concerning our knowledge of the crappies and their ability to adapt themselves to the various waters and climatic conditions of Kansas, they must be considered as among our very best general-purpose pond fishes. The Black or Calico crappie is generally considered to be a fish that naturally likes and belongs to the clearer and cooler waters of regions further east and north, yet it has done well in Kansas ponds and streams. At Lake View the Black (or Giant crappie, as fishermen call it) does exceed-

ingly well, notwithstanding the fact that the great flood of 1903 destroyed all the water plants, including acres and acres of water lilies (lotus) and left the lake in such condition that the waters have been roily and even muddy at times ever since.

The White crappie formerly did as well in Lake View as the dark or "calico" variety. However, it is being replaced, not only at Lake View but apparently in many localities, by the dark variety.

The White crappie was in former years very common in many Kansas streams. In years past the writer has caught dozens and dozens of fine strings of them in the Wakarusa and its tributaries.

All things considered, we know of no better fish with which to stock Kansas ponds than the crappies. As we have seen, their hardiness, their productiveness, their food habits, their adaptability to Kansas conditions, their food, and even game qualities, all recommend them for Kansas fish ponds. Furthermore, owing to their food habits and to their peaceful natures, they can be propagated successfully in ponds with other fishes, such as some of the basses and catfishes. However, when food becomes scarce, the fact must be borne in mind that both the basses and the catfishes feed upon the young and smaller-sized specimens of crappie. The Department of Fish and Game hopes to supply every pond, lake and stream in Kansas at a date as early as possible, with Crappies, one of our very best *native* general-purpose fishes.

PUMPKINSEED SUNFISH (*Eupomotis gibbosus*).

This is the common sunfish. It is called the pond sunfish or pumpkinseed, and is found in most of the streams and ponds of Kansas. It is a good pan fish, but rather small, weighing from four to eight ounces. It is a boys' fish and is especially valuable, as it feeds upon mosquitoes and their larvæ and keeps ponds and streams free from these pests.

GREEN SUNFISH (*Lepomis cyanellus*).

A beautiful and very husy little fish that takes the hook readily. It lives in most of the smaller streams of Kansas and does well in ponds. Though small, not weighing over one-half pound when full grown, yet it is one of our very best pan fishes.

THE BLUEGILL (*Lepomis pallidus*).

It is found in some Kansas streams and should be introduced into all of them. It is one of the largest of the true sunfishes, weighing from eight to twenty-four ounces when well grown. It is a beautiful fish and when fed becomes quite tame, spawning near the shores. No fish does better in the ponds at the State Hatchery.

The Sunfishes.

There are several varieties of sunfish in Kansas streams and ponds; some are native, and others have been introduced. The sunfish family (*Centrarchidæ*, having spines in the anal fin,) include such fishes as the Black basses, the crappies and the Rock bass, as well as several species and varieties of smaller fishes commonly known as sunfishes. All the members of this family inhabit fresh waters and are found native only in the waters of the North American continent.

There are about a dozen genera and between thirty and forty species and varieties, nearly one-half of which are represented in Kansas waters, either native or introduced. Among the forms found in Kansas are the large- and small-mouth Black basses; the White (river or large-mouth) and the dark, Giant (or small-mouth) crappies; the Rock and Warmouth basses; the Bream and Bluegill, with such other small and common forms as the green, pond, and little red and orange spotted sunfishes. The fish in this family vary in size when full grown from specimens three to four inches in length and weighing but a few ounces, in case of the small red and orange spotted "sunnies," to forms as large as the Black basses. These latter vary from a foot to sixteen inches in length in northern waters, weighing from two to three pounds, to forms varying from twenty to thirty-six inches in length in southern waters and weighing from five to twenty pounds.

THE COMMON SUNFISHES.

In this article we desire to speak more especially of the common, every-day pond or creek sunfishes, such as are found in the smaller rivers, creeks and ponds of Kansas. These smaller forms seldom attain a length of more than eight inches and usually weigh from four to ten ounces, though occasionally specimens may be taken that are larger.

The sunfish is frequently spoken of by grown-up fishermen as a "boy's fish." The writer is one of the boy fishermen whose heart has been made glad hundreds of times by catching the gamey little sunfishes.

The first fish we ever caught was a "sunnie." We have been catching them for more than two-score years and are free to confess that we still enjoy catching sunfish. Next to the brook trout the "sunnies," for their size, are the most active fishes in the waters. From early in the morning until late in the evening they are always ready to bite and are not at all particular or finical about the kind of bait they take. Old-fashioned angleworms and grubworms are undoubtedly most acceptable; however, grasshopper bodies—in fact, almost

any insect—pieces of meat or fish, crayfish tails, small frogs and minnows, and even artificial lures are taken, one and all, with a greediness scarcely excelled by any other member of the finny tribe.

FISHING FOR SUNFISH.

I have not forgotten how, when a boy, we would work with an old spade or hoe digging a can of worms for bait. Then we would hunt the woods through and through for a long, slender, light pole—hickory with bark and knots trimmed off preferred. Sometimes fish-poles were cut in winter or early spring, the bark removed and the large end and heavy places shaved to make the pole of proper size and shape. Then the pole would be passed rapidly through the flames and hot smoke of a little camp fire until seasoned and put in condition for use in the early springtime when the fish would begin to bite. With pole and line (the line made by twisting together a few strands of mother's thread) and bait-can well supplied with worms, up or down the creek to well-known fishing "holes" we would go.

"Sunnies" could be found in small streams, in ravines or ponds, where the water was two or three feet deep, and even in some quite small prairie creeks where the deeper places were partly protected and shaded by overhanging grass. With cork about a foot above the hook and a small bullet fastened a few inches above the hook for a sinker, we were ready for fishing and not afraid to tackle the largest "sunnie" on earth. The baited hook would be dropped into the first pool we came to and almost instantly the cork would begin to bob up and down. Sometimes the bobbing of the cork would continue for a few seconds before it was pulled under. When it did go under the rule "to jerk as soon as it was out of sight" was always obeyed. The "jerk" was always made with about five times too much force and energy, resulting in landing the fish as far behind the enthusiastic urchin as the pole and line would reach, or else in a bush or on the limb of a near-by tree. Much impatience and excitement attended the freeing of the line from its entanglements and the securing of a properly forked stick on which to string the first prize of the day's catch. As time went on this performance would be repeated again and again with more or less variation, and sometimes as many as a dozen fish would be taken from one little pool. Just below a little riffle or waterfall where there was an eddy in the current was always a good place to get bites. A little brush or some driftwood lodged along the sides of some of the larger water-holes was always "a sure good place" for large "sunnies."

The excitement of such an outing would be enthusiastically kept up until two or three dozen fish were on the stringer. By this time the fishing outfit, with line knotted up and hooks broken or lost, would be more or less of a wreck, and the

youthful fisherman would hasten home, proud of his splendid catch. His torn and muddy clothes, scratched hands and sore feet, and the many fish stories that followed each other in quick succession, all went to show that he had not only been fishing, but that he had had "one of the times" of his life. After all the members of the family had expressed their doubtful admiration for the fish and had complimented the fisherman, not forgetting to mention his good luck and the general appearance of his belongings, the string of fish that had been dragged along through weed patches and over dusty roads until they were half dry were thrown into a pan of cool well-water and refreshed. With a "Barlow" knife and an almost exhausted supply of patience, an unhappy hour was spent in most uninteresting labor in attempting to clean those most unfortunate fish. It was a rule of the house that each fisherman must clean his catch of fish. When rolled in flour and fine meal and fried in hot butter or ham fat to a crisp brown those same "sunnies," though small and with more or less bones in them, were simply delicious, and in the judgment of a boy fisherman of those by-gone days there were no better fish in the whole wide world.

Many such fishing incidents as the above took place when the writer was a boy. Since that time he has become a "grown-up," but still enjoys taking a day off semioccasionally to "go a-fishing" for "sunnies." He still loves to catch these fish, and when the little "sunnies" are properly dressed and cooked he is still of the opinion that they have few, if any, superiors as a delicate, sweet-tasting table fish.

LAKE VIEW SUNFISH.

For thirty-four years the writer has been connected in one capacity or another with the Department of Zoölogy at the State University, and for thirty-four years he has been going to Lake View to fish and get material for the University Zoölogical laboratories. This lake, five miles northwest of Lawrence, is part of an old, deserted bed of the Kansas river, and ordinarily covers from one hundred and fifty to two hundred acres of territory with water.

While there were places in the lake that were from ten to twenty feet deep, there was also a great deal of shallow water from one to four feet in depth that furnished an abundance of aquatic vegetation and the best of breeding and feeding grounds for sunfish. There were also acres and acres of water lilies or lotus (var. *Nelumbo luteo*). These splendid lilies grew in great profusion and covered nearly one-half of the water's surface with their fine, large leaves; and during that part of the year when the plants were putting forth flowers it was possible to see a flower garden with one hundred acres of beautiful, large, cream-like lily blossoms as large as saucers or small plates. The great flood of 1903

destroyed all the lilies in Lake View and since that time there has been neither lilies or moss in the lake. This is a great misfortune, as the water has been roily and the bass and other scale fish have not done so well and fishing for the game fishes has not been carried on with such success and eagerness as before, in the good old days before the flood.

Lake View has always been a famous fishing place, and during the many, many collecting and fishing trips to that body of water, hundreds of good catches of Black bass, crappie, Calico bass, Channel cats and other kinds of fish have been made; but the Lake View "sunnie," the fish of my boyhood days, was not then nor never has been neglected. If any body of water was ever well stocked with sunfish it was Lake View.

While others were enthusiastically casting for bass and crappie, which on many occasions they were not catching, the writer frequently moved his boat from place to place among the lily pads, casting for "sunnies" with a light rod and line with artificial fly, or perhaps a small trolling spoon with or without a small bait attached. It was altogether a different outfit from that used by the boy-fisherman years before, but the results, and particularly the mental exhilaration, were one and the same.

A few careful casts in an open spot among the lily pads with a long hair-like leader that would allow a small fly or a tiny glittering spoon to strike the water with a light moving and skipping motion would usually result in a swirl in the surface water, showing that a "sunnie" had made a rise; that is, one had from some secret hiding place made a quick dash at the strange moving object. A quick, gentle pull at just the right moment with a light, springy rod would usually fasten the hook in the fish's mouth. Now, this "sunnie" that we have been angling for is no mean game fish, and for its size, ounce for ounce, will put up just about as hard a fight as any living fish, even the ever-praised brook trout not being excepted. How the cunning little gamester will pull and tug at the line and instantly twist it around a lily pad; and it is only after repeated attempts that the angler under such circumstances succeeds, if he succeeds at all, in getting the little fighter to the surface of the water and over the lily pads to the boat. Then the fish is carefully removed from the hook and placed in a live-box or net. It is cruel and barbarous to place fish on a stringer and drag them along the side of the boat, or throw them in the boat and allow them to flop around until they die, or carry them in the air and occasionally throw them in the water until they are dead.

Two or three hours of such sport, resulting in the capture of two or three dozen fish weighing from four to eight ounces each, gives an outing and a catch of fish second to almost none that could be found anywhere in the country.

Another way of taking sunfish at Lake View, in the good old days before the great flood of 1903, was to put on rubber hip-boots and wade in the shallow waters near the shore and cast ahead and to each side. When fishing after this manner the angler needs a hunting coat with pockets enough to carry his several conveniences in; also a small live-net that closes with a drawstring, fastened to his belt. This kind of fishing proved on many occasions a most satisfactory way to spend a few hours casting, not only for sunfish but for other fish such as crappie and bass. When the line gets "fouled" in the moss and lily pads, as it does many times under such circumstances, it can be loosened easier and with less disturbance than if the fisherman was in a boat which has to be moved from place to place. Again, there is a real fascination that comes from wading in the water and fishing. It seems to be the real thing and is a sport much sought after by many well-mannered, enthusiastic fishermen.

Why so much talk about the little sunfish? It comes mostly from the fact that fishing has had a good deal to do with the life of the writer of this Bulletin, and fishing for the little sunfishes has given him a great deal of pleasure, many satisfactory outings, and many good messes of fish, not only when he was a boy but also since he has become a "grown-up."

Furthermore, it is his desire that the boys of to-day in the state of Kansas may have a taste of the same kind of life, an opportunity to enjoy something of outdoor life, and to learn something of the thousands of simple and wholesome truths that nature has in store for youthful fishermen. Going fishing will help make better men out of boys, and if they have an opportunity to go fishing occasionally, even after they are men, the outing will do more for them in the way of healthful recreation in a few hours than almost any other kind of sport that can be named. Therefore, let us take care of and improve our streams, lakes and ponds, and make more and better opportunities for both boys and men to go fishing. Come! Come! This writing about fishing makes me fidgety and reminds me too forcibly of the many happy hours spent with rod and line and the dozens of fine fish that have been taken! So much thinking and writing makes me weary. Come! Come! I've got the fever and can stand it no longer. Let's go out among the lily pads and fish for "sunnies." "Nuff said."

SUNFISH FOR PONDS.

There are a number of varieties of sunfishes in Kansas, as stated before, and most of them do well in ponds. In fact, there is scarcely a pond or stream in the state where sunfish and bullheads are not found. Though the ponds may be shallow and the water warm, yet these fish manage to survive, and when the cold of winter comes and the ice freezes, if any fish at all survive there will be sunfish among them.

FOOD HABITS.

The sunfishes, especially the common green and pond varieties native to Kansas, are more or less omnivorous in their habits, eating a considerable amount of vegetable matter, various kinds of insects, worms, small minnows and young fish, sometimes including specimens of their own kind or near relatives. For this last reason I very much doubt the value of their presence in some ponds. For example, if the ponds were stocked with crappie, both kinds of fish would be competitors for almost the same kinds of food. The food that would be consumed by the sunfishes would feed crappie—a fish that grows much larger and one that does not destroy its own kind, so far as my observations go, unless pressed to the starving point. The crappie eats but very few young fish of any kind, but confines its fish-food diet almost exclusively to small minnows, which constitute ordinarily but a small proportion of the food of this fish. However, if you have a pond, the chances are that you will have some variety of sunfish in it, for they are in nearly every body of water. Water birds are said to carry the sunfish, catfish and other fish eggs of the sticky or adhesive variety on their feet and feathers from one body of water to another. Thus ponds are sometimes stocked with fish in a manner not easily explained by those who have not given some attention to the subject.

SUNFISH REARED WITH OTHER FISH.

We know of ponds that have bass, crappie, catfishes and sunfishes in them. They all seem to get along very well in a way. We also know for a certainty that in certain localities and under certain conditions Black bass feed very extensively upon sunfish; and on the other hand we also know for a certainty that when a Black bass is caught or driven from its spawning bed, the little sunfishes, if they are present in the pond or stream, will devour the bass eggs in the spawning bed in a very short time.

The entire subject of the relationship of various kinds of fishes in ponds of various sizes needs to be carefully studied to determine just what species can be reared together to advantage under known conditions.

The purpose that the breeder has in mind must also be taken into consideration. If you desire to raise Black bass, and the bass are known to eat young crappie and sunfish, they can all be placed in the same pond, the old crappie and sunfish producing thousands of young which may serve as food for the bass under such circumstances; provided, further, that the yearling sunfish do not eat up the bass fry.

GOOD TABLE FISH.

Though small, the sunfishes are considered good table fish. When dressed, the bones forming the shoulder girdle should be removed by cutting them loose from the body and removing them with the head. All the fins and attached bones should be removed by cutting on each side of them with a sharp knife and pulling them out, leaving only the back bone and a few ribs in the body of the fish. When fried to a rich brown in good clean butter and bacon fat, they have a flavor that places them among the very best of food fishes, only a little inferior, if inferior at all, to the mountain trout.

YELLOW BULLHEAD (*Ameiurus natalis*).

This is not so common as the others, but is found in some localities. It sometimes attains a weight of two pounds and is a good pan-fish when properly handled.

SPOTTED CHANNEL CATFISH (*Ictalurus punctatus*).

Is found in most of the larger streams of Kansas, and as a combination game and food fish has no superior in the state. It does not breed in ponds, but the young do well in ponds when placed there. These fish prefer the streams where the water is moving in channels and currents.

BLACK BULLHEAD (*Ameiurus melas*).

This is perhaps the most common native fish in the state and is, as far as we know, in all the waters of the state where fish live. It is abundant in the smaller streams and in most ponds. It is a good pan fish when taken from good water.

BROWN BULLHEAD (*Ameiurus nebulosus*).

This fish is well distributed in the waters of the state, but not so common as the Black bullhead. Like the Black bullhead, it is a good food fish when taken from good water.

The Catfishes.

DISTRIBUTION AND GENERAL HISTORY.

Catfishes are more or less common in the Mississippi and Missouri rivers and their tributaries. The common catfishes are said not to be indigenous to the streams and waters west of the Rocky Mountains on the Pacific slope. However, they have been placed in these waters during recent years by the United States Bureau of Fisheries, and reports go to show that they are doing well.

There are about nine species and varieties in Kansas (including the "stone" cats), and every stream in the state that has fish life in it has one or more kinds of catfish in its waters. The fact that the great majority of these streams are more or less turbid, and even muddy at times, does not seem to seriously interfere with these fish, but seems rather to produce conditions favorable to their propagation and development. Catfish have small eyes and they undoubtedly see poorly. They are bottom feeders and omnivorous in their habits, taking more or less vegetable and a great variety of animal foods. They have large mouths, large stomachs and "large" appetites, and are able to adapt themselves to a wider range of conditions than any other native Kansas fish. They are rated in various ways by sportsmen, anglers and fish-loving people as regards their value and quality as food fishes. There is always a ready demand for them in the market as food fish at good prices, equaling or even exceeding that of beef, pork, and mutton.

From a government report we learn that in one year twenty-three states reported a catch of 14,726,000 pounds, the state of Illinois alone reporting nearly two million pounds.* From the United States Fisheries' Report we learn further that "both commercial fishermen and anglers throughout the country are showing increased interest in catfishes, and requests for stocking public and private waters have recently been numerous." It might be added that the demand for these fish, at least in the state of Kansas, is constantly increasing. Hundreds, even thousands of requests are being made for catfishes for stocking ponds and small streams.

* However, the supply seems to be diminishing, for the total of the United States (17 states) had fallen to 7,648,000 pounds in 1899, and to 5,191 pounds in 1903. (See Natural History Survey of Illinois, vol. III, page 174.)

THE NAME "CATFISH."†

Just why these fresh-water fish are called catfish is not very apparent. They may have taken the name from their general resemblance to the salt-water wolf fish which also goes by the name of the wolf-eel, sea cat or catfish. This peculiar fish is covered with a smooth, unprotected, slippery skin like most catfish. It has a large head full of large, sharp teeth that somewhat resembles that of a cat. A specimen of fish called the wolf-eel, related to this group, was taken while fishing in Monterey bay, California, in 1900, which was said by my boatman to be dangerous on account of its snapping and biting; after it was landed in the boat the fisherman clubbed it on the head and killed it immediately. The size and general shape of the skull, with its large eye-holes and with both jaws full of sharp, cat-like teeth, gives it a decided analogous resemblance to that of a cat. Another reason may be given for the name; it rises from the fact that when some of the common Channel cats are taken from the water they frequently make an audible noise that somewhat resembles the purring of a cat. This may have had something to do with fixing the name "cat" to these fishes. Catfishes also have whiskers analogous to those of the cat in their general appearance. Cats are very fond of the flesh of catfish, but we do not see how this would have anything to do with fixing the name "cat" to these fish.

THE BLUE CAT.

In the larger streams of Kansas the great Mississippi chuckle-head or Blue cat (*Ictalurus furcatus*, or *ponderosus*) is quite common. Specimens are not infrequently taken that weigh from 50 to 100 or even more pounds. Mr. J. C. Saunders of Lawrence, Kan., caught three of these fish several years ago that weighed 128, 133 and 147 pounds respectively. The writer saw the 133-pound fish when it was taken. At another time Mr. Saunders caught six of these fish that weighed 651 pounds, all six being taken at one time in one hoop net. At another time Mr. Saunders caught in one net at one time twelve of these fish that weighed from 35 to 85 pounds each. Other specimens taken below the milldam at Lawrence have been reported as weighing from 150 to 177 pounds. The writer never saw such a large specimen. Though large, they are considered a good food fish, the steaks selling at prices equal to the best beef and pork steaks.

† *Ailurichthys* is a name that was applied by Baird to a genus of salt-water fish called sea cats. The first part of this Greek word (*αἰλουρος*) *ailouros*, means cat, and the second part (*ἰχθῆς*) *ichthys*, means fish. The Greek word (*αἰλουρος*) *ailouros*, which means cat, is made up of two parts, (*αἶβλος*) *aiolos*, which means quick-moving, and (*οὐρά*) *oura*, meaning tail.

THE BIG MUDDY OR YELLOW CAT.

The river Muddy or Yellow cat (*Leptops olivaris*) is another large catfish that is quite common in the larger streams of Kansas. The writer saw one a few years ago that was taken below the dam at Lawrence, that weighed 47 pounds. The Kansas river fishermen frequently report taking specimens that weigh over 50 pounds. Some few have been reported that weighed over 70 pounds. A few years ago the writer saw seven that had been taken in one forenoon by Mr. G. A. ("Dolly") Græber. These fish weighed from 25 to 65 pounds each and were captured by Mr. Græber by rather a unique method. He would dive down by the side of the mill wall and enter holes or open places in the wall where the fish could be found resting or moving slowly about. He would carefully move around while under the water and locate a fish and its position by gently moving his hand over it; then he would fasten a large hook that he had in his hand in the fish somewhere back of the dorsal fin. The hook was fastened to a short line that Mr. Græber had tied to a strap bracelet that fitted over his wrist. When he came to the surface there was usually a great commotion in the water and it was sometimes hard to tell which was man and which was fish. At such times he was usually assisted in landing the fish by a man in a boat who carried a gaff hook. Some of the large fish seemed to be all he could manage and at times it seemed to me that it was a mighty dangerous way to capture those big bull-headed river catfish.

The flesh of these large catfish is considered good food and sells in the market at prices equal to that of the large Blue cats or the best beef.

THE CHANNEL CAT.

Another species, the common Channel catfish (*Ictalurus punctatus*), more commonly known as the Spotted Channel cat, is called in some localities the "fiddler," presumably from the peculiar noises it makes when taken from the water. It is not so large as some of the other catfishes, seldom weighing more than 10 or 12 pounds when full grown.

The largest one the writer ever caught was in the Wakarusa, near Auburn, Kan. It weighed 12½ pounds. Mr. J. C. Saunders tells me that he has taken them as large as 18 pounds out of the Kansas river.

This fish has a deeply forked tail and a rather slim, pointed head as compared with most other catfishes. Its general color is ashy blue on the back, shading into lighter colors on the sides and white on the under parts. There are more or less small, scattering, sooty-colored spots on the sides of this fish, hence the name "Spotted cat." These fish are found in nearly all the streams of Kansas where the water has not been polluted with oil, lime or some other deleterious sub-

stances which are sometimes allowed to run into the streams from manufacturing establishments or other sources of pollution.

A Good Food and Game Fish.

This Channel catfish is the most satisfactory combination of a good food and game fish in the state of Kansas. Speaking of this fish, Dr. Jordan, of Stanford University says: "It is a very delicate food fish, with tender, white flesh of excellent quality."

There are many good fishermen who give the Channel cats a high rating as game fishes. When once hooked they are good fighters and produce a pull on the line that sends a thrill through the angler that almost equals that produced by the hooking of a Black bass of equal size and weight.

Food Habits of the Channel Cat.

The Channel cats eat a great variety of foodstuffs, including, especially among the young and smaller fishes, a considerable amount of vegetable matter. Fish, both minnows and young fish of other species, as well as crayfish, frogs and insects enter largely into their bill of fare. The writer has taken such food material as birds, snakes, half-grown muskrats and young turtles, and many kinds of fish, including, in a few instances, good sized bullheads, from their stomachs. They eat seeds of various plants in season and are apparently fond of corn and wheat, as these grains have been taken many times from the stomachs of specimens that have been dissected.

A Fish Not Adapted to Pond Culture.

It is very unfortunate that such a popular and valuable native fish will not breed in ponds. The writer has not performed any definite experiments in trying to breed Channel cats in ponds, but has made observations on their behavior in ponds where they have been kept, and has collected information upon the subject from various sources. The consensus of opinion seems to be that Channel catfish do not propagate in quiet bodies of water. When young Channel cats are placed in good ponds, where there is plenty of good food material for them, they do well and grow to large size. However, they do not spawn, or if they do spawn, the eggs do not hatch, for young Channel cats do not appear in ponds that do not have streams flowing into or through them. While the spawning habits of these Channel cats are not well understood, it is generally believed among fish culturists that the eggs will not hatch except in currents and channels of moving water. They are called Channel cats apparently owing to the fact that they are usually found in and undoubtedly prefer streams where the water is moving in currents and channels.

A Good Fish for Kansas Streams.

The Channel cat is one of our very best fish and an unusual effort should be made to propagate and protect it in Kansas streams. This would mean, among other things, that the young fish should not be removed from the streams, at least in any great numbers, until after they attain a weight of three or four pounds. This would give them a chance to spawn at least once before being caught, which would be a safeguard against their rapid diminution.

Save the Young and Eat the Old Fish.

The present Fish and Game Warden believes that it would be an advantage to the streams possessing thousands of young fish to have the larger fish of all kinds removed and used for food purposes, and will in the future favor methods and laws best suited to all the people of Kansas that will tend to carry out the above ideas.

The best way to propagate and thoroughly stock any body of water with fish is to protect the young or baby fish. If the young of any species can be protected until they are large enough to spawn even once, the chances for propagating and developing that species of fish are good. We want to emphasize the idea that methods of taking fish by seining, netting, trapping or any other method that will remove any kind of fish from the water before it has had an opportunity to spawn at least once should not be tolerated. Large-meshed nets and seines for taking the large fish that have attained a good part of their growth might be used to the advantage of both man and the growing crop of fish. Small-meshed nets have been used in many of our streams to such an extent that their supply of fish has become almost exhausted. The Department of Fish and Game will, in the future, make an effort to restock these streams with good varieties of fish if the people living along these streams will protect them and not catch and destroy them by unlawful methods.

THE SPOTTED CHANNEL CAT AS A GAME FISH.

After the Black bass, the Spotted Channel catfish is perhaps the most satisfactory game fish in the state. The writer has fished with rod and line in a good many waters in various parts of the North American Continent and has caught a good many kinds of fish, and yet he feels safe in saying that no fish has ever given him more satisfaction and pleasure (aside from the Black bass), in the catching and handling on the line, than the Channel cats caught in the streams and lakes of Kansas.

At various times from 15 to 65 pounds of fish have been taken with hook-and-line in a single day or night, or in a day and night, for we have fished many times all night. How a five- or ten-pounder does surge and pull on a line! He plunges

deep, circles, pulls, and plunges again and again. How it does make a fisherman's nerves tingle and his heart beat to land such a fish after playing it with bated breath for ten or fifteen minutes on a doubtful line! Here! Here! I have got the fever right now and want to go and fish for a big Channel cat! Don't you want to go along?

Fishermen say that there are not many of them in the streams any more. Too much seining and too much destruction of the young fish have thinned their ranks. Well, then, let us all work together to protect them and give them a chance to become common in the streams again. They are a hardy fish and do exceedingly well in Kansas streams wherever they get started and receive reasonable protection.

FISHING FOR CHANNEL CATS.

It was just 43 years ago on the 20th day of March—it happened to be my birthday—that we were fishing on the Wakarusa, near Auburn, Kansas, just below the old stone bridge. We had taken several small fish with a hickory pole and a line made of shoe thread. The cork went down and out of sight. The rule among small boys when fishing for cats was to let 'em take it until they pulled on the pole. In another second there were two of us pulling! We sure had a whale on the line, and how things did hum for a few seconds. What excitement, what see-sawing and pulling. Finally the fish was dragged out on the low, sandy bank of the stream. It was a whale indeed for a boy ten years old; it weighed over six pounds. Just seventeen years and three months later we were fortunate enough to kill a grizzly bear on the headwaters of the Pecos river in New Mexico. The excitement and satisfaction of the occasion was great, but no greater than when the big Channel cat was taken years before.

Four years after the six-pounder was taken, on the 20th day of March, while fishing in the Wakarusa about two miles east of Auburn, we caught more Channel catfish with hook and line in one day than we could carry. My father came after me in a wagon. The catch amounted to over seventy pounds.

Ten years later, fishing all night near the mouth of the One Hundred Ten creek, in the Marais des Cygnes river, from a boat that was managed for me by my uncle Hiram Reilly, over 100 pounds of Channel catfish were caught. And so on for hundreds of times this splendid fish that we hope soon to see abundant in the streams of Kansas furnished us some of the finest sport we have ever enjoyed.

BAIT FOR CHANNEL CATS.

What did you use for bait? That is a question that has been asked of us many times. A Channel catfish will bite almost any kind of meat or fish bait. Large worms and small frogs are especially good. We usually succeeded well

in catching the larger fish with minnows or pieces of fish that had been cut from some vegetable-eating variety of scale fish. A five- or six-inch chub cut in from two to four pieces always makes a good bait. Small frogs, beef or hog liver, and bird meat have all been used with success. A mouse on a hook makes one of the very best of baits for the larger Channel cats. Crayfish is another good bait. From the stomachs of the Blue Channel catfish we have taken such things as snakes (sometimes longer than the fish themselves), common rats, young half-grown muskrats, birds, young turtles, various kinds of fish and insects and such vegetable matter as wheat, corn (stomach full of it), and various kinds of aquatic plants, and both land and aquatic insects.

THE COMMON BULLHEAD, OR HORN POUT.

Kinds and Habitat.

Some of the most common and yet most valuable general-purpose fishes in the state of Kansas belong to the group commonly known as bullheads or horn pouts. The three varieties more or less common in the waters of Kansas are the Black, the Brown and the Yellow bullheads. They look so much alike in their general appearance and make-up, there being no very apparent characteristics that will especially distinguish any one of them, that they are all usually dubbed with the common appellation "bullhead." Even experienced fishermen do not distinguish them other than sometimes to call some of them Black and others Yellow bullheads. There are also two or three varieties of Stone cats that are somewhat smaller in size than the bullheads, but closely allied to them in general appearance and make-up. These, though belonging to a different genus or group are usually called bullheads. The various species of bullheads found in Kansas are small, growing from twelve to eighteen inches in length and weighing from eight ounces to thirty-two ounces each when well grown. The sizes most commonly taken with hook and line range in weight from one-quarter to one and one-quarter pounds each. For a general-purpose fish that can feed upon almost any kind of food and adapt itself to all kinds of streams and all kinds of ponds with their various water conditions, it would be difficult to find one that could adjust itself to so many conditions of environment as the horn pout or bullhead.

As a rule these fish prefer the more quiet bodies of water, such as the slow-flowing creeks and small rivers, and are frequently found in abundance and apparently doing well in ponds and in the rather shallow, warm and muddy overflow bodies of water where other varieties of native fish could scarcely live. So long as there is any water in the stream or pond that would make it possible for any fish to live, specimens of bullheads can be found "alive and kicking."

These hardy little adventurers will follow a stream to its very headwaters, and it is not uncommon to find them in small ravines or even in open ditches along roadsides; in fact, in almost any little pond that has at some former time been connected by a small stream to larger bodies of water where these fish live.

Bullheads do not move about much during the daytime when the sun is shining. They are active and do most of their feeding during the morning and evening and especially during the night. They will take and bite vigorously and persistently at almost any kind of bait, but are especially partial to large angleworms and pieces of small scale fish, such as shiners and chubs, when cut into proper sized baits.

The Bullhead as a Food Fish.

One of the fortunate things about this small catfish is that it is really a good food fish. The flesh is rather dark, but tender and juicy and of fine flavor. It is in great favor in the markets and commands prices equal to that of the best poultry and meats, and is eagerly sought after, the demand being so great in most places that it is not possible to supply the market.

A Good Pond Fish.

No one of our native fishes can be more highly recommended than the horn pout or bullhead for pond-fish culture purposes. Their extreme vitality, their ability to adapt themselves to a variety of conditions of environment, and their omnivorous food habits make it possible to raise them successfully in bodies of water ill adapted to the culture of most other kinds of fish. They will spawn in almost any kind of water; in a large lake, large river, small lake, small river, creek, ravine, pond, or even a pool, ditch or mudhole where the water is scarcely a foot deep. We have kept bullheads in ponds not over twenty feet in diameter and not more than two feet deep. In these limited quarters it was necessary to feed them, but they seemed to do well and spawned and hatched and even reared bunches of young. They are rapid growers and at from two to three years of age will attain a weight of from eight to twenty-four ounces each and are ready for the frying pan.

Food Habits.

These catfish are good feeders, as before stated, being omnivorous in their nature, eating almost anything in the way of animal and vegetable matter, devouring some aquatic vegetation and quantities of aquatic forms of animal life such as insects, insect larvæ, crustaceans, including many crayfish and mollusks, both thin-shelled clams and snails. They are also fond of seeds of various plants, the elm, foxtail grass and smartweed seeds being some of the common ones taken. We have many times found their stomachs well filled with

corn or wheat. The ones that were kept in small ponds and tanks were fed on various animal substances such as insects and chopped-up meats. They soon learned to eat cooked meat, and in partial captivity they seem to like bread, usually preferring corn or graham. At the State Hatchery a bunch has been fed this summer on corn chop, wheat and graham bread, with an occasional carcass of a bird or animal hung on a wire from the end of a pole for them to pick at. In the course of a day or two the bones would be picked clean. Bullheads also sometimes eat minnows and small fish, but seem very much averse to devouring specimens of their own kind except when driven to it from starvation. They feed morning and evening and especially at night, no matter how dark the night may be. Fishermen usually consider dark, rainy nights the very best times to catch them with hook and line or on "trot" lines. Bullheads are essentially bottom feeders, though we have seen them come to the surface for insects. At the Hatchery they frequently come to the surface, when fed in the evening, to get bread and other food that is thrown on the water. During the day they spend most of their time in shady places about old logs, treetops and piles of driftwood that may be in the streams. In ponds, during the warm and sunny part of the day they seek the deeper water and the shady places afforded in such bodies of water by the growth of various kinds of moss and weeds.

Fishing for Bullheads.

The bullhead is the one fish above all others that has gladdened the hearts of thousands of boys and amateur fishermen. It does not take an elaborate outfit of artificial flies, spoons and lures or fancy tackle and fixtures for an enthusiast who desires to fish for bullpout. A fish pole of hickory, willow or pawpaw will do if the cane pole is not at hand, and almost any kind of line and hook will answer the purpose. There is no better bait than old-fashioned angle or fish worms, though the bullhead will take almost any kind of meat or scale fish cut in pieces small enough for him to swallow.

Though the bullhead is essentially a night feeder, yet even during the bright, sunny day the well-informed bullhead fisherman can usually find the object of his quest by dropping a well-baited hook by the side of some half-submerged brushwood, old treetops or driftwood that may be lodged on the side of a stream or pond. The "catties," as the boys frequently call them, are especially active during a cloudy or rainy day and many are taken at such times.

Uncle Jake's Philosophy.

To Uncle Jake, a colored friend of mine who has spent a lifetime fishing for catfish, we are indebted for the following information. In a few characteristic phrases, which we are unable to quote word for word, Uncle Jake has given ex-

pression to some fisherman's lore and divulged some secrets that every member of the Catfish Aristocracy Club knows and cherishes as gems of knowledge that never fail in their ominous portentions:

"No use fishing during thunder storms; better dig bait, for the "catties" are hid away in deep water and do not bite.

"No better bait in the world than big, fat fish worms.

"Old, strong cheese is a powerful good bait to attract them.

"A little anise oil or asafœtida on the bait works wonders, but don't tell the other fishermen.

"The dark of the moon is the best time to fish for "catties." When caught in the light of the moon the meat shrinks up on the bones powerful bad, same as it does with chickens and pigs.

"The bullhead ain't worth nothing during dog days.

"They bite least when the wind is in the east; they bite best when the wind is in the west; but they bite good when the wind blows up stream.

"Nothing better—not even possum meat—than bullheads fried brown in bacon grease and eaten with hot corn-pone."

The Bullhead as a Game Fish.

The bull head does not take the hook with a quick, active dash like the sunperch, but is slow and deliberate in its movements. The cork that is being closely watched by the anxious fisherman will move off slowly and it frequently stops a number of times before it is finally pulled under and out of sight. Just as the cork is going out of sight is the time to jerk, so my small boy George, (who has become quite an expert bullhead fisherman,) tells me. This same rule held good among boy fishermen forty years ago. However, it is a poor rule, as it frequently allows the fish to swallow the hook. When the fish is hooked it puts up a stout, persistent, bull-like or bull-headed fight for one of its size. When caught these fish must be handled with care, as their stout, sharp pectoral and dorsal spines have inflicted many a painful wound in the hands of the inexperienced.

The bullheads have not only afforded pleasure and sport for thousands of enthusiastic boys and old-time hickory-pole fishermen, but have also furnished them with millions of messes of good fish. Dr. G. Brown Good, former assistant secretary of the Smithsonian Institution and one of America's greatest authorities on fish, says, speaking of the bullhead: "If taken from clear, cold water, it is very palatable when properly cooked, even delicious, in texture and flavor resembling the eel."

Dr. Jordan, of Stanford University, says: "All the species are good food fishes."

Preparing Fish for Cooking.

When taken from warm, muddy, shallow water they can be much improved in quality and flavor and put in good shape for table use by putting them in small ponds or pools or even in galvanized-iron stock-tanks where fresh water can be supplied from a spring or pump. Under such circumstances fish should be fed with corn chop, wheat, corn or graham bread, or almost any kind of clean vegetable or animal food.

For food purposes they should not be allowed to die but should be killed and allowed to bleed and immediately dressed. Fish that are allowed to die either in or out of the water, are never as good as those that have been killed, bled and properly handled.

Catfish should be skinned and dressed soon after being killed.

After washing the fish in cool water, using a little salt in the water when the fish are bloody, allow the water to drain from them for a few minutes. Then roll each piece in very fine corn meal, flour or cracker-crumb dust, or a combination of these materials, and fry or bake to a good, rich doughnut brown in a mixture of hot bacon fat and good butter.

Never place fish in anything but smoking hot fat to cook them, and never use what some people call "cooking butter" for frying fish or anything else. Thus handled and cooked bullheads will be found tasty, nutritious, if not a delicious food fish.

PART III.

POND FISH CULTURE.

“EARLY DAY” OBSERVATIONS.

Part III of this bulletin on Pond Fish Culture will include many observations which the author made on fish in the early history of the state of Kansas. His first knowledge of fish was gained in the sixties and seventies, when he was a boy, and when he spent a large portion of his time fishing and hunting on the Wakarusa and many of its tributaries. While many of these “early day” observations may not be so accurate as those made in later years when the writer had more knowledge and was guided by a more scientific spirit, yet they were made at a time when conditions were quite different from what they are now, and we consider them of more or less value because they were made when the streams and ponds and lakes were in a different condition from what we find them at the present time.

Lessons learned from those “early day” conditions may be of value when it comes to considering the possibilities of raising fish under present-day conditions. In those early times the streams, lakes and ponds were well supplied with fish, and the early settlers who fished with hickory poles, using worms for bait, had little trouble in catching all the fish they wanted for table use. Those “early day” fishermen found the streams, ponds and lakes in their natural condition. The water was pure and usually clear, and was free from sewage and other civilized pollutions. Since the state has been settled and much of the land put under cultivation, more or less change and modification has naturally come to its streams and ponds. In many localities the streams have been polluted and partly filled with mud and trash. This pollution comes from various sources. Wastes from manufacturing establishments, wastes from oil and mining districts, and wastes in the form of sewage from many towns and cities are the chief sources of contamination. Most of the mud deposited in the streams comes from the soil that has been washed from cultivated fields.

FISH CULTURE IN GENERAL.

While it is the primary object of this bulletin to treat of Pond Fish Culture, in order to do it intelligently it will be necessary to give a certain amount of information concerning fish culture in general, and especially the kinds of fish culture best adapted to the streams, lakes and ponds in this part of the country. We desire to make this part of the bulletin, at least to a limited extent, cover all fish culture in the state, for the simple reason that the natural streams and lakes will produce more fish for many years to come than it will be possible to raise in artificial ponds. However, artificial ponds and reservoirs properly managed and cared for will perhaps, in the course of time, produce more fish than can be raised in the natural streams and lakes of the state. As will be apparent from the study of this entire bulletin, artificial ponds can be better managed and cared for and are more completely under the control of the owner and manager than natural bodies of water. Fish will do better when cared for, fed, handled and sorted in well managed artificial ponds. They can be bred and reared under conditions of domestication, and in time will undoubtedly yield to the treatment under these influences, the same as other wild things in nature have yielded to influences of mankind.

METHODS OF FISH CULTURE.

When we come to study the subject of fish propagation throughout the country, we find that there are two well defined methods. Each method is based upon the nature and habits of the fish. There is one large group of fishes that spawn free eggs, of which the trout family is one of the best examples. The eggs and milt can be taken or stripped from such fish by hand, so to speak, and these same eggs after being artificially fertilized, can be hatched in specially constructed troughs or runways, or even in jars. Hatcheries with hatching houses are built in many parts of the country to accommodate fishes of this kind.

There is another group of fishes, of which the Black bass and the catfish families are good examples, that do not produce the so-called free eggs. On the other hand, the eggs are adhesive—that is, they stick together more or less and adhere, when they are spawned, to various objects that they may come in contact with. Fishes belonging to this group can not be handled in the same manner in hatcheries as fishes belonging to the groups that produce free eggs.

This natural division that we find in nature makes it necessary to handle the two groups of fishes in altogether different ways when it comes to building hatcheries for their propagation. Fish hatcheries, such as we find in Colorado and many other states where trout are to be propagated, are built along

different lines and are different from those built in states like Kansas, Missouri and Illinois, where fish that spawn adhesive eggs are to be hatched and reared. For the successful propagation of fish that produce adhesive eggs it is necessary to furnish a water supply great enough for the fish to live in and for them to spawn in and care for their own eggs, nests and young. Therefore, the number of fish producing adhesive eggs that can be hatched and raised to any given size, in any given body of water, depends largely upon the "household room" furnished by that particular body of water, and its successful operation depends largely upon its natural food supply.

THE KANSAS FISH HATCHERY.

The fish that will be propagated at the Kansas State Fish Hatchery belong to the group which produce adhesive or sticky eggs. The number of spawners or breeding fish that should be placed in a given body of water, say an acre, depends upon a number of things, and especially upon the kind of fish and the food supply of the water. First, it is necessary for that acre of water to have a supply of food that will support the breeding stock. Second, that acre of water must contain minute animal and vegetable life sufficient to supply food for the thousands and hundreds of thousands of young fish that hatch and come into existence soon after the spawning or egg-laying season is over. If the food supply of animal

A view of part of the east end of the Kansas Fish Hatchery grounds overlooking a number of ponds, with Hatchery buildings in the distance.

and plant life is not very great, it is easy to understand that a great number of these young fish will perish, a thing that actually does happen in all ponds that are not well supplied with food. The above suggestion will explain in a way what will be more fully explained later, namely, that it is necessary to have a large fish hatchery, or at least a large acreage of

water, in which to raise fish such as the basses and the catfishes, because these fish produce adhesive eggs and require plenty of room for their spawning beds and a good supply of water to produce food for their young. These varieties of fish not only prepare their own spawning beds or nests, but look after and care for the young fish after they are hatched. Some of these fishes remain with their young for only a week or two; others, such as some of the catfishes, remain with their young, guarding and protecting them, for several weeks.

The point that we especially desire to make in regard to the two groups of fishes above mentioned is that it is necessary to understand the kind of fish that are being propagated at any particular fish hatchery before you can intelligently understand the literature and general information that is being put out by the various fish hatcheries of the country. A fish hatchery built to accommodate fish that spawn free eggs would be of little or no value to the fish culturist who desires to raise fish that produce adhesive eggs. The Kansas State Fish Hatchery, which has nearly 100 ponds, varying in size from a quarter of an acre to over two acres, is given entirely to the production of such fishes as the Black bass, the crappie, the sunfishes and the catfishes. All these produce adhesive eggs, and it is necessary to furnish them with the proper spawning grounds and a sufficient amount of water properly stocked with food in which to rear their fish families.

THE LARGE-MOUTHED BLACK BASS.

In the early history of the state of Kansas the Large-mouthed Black bass was reported common in most of the streams. Fishermen have continued to report this fish as more or less common in the larger streams of the state and their tributaries. However, it does not thrive well in muddy water, and for this reason has always been rare in the main channel of the larger streams of the state, and especially in the Kansas river. However, in many of the tributaries of this river the bass have always been more or less common. It has always been found in the streams in the central, east, south and southeastern parts of the state. Such streams as the Neosho, Cottonwood, Walnut, the Marias des Cygnes and their tributaries afforded good bass fishing for many years. Even now fishing is good in places. However, during the past dozen or twenty years the fishing has not been so good, due to a number of things, one of the chief of which is, perhaps, that the number of fishermen has increased as well as the number of contraptions and contrivances for destroying fish life in the streams. Many of these streams have been fished with nets, such as gill nets, trammel nets and hoop nets, which are very destructive to fish, inasmuch as these nets can be set in such a manner as to make it almost impossible for fish to go up and

down stream without being caught. The young and undersized fish are frequently taken in large numbers with such nets. Dynamite and other explosives, very destructive to all kinds of fish, have been used in many localities. By this latter method of taking fish, not only bass, but all fish, both large and small, within a certain radius of the explosive are either killed or so stunned that in the course of time they perish.

Pollution of the water in the streams by sewage and various wastes from manufacturing plants and other concerns has rendered many streams unfit for the Black bass. This fish likes pure water, though it will live and even flourish in roily water if it contains no other deleterious matter than what comes from the open clean fields and good soil.

At the present time Black bass are found in a very considerable number of Kansas streams, but are not common in many of them. It is a fish of peculiar habits, as we will learn later on, which does not tend to make it very common in any except some of the larger bodies of water. However, the fish will live in almost any creek, pond or lake where there is water from three to five feet in depth. The water must not be muddy or polluted with sewage, or any such foreign matter as oil, or very much drainage from barnyards, or waste from manufacturing establishments. While, as we have said before, the fish will live in almost any ordinarily pure body of water, the number that can be raised and the number that can be maintained in any creek, pond or lake depends to a very large extent upon the natural food supply of the water.

The subject of the food habits of the Black bass and other related matters is discussed under the head of "The Black Bass," in Part II of this bulletin, and should be referred to in connection with the notes given on that subject in this, or Part III of the bulletin.

Spawning Habits of the Black Bass.

What we have to say concerning the spawning habits of the Black bass will be taken almost altogether from our own observations of the habits of the Large-mouthed Black bass as observed in the ponds, lakes and creeks of the state of Kansas. We have been catching and studying Black bass more or less since the spring of 1867, when, as a small boy, we caught some fine specimens of this fish in the Wakarusa, near Auburn, Kan. At that time and for some years afterwards Black bass were common in the Wakarusa and its larger tributaries. We have also during a period of about thirty years caught and studied the Black bass at Lake View, five miles northwest of Lawrence. This lake was formed by the river changing its course many years ago. It was well stocked with Black bass until after the flood of 1903. This flood killed the large water lilies and various other kinds of water plants, especially the "chara

moss," that up to the time of the flood of 1903 grew in great abundance in the lake. Since the vegetation has been lost the water of the lake has become more or less roily, and even muddy at times. Bass have not done well in the lake since the flood. When the proper vegetation is restored it will be possible for the bass to become common in that body of water again.

However, our most accurate observations concerning the life history of the Black bass have been made during the past four years, or during the period that we have had charge of the Kansas State Fish Hatchery at Pratt.

The spawning period of this fish varies with the season, in the state of Kansas, from the middle of March to the middle of June. We have records of the fish being on their spawning beds as early as the 11th of March and as late as the 17th of June. However, the common spawning season extends from about the middle of April to the middle of May. Weather and water conditions cause the season to vary. In 1911 the warm weather during a considerable part of the month of March caused a number of bass to mate and spawn. In some of the ponds the fish made nests and deposited their eggs in the shallow water along the north shores that faced the south. However, later in the season a cold spell chilled the water almost or quite to the freezing point. Many of the bass nests were in water that was not more than from twelve to sixteen inches in depth. Most of the fish deserted their nests and eggs when the temperature of the water got below 40 degrees (Fahr.), and when the temperature neared the freezing point all the fish deserted their breeding grounds. Many of the deserted eggs were eaten by minnows and other small fish. Those that remained in the nests were soon covered by a white fungus such as usually destroys fish eggs deposited in nests that are not continually cared for by the parent fish.

The above instance is mentioned to show, among other things, that the bass have no definite spawning season, but are governed largely by weather conditions. If the water gets warm and conditions are favorable, they may spawn so early that other conditions developed later on will cause them to desert their nests and eggs. Observations go to show that when the water gets cold, nearing the freezing point, the eggs usually turn white, due to fungus growths. Even though the parent fish should remain over the nest, the chances are that the eggs would mostly go bad. The spawning season this year (1913) began about the middle of April, and by the middle of May all the larger fish had spawned. The colder the water the longer it takes the eggs to hatch. We have watched nests in the cold water of early springtime where the eggs were deposited seventeen days before hatching began. In May and June, when the water is warmer, the eggs usually hatch in from seven to twelve days.

The Spawning Bed.

The spawning bed or the nest that the Black bass prepares here at the State Fish Hatchery is usually built on the north, east or west shores of the ponds, where the sun naturally warms the waters first in the early springtime. At this season of the year one does not have to walk far until more or less bass are seen swimming near the shore. One or two bass may be observed hovering over a certain spot. If it is a single fish it is usually a male, and if one will take the trouble to sit or lie down on the bank and keep perfectly still, in a not too prominent place, in from fifteen to twenty minutes the bass will usually become accustomed to the situation and will proceed with the ordinary work of nest-building that was being carried on, just the same as if there was no observer watching.

We found that a few bushes stuck in the bank for sort of a blind and left there, so that the fish would get used to them, made the approach to the nest much easier for future visits. If the bass should happen to be a male preparing a spawning bed or nest, a number of things can be learned by watching concerning the habits of the fish. The place selected for the nest depends upon the nature of the shore of the pond. A good many observations made by different persons have been recorded concerning the spawning habits of the Black bass. In many cases the observers do not state whether the fish observed were Large-mouthed or the Small-mouthed Black bass. This may account for many discrepancies, as the two varieties differ more or less in their habits. Many observers record the fact that the nest is built in places where gravel and coarse sand are present and that the eggs are placed on the gravel beds. Some fish culturists prepare special gravel beds for fish to spawn on. Sometimes the gravel is placed in shallow boxes about two feet square, and sometimes the gravel and coarse sand mixtures are embedded in cement-formed nests and placed where the fish can find them. Such devices have been reported more or less successful with the Small-mouthed Black bass.

Here at the Kansas State Fish Hatchery the Large-mouthed Black bass do not seem to pay much, if any, attention to gravel beds. The male fish usually starts the nest by selecting a place where the water varies from ten inches to two feet in depth. The places selected, so far as our observations have gone, are usually spots where more or less vegetation in the shape of small water plants may be found growing. The fish usually removes most of this vegetable matter, and then fans the spot with its fins and tail at intervals for a period of two, three or more days. The excavation which forms the nest or spawning bed varies from two to five or six inches in depth, and is from twenty to thirty-six inches across, or about twice the length of the fish. However, where the ground is hard the

nest is frequently a shallow basin that does not much exceed the length of the fish.

After the male has the nest completed he begins to search for a mate. In case he finds one before the nest is completed, the female usually helps with the work of completing the home. We have seen both fish working on the nest before the spawning was commenced. A completed nest is one ready to receive the eggs. Such a nest has all the soft mud and debris removed. This the fish accomplished chiefly by the use of its fins, especially the tail fin, though the fish is not averse to grabbing certain kinds of material that is in the way in its mouth and removing it. The nest as completed in the ponds here at the Hatchery is usually fairly well lined with the roots and stems of water plants that naturally grow in such places. In some nests there is a sufficient amount of growing roots and stems of these plants to completely cover the bottom of the structure. Examination showed that nearly all of these roots and stems were attached to the earth and were green, and are not loose pieces of stuff resting on the bottom of the nest.

The male fish drives away all intruders, including other fish, whether large or small, dashing ferociously at any animal, friend or foe, that may come in that particular locality. Even though completed, the male fish spends much time over the nest fanning it with its fins, apparently to keep the nest bed fresh and clean, until a mate has been chosen and the spawning and hatching season is over.

After the Nest is Finished.

After the nest has been finished, as above described, by the male fish, he retires at short intervals, making many near about excursions apparently in search of a mate, and within a day or two, if you take the trouble to visit and watch the place at various times, you will see two fish swimming about the nest. During these excursions it is necessary for the builder of the nest to leave it for short intervals. At such times other fish seem to take a fiendish delight in swimming over, around and about the nest. However, when the owner returns he immediately gives hot chase to all such intruders and meddlers. We have seen two fish which we took for males chasing each other and apparently contending for the ownership of a nest.

The male, which is usually the smaller fish of a pair, continues his search as stated above for a partner until he finds a female that is willing to visit his newly-made quarters and examine the home and nest that he has prepared. If she likes the situation and is pleased with the homestead she remains at the nest, and usually works upon it a while herself, putting on certain finishing touches. Now the male becomes very active and jealous; he swims here and there and continually

guards the female; he takes on the courage and ferocity of a warrior and dashes at any other fish that may come near; he heads off with great dexterity any move that would indicate that the female wanted to leave the premises. If the female is satisfied, or as soon as she becomes satisfied, the pair will swim around and around over the nest and in its immediate neighborhood, frequently moving side by side. In one instance observed this summer the male fish seemed to butt up against the side of the female with his head and shoulder, and would throw the female on her side. The two fish would frequently strike the sides of their bodies together, and whirl and turn in different directions, making various grotesque maneuvers.

After a courtship of this kind, which may last for one or more days, the female begins to deposit her eggs* in the nest. At this time the male is very active, swimming around the female and half knocking her over with his head and shoulder, and when the eggs are deposited he ejects his milt in the water immediately over or above them. In this manner, without any act of copulation, the eggs are fertilized. While this spawning business is going on, the fish are usually in from one to three feet of water and in quick motion. We have watched them until we were dizzy trying to see and figure out just what took place. It is a difficult matter under the above circumstances to make exact observations.

The eggs, at least in some instances, are deposited in elongated bunches or strings by the female, but soon spread and adhere to the particles of vegetation in the nest. Other observers note that the eggs adhere to the gravel in the nest. This would be true in gravel and pebble nests, and where there is no vegetable matter to form a lining for the nest bed, and is especially true with the small-mouthed Black bass, as reported by various breeders of this species.

We have not been able to figure out just how long this spawning process lasts. We think, however, from observations made at the Hatchery, that at least in some cases it does not last very long—only a few minutes. We are not certain, however, about the number of times the operation may be repeated. Such observations are hard to get when fish are active and in from one to two feet of water. We have observed certain fish spawning on a few occasions, and when we would examine the place a few hours afterwards the spawning would seem to have ceased. After the spawning has been finished, the male usually takes charge of the nest and attempts to drive the female away. After a day or so, if you will take the trouble to watch the nest, you will find that the female, which is usually the larger fish, has disappeared; or she may be seen swimming around several feet from the nest.

* The number of eggs deposited in a bass nest varies from 2000 to 20,000 and depends upon the size, age and condition of the spawning fish.

The Male Guards the Nest.

The male fish guards the nest and eggs during the greater part of the period of incubation, so to speak, and is now more pugnacious than ever. He will fight anything that comes in his dooryard, and is very active and very busy flying around from place to place. When he is not annoyed by intruders he spends much of his time over the nest, his fins continually moving, in order that fresh currents of water may continue to flow over the eggs and prevent any sediment from settling upon them. This great vigilance and activity on the part of the male fish is kept up until the eggs hatch. The period of incubation depends largely upon the temperature of the water. Three years ago we marked a nest where fish were spawning and visited it regularly every day. It was in early springtime, and was one of the first nests we observed. The water was cold and it took fifteen days for the eggs to hatch, and only a small per cent (we should judge about 10 per cent) of them hatched. Many of the eggs, for one reason or another, disappeared. The eggs that were lost from this and some other nests that we were watching disappeared apparently during the nighttime. We were not able to discover the cause of their disappearance. Some of the eggs turned white, due to fungus growths. Another nest that we marked later in the season came off, so to speak, in twelve days; and another still later in the season hatched in seven days. We found one this spring which, if no mistake was made in the day when the eggs were deposited, hatched in five days. This was in the latter part of May, when the water was warm and all conditions most favorable.

The Young Fish, or Fry.

When the eggs first hatch, the little fish, with head and tail free and the yolk of the egg attached to the body, remain in the nest close to the bottom, but they soon (in two or three days) begin to move around more or less, rising above the nest and spreading out. At this time the parent fish is very active and very pugnacious, and will fight almost anything that comes near the nest. They sometimes get so bold that they will grab at one's hand if it is placed in the water near the young brood or school of fish. As the young fish, or fry,* grow older they move about more and more, and rise up nearer and nearer to the surface of the water. The old fish is still very vigilant, and will chase a minnow or any other fish that happens to come near to this school or family of baby fish. We have wondered time and again how these old or parent fish could keep up such a continuous warfare, without any apparent rest, for days and days for the care of the young fish.

* For explanation of the term "fry," see page 133.

When from two to five days old the little fish are still in a bunch, but rise near the surface of the water and spread out more and more. The old papa fish continues to swim over and around the little baby fish or young fry, showing the utmost solicitude for their welfare. The young fish continue to become more active and restless and begin to move in certain directions. The parent fish, as observed here at the Hatchery, seems to herd the young fry and keep them near the shore, and especially round them up in places where there are bunches of aquatic plants, which not only furnish good feeding grounds, but give a certain amount of protection to the youngsters. When these small fish are a week old they show more and more signs of restlessness; they want to go somewhere, and one will see the schools moving in irregular bunches, which in some instances resemble small clouds in the water, shifting from one place to another, the old parent fish continually standing guard between them and the deeper water of the pond. The young fish have begun active feeding now, and by watching one can see them gathering particles of food as they pass through bunches of loose spreading aquatic plants.

They frequently come to or near the surface, gathering minute and microscopic animals, which they swallow in great numbers. From the time they are from one to two weeks old they are constantly moving around, and instead of being in compact masses they swim along the shore from place to place in long strings, or bunches, ranging from a few to many feet in length. At about this age the young fish begin to work out and make excursions in the deeper water; one can frequently see them five, ten or twenty-five feet from the shore. To herd, guide and direct their movements now is more of a task than even the vigilant parent bass can hope to perform. These family bunches or schools, when about two or three weeks old, begin to separate into smaller groups, and are, according to nature's provision, able to take care of themselves; at any rate, about this time the old parent bass deserts them. While they remain in schools for some time, the bunches get smaller and smaller, and by the time the fish are an inch or more in length they are well scattered and are frequently out of sight much of the time in the deeper waters.

From now on they can be observed occasionally, sometimes swimming in small schools along the shore and sometimes around bunches of water plants, such as lily pads and stone-worts, where they can be seen feeding. This spring at various times we noticed large schools of them in among the lily pads. They would come up near the surface of the water and frequently rest with their heads up against the lily pads, being in bunches from a dozen to a hundred or more under a single large lily leaf. As the fish grow older they become more active and scatter more and more, so that by the first of July or

August they may be seen swimming everywhere in the pond, not necessarily in schools. However, large bunches, ranging in size from a few to many thousands, may frequently be seen feeding along the shores where there are good growths of water plants. When frightened each one will make for shelter in deep water independent of the movements of any of the others. In other words, at this age and stage of growth each young bass is looking out for itself.

Observations on Hatching, Growing and Development of the Young Fish.

We have already stated that the old bass or parent fish guards the nest continually and spends all the time in which intruders are not being chased away fanning the eggs with its fins. This seems to be absolutely necessary, because observations made on various nests go to show that unless the eggs are kept perfectly clean with fresh currents of water they will turn white and will not hatch. When these white eggs are examined with a microscope it is seen that they are affected with a disease, apparently white fungus; and a few diseased eggs in a nest cause other eggs that touch them to become diseased, and in a short time many of the eggs will go bad. If for any reason the old bass deserts the nest, the eggs left within the deserted nest without parental care will, as a rule, if not stolen by other fish, go bad and turn white within two or three days.

We have performed some experiments by driving the old bass away or catching it while the eggs were in the nest. Under such circumstances small sunfish or bunches of minnows, if present, will in a very short time take all the eggs. The constant care which the old parent bass gives to the nest and eggs seems to be necessary in order to secure a hatch of young fish.

Two years ago we found a bass nest in the Ninnescah river near the Hatchery ponds. Our near approach frightened the fish away and in a very short time there was a bunch of minnows over the nest. After the minnows had found the nest we retreated, and the old bass returned, to find, however, that many of the eggs had been taken.

The above observations would indicate that to secure a good crop of young fish the old papa and mamma bass should not only be left alone, but should receive as much protection as possible from enemies and from intruders during the mating and spawning season.

It is our further observation that the young bass, or "fry" as they are usually called by a fish culturist, are very tender and about as incapable of taking care of themselves as any young fish we know of. Only this spring we observed schools of large-mouthed minnows dash into bunches of young bass and devour the young fish as fast as they could grab them.

The smaller sunfishes, especially the yearlings, seem to be fond of young bass, and make an especial effort to catch them.

After the old male bass deserts the young brood, if food is not plentiful and easy to secure, he too may begin to feed upon the young fish which only a day or two previously he was guarding with such jealous care. If there are any yearling bass in the pond, left over from the previous year, they may prove especially destructive to the younger and smaller bass. If it is necessary that yearling bass be kept in a breeding pond, there should be a good supply of minnows and other small and young fish for them to feed upon.

Certain insects, as the larvæ of the dragon fly, also feed upon the young bass. It makes the fish culturist who gets such information by observing what takes place in his own ponds wonder that any young fish at all survive. However, when we consider that the parent fish deposits from two to twenty thousand eggs, we can understand how it is that it is possible for from 1 to 10 per cent to survive under not too unusual natural conditions. When the fish are cared for in ponds where the fish culturist has control of the water, a greater per cent can be raised. If all the eggs hatched and all the young fish lived, in a very short period of time any ordinary body of water would be almost a solid mass of fish.

Nymph or immature stage of dragon fly. Enlarged to twice its natural size. It lives on many different kinds of small animals, including small fish. It is very fond of mosquito wigglers when it can get them. It serves itself as food for game fishes.

If a hundred good breeding fish were placed in an acre of water it would be possible for the fifty females to produce 500,000 eggs. If one-half of these eggs hatched, there would be 250,000 young fish. It is conceivable how a good body of water well stocked with vegetation might produce small animal life enough to support this great number of fish while they are small. However, as these fish grow and become larger they eat more and more

in proportion to their size, and when they get to be from an inch and a half to two inches long, small fingerlings* in size, the amount of food of suitable kind and size required for such an army of youngsters would be very great. Twenty-five thousand, or 10 per cent of the hatch, raised to fingerling size in the pond would be considered a fine crop, and can only be produced where conditions are favorable.

* For explanation of the term "fingerling" see page 133.

Caught in the act. A two-pound cannibal black bass swallowing a one-pound bass.

The small animal life, such as the small crustaceans, mollusks, and insects, and the various forms of larvæ in any ordinary pond, is limited and will support only about so many young fish. Where a great number of young fish are spawned, the mortality from one cause or another must of necessity be great. We find that as the fish grow they are continuously searching for food. Their appetites seem to be of a nature that can scarcely be satisfied, and their growth depends upon the kind and amount of food they can secure.

Two years ago we stocked a pond with bass and such other fish as we thought should be placed in it for food for the bass. During the first week in September the pond was drained, and from the 5th to the 10th of September the young fish were removed. The young bass which had been spawned in the latter part of April and May varied in size from two to six inches in length. A number of the larger specimens were killed, and the contents of their stomachs examined. As a rule we would find from one to three of the smaller bass in the stomachs of the larger carnivorous specimens. Experiments and observations here at the Hatchery go to show that as soon as the young bass reach one and a half or two inches in length, unless food is plentiful, the stronger and larger of these fish begin to show their cannibalistic nature by feeding upon the smaller and weaker members of their own kind.

It is not an uncommon thing, while handling these young fish and shipping them on the car, to discover that they are feeding upon each other. The fish that undertake to swallow each other are frequently so nearly of the same size that on many occasions we have found them, one with the head and shoulders stuck in the mouth and throat of the other, dead as a result of their choking and smothering to death. This occurs in the ponds as well as in the shipping tanks, and is not confined altogether to the small and young fish, as we have found fish from one to five pounds in weight that were cannibals, swallowing other fish not much smaller than themselves. However, opportunities for making observations are not so good in the ponds as in tanks where the fish can be easily observed.

Some fish culturists think it advisable to separate the young and the old fish soon after the spawning season is over, with the idea of protecting the young fish. The young bass, after they have been assorted as to size, are placed in quarters where they can not be devoured by the old fish, and where they are not so likely to feed upon each other. Under certain conditions this might be a good idea. It involves a very considerable amount of work, and also makes it necessary to handle both the young and the old fish at a season of the year when more or less injury may be done to both of them. We doubt very much whether it is advisable to disturb them under such conditions as we have at the Kansas State Fish Hatchery before the first or the middle of August. When other food is plentiful

the old fish do not feed upon their own young very much, and when the pond is well stocked with aquatic plants the young fish have a good chance to protect themselves from the old fish and from their cannibalistic brothers and sisters.

An early distribution of the young fish, beginning even when they are fry, makes it possible to distribute greater numbers of them. However, to do this it is necessary to begin moving them soon after the spawning season has closed. We have had much better success handling and distributing fish when we waited until the cooler weather of September and October arrived. We have said it before, but desire to say again, that if the ponds in which the young fish are being raised are well stocked with water plants, the young fish will soon distribute themselves throughout the pond after they are deserted by the parent fish. The stoneworts, or "chara moss," and other water plants afford them a great deal of protection against their natural enemies and the cannibalistic members of their own tribe. In this growth of vegetation the young fish find the greater part of the food upon which they live, in the form of mollusks, insects, crustaceans and the young of other kinds of fish. Under such circumstances the young bass are not so liable to be given to cannibalism. The breeding ponds should also be supplied with gold fish, gizzard shad, crayfish, or some other animal life that will serve as food for the adult breeding bass.

This morning (July 16, 1913) we spent two hours walking around the edges of the ponds and saw great numbers of young bass feeding near the shores. Many of them were very busy grabbing small gnats that were hovering in bunches near the surface of the water. When any small insect touched the water, a young bass would snap it instantly. They would grab any insect that we threw on the water. This goes to show that insects are a natural food for young bass, which they are perfectly willing to take if they can find them. If they could get all the insects they wanted it might produce a change in their food habits and reduce their cannibalistic appetites very materially.

While walking around the ponds we have noticed at different times and in various places schools of minnows swimming near the shore. Six weeks ago, when the bass were small, of fry size, these minnows would dash into a school of them and devour numbers of the young fish. However, this morning when the smaller minnows saw the bass they themselves would dash away to places of safety among the water plants to save their own lives, the young bass giving chase. The bass are evidently large enough now to take care of themselves and to give chase to any small minnow that they might be able to swallow, and their large mouths makes it possible for them to swallow almost any minnow not larger than themselves. However, when a yearling bass or sunfish appeared these same young bass immediately skipped for hiding places among the water plants.

While shipping young bass in the fall and spring we frequently put minnows in the tanks with them. It is not an uncommon thing to see a young bass swimming around with the tail of a minnow protruding from its mouth. When young bass and crappie are shipped in the same tank, it is not unusual to see a bass swallowing a young crappie. However, the crappie is such a wide fish that a bass can not swallow one that is much more than half its own length.

The above observations have been given so that the reader may know something of the nature, habits and early life history of the Black bass.

Voracious Eaters.

The bass are among the most voracious eaters we have among fishes. Their growth and size depends largely upon the supply of food. We find that when the fish are four or five months old they vary greatly in size. If young bass are placed in ponds where there are minnows, young goldfish, carp and other small fish that they can swallow, it will be found that they grow very rapidly. In other words, where the food supply is greatest they make the most rapid growth. The young fish under such conditions at the State Fish Hatchery have reached a length of from five to ten inches in a period of from five to seven months. If young and growing bass are placed where conditions are favorable, we find that when they are a year and a half old they will weigh from half a pound to a pound or more, and when two years old they may weigh from a pound to two pounds. We have had fish here at the Hatchery which at the age of from four to five months were from four to six inches in length, and when four years old would weigh from three to five pounds. However, as a rule our fish at the Hatchery do not grow so rapidly, from the fact that we try to raise as great a number as possible in the various ponds rather than to produce as large fish as can be produced in any given period under the most favorable conditions.

Food for Breeding Stock.

It is necessary for us to produce food enough at the Hatchery for the breeding stock. In the ponds where we breed bass, we usually place a number of yearling goldfish, gizzard shad and other small fish for food for the old breeding fish. In these same ponds we sometimes place spawning goldfish and spawning gizzard* shad with the spawning Black bass. If the young of these fish are too large for the young bass of the same year to feed upon, they make good food for the breeding bass, during the summer and fall, before the ponds are drained and the fish separated, and this helps to prevent the old bass from eat-

* Gizzard shad are very prolific and too many should not be put in any pond, enough only to supply food for the other fish. My chief fish man—Mr. R. D. Lindsay—says, "Go slow on shad."

ing their own young. We have also placed crayfish for food in the ponds where the Black bass are spawning, but we are not sure, as yet, that this is a good thing to do. A few crayfish may serve as food for the bass, but when there are many of them, we are inclined to believe that they will kill many of the young fish. When we have them we place tadpoles of the large green bullfrog variety in spawning ponds. We have had good success with ponds stocked after the above methods, but we are not ready to say just what is the best method to pursue when it comes to handling and raising the Large-mouthed Black bass, as conditions vary so much in different localities and in different ponds in the same locality. However, we have made up our mind to one thing, and that is that it is necessary to have plenty of food for both old and young fish in a pond where Black bass are to be raised. It sometimes happens that most of the breeding goldfish placed in ponds with the breeding bass are eaten up by the bass. This is likely to happen unless the goldfish are too large to be swallowed and other food is plentiful.

The spawning goldfish produce schools of young goldfish in these breeding ponds. Many of them usually disappear before the ponds are drained. These young goldfish are devoured by any bass that is large enough to swallow them. Yearling bass are very fond of them. As a rule, large bass do not care for small fish or small minnows, and our observation goes to show that they will eat larger fish, frogs and crayfish and let the young fish alone when they can get the larger food.

We have never known bass to eat tadpoles unless the tadpoles were caught and thrown to them on the surface of the water. Under such circumstances the bass will sometimes strike at the tadpoles, but we are not sure even then that they swallow any of them, for a few specimens of bass taken with hook and line after the tadpoles had been thrown to them had no tadpoles in their stomachs. However, during the latter part of June, and in July and August, the tadpoles are usually transformed into young bullfrogs. When these frogs appear, as they do at a very opportune time for bass food, the bass make quick work of them, as they are very fond of young frogs.

From the spawn of Hickory shad large schools of fish are hatched. These young fish are large enough in September and October to make good food for the larger bass, but are too large for food for spring-hatched bass.

*Intelligent versus Haphazard Methods.**

The reader will see from the suggestions made above that the fish culturist has a great many things to contend with. It is necessary for him to make a good many plans for the care of his fish, both young and old. These plans do not always work out, but intelligent and scientific work always shows up to ad-

* Continued on page 136, under "Intelligent versus haphazard work."

vantage when compared with haphazard methods. Ponds that are not properly stocked and cared for do not, as a rule, produce a good crop of fish.

This is not altogether true when it comes to raising a certain quantity of fish for home consumption with the least possible care and expense. The pond that has several kinds of fish thrown into it usually produces as many fish as the food supply will support. The so-called "game fishes"* feed upon the other varieties, and when food is scarce they feed upon each other, the larger and stronger fish devouring those smaller and weaker than themselves. While it is true that about as many fish can be raised in any pond as the food supply will support, a number of conditions must be considered and met. The natural enemies of the fish in any pond must not be forgotten. They may exist in such numbers as to destroy most of the fish in the pond. A few old large fish may eat up nearly everything in the pond, or there may be so many fish, such as bullheads and crappies, of nearly equal size that are not real cannibals that all will get poor and for want of food develop a disease and die.

Special Note on Spawning Habits.

In the spring of 1911 we found a spot where three bass were guarding their nests in a little narrow protected body of water in the Ninescah river, just north of the Hatchery ponds. It was our custom to go every morning, and at other times during the day, to make observations on these fish. When we first approached the nests the fish would show signs of nervousness and swim excitedly from place to place. By sitting quietly by some bushes that we had temporarily stuck in the ground, the fish would soon come to rest over their spawning beds and resume the regular duties of "incubation," paying little or no further attention to our presence. The spawning beds were not more than ten or fifteen feet from our position. The little narrow strip of water was formed by a sand bar that had been thrown up about ten feet from the shore to protect the south bank from being undermined by the river. In this special locality this body of water was so protected that it was usually quiet, not being interfered with by the current of the river or

* The term "game fish" is not well defined. The trout is always spoken of as a game fish, and so is the Black bass. There are a good many fish that anglers speak of as "game fish." The Channel catfish is frequently spoken of as a good game fish by some lovers of the rod. The crappie is too slow to be considered a good game fish. The sunfishes are frequently spoken of as "game" for their size. The bullheads are on the doubtful list and are not considered by some as game fish.

The terms "game fish" and "food fish" are surely not well defined if we are to judge from the way they are commonly used. Most game fishes are good food fishes. However, many food fishes, such as the buffaloes, the carp and the suckers, in general are not considered game fishes. In this bulletin the Black bass, the crappies, the sunfishes and the catfishes are, for convenience of terms of designation, all treated as game fishes.

by any ordinary wind. The bass had their beds in water that was from ten to sixteen inches in depth. Many other fish seemed anxious to come up from the river into this little neck of water. The nests of these three bass were not a great distance apart. Two of them, numbered 1 and 2, were within four or five feet of each other, and the other, number 3, was about seven feet up stream from number 2. Each fish attended strictly to its own business, guarding its own nest. The fish would stand over the nests constantly unless disturbed by intruders. They fanned their nests almost continuously with their fins, creating a current of water over the beds. The pectoral or chest fins were especially active. The fish would move around over the nests like the hands of a watch; however, in no particular direction. The head of the fish might be pointed to the south, and in the course of time it might move around so that it would be west or east, and it would not be a great while until the head might be pointed to the north; however, this position was rather rare, because when the head was pointed to the north it was directed toward the bank of the sand bar, and intruders coming up the little neck of water could not be observed so well.

The nests, as indicated above, were on the north shore of this little body of water and on the south shore of the sand bar, so that when the fish faced south the body of water and the opening inlet, which was to the east, could be easily watched. The mouth of the inlet was from fifteen to twenty feet below the nearest nest. Occasionally a school of minnows would make their way upstream and enter the mouth of the inlet. Before they had proceeded very far one of the old bass would make a dart at them, and almost instantly they would get out of sight in the grass, weeds and rushes, or return quickly to the deeper water.

Carp Visit Bass Nests.

It was not until the third morning that we saw what we had been hoping that we might see, and that was a bunch of three German carp coming up the Ninnescah and nearing the mouth of the inlet. They came slowly and apparently cautiously to this neck of water. There were five of them altogether, but two were lagging several feet behind. The bass guarding these nests were rather small and would weigh somewhere in the neighborhood of from one and a half to two pounds each. The carp would weigh from two to four pounds each. When the carp got within ten to fifteen feet of the nests the bass became very nervous and began swimming with rapid motion back and forth in short circles around and over their nests. Finally one of them made a dart at the carp that was in the lead, and before the carp could turn around or get its bearings the bass seemed to have passed under it or over it, and there was such a commotion in the water that further accurate observations

were not possible. The other two bass had also disappeared from their nests and were evidently somewhere in the mixup with the carp. When the water became quiet the bass were swimming in rather large curves near their nests. It was some four or five minutes before they were sufficiently quieted to resume their ordinary work of caring for the nests. It is almost needless to say that the carp made a hasty retreat down the river, stirring up clouds of muddy water that plainly marked their routes of retreat.

Turtle Visits Bass Nests.

It was about four o'clock in the afternoon when we had an unexpected opportunity of making another observation which we consider a rare one. We were delighted to see a turtle of the variety usually called a "skillypot" or "painted turtle" slowly making its way up this narrow channel in the direction of the bass nests. This turtle came along in turtle fashion, slowly and carefully, until it got within five or six feet of the nearest nest. Being on the bottom and moving slowly the fish did not seem to notice the turtle until it got within a short distance of them. When the fish did recognize the turtle they immediately became very much excited, swimming over and around their nests and around and over each other. Finally one of them made a frantic dart at the turtle, which was an animal with a shell some six or eight inches long and some five or six inches wide. After the first two or three movements there was such a commotion in the water that it was hardly possible to see just what took place. Apparently the bass grabbed the turtle by the head,* which would seem an unreasonable thing to do. However, this was the best observation we could get at the time, of what took place. The turtle was turned up-side-down, at any rate it appeared that way.

All three bass made an attack on this animal, swimming past, around and under the turtle and striking the animal in some manner. It was not possible to see whether they grabbed the turtle with their mouths or whether they raked the animal with their dorsal spines. Apparently they grabbed him by the feet or tail or most anywhere with their mouths. They must have used their sharp dorsal spines as they passed under the animal. The turtle was on his back or side part of the time, and was apparently turned over by the fish grabbing it. Finally the turtle got his feet in some weeds, which enabled

* Since the above observations were made we saw a Rock bass grab a turtle by the head and turn it completely over. At the time we were watching the Rock bass perform on its nest at a distance of not over two feet. The turtle, a small one with a shell not over five inches in length, came along almost crawling into the nest before it was discovered. The fish grabbed the outstretched head of the turtle and there was an immediate commotion in the water that left the turtle on its back a foot or more from the nest. The turtle immediately disappeared and the fish was soon settled over the nest that it was guarding.

him to get to the bottom, and he immediately disappeared under a bunch of water plants that was near the shore. The fish were very much excited and swam up and down the small inlet for some time. It took them several minutes to become quiet and settle down to their regular work of guarding and fanning the eggs in the nests.

The nests were visited the following morning, but no observations of importance were made. We caught three snakes with which to perform experiments by turning them loose near the bass nests. However, we did not succeed in inducing the snakes to swim near the bass as we desired. The snakes would not perform as we hoped they would. They were stubborn and mulish, and always went in the wrong direction. We have on other occasions seen bass tackle snakes and disable or even swallow them. One snake that was apparently too large to be swallowed was so disabled that it could not swim except in irregular curves. During the afternoon of the same day these nests were destroyed by parties who were seining for minnows, and who were unaware of the presence of the bass nests and of their value to a student of fish culture. A minnow net had been pulled over the beds, and the following day there were no eggs in the nests and no bass present guarding them, which goes to show that if the nests are disturbed by pulling a seine or net over them the parent fish do not return, and the eggs, if not destroyed or eaten by small fish, would soon die of white fungus disease.

Teaching Adult Black Bass to Eat.

In Part II of this bulletin we gave some account of the food habits of the Black bass, especially of the larger and grown fish. We have carried on some experiments feeding Black bass here at the Hatchery. In a pond where there were adult specimens we found that we could feed them by going to places that they naturally frequented. If the fish were fed at the same place every day or every few days it would not be long until one could expect them at that particular spot when feeding time came. We were accustomed to feed them about five or six o'clock in the afternoon. These fish were taught to eat, when we first began to feed them, by throwing some live animals such as grasshoppers, young frogs or minnows on the water. After the fish had learned the feeding places they would be on hand an hour or two before feeding time waiting for any food that might be thrown to them. In fact, they became so accustomed to being fed that when we were walking along the bank it was not an uncommon thing to see a school of fish swimming along opposite where we were walking, keeping even with us and waiting for something to be thrown on the water. They would instantly grab any food animal that was thrown in. Live grasshoppers were usually fed first, and then minnows and young frogs. Goldfish from two to six inches in length were greedily seized by the fish.

The frogs fed were usually from six to twelve inches in length. These the bass took the instant they struck the water. They would then immediately retreat, leaving the surface of the water a swirl of waves. After throwing a few minnows and frogs on the water, we would follow this up with a few pieces of fish, carp or hickory shad, cut in strips, and these would be followed by a few pieces of meat cut in strips three or four inches long, one-half an inch wide, and a quarter of an inch thick. Being fed as above described, the fish soon learned to take strips of bacon, liver, and even beefsteak. At first they were rather shy about taking the meat, but eventually they learned to take the meat, and seemed to enjoy it. It would take from three to ten pounds of liver or fish cut up to satisfy the appetites of some twenty to fifty fish that might be congregated at the feeding station waiting for food.

After the bass learned to eat the liver and fish (usually German carp, suckers, quill backs or hickory shad) it was not necessary to cut it in long strips; it was simply chopped up in small pieces and thrown into the water. Meat and liver were fed in the same manner. Thus, these fish that had not been trained to eat artificial food when young were gradually taught to take a meat diet. Ordinarily, as you will find out for yourself if you carry on experiments, Black bass that have not been taught to eat when young do not care for meat or any kind of food that is not alive. In their native haunts they feed almost entirely upon live animals such as crayfish, frogs and other fish. The younger and smaller specimens eat many insects and crustaceans, but they usually watch for them and catch them while they are alive and in motion.

Feeding Young Bass.

We have already given more or less information concerning young bass and their food habits. We found by experimenting that we could feed young bass if we used the proper kinds of food. The feeding was done at places along the shore where the young fish naturally congregated while searching for food. We have fed grasshoppers in the following manner: a bunch of grasshoppers were caught by the use of a net. When we desired to feed them alive they were slightly squeezed in the net until they were crippled so that they could not get away easily. When we desired to feed them dead or cut them up, holding them under the water while in the net and drowning them proved a better and more humane method. The hoppers were then placed on a chopping block and cut up fine with a long, heavy butcher knife. Small bunches of this fine material were thrown upon the water. Little sunfish and other fish would begin feeding on this grasshopper hash, as the boys called it, and it was not long before the little bass would do the same thing. After a few days they took very readily to this kind of feed.

Crayfish chopped up fine in the same manner made excellent food for the young bass. Fish such as German carp, gizzard shad, goldfish and suckers were chopped up and put through a meat grinder until the flesh was reduced to a paste. This fish hash also proved to be a good food for the young bass. By mixing it with water the fish hash or paste spread out better when thrown on the water, otherwise much of the ground fish stuck together in small chunks and would sink before the fish could get much of it. We tried the young fish with ground pig's liver and heart. They did not seem to enjoy the liver and heart very much. However, they would nibble at it, and if one should continue to feed them with liver, undoubtedly they could be taught to take it in generous quantities. It might at first be mixed with ground-up crayfish or fish. We tried this experiment with apparent success.

It is not our purpose here at the State Hatchery to feed young fish very much, and the above feeding was done only as an experiment. It takes time and is rather an expensive way to care for them, at least on a large scale. It may be successfully done in a small way, but does not appeal to us as being practical or economical in a fish hatchery as large as the one we are trying to operate. It might work to advantage under some conditions where there are but few acres of water and where a supply of food can be had at no great expense. The only serious objection to feeding fish, whether young or old, is the cost of the foodstuff in time, labor or money.

The idea put forth further on in this bulletin of raising natural food and allowing the young fish to find it and feed themselves, is the one which we intend to hold to very largely in the raising of young fish at the Hatchery for distribution over the state of Kansas. We desire that the young fish should "hustle," so to speak, for their living. By so doing they will learn how and when and where to find food, and how to care for themselves, so that when they are placed in strange waters they will not expect some one to come around with a basket of food and throw it to them. The training which they have already received, or rather the habits of life which they have formed, will enable them, when placed in strange waters, to immediately seek for food, and if there is anything that can be had they will not be slow about finding it.

However, we are convinced that where a small body of water is stocked with fish, that the number of fish that can be maintained in it, and the number of pounds of fish that can be produced in it, can be largely increased by judicious feeding. The food to be used should be anything that the fish will eat, and that can be most conveniently and cheaply secured. The fish culturist with a few ponds can separate, sort and feed his fish, and do a number of things that can not be done economically on a larger scale. At a fish hatchery such as we have in Kansas, where there are a hundred ponds to look after, our idea is

to stock the ponds with the proper kinds of life that will serve either directly or indirectly as food, and to encourage the growth of this life in the ponds by producing the proper conditions for its development. In other words, we hope to raise in the ponds themselves natural food enough for the growth and development of the young fish.

General Note on the Black Bass.

We have given more or less information in Part II of this bulletin, which we have continued in Part III, on the Black bass. This is the most important and highly prized game fish found in Kansas waters, and is the fish above all others that is eagerly sought everywhere by lovers of the rod and line, both for the pleasure of catching it and because it is an excellent table fish. We have given more or less in detail the life history of this fish because, in a general way, it represents the whole sunfish family, including the crappies and sunfishes proper, which are common in most of the ponds, lakes and rivers of Kansas. Nearly every person in Kansas who writes to the department for fish wants Black bass.

Fish for Distribution and for Food.

At the Hatchery the idea is to raise and grow a number of young fish for distribution in the ponds and lakes and streams of the state, so we make our plans to do this, rather than to raise fish to proper size for food purposes. If we were raising fish for food purposes it would be necessary for us to change our plans. We would have breeding ponds such as we have now, and other ponds where fish could be raised to a certain size for food purposes. This subject we will treat of in another place in this bulletin.

THE CRAPPIE.

By reference to Part II of this bulletin the reader will find that there are two kinds of crappies—the dark- and the light-colored forms—which are described as two distinct species, though in general appearance they are much alike. The dark form in some localities is known as the “Strawberry bass,” and is the one which we propagate here at the State Fish Hatchery. It does well and is very prolific, and in our judgment is one of the very best pond fishes. It is a very quiet fish and one that is not seen very much. The old ones are not often seen playing and feeding along the shore, as is the habit of the Black bass and the Green and Bluegill sunfishes. As a rule, these fish seem to keep under cover and to the deeper water, and it is only occasionally that they may be seen.

Their Spawning Habits.

Their spawning habits are thought to be somewhat similar to those of the Black bass. Unfortunately, thus far we have been unable to get any good observations on the spawning

habits of the crappie. On a few occasions we have seen the fish apparently paired off. We found what we took to be the nest of one pair in water from two to three feet deep. We watched the old fish at different times. However, the water about the spawning bed was deep and slightly roily and sometimes agitated by the wind, making it impossible to get satisfactory observations. On two or three occasions we saw two fish swimming over a depression in the ground some four to six inches in depth that had been thoroughly cleaned. This spot on the bottom of the pond, that had been freed from all loose vegetation, with all soft mud and earth cleaned away, we took for a spawning bed.

One morning about nine o'clock, when the wind was quiet, we watched two crappie over one of these spawning beds. We were lying on the end of a plank that extended from the shore about sixteen feet. The plank served as a sort of a gangway to a wire that controlled a water pipe, and made a good place to rest and watch the movements of the fish below on the bottom of the pond. The two fish would swim around each other, and at times they paralleled each other in their movements and apparently stuck so close together, swimming side by side, that the two would seem to be but one fish. They would swim around and around, side by side. Whether they were spawning or not at this particular time we can not say, as it was not possible to make correct observations. Three days later one fish could be seen over the same spot, but the water was a little roily and it was not possible to make good observations.

The Young Fish.

When the young crappie are hatched they are almost transparent, and it is hardly possible to see them. When dipped up on a piece of cheesecloth the eye seems to be the most prominent part. We saw a number of schools of them this spring. We used an opera glass in watching them and a hand magnifying glass to examine them. They apparently go around in bunches that sometimes get strung out several feet in length, much the same as the schools of young bass. We found the young fish when less than an inch in length scattered through the water plants that grew in the ponds. While feeding among the plants many of them would rise to the surface, apparently attracted by small insects, such as certain kinds of gnats that were hovering over the water.

We found out this spring that the young crappie are weak swimmers when they are from one-half of an inch to an inch and a quarter in length. If there is very much current in the water they will drift with the running water against the screen gates that separate the ponds from each other. We found it necessary to regulate the water so that it would flow very slowly, or not flow at all, in the ponds where the young

crappie lived. Young bass are also weak when small, and are liable to drift with the current, but we did not find them, as we did the crappie, drifting against and adhering to the fine wire screen gates. After they attain a length of over an inch and a half both bass and crappie will swim against an ordinary current, and they are frequently found with heads pointed upstream in places where the water is coming into the ponds rather than where it is flowing out.

Raising Crappie.

We have never tried to feed young crappie. The fact of the matter is, we see very little of them. However, we have been very successful in raising them in ponds without feeding. Where there is a natural food supply for them we especially recommend the crappie as a good pond fish. They do well in the Hatchery ponds. We have raised to the age and size of yearlings as many as 30,000 fish in an acre of water. They were raised by placing from fifty to sixty spawners in the acre of water and leaving them there for a year. Goldfish and Bluegill sunfish were placed in the same pond with them to serve as food fishes, with the result that about 15,000 yearling goldfish and Bluegills were taken from the pond with the 30,000 yearling crappies. The crappie fed on the other fish, but 15,000 escaped.

If a few thousand of these yearlings, all kinds, could be placed in a pond by themselves where there was plenty of food, in two or three years' time there would undoubtedly be an abundance of fish in the pond for table use. Spawning Bluegills and goldfish placed in the pond with the crappie could be made to produce much of the food supply for raising the crappie. The size of the fish when two or three years old would depend largely upon the food supply. While young crappie eat insects and many small forms of animal life found in the water, the larger specimens are fond of small minnows, young fish, and various kinds of crustaceans and insects.

The crappie are not usually considered cannibals, and do not eat their own kind except when food is very scarce. We have found out here at the Hatchery that when young crappie, taken from the ponds in the fall, are placed with those that are a year older, the older fish will devour the younger. They will also devour young bass that are a year younger than themselves. This took place where food was scarce owing to the fact that there were entirely too many fish in the pond in proportion to the food supply. However, we have kept one- and two-year-old crappie together successfully when there was a good food supply of minnows and the young of other fish, and we are still of the opinion that the crappie is not a cannibal except when hard pressed by hunger. If young goldfish and other young fish, as well as minnows, can be had in addition to

crustaceans and various forms of insect life, the growth of the crappie is assured in proportion to the food supply. The food supply for fishes will be further considered when we speak of the plant life of the pond.

Crappie will do well in almost any pond where there is a supply of water from three to five feet in depth. There ought to be some deep water in the pond to guarantee a place of retreat for the fish in both hot and cold weather. A considerable quantity of shallow water from six inches to three feet in depth can be utilized, as it is in the shallow water that the vegetation produces most of the water animal life that the fish depend upon. The crappie, especially the younger fish, that have been examined at the Fish Hatchery, feed very extensively upon such forms of life as naturally grow upon this vegetation, including mollusks, crustaceans, insects and various forms of larvæ.

When three years old, if properly fed, crappie are (when dressed) as large as one's hand, and are ready for table use. At two years old they are rather small, but if one will take the trouble to dress them it will be found that when properly cooked they are a sweet and delicate fish of fine flavor.

We would advise the reading again of what is said in Part II concerning the general life history of the crappie by those who contemplate the rearing of these fishes. It is not possible to give any "right way" of how to proceed in the raising and management of these fish, or any other fish for that matter. We give you the benefit of such knowledge and observations as we have made on the life history of certain kinds of fish. This we hope will guide and direct you in a certain measure when you begin your work. No two ponds are alike, and no advice that we might give would exactly fit the conditions that you may have to contend with. By raising fish, and at the same time being guided by the intelligent experience of others, you will learn how to do it quicker than by any other method. We only hope to help you by giving something of the natural history of the fish, and something of our own experience.

THE SUNFISHES.

Bulletin No. II contains a general account of the sunfishes found in Kansas waters.

Two varieties, the Green sunfish and the Bluegill sunfish, are propagated at the Kansas Fish Hatchery. The common Green sunfish (*Lepomis cyanellus*) is found in most of the waters of the state. It is not a large fish. The full-grown specimens do not attain a size greater than one's hand. However, these sunfishes are an important factor in Kansas waters. They are very prolific and do especially well in the smaller streams and ponds. They are a good pan fish, and their young serve as food for other fishes.

Spawning Habits of the Green Sunfish.

In their spawning habits, in a general way, they resemble the Black bass. Here at the Hatchery they begin to spawn about the first day of May. However, the spawning season for sunfishes is a long one. Yesterday, July 23, we found a few sunfishes on their spawning beds. Like the bass, they usually seek locations in water from one to three feet deep and near the shore for their spawning beds. Their nests are usually about twice the length of the fish in diameter and vary from one to four inches in depth. The fish, by a vigorous use of its fins, especially the tail fin, fans away the soft material, leaving the harder earth, sand and gravel for the nest bed. More or less roots and stems of water plants usually line the bottom of the nests, the same as found in the nests of the bass. In streams we have seen the nests in gravel beds.

So far as our observations go, it seems to be the male fish that builds the nest. Frequently there are many nests in the same locality, and these nests are quite near each other, and there are so many fish present that it is not easy to make out just where each individual belongs and what it does. We feel quite sure that we have seen two females spawn in a nest that was being guarded by a single male fish. The females also work at the nest-building business, especially when the nests are being finished.

Spawning Habits of the Bluegill Sunfish.

The Bluegill sunfish (*Lepomis pallidus*), which is the one we propagate most extensively at the State Fish Hatchery, also has a long spawning season. However, this variety of sunfish does not begin to spawn as early as the Green sunfish. We seldom see a nest of the Bluegill before sometime in June. Last year there were hundreds of nests to be found in July and August.

On favorite spawning grounds in shallow water, near the shores of some of the ponds, from a few to as many as fifty nests might be counted in an area embraced by a few square yards. These nests were in water from about eight inches to two feet in depth, and were about the size of dinner plates and almost as close together on the bottom of the pond as dinner plates could be placed. In other words, the nests touched each other. It was possible to observe the fish in their various movements while building these nests. The work of building the nests seemed to be carried on principally by the male fishes, though females were seen working on the nests. The fish were chasing each other around more or less, and they especially chased any intruder of their own kind or any other kind that came near them. However, the fish that were actually at work building nests seemed to know one another and did not interfere with each other. In fanning away the soft material in the bottom of the nest the fish would frequently

stand at an angle of about 45 degrees (sometimes almost perpendicular) and vigorously lash its caudal or tail fin over the nest that was being built. The dirt and particles of vegetation would fly in every direction. This material would have a tendency to settle on the nests of other fish. These likewise would get busy, and the fanning process was kept up until the nests were satisfactorily completed and cleaned.

Difficult to Secure Accurate Observations.

However, it was difficult to get accurate observations on the spawning habits of these fish. The male and female fish would swim around each other, by the side of each other, and over each other, with such rapidity that it was impossible to see exactly what was going on. However, during these movements the eggs were deposited in the nest and fertilized, apparently after the same fashion as in the case of the Black bass. We find that it is very difficult to make accurate observations on the spawning habits of any fish for the simple reason that the fish are in constant motion and are from eight inches to two feet under the surface of the water. The nests are, as a rule, from one to several feet from the shore line. It is very seldom that the water is perfectly clear, and the fish themselves stir up more or less sediment by their actions during the spawning period. Frequently there is more or less wind that causes little waves or ripples on the surface, and these interfere very seriously with making correct observations. In a general way one can see what is going on, but we find it difficult to get absolutely accurate information.

Rearing Sunfish in Ponds.

The sunfish (either the Green or the Bluegill) is one of the easiest fish we have to propagate in the Hatchery ponds. A pond supplied with food material and stocked with sunfish is almost sure to yield a good crop, unless the young are destroyed by their natural enemies, which include other fish.

The little sunfish when they first hatch out are in schools, and keep near the shore for a short time. They are guarded to a certain extent by the old or parent fish, but, according to our observations, they soon scatter and hide in the various growths of water plants that are usually found along the shores of ponds.

Serve as Food for Other Fish.

The Green sunfish are hatched later in the season than the bass, and for this reason they have a better opportunity to secure particles of food. And for this same reason, also, many of them serve as food for the young bass, that are always hungry and are especially looking for small young fish for food. By the time the sunfishes hatch the water plants have made a good growth and are covered with minute forms of

life that serve as food for the fry. While the sunfishes are essentially carnivorous, yet they eat a considerable amount of vegetable food.

The very late spawning season of the Bluegills causes the young fish of this species to appear also at a time when the ponds are full of minute life and the young fish have a great opportunity to feed and grow, and also to sacrifice themselves or be sacrificed as delicate morsels of food for other and larger fishes.

We find that by building ponds double, so that the young bass can be allowed to pass into the sunfish ponds, that the Bluegill and the Green sunfish can be made to furnish a great deal of very desirable food for the bass, some of which have attained a length of from one to two inches, or even more, before the sunfishes, especially the Bluegills, appear. Young bass are such enormous feeders that we find it necessary to resort to all kinds of schemes in order to get food enough to keep them going. We find it necessary to raise a number of varieties of fish at the Hatchery that serve as food for both old and young bass.

Sunfish Good for Ponds, and Easily Fed.

Take it all in all, the sunfishes, especially the Bluegills, are among the most satisfactory fish that it is possible to raise in a small pond. By a small pond we mean one in size from, say, one-eighth of an acre to one acre. If the pond is properly stocked with water plants a great number of fish can be raised.

Sunfish are cannibalistic when food gets scarce. The larger specimens eat up the smaller ones. However, it is necessary for something of this kind to happen, as such an enormous number of fish are hatched out that if all lived and grew to any size the water would soon become a solid mass of fish. These fish, when fried brown and crisp, can be eaten when they are about two years old; though rather small at this age, they are sweet and of a very delicate flavor. At three and four years of age they are of fine size for table use.

They can be raised in ponds with other fish, and can be taught to eat almost anything, and are especially fond of insects. This can be demonstrated easily by throwing insects on the water where the fish are accustomed to feed. They will eat almost any kind of meat that is chopped up. We found, while feeding the goldfish bread, that the sunfish were always on hand getting their share of it. We fed table scraps, including beans, potatoes and oatmeal, and found that the sunfish would eat almost anything. They learned to come to certain places, where they were fed at a certain time of the day, usually at five or six o'clock in the evening. One day we chopped up a piece of watermelon just to see what would happen, and we found that the Bluegills, sunfish, and even

catfish, came and fed upon it. They also would feed upon raw corn chop, but ate it with greater relish when it had been cooked or steamed. They, as well as the catfishes and carp, were especially fond of green corn cut from the cob.

THE BULLHEAD CATFISHES.

There are no better fish for small ponds and streams than the common Bullhead or Bullpout catfishes. These fish are natives of nearly every body of water in the state of Kansas. They are very hardy and prolific and will thrive in almost any body of water where it is possible for any fish to live. In the judgment of a great many people who are fond of fresh-water fish, these catfishes are considered to be among the very best table fish we have. When taken from clean water—we do not necessarily mean clear water—their flesh is sweet, tender and juicy and of an excellent flavor. People who complain of bones in fish will find them most satisfactory. When properly dressed there are no bones left in the fish except the backbone and a few short ribs. These, as a rule, fit loosely in the flesh and can be easily removed from the fish after it has been cooked.

Spawning Habits.

We can not give very much exact information concerning the spawning habits of the Bullhead catfishes. We have seen thousands and thousands of the young of this fish only a few days old, but have never had the pleasure of examining the nest of a Bullhead catfish while the young were hatching. These fish usually live and spawn in water that is more or less roily; the nest beds or pockets for the eggs are found in water from sixteen inches to three, four or more feet in depth. We have found what we supposed to be their nests in certain ponds after the water had been drained off.

Two years ago this summer we found a school of very young catfish in a pool that was not more than sixteen inches deep and not over eight feet across. This pool was formed by water that came through an overflow pipe from the open ditch that supplied the old Hatchery with water. It was an easy matter to drain the pool and run the water into another near-by pool that was a few yards below. This we did. We found a place on the north side of the pool by the side of a piece of broken tiling that we took for the spawning bed of the catfish. There were five catfish of spawning size in this little water hole. The place that we took for the nest bed was more than a foot in diameter and was on the hard ground. All loose sand and other material had been removed. This clean, hard spot extended up to the tiling and several inches under it. If this was the nest—and we thought it was—it had been made by cleaning the ground thoroughly along the side of the piece of broken

tiling and making a cavity or pocket under one side of it. There was no other place on the bottom of the pool that looked as though it had been used by a spawning fish.

As near as we can figure out from examining other spawning places, these fish choose a spot for spawning along the side of some log, rock or bank where there is a certain amount of protection for the nest and its eggs. The place is thoroughly cleaned, and a little excavation or pocket made under a root, log, stone, or even in the side of a bank. In artificial ponds the bullheads hollow out places under any board, stone, or even under a piece of galvanized iron, that may be left on the bottom of the pond. The eggs are placed on the hard ground, and are heavy, sticky or adhesive, the same as those of fish of the sunfish kind, so that they remain where they are placed. We have had Bullhead catfish spawn in very small bodies of water—pools that were not more than from five to twenty feet across and not more than from twelve to twenty inches in depth. These small pools had soft mud bottoms. We know the exact conditions under which they spawned, but the water was always too roily for correct observations to be made.

One such pond, when drained, showed a pocket about eighteen inches long that had been cleaned out in the bank where the latter joined the bottom of the pond. In another place the pocket had been placed under an old piece of sheet iron.

Many years ago, while a number of us boys were in swimming below an old stone ford, I remember that we located some Bullhead catfish between some large stones. We tried to catch them in our hands, but they would get away. However, the fish would soon return, and by trying several times we did manage to catch one out of a pocket under a large stone. We were told by an old fisherman, Clark Cunningham, that we should not bother the fish, because they were "laying their eggs" in the holes they had made under the rocks. The same man afterwards showed me the nests or beds where sunfish were spawning. This was our first lesson in fish culture. We have found Bullhead catfish in hollow logs sunk in the water. In fact, we once used a hollow log for a trap for catfish and caught a number of specimens in it. This was during the early summer, when the water was warm enough for boys to go swimming. At that time we did not think of the possibility of fish "laying eggs" in such places.

Young or Baby Catfish.

The little baby catfish, as we have ordinarily observed them, usually appear near the shores of ponds or slow-flowing streams in bunches or schools. When first observed they are usually about one-half inch in length, and the schools or

bunches of little youngsters usually vary from one to two feet in diameter.

The individual fish in these bunches are usually moving in and out. At times the entire school would take on a rolling, revolving or milling motion. Meanwhile this little cloud of fish is slowly advancing in some one direction. We have watched many of these fish families here in the Hatchery ponds from the time they first made their appearance until the fish were an inch or more in length. These family schools of fish usually stay together until early fall, when they begin to break up into smaller bunches and finally become scattered.

When the water is clear enough it is not uncommon to see an old parent fish swimming around and under the bunch of young fry. It seems to be the object of the old fish to keep the young fish near the surface of the water and near the shore. The old fish swims around and under them. At times the parent fish will make a quick motion with its tail. The water will boil up and the little fish will make a sudden dash in various directions and frequently go down and out of sight for a few moments or minutes. We have seen this performance several times during the last two days.

On various occasions we threatened to catch the old fish and find out whether it was the male or the female that was caring for the young. Then the thought of leaving such a bunch of orphans dissuaded us from the idea, so that we do not know, from examination of specimens, whether it is the male or the female that is caring for the young. Some day we hope to overcome our sentiment on this question and actually catch and if necessary kill the fish that is caring for the young, and find out whether it is the male or the female. The general appearance of the guardian fish that we watched was that they were of more slender build than females of the same length would be, and this would indicate that they might be males.* However, one can not be sure unless the fish are caught and examined.

Last year we found old fish guarding these bunches of milling young as late as September. The young were an inch or more in length, which would indicate that, in some instances at any rate, catfish guard their young for several weeks. We usually see the first bunches of baby catfish about the first or second week in June, which would indicate that here at the

* Since the above was written we have taken three of the parent fish that were apparently guarding the young, and found that two were males and one a female. They were caught with a hook and we are not absolutely sure that we got the parent fishes. However, we dropped the hook in the right place under the schools of small fish and caught the fish that we supposed was guarding and caring for the young. Of course there was a possibility of picking up a stray fish under such circumstances. We noticed two large fish with one bunch of youngsters. This would suggest the idea of both male and female parents, or two bunches of young fish combined, with both of their guardian parents attending.

Hatchery, at least, these fish do not spawn early. By spawning late these catfishes have the same natural advantages as the Green sunfishes and the Bluegills. That is, they appear at a time when the waters are warm and teeming with various kinds of minute life which serves for their food. In this respect the Black bass is at a disadvantage. These fish spawn early, and great numbers of fish are brought into existence before the water is warm enough to produce that abundance of life that appears later on when the water is warmer.

Food Habits.

Catfish are omnivorous in their food habits. (See account of food habits in Bulletin No. II.) The dissection of some of the small and young Bullhead catfish went to show that they are omnivorous in their food habits, the same as the larger and older catfish. The whole catfish tribe seem to eat almost anything edible they can find when food is scarce. However, they prefer animal food, and ordinarily the greater part of the food of the younger and smaller fish is made up of various kinds of insects, mollusks, worms, crustaceans, and various kinds of larvæ. We have dissected two or three bunches of Bullhead catfish taken from the Ninnescah river, where animal food was apparently plentiful, that did not have much of anything in their stomachs except green vegetable matter. Small water plants and pieces of plants made up the greater part of the food contents of their stomachs, with a few small larvæ, worms and snails. This would seem to indicate that Bullhead catfish sometimes eat vegetable food, even when much animal life is present. Sunfish taken at the same time and from the same water had their stomachs full of animal life.

Not Cannibals, but Eat Other Fish.

The Bullhead catfish do not eat their own kind, so far as our observations go, at least until they are in a starving condition. It is very seldom that we find a catfish has been eaten by another catfish. We are speaking especially of the Bullhead catfish family. The larger river "cats" spoken of in Part II of this bulletin feed quite extensively on bullheads when they can get them, and river fishermen use bullheads to bait trot-lines for big river "cats." The food of specimens of bullheads taken from the ponds here at the Hatchery is made up of different kinds of material, depending to a large extent upon the season of the year, and, of course, the kinds of food material that the ponds furnish. When food gets scarce, and sometimes when it is not scarce, the bullheads will feed upon other fish. We have found crappies, Bluegills and young bass in their stomachs. They are not averse to feeding on other fish at any time. However, we raise them here at the Hatchery with Bluegills and crappie, and, as a rule, we get a pretty good crop of

all three kinds from the same pond. While it is true that the larger bullheads will eat up the smaller crappie and the smaller sunfish, yet we have no record of finding a bullhead in the stomach of another bullhead.

We find, however, that it is a very easy matter to overstock a pond with bullheads where the water is not well supplied with food. If thousands of young bullheads are placed in a small body of water they will almost starve before they will eat each other; even then the live ones eat the dead ones by nibbling off pieces, and not by swallowing each other whole as the cannibalistic bass would do. If the water is overstocked with sunfish or bass, the larger and stronger fish will feed upon the smaller and weaker ones. In other words, the stronger specimens survive at the expense of the weaker, and thus the balance of nature is maintained and one of its hardest and most cruel problems is solved.

Should Keep Track of Fish in Ponds.

Ponds stocked with such fish as bullheads, where there is not sufficient food, should be drained and the fish sorted in the fall or in the early spring before spawning time. This should

This picture shows the Hatchery fishermen removing the larger fish from a pond. Notice how well banks are protected by swamp grass. This grass has grown and spread from strings of sods only one foot wide that were planted along the edge of the ponds in the spring.

be done once a year, or at least once every two years. If the ponds can not be drained they should be seined and the fish sorted. From one hundred to ten thousand catfish of the same size and age could be placed in some special pond, depending upon its size, where they could be fed until from two to three years old, when they would be of fine size for table use. If

they are well fed from the first, they may be of edible size when they are two years old.

There is no danger, as we have shown before, of overstocking a pond with bass, crappie or sunfish. They feed upon each other to such an extent that the pond would perhaps never be overstocked. As food gets scarce the larger fish would eat the smaller ones. In this way the number of fish and the food conditions adjust themselves. We find, however, that when a great number of catfish are left in a pond and food is not supplied, they will get very poor, and before we know it we may have a large number of what might be called "razor-back" cats in the ponds.

Easily Fed.

There is no fish which is so easily fed and will take such a great variety of food as the common bullheads. If a person is interested in feeding them and separating them so that they may be placed in different ponds, according to size and food conditions, a very considerable number can be produced in comparatively small bodies of water. A hundred or more, depending upon the size, can be placed in a small pond, or even an ordinary tank, and they will grow in proportion to the amount of food that is furnished them. If there is plenty of food, large and small specimens can be kept together more or less successfully. However, they should not be given more food than they can eat, as decaying food pollutes the water and invites the growth of white fungus.

If I could have but one kind of fish in a small pond I think I would choose the Bulhead catfish. However, there is no particular reason for having catfish in a pond by themselves; just as well put in other kinds of fish. As a rule, the other fish, such as goldfish and sunfish, do not eat catfish, and their young will furnish a very considerable amount of food for the catfish. Stock a pond with several kinds of fish and the result will be that you may have more or less of each kind of fish; but you are sure to have catfish.

THE CHANNEL CATFISH.

We receive hundreds of applications for Channel catfish by persons who have or are building ponds. While the Channel catfish is perhaps the best general-purpose fish we have in the state of Kansas, we regret to say that we have been unable to breed them in ponds. No fish seems to grow better in the ponds than the Channel catfish, but it is necessary to catch the young fish from the streams and place them in the ponds.

We have given the Channel catfish every opportunity here at the Hatchery, and have kept more or less fine specimens in ponds ever since we have been here. So far as we know, none of them ever spawned, or if they have spawned, no schools of

young fish have ever been seen or found in the ponds. If they do spawn the water conditions may not be right for the eggs to hatch. We have no reliable information concerning the spawning habits of the Channel catfish. River fishermen tell us that they spawn in nooks and holes along the banks of the river near where the water is running in currents. Some say that they spawn in running water where there are logs that afford a certain amount of protection and make it possible for the fish to deposit their eggs in safe places.

As we said before, catfish spawn in water that is more or less roily. This makes it difficult for fish culturists to get accurate information by studying the fish in their natural haunts. For further information concerning the Channel catfish we would refer the reader to what has been said about this fish in Part II of this bulletin.

We have taken young Channel catfish in the Ninnescah river, which borders the Fish Hatchery on the north, that were not over an inch in length, as late in the season as September. This would indicate that at least some specimens spawn very late. These young fish were so small and slender and so transparent that it was not apparent at first just what they were. On examination, however, it was very plain to be seen that they were Channel catfish.

Some years quite a number of young Channel catfish come into the Hatchery through the water pipes, which makes it possible for the Department to have a few for distribution, to be placed in streams where they are needed. However, the Channel catfish is found in nearly all the streams of the state, and all that is necessary for the increase of the supply is for people to treat them fairly in the various streams where they already exist. I mean by this that the young or undersized fish should not be caught and destroyed. If the fish are protected in the streams and given a reasonable show, the streams will soon be well supplied. No Channel catfish should be taken out of the water that is less than ten inches or a foot in length, even by hook-and-line fishermen.

If all people who like fish and who enjoy fishing would interest themselves in this fish business, and would give some little time and thought to the protection of fish, the supply in Kansas streams could be greatly increased in a very few years. Let us get together and work together on this proposition of fish protection, which will give us more fish and better fishing.

THE GERMAN CARP.

In some respects the German carp is perhaps the greatest pond fish in the world. Over two hundred thousand acres of water is given to pond-fish culture in Germany alone, and the carp is raised almost to the exclusion of other varieties of fish. This fish is propagated throughout the greater part of Europe

and Asia. The fish was brought to this country more than twenty-five years ago, and is more or less common in the lakes and streams throughout the United States. It seems to be generally despised by sportsmen throughout the country. However, it is a food fish and not a game fish, and according to statistics is one of the most valuable food fishes of the Old World, and judging from the statistics that are being published it will soon be one of the leading, if not the leading, food fish produced in our own country.

Henry T. Finck, author of *Food and Flavor*, page 360, N. Y., The Century Company, 1913, says:

"All over Germany fish-breeding in ponds is an important industry. Bavaria alone had, in 1909, over 33,000 acres of such ponds, and probably has many more now; Saxony had 200,000 acres, while Silesia had nearly 60,000. The total area of fish ponds in the Empire probably does not fall short of a quarter of a million acres.

"Carp are grown in special abundance, and German carp are a very good fish to eat, especially when they have been artificially fed and fattened with rice, potatoes, fish meal, or dairy products."

Doctor Forbes, of the Illinois Biological Survey, page 75 of the *American Fisheries Society*, says: "The carp is the most abundant fish in the Illinois river, giving us \$412,000 of income in 1908, while all other fishes together gave us only \$309,000." On page 78 he says, further, that "the product of Black bass, according to the United States census of this year, has risen from \$11,000 for the Illinois river in 1899, to \$58,000 in 1908, when the census statistics were obtained." It would appear that the Black bass has increased at the same time and in the same waters where the carp increased. This is explained by saying that the carp is a food fish for Black bass.

The carp is found in nearly all Kansas streams and in many of the ponds. It is a coarse fish and not such a good fish as the bass, the crappie and the Channel catfish, but it is a food fish of importance, and not bad to eat when properly handled and prepared. It can usually be purchased in the market at about one-half the price of the above-mentioned fishes. When compared with the bass, the crappie and the Channel catfish, it is compared with a few of the best fishes in the world. When compared with such food fishes as the butterfish, the haddock, the flounders, the hake, the pollock, and the cod, it is found that it brings as much or even more than these fish do in New York and other eastern fish markets. In the central part of the United States it sells for about the same price as the American carp, the redhorse and the buffalo fishes.

It is one of the hardiest as well as one of the healthiest and cleanest of fishes in our waters. The flesh of the carp, so far as we have been able to discover, is practically free from the

fish parasites that are more or less common in many other fishes, especially those varieties of parasitic worms that are found imbedded in the flesh of many fresh-water fishes.

For table use the fish should not be taken from polluted or stagnant water, as is frequently done, but should be taken from clean water, not necessarily clear water. The fish should not be allowed to die, either in the water or out of the water, but should be killed, thoroughly bled, and then dressed. The skin, at least the outside skin that holds the scales, should be removed and the fin bones cut out. Some cooks advise that the fish be soaked for one or two hours in cool salt water before it is prepared for the table. This we do not find necessary when the fish is taken from clean water, though it may not do any particular harm. However, we do not think any fresh fish is improved by soaking it in water.

The carp are very prolific, good-sized specimens spawning from one to three and a half million eggs each season. The carp is essentially a vegetarian, and eats many aquatic plants such as the so-called "mosses,"* and other aquatic plants found growing in ponds and sluggish streams. The lower forms of life that the carp devours are made up, for the most part, of small crustaceans, small mollusks, and various kinds of small larvæ, such as the minute forms of animals and plants found on the bottom of ponds and streams, and adhering to various objects in the water.

We have opened the stomachs of more than a thousand specimens of carp, and never found any of the eggs of other fish in the food material of the carp. In a few instances a small number of their own eggs were found in the food masses of the stomachs. It is not strange that the fish should suck up some of its own eggs while feeding among the aquatic plants that grow upon its own spawning grounds. The carp usually scatters its eggs among aquatic plants in rather a promiscuous way, and does not watch over or care for them. Thus far we have found no evidence that it eats the spawn of other fishes.

However, we know of no reason why the carp might not eat the eggs of other fish if it found them unprotected. Such a fish as a bass can easily put a carp to flight. A lot of carp in a bunch might drive a bass from its nest, if they persisted in their attack, and devour the eggs. We have been told many times that the carp destroy the spawn of bass and other fish. We have taken many of them from streams and ponds where

* The term "moss," as used by many people, refers to a number of water plants, such as the various kinds of *Chara* or stoneworts, the liverworts, in fact nearly all the green algæ, including almost any plant that grows in the water and has slender leaves and branches. The true mosses, for the most part, grow in moist places on earth, rocks, logs, the sides of trees or in other such favorable places. There are comparatively few aquatic forms, the best-known being *fontinalis* species; these plants, so far as we know, are rare in Kansas.

bass and other fish live, during the spawning season, and thus far we have found no evidence that the carp eats the spawn of other fish. So far as our observations go, one small-sized bass, weighing from one and a half to two and a half pounds, can easily put to flight several carp larger than itself, that may approach or come near the spawning bed of the bass. The bass usually makes the attack on a single carp—the one nearest the nest—but all the carp in the bunch make a hasty retreat.

Carp as a Food for Other Fish.

The young of the carp, which sometimes appear in very great numbers, serve as food for the bass, the crappie, the catfishes, and the sunfishes. It is not possible to raise any great number of the so-called game fishes unless they are supplied with great quantities of food. Observations and studies in and out of the laboratory go to show that a very considerable amount of the food of these fish is made up of other fish. These other fish are, for the most part, those that eat vegetable and waste matter, such as the German carp and other fish that belong to the Cyprinidæ or minnow family, and the Catostomidæ or sucker family.

The so-called German carp belongs to the minnow or Cyprinidæ family. The goldfish (*Carassius auratus*) also belongs to this family. Both of these fishes have a serrated spine in the dorsal and anal fin. The Cyprinidæ are mostly small fish. However, the European carp and some American species of this family attain considerable size. There are about one thousand species of fish in the world that belong to the minnow family. There are about twenty-five species in Kansas. As yet they have not been carefully determined.

The American carp does not belong to the Cyprinidæ or minnow family, but to the sucker or Catostomidæ family. Over a dozen species of this latter family have been determined; in Kansas waters they include the buffalo, the carp, the redhorse, and other common suckers.

Carp as a Food Fish.

The carp are used as food fish all over the country, and there are thousands of people who are willing to testify that they are a good food fish. If certain individuals do not care to use them for food, they must not forget that the carp is a very large factor when it comes to producing fish food for the mass of the people. It is also a valuable fish for producing food for other fish, such as the bass, the crappie, and the catfish, all of which are considered most excellent for table use. In time the carp will become an important article of food in this country, the same as it now is in parts of Europe. It will furnish a cheap and wholesome food for a great many people who are unable to pay the high prices that most of the choice varieties of fish command in the market.

One of the great advantages in raising carp is, that they feed largely upon the vegetable and waste matter that naturally grows in the ponds and streams. Carp eat up tons and tons of what might be called waste in the form of various water plants common in most Kansas waters. These fish are very rapid growers, and it frequently happens that five or ten pounds of carp can be raised where it is possible to raise but one or two pounds of other fish, such as the crappie or Black bass. The carp are undoubtedly a very useful fish when properly understood and handled. At any rate, we have them in our streams, and it will not be possible to get rid of them. It is the purpose and will be part of the business of the Department of Fish and Game to study them with the idea of making the very best possible use of them, either directly, as food for human beings, or indirectly, by making them serve as food for other fish.*

Food Habits.

In addition to various kinds of growing vegetable matter, the carp seem to be fond of all kinds of grains and seeds. In the examination of the contents of their stomachs we have found such grains as corn, wheat, oats, kafir corn; and among the seeds of wild plants, the elm, smart weed, foxtail grass, sourdock, the sticktights, and the old-fashioned beggarlice were among the varieties found. As many as from 1000 to 5000 seeds have been taken from a single stomach of a carp. The examination of over 1200 stomachs of the carp did not show a single little fish or minnow, and no spawn or fish eggs were discovered except in a few instances where a small number of carp eggs were found in the food contents of some of the stomachs; these we have reason to believe had been sucked up with other food, as stated before, while the fish were feeding on their own spawning grounds.

Live minnows placed in a pool nineteen feet in diameter, with water sixteen inches deep, were not eaten by the carp, even though the latter were deprived of their regular food for several days at a time. When the minnows were killed and thrown on the bottom of the pool they were sometimes taken by the carp. Minnows fastened on hooks so that they could move about but little were also sometimes taken. The mouth of the carp is not properly constructed for catching live minnows. When small pieces of fish and dead minnows were fed with corn the carp would take the corn before they touched the minnows, and if there was sufficient corn for them they would not take the minnows or pieces of fish. They were very fond

* This department has been criticized a good deal because it has presumed to offer something in defense of the humble carp. We only mean to be fair to this fish and make the best possible use of it. We may in the future publish a special bulletin on the carp. Meantime we presume certain critics will continue to harp, and the carp will continue to carp.

of cheese, graham bread, boiled potatoes cut up, and in fact almost any kind of table scraps.

When feeding in the creeks and ponds we have seen them sucking up the soft material on the bottom that contains low forms of animal and plant life. After holding this material for some little time in the mouth, the fish would blow it out with sufficient force to throw the muddy stream a distance of from twelve to eighteen inches beyond the fish's mouth. The fish seemed to be able to extract certain food material out of the stuff taken in the mouth, and then cast or blow the useless or surplus parts away. The action reminded us of our small boy, George, who, after filling his mouth with wild grapes and chewing them for a while, extracting the juice, would blow out the seeds and skins.

It was noticed that the carp left a mark or track on the bottom of the pond about an inch in width, where the ooze had been sucked up. This track was about a quarter of an inch in depth, and was almost continuous in places for a distance of several feet. Before we saw the carp make these tracks we thought they marked the course of some animal that had crawled on the bottom of the pond. They much resembled the "tracks" that a snake leaves in the soft mud or dust, but they were not continuous.

At other times carp were seen to suck the soft material from posts, sticks, and from the stems of plants that stood in the water. The contents of the stomach of a fish that has been feeding upon such material, when emptied into a white plate and examined with a microscope, reveals a multitude of the smaller forms of both plant and animal life too numerous to be counted or classified without the use of much time and labor.

GOLDFISH.

Goldfish, as well as carp, are natives of the Old World. They both belong to the same family, and the goldfish might be classed as a first cousin of the carp. They came originally from Asia, China and Japan. They belong to the carp or minnow family, and their habits are very much like those of the carp. They are frequently kept in jars, tanks and fountains for ornamental purposes, and have never been considered of much value from an economic point of view. Like the carp, they are very hardy and very prolific; like the carp, they are free, at least while living in earth ponds where aquatic plants grow, from nearly all kinds of diseases that usually attack fish. Other fish in the same ponds may die by the hundreds, but one seldom finds goldfish dying, except one or two at a time, and with no greater mortality than is found in schools of other fish when in good condition.

Food for Other Fish.

Here at the State Fish Hatchery we hatch them in great numbers and raise them to different ages and sizes as food for other fishes. They feed upon the so-called "mosses" and various other kinds of vegetable matter. They also feed upon many small and low forms of animal life, the same as carp. They make most excellent food for the game fishes, and the young of the goldfishes at the Hatchery constitute a good portion of the food for the bass and the crappie, as well as for the sunfishes and the catfishes. The goldfish, when from one to two years old, make fine food for the large spawning bass. When not too large, they are also eaten by the other spawning game fishes in the ponds. Great numbers of goldfish are spawned in some of the ponds, and especially in the ponds connected with the bass ponds. In these double ponds the fish are turned together at the proper time, and both young and old bass feed upon the goldfish when they are of the proper size.

Food Habits.

The goldfish, like the carp, eat a great variety of vegetable matter and waste stuff that naturally grows in the ponds and streams, including small and minute animal life. When we feed goldfish at the Hatchery we give them oatmeal, bread, fine corn chop, and a variety of other stuff. They seem to prefer bread, oatmeal and corn chop, especially when the latter is partly cooked. We have over 20,000 yearlings that are being kept this summer (1913) in a pond which is not over eighty feet square. They are fed on such green food as aquatic plants that are raked and gathered from other ponds. They are very fond of stonewort (*Chara*) and duckweed plants. They also get such food material as a stream of water coming through a three-inch pipe brings from an open ditch that is fed by the Ninnescah river. However, bread, oatmeal and corn chop make up the bulk of the artificial food that we feed them. The water in this special goldfish pond is from two to five feet deep. Every week or two a wheelbarrow load of "moss" (aquatic plants) taken from near-by ponds is thrown into this goldfish pond. Goldfish seem to prefer duckweeds to all other plants. They eat much green vegetable matter, especially the small and minute stuff that naturally grows in ponds, and in this way the fish help to purify any body of water in which they are placed. They are especially fond of such small animal life as mosquito larvæ, and one or two little goldfish will keep the water in a "rain barrel" free from such insects. Goldfish placed in ponds, or even in small pools, will destroy the mosquito wrigglers.

Goldfish do not grow large. In the fall of the year, during September and October, when the ponds are drained, the young

ones are usually from two to five inches in length. When a year and a half old they will vary from four to seven inches in length, the size depending largely upon the food supply, the same as with other fishes. When two years old they vary from six to ten inches in length, and are still good food for Black bass. Full-grown specimens at from three to five years of age will attain a weight of from two to three pounds. On account of their slow growth and small size, we prefer them to German carp for bass food.

The young carp grow so fast that they are frequently too large for food for bass when they are a year old. The carp will usually weigh from one to five pounds when they are one and a half to three years old. They grow very fast when the food supply is good, and sometimes attain a weight of from five to ten pounds when from three to four years old. Specimens that would weigh about a pound were placed in a pond here at the Hatchery. Three years afterwards, when they were removed from the pond, there were fish in the bunch that weighed from five to twelve pounds. After they reach a size of from one pound up, not a great many of them are caught by other fish, though we have seen carp that would weigh from three to five pounds taken from the stomachs of large catfish that were caught in the Kansas river at Lawrence.

Goldfish as a Food Fish.

Goldfish are not ordinarily considered at all when we speak of food fishes. However, we have tried them and find that they are edible and are a very fair food fish. They should be killed, bled, dressed and cooked all the same day. They grow from two to even three pounds in weight when in ponds, and might be raised as a food fish in small bodies of water. In Washington, D. C., we noticed a fish on the market that was sold under the name of "Sand perch." The fish were selling at 12½ cents per pound. We examined some of them and found that they were nothing more than an uncolored variety of goldfish. These fish would average about one-half a pound each in weight. They were plump and fat and seemed to sell readily. We questioned some of the purchasers, and were informed that, for the price, the "Sand perch" was one of the best fish on the market. In the same market fresh carp were also sold at from 10 to 12½ cents per pound, in competition with all the various fresh- and salt-water fish that were being placed on the Washington markets. We know of no fish that could be produced in greater quantities in small ponds than goldfish. Catfish and sunfish might be raised in the same ponds with them. Goldfish taken out of ponds where the water is warm and not very good should be placed in a small pond or tank where a small stream of fresh and good water could be supplied. The fish should then be fed on clean food, such as

graham bread, oatmeal and corn chop, with green vegetable matter, and in this way they could be put in good condition for table use in a short time. Goldfish handled in this way might be made to supply a considerable amount of good, wholesome food in places where it might not be possible to handle other fish to advantage.

We spoke above of raising catfish and sunfish in the same pond with goldfish. The catfish and sunfish would eat many of the goldfish. This might be an advantage in some respects. The goldfish are so very prolific that it is usually necessary to have some fish with them that will reduce their numbers; otherwise there would soon be so many of them in a pond that they would not do well. Indirectly they can be converted into other fish, such as bass, crappie, sunfish, and catfish. Catfish and goldfish did well together in some ponds that we experimented with at the State Hatchery. Both these fish can be fed on the same kinds of food, and the catfish will eat the small goldfish when the latter get too numerous.

MINNOWS.

There are several species of minnows, perhaps as many as two dozen kinds, in the ponds and streams of Kansas. In classification the German carp and some other large fish belong to the Cyprinidæ or minnow family. They will be considered in another place. The common creek and pond minnows grow in size from two to perhaps six or seven inches in length, and are full-sized fishes when they attain these lengths. There is no more delicate or sweeter fish in the world for table use than some of the larger minnows, for instance the larger shiners and chubs.

They are as large as smelts, sardines and some other fish that are used for food, and considered great delicacies. Some of these large minnows are as fine when fresh and fried crisp and brown in bacon fat and butter as any speckled trout. However, like the trout, they are of not much economic importance when considered as food fishes. Their chief function in the animal kingdom seems to be to supply food for other varieties of fish. They are very productive, and can be found in almost any stream where there is living water.

It is of great advantage to have them in streams, because they supply much food for the game fishes. In their growth and development they gather together a great amount of minute life that otherwise would remain as nothing more than waste in the water.

However, the large-mouthed minnows are sometimes very destructive to the fry of other varieties of fish. Even such a game and pugnacious fish as the Black bass is frequently kept mighty busy guarding its eggs and young from the attacks of schools of minnows. We have observed schools of min-

nows here at the Hatchery dart out from points of vantage, where they had apparently been hiding among the aquatic plants, and make quick onslaughts on bunches of baby bass or crappie that might be passing near by. In this way the minnows sometimes destroy a good many of the fry of other fish. As soon, however, as the other fish, especially those designated as game fish, such as the bass, crappie and catfishes, exceed the minnows in size, the tables are turned and the poor minnows are chased as proper delicate morsels of food for the rest of their natural lifetime.

A good many people, including some of our correspondents, call all small fish minnows. Minnows belong to a pretty well defined family (the Cyprinidæ), and while all the species are not small, yet they should not be confused with the young of other fish. A great majority of the minnows are small, ranging in length from two to six inches. The young of other kinds of fish should not be called minnows just because they are small. Young fish are called "fry"* by fish culturists when they are first hatched. When they become larger and attain an inch or so in length they are usually called "large fry." From the time they are an inch and a half in length, and until they reach four or four and a half inches, they are usually called fingerlings.† In a general way the average length of these young fish is about the same as the fingers of one's hand. The terms "fry" and "fingerling" to designate the size of young fish are in common use by fish culturists and in books and articles on fish culture.

VEGETATION.

The animal kingdom lives on the vegetable kingdom. In other words, vegetable matter constitutes and forms the basis of all animal life. A great number of forms of life, both animal and vegetable, are dependent one upon the other, but animal life is essentially dependent upon vegetable life. Many forms of animal life live entirely upon other forms of animal life, but somewhere along the line of growth and development it will be found that vegetable life forms the basis, either directly or indirectly, of all animal life.

* FRY.—When fish are first hatched they are called small, young or baby fry. When they are from about one-half to one inch in length they are simply called fry or medium fry. When from one inch to one and one-half inches in length they are called large fry.

† FINGERLINGS.—When the young fish are from one and one-half to two and one-half inches in length they are called small fingerlings or No. 1 fingerlings. When from two and a half to three and a half inches in length they are called fingerlings, medium sized fingerlings, or No. 2 fingerlings. When from three and a half to four and a half inches in length they are called large fingerlings or No. 3 fingerlings.

A tadpole is essentially a vegetable feeder* and has a very long intestine, like other animals that eat and live upon vegetable matter, for digesting and assimilating such material. The tadpole is gradually changed or developed into a bullfrog. A bullfrog eats no vegetable food; it feeds on insects and various other forms of live animals. The Channel catfish or the Black bass may devour the bullfrog, and these fish in turn serve as food for man. Whether we eat bass or beefsteak the basis of the food is vegetable matter that has been consumed and changed into animal tissue by vegetable-eating or herbivorous forms of life. Thus it is that vegetation becomes the basis of all fish life, and it makes little difference whether the fish eat worms, mollusks, grasshoppers, crayfish, frogs or other fish, the fact remains that the basis of all fish life is vegetable matter. Therefore it becomes necessary for the fish culturist, and for all parties who expect to engage in the fish culture business, to have more or less knowledge of the vegetable life that is or should be produced in the waters where fish are to be raised.

The Vegetable Waste in Ponds and Streams.

It is possible for the fish culturist to study the vegetable growth in any body of water and to utilize it to a greater or less extent for fish food. We have by way of experiment utilized a good portion of the vegetable matter in small ponds by placing goldfish, carp and gizzard shad in them. These fish converted much of what was the natural waste in these ponds into fish flesh. Thousands of young fish were reared and the old fish increased in size upon what naturally grew in the ponds. Much of this growth of low forms of both plant and animal life in the ponds was nothing more than waste until converted by fish into an economic product.

The idea of using the waste material in any body of water for food and converting it into fish is one of great importance to the fish culturist and to the commercial interests of the country. The vegetable-eating fish, so to speak, belong chiefly to the Cyprinidæ or minnow, and the Catostomidæ or sucker, families, and include such fish as the buffaloes, the carp, the goldfishes, and in fact nearly all fish with suckerlike mouths. These fish not only eat coarse vegetable matter, but much stuff that belongs to the lower orders of both plant and animal life. In other words, they convert much of the natural waste in any body of water into fish. If we do not care for such fish as the buffalo, the sucker, the goldfish and the carp, they can be used as food for other fish, such as the bass, the crappie, the sunfishes and the catfishes.

* The food of the tadpole, so far as our observations go, is almost entirely made up of vegetable matter. The common *Spirogyra* and other green algæ are among the common articles of diet. However, at the State Fish Hatchery we have noticed them feeding on pieces of fish, meat or bread that were left on the feeding grounds where fish had been fed.

In this way the waste of the pond can be converted indirectly into varieties of fish that are considered among the very best for table use. However, some of the fish that live on the waste in our waters, such as the German carp, the buffalo and the redhorse, are classed as among the important food fishes. In most streams and ponds the food supply for such fish is usually abundant, and for this reason the number of pounds of fish that can be produced in any given body of water is several times as great as could be produced if game fish alone were being raised. Most any kind of carnivorous fish will eat, in waters where other food becomes scarce, two, three, four or even five times its own weight in other fish each year. If we have in mind the raising of pounds of fish, rather than some particular kinds, the fish that eat vegetable and waste matter would surely be considered more important than many of the carnivorous forms that are usually considered as game fishes,* and are so highly prized by so many hook-and-line fishermen. However, we have always been a hook-and-line fisherman, and have spent some of the happiest and most delightful days of our lifetime with rod and line on the banks of streams and ponds. We hope to continue our hook-and-line fishing and do what we can to encourage and help others do the same thing. It will soon be about the only real sport and recreation left for people in this part of the country.

Kinds of Water Plants.

It is quite important that the proper kinds of aquatic plants be grown in waters where fish are to be raised. Almost any kind of water plant is better than nothing. However, certain kinds of fish feed upon certain varieties of plants. Again, plants furnish food for many animals, especially the small and low forms of life that fish feed upon. Plants, especially those with large leaves like water lilies, are not only beautiful to grow in ponds, but they furnish both shade and protection for both old and young fish. However, the lilies should not be allowed to take possession of the entire pond to the exclusion of all other plants. They are not good food producers. So long as they can be confined to certain localities in the pond they are all right, but when they cover most of the surface area of the pond, the natural animal life food supply of the pond is greatly reduced. In our judgment not more than one-fifth of the area of any pond should at any time be covered with lilies.

We learn from a study of the relations of plant and animal life that certain varieties of plants not only in themselves serve as food for many kinds of fish, but these same plants make good harboring places and feeding grounds for numerous lower forms of water animal life which serve as food for fish. A good fish pond is one that is so properly stocked with vegetable

* See note of explanation on "game fishes," page 105.

matter that it will produce insects, mollusks, crustaceans and other life in abundance at a time when fish need such food. Fish need certain kinds of food while young and growing, and still other kinds later on to bring them to maturity. Nearly all this food comes directly or indirectly from the vegetation that grows in the water. It is necessary, therefore, for the fish culturist to know something about aquatic vegetable life, in order that he may intelligently stock ponds and streams.

It is the purpose of this department to make a careful study of the ponds and streams of the state and supply them so far as the department is able, not only with the proper fish, but also with the proper plants, and it is also the purpose of the department to supply needed information, through bulletins and otherwise, to persons who desire to raise fish.

Intelligent versus Haphazard Work.

A number of fish might be dumped into a pond and allowed to remain there, and the owner of the pond might get more or less fish out of it, but with some intelligent work the pond could be made to produce as many fish as its natural food supply would support. If the fish culturist knew how to properly stock the pond with plants, and how, when and what to feed, the results would be much greater and more satisfactory than could possibly result from haphazard work.* In other words, a given body of water would naturally produce a certain amount of fish, just the same as a given amount of pasture would naturally produce a certain amount of mutton, pork or beef. The same body of water or same amount of pasture, properly stocked and properly cared for, could be made to produce much greater and more satisfactory returns.

People who successfully raise poultry know that it is necessary to possess a certain amount of knowledge of the business or the raising of chickens, turkeys and other fowls can not be made a success. The results obtained from turning a few domestic birds loose on a farm can not be compared with those obtained where the fowls are properly housed, fed and cared for. In other words, it is intelligent work that produces domesticated animals for the benefit and profit of man. The same is true with fish. A pond might be stocked with one or several kinds of fish and the fish allowed to shift for themselves, and under such conditions the pond would produce more or less fish. However, if the pond was stocked with regard to its natural food supply and conditions, much greater results could be attained.

It is important and often necessary that fish of certain kinds, sizes and ages be looked after and at times sorted and separated. If there are game fish in the ponds they should receive different treatment from that accorded to what we have termed

* See notes bearing upon this subject on page 104, "Intelligent versus Haphazard Methods."

vegetable-eating fish. If both kinds are in the pond, then the relations one to the other should be studied and watched in order to get the best results.

Experience has taught us that a pond with no water plants growing in it is a rather poor place for fish. There is but little food and almost no protection in such a pond for the fish. At the State Hatchery the ponds that are well supplied with water plants are by far the best for producing fish. When many fish are hatched in ponds where there are few or no plants, one of two things usually happens—the fish either eat each other up, or, owing to their impoverished condition, they become stunted and are liable to become diseased and die.

Removing Aquatic Vegetation.

However, ponds sometimes get so full of aquatic vegetation that they become almost unmanageable. It may become necessary at times to clean out part of the water plants. This can be done by various methods. On a small scale it is usually accomplished by the use of rakes and pitchforks. The vegetation thus removed can be piled up in the shallow water of the pond and afterwards removed to the banks. We have an old scow or flat-bottomed boat, twelve feet long, six feet wide and one foot deep, that is frequently put to use when the so-

This picture shows the bottom of one of the old ponds at the Fash Hatchery. The water plants, mostly *Chara* "moss," gathered into piles with six-tined pitchforks, resemble small hay cocks.

called "moss" is being removed from ponds. When loaded it can be pushed near the shore by the use of poles and unloaded. Aquatic plants, in bulk, are mostly water. When dried there is not much to them. They seem to do no harm when piled up in the ponds and left there, even though the water is turned on and the pond filled up before they get dry. If the weather is

good they can usually be dried in a short time by spreading them on the ground or over the bottom of the pond when it is drained. If this can be successfully done it saves much work that would be necessary to move the mass of wet stuff.

One good way to move or shift the vegetation in a pond—where the contour of the ground will admit of it—is to plant a post on the bank near the edge of the water, and to this post one end of a rope, or better, a barbed wire may be fastened. The wire can then be carried out into the pond in a loop from twenty to fifty feet in diameter and sunk about half way to

This illustration shows one of the *Chara* plants. It is very common in some Kansas streams and ponds. It is commonly called "moss."

the bottom. If the wire does not encircle too much "moss" it can be pulled by human beings. However, if the area encircled by the wire is very large it will be found that about the only way to manage it is to hitch a horse to the wire. In this way very good results can sometimes be obtained in a short time. The "moss," after it has been pulled near the shore, can be left, or, if desirable, can be thrown on the banks with a pitchfork. It sometimes happens that a good many fish are caught in the "moss." These should be shaken out of the wet mass of plants and returned to the water. The conditions as you find them will frequently suggest the best methods of managing them.

Stocking a Pond with Plants.

Nearly all natural ponds that are fed by springs or streams are stocked with some kinds of aquatic plants. Artificial ponds that are supplied with water from drainage slopes and

The plant commonly known as *Chara* "moss" drawn more in detail.

Habit sketch of *Chara fragilis* and its fruiting branches, magnified. 1. The general appearance of *Chara*. 2. A segment from 1, with fruiting branches, magnified. 3. A branch from 2, showing at *a* a sac containing an egg cell, and at *b* a sac containing sperm cells. After the egg has been fertilized by the sperm the fertilized egg remains dormant for a time, and then it germinates and grows into a mature plant. (After Kerner.)

ponds that are fed by windmill or other pumps are not so likely to be stocked. These ponds are sometimes supplied with aquatic plants by water birds that carry seeds or spores from one body of water to another. The best way to stock a pond is to plant desirable plants, which can usually be secured from some pond, lake or stream in the neighborhood. Sometimes it is necessary to have plants shipped from places where they are known to grow. There is a good supply in the State Hatchery ponds. They can be distributed to persons who ask for them, at the same time the fish are being delivered.

It is not our purpose in this bulletin to give illustrations of the most desirable plants for pond culture purposes, and without cuts the names of the plants would not be of much value. We contemplate publishing a bulletin at some future time on aquatic plants in Kansas ponds and streams, with illustrations that will make it possible to identify the chief varieties.

Some of the most desirable plants for fish-culture purposes in this locality belong to the "green algæ," a low order of plant life. Of these the *Chara* "moss" or stoneworts (order Charales) are among the best. They grow in water from two to five feet in depth, and are fixed to the bottom and form great masses. The stems are cylindrical and do not vary much in size from bottom to top. The stems are jointed, the joints sending out circles of lateral branches which themselves send out branches. Some of the stoneworts or Charales become incrustated with carbonate of lime, and this has caused them to be designated as "stoneworts" (stone plants). This plant is very common in Kansas ponds where the water is not too roily and is more or less permanent. In most localities it is called "moss."* The leaves are long and slender and in whirls around the jointed stem. Any pond that has a supply of stoneworts and bunches of water lilies growing in it should be in good condition for fish. Once stocked with the above plants it will be easy to introduce other varieties, if they do not soon appear as volunteers.

There are many semiaquatic plants, such as sedges, rushes, pondweeds, pickerel weeds, smartweeds, arrowheads, a number of grasses and cattails, that grow around the borders of ponds. These are all more or less valuable. Various forms of life are found on them under the water, and they attract various kinds of land insects that frequently fall or are blown into the water where the fish can get them. These plants also form windbrakes and protect feeding grounds for the small fish near the shore. So we learn that plant life not only nourishes and sustains all animal life, but in many cases protects and in a way cares for animal life.

Plant life also plays an important part in the purification of water. Plants during their growth use carbon dioxide (car-

* See note of explanation on page 126.

bonic acid gas) and give off oxygen. Decaying matter in the ponds uses up oxygen and gives off carbon dioxide, and growing plants take up the latter and use it in the manufacture of plant food and new plant tissues, at the same time setting the oxygen free once more for the use of both growing plants and animals which use oxygen in respiration. Thus a pond that is well stocked with growing plants that are good "oxygenators," so to speak, has a chemical laboratory for using up some of the products of this dead waste in the pond, and re-liberating the life-giving oxygen. It is possible to have an aquarium or a pond so stocked with growing plants that there is an equilibrium in nature between life and growth on the one hand and death and decay on the other; and the water can be kept in good condition for weeks or even months without the addition of any fresh supply. Therefore it is not necessary to have a stream of water running through a pond in order to keep it pure and in good condition for fish. If the original supply is good and is sufficient to offset the leakage and evaporation, the water in such a pond can usually be kept in very good condition by the use of growing plants.

FEEDING FISH.

This is a subject that is continually being discussed by fish culturists. Many factors, such as kind, size and number of fish, enter into the problem, which must be solved under many and varied conditions. Many trout culturists have the business pretty well in hand as applied to the particular locality and conditions they have to contend with. However, the whole subject seems to be open for debate, amendment and further consideration.

Feeding Fish at the State Hatchery.

What we have done along this line has been more in the way of experiments for the purpose of finding out certain things than to get actual results from any system of feeding. The subject has been discussed at various places in this bulletin, and especially in Part III, in connection with the consideration of the habits and culture of each kind of fish.

Feeding fish at the State Hatchery, where there are ninety-nine ponds, is a proposition that can not be entertained except on special occasions and in ponds where a number of fish are being held for a definite purpose and for a definite length of time. The fish that we most commonly raise, such as the bass, crappie, sunfish, catfish and goldfish, can be fed with any available food suitable to their tastes. These fish soon learn to come to places near the shores of ponds where food is thrown to them. After the fish become accustomed to these feeding places it is surprising how regularly they will appear for their food, and how tame some of them will become.

Feeding Black Bass.

Black bass will feed on live grasshoppers, crayfish, frogs and minnows—in fact, almost any live fish small enough for them to swallow; they are especially fond of goldfish. If they are in a feeding humor, they will take such food as fast as it is thrown in the water, and will frequently follow the person who feeds them along and near the shore while waiting for their food. We have had them grab a goldfish that we were holding by the tail and pulling through the water. They learn to take various kinds of food, but seem to prefer live grasshoppers, crayfish, frogs, minnows and young fish in preference to any and all other kinds of food.

Young bass will learn to eat the above kinds of food when it is cut or ground fine enough for them to swallow, or they will take it whole as soon as they are large enough to handle it.

Feeding Crappie.

In a general way crappie, both old and young, eat about the same kinds of food as the bass. However, they are more shy and do not come to feeding places so readily, and usually keep pretty well out of sight. We have seen them take live grasshoppers and small minnows that were thrown to them. We consider them a hard fish to feed on artificial foods. The larger fish will eat small minnows and young fish greedily when the little fish and minnows are turned loose in the pond with them. Young crappie, judging from the dissections we have made, seem to feed largely upon small insects, crustaceans and various forms of larvæ that are found on aquatic vegetation. They also grab small land insects that may fall or get blown onto the surface of the water.

Feeding Sunfish.

Sunfish are the best feeders of them all when it comes to taking artificial food that is thrown to them. They will take all kinds of insects and crustaceans and other forms of life. Almost any kind of meat (except turtle) chopped or ground up seems to please them. They will come right up to the shore any time of day and feed greedily. They soon learn to take such food as bread, oatmeal and corn chop, and can gradually be taught to eat almost anything that is food for them.

Feeding Catfish.

Catfish are in a measure very much like the sunfish. They can be taught to eat almost anything, but prefer some kind of meat or fish chopped or ground up. The bullheads, supposed to be bottom feeders, will frequently come to the surface to get bread, meat and other kinds of food.

Feeding Goldfish.

Goldfish are essentially vegetable feeders and are very fond of bread, oatmeal, corn chop, wheat chop, potatoes cut up fine—in fact almost any kind of grain or vegetable stuff that they can manage. They are especially fond of many of the green algæ, as well as the duckweeds, and eat up great quantities of green vegetable matter that naturally grows in the ponds. They also eat some of the soft mud or ooze that accumulates on the bottom of the ponds. This material is made up to a large extent of low forms of plant and animal life. It is for this reason that such fish as the carp and goldfish, and the suckers in general, eat it.

The Problem of Feeding.

The problem of feeding fish is one that will have to be worked out individually by each person who has charge of a fish pond. It will depend largely upon the kinds of fish that are in the pond, its conditions and natural food supply. What is to be fed, if anything, depends largely upon the most natural and cheapest available food material.

Where game fish are to be raised for pleasure, sport and food, a number of special things are to be taken into consideration. We are experimenting at the Hatchery with various methods that may prove suitable for such fish culture. One of these methods is the use of double ponds. In some respects the plan seems to be good. In one pond the game fish can be kept, and in another such vegetable- and waste-eating fish as goldfish, carp and hickory shad. After the game fish have spawned and their young are large enough to care for themselves, they may be allowed to go into the ponds where there is a good food supply of young vegetable-eating fish. This can easily be done if there are wire screen gates separating the ponds by using gates with different sized meshes.

We also raise bass, crappie, sunfish and catfish by placing goldfish and gizzard shad in the spawning ponds with them. The young of the goldfish and shad serve as food for the other fish. In some ponds stocked after the above methods we have had good success. However, we feel that there is no absolute method of stocking a fish pond. All conditions must be considered. What will work well in one pond will not work in another. Experience is a teacher that is of great value in this and other lines of fish-culture work. The more knowledge one has of fish and their habits the more likely one is to manage any branch of the fish-culture business successfully.

By using nets and other contrivances which have been specially built for the purpose, large numbers of grasshoppers can be caught and fed to fish. We have taken two or three quarts at a time in hand nets and fed them to the fish. It is usually necessary to partially disable the hoppers by squeezing

or drowning a bunch of them while they are in the net. Otherwise, when they are thrown in the water many of them may swim out before the fish catch them. Full-grown, healthy and uninjured grasshoppers, if thrown into the water several feet from the banks of a pond, will not remain there very long. They are excellent swimmers and soon get ashore. Whether it pays to catch such material and feed the fish depends altogether upon conditions and the time and disposition of the person who has the matter in hand. It sometimes pays to feed fish for a certain given length of time until circumstances and conditions change whereby the fish may be able to secure sufficient food for themselves.

At the State Hatchery, in addition to such green vegetable matter as can be collected in the ponds, carp and goldfish are fed bread, oatmeal, corn chop; in fact, almost anything cut up fine. The Bluegills and catfish also feed on the same kinds of material. The catfishes and sunfishes are always ready to eat almost any kind of food, especially any meat that is thrown into the water. Rabbits, cut or ground up fine, make good food for such fish. During the past summer we ground up and cut up suckers, German carp and gizzard shad and fed them to the young game fish.

Taking the above suggestions as a starter, in connection with what has been said in other places in this bulletin, we hope that the reader will be aided when he comes to consider how, what and when to feed the particular kind of fish that he is caring for. No set and fixed rules can be given.

The Dead-box Experiment.

A box about five feet square and one foot in depth was placed about half way between the north shore and the center of one of the ponds at the State Fish Hatchery. Over the framework of the bottom of this box one-half-inch wire-mesh screen was stretched. The box was supported by four posts and was placed about a foot above the normal water level of the pond. A little fine brush and some coarse hay were thrown into the box with just enough sandy loam to hold the hay and brush in place. Sometimes a makeshift of a top that partly concealed the contents of the box was made by placing a few boards or a little brush or hay over it for a partial cover or shelter. Into this box or platform structure were thrown dead animals, such as muskrats, turtles, kingfishers, snakes, and all other animals that were killed because they were doing damage on the Hatchery grounds. Flies would soon fill these dead animals with eggs, and thousands of maggots would fall from this "dead box," as we were accustomed to call it, into the water. The "dead box" not only furnished a good place for disposing of useless animals that it was necessary to destroy on the Hatchery grounds, but was the means of furnish-

ing a very considerable amount of food for the fish, especially the small and young fish.

Animals that were not or could not be chopped up and fed to the fish were satisfactorily disposed of in this way. No odors from the "dead box" were noticeable from the shore. Just how much benefit was derived from the "dead box" could not be estimated. The experiment did not cost much, and it proved a satisfactory way of disposing of dead animals. We found it advisable in many cases, particularly in windy weather, to leave the dead animals on the shore long enough for the flies to fill them with eggs. A fish culturist with a few ponds might work some such device and get a considerable amount of benefit from it, especially in the feeding of small and young fish.

The Lantern Experiment.

Lanterns are sometimes hung over ponds to attract various kinds of insects, which drop into the water and serve as food for the fish. The lantern may be hung by the side of a piece of cheesecloth stretched between two posts. Many insects fly against the cloth and tumble into the water. A pane of glass is better than the cloth, and when the lantern is hung between two sheets of glass the scheme works best. At certain seasons of the year, when insects of some species are common, the device seems to work well, and a considerable number of insects are thrown into the water for the fish. We tried the lantern business, but have no way of knowing just how much good came from its use. In our judgment, it would be necessary to keep the thing in operation until the fish got accustomed to it. We would advise placing the lantern near a feeding place, or feed the fish near the place where the lantern is located.

ENEMIES OF FISH.

Among the greatest natural enemies of fish are the fish themselves. The so-called "game fish" feed very largely upon other varieties, especially the vegetable-eating fish, and when food becomes scarce, upon their own kind. The subject, however, of fish feeding upon each other has been touched upon in different places in this bulletin, and by reading up what has been said of the various kinds of fish this information can be secured, especially under the various headings that touch upon the life histories and food habits of the different kinds of fish.

The Turtle.

One of the chief natural enemies, outside of the fish themselves, here at the State Fish Hatchery, is the turtle. There are different kinds of turtles, and outside of a few that seem to feed for the most part upon vegetable matter we find that most of them are not averse to eating fish. The Snapping

A turtle trap photographed in its natural position, being dumped into trap from the drop or trap board.

Three turtles on the boards that serve as a roadway to the drop board. One turtle See plans for constructing trap, on page opposite.

TURTLE TRAP.

FIG. 1 shows side of the box trap, which is 4 feet long, 2 feet high and 2 feet wide. It is built by stapling $\frac{1}{2}$ -, $\frac{3}{4}$ - or 1-inch wire screening on a framework built of boards from 4 to 6 inches in width and 1 inch thick.

FIG. 2 shows cross section of the box trap, and shows the 6-inch strip of tin or galvanized iron that has been tacked on the inside of the top of the trap and bent down. It prevents the turtles from crawling out of the trap.

FIG. 3 shows top of trap with arrangement of the 6-inch boards that drop as soon as the turtles crawl upon them and allow the animals to fall into the trap.

FIG. 4 shows these drop boards with weights near the end. The turtles crawl upon these drop boards, using the inclined boards that extend into the water as roadways. At the State Hatchery over fifty turtles have been taken from a single trap in a week's time.

turtle is the worst, and on the Hatchery grounds destroys more fish than all the others combined. An examination of the stomachs of Snapping turtles taken from the Hatchery ponds has shown that they are greedy feeders, and that in many instances a large portion of their food is made up of fish.

Snapping turtles secrete themselves among the aquatic plants and apparently watch for fish that are passing by. They catch the fish by a quick stroke of the head, which their long necks allow them to throw out several inches from the body. We never had an opportunity of observing this operation until last year, when we saw a Snapping turtle catch a Bullhead catfish. The fish was taken in the turtle's mouth, and without any chewing or particular biting, was swallowed head first. A few minutes later we shot and secured the turtle, which was one that would weigh about twelve pounds. Dissection showed that the catfish that had been swallowed was lacerated in a few places by the sharp beak of the turtle, but was not cut up or pulled to pieces. In the stomach of this same turtle we found two sunfish, a half-grown bullfrog and a crayfish, in addition to the Bullhead catfish mentioned above. Altogether, a rather large amount of food—about a pound—for an animal that weighed only twelve pounds.

We get rid of the turtles by shooting them and by means of a wire-screen box trap which we illustrate on pages 68 and 69 of this bulletin. We also use steel traps set near the edge of the water and baited with a piece of fish for the capture of Snapping turtles. The fish or part of a fish used for bait may be fastened near the shore and just under the water by running an iron rod or sharp stick through it and down into the ground to hold it in place. The chain of the trap should be fastened to a wire, stake, or something that will hold it. Steel traps are used for the Snapping turtles as these animals do not climb into the box traps as readily as other varieties.

The Snake.

Another natural enemy of the small fish on the Hatchery grounds is the snake. The water snakes are the worst, though the garter snake and some other varieties also catch fish. We begin to kill snakes early in the season and keep it up through the entire summer and fall. We have been thinking ever since we came to the Hatchery grounds that we would soon have all the snakes killed. We believe that, on the average, two or more snakes have been killed each day on the Hatchery grounds during the summer months. However, the snakes are decreasing in numbers each year.

THE BULLFROG.

General Note.

Another enemy of small fish is the bullfrog. We raise more or less bullfrogs at the Hatchery. These animals do not always stay where you put them. In the evening they may be seen migrating from one pond to another. However, some of them seem to remain in certain localities, simply making short excursions for food and exercise. They have good strong voices, and well developed vocal cords, and frequently entertain each other by singing solos. However, they spend most of their time sitting around, looking wise and doing nothing.

Food Habits.

Their natural food is made up largely of insects, although they eat many different kinds of live animals, including fish. They are especially fond of the larger water beetles, such as *Hydrophilus triangularis* and *Dytiscus fasciventris*. These are large water beetles from an inch to an inch and a half in length, frequently found in Kansas ponds and streams. An examination of a number of stomachs taken from frogs that lived in ponds showed that a good portion of their food at certain seasons of the year and under certain

conditions was made up of fish. In the spring of 1910 we made some investigations concerning the food habits of the bullfrogs then living on the Hatchery grounds. At that time there were quite a number of these animals in the ponds. One morning we started some of the Hatchery men out to collect large bullfrogs. They took thirty specimens all told, five from each of the six ponds in the old Hatchery. These animals were killed and immediately dissected in order to find out exactly what they had in their stomachs. The following table will show what they had been eating.

Predaceous diving beetle. Common in Kansas waters.

Larva or immature stage of the predaceous diving beetle. It feeds upon various forms of small water animals, including young fish and tadpoles. In some localities it is known as the "water tiger."

Food of Thirty Specimens Taken from Hatchery Ponds.

The specimens below considered were taken for examination from the ponds on the State Hatchery Grounds on April 7 and 8, 1910, between 8:30 and 11:45 A. M. For total length of specimens the animals were stretched out on a board and measured from the end of the nose to the end of the toes.

POND NO. 1.—This was a crappie pond. That is, it had been stocked with crappie the previous spring. It had young crappie in it and a few fish of other kinds, such as small minnows and sunfish.

Specimen No. 1—Pond No. 1.

Total length, 15 inches.

Food contents of stomach:

Two young crappie, each about 3 inches long.

Three large water bugs.

One black beetle about an inch long.

Three feathers, each about 3 inches long, from the tail of some bird, apparently a sparrow.

Specimen No. 2—Pond No. 1.

Total length of specimen, 14.25 inches.

Food contents of stomach:

Three young crappie from 2.50 to 3.25 inches in length.

Parts of some unidentified insects and pieces of snail shells.

Specimen No. 3—Pond No. 1.

Total length of specimen, 13.75 inches.

Food contents of stomach:

One medium-sized crayfish.

Three large water beetles.

Two land beetles.

Seven snails.

Specimen No. 4—Pond No. 1.

Total length of specimen, 14.25 inches.

Food contents of stomach:

Two crappie, each about 3 inches in length.

Some pieces of snail shells and some small fish bones.

Specimen No. 5—Pond No. 1.

Total length of specimen, 13 inches.

Food contents of stomach:

One sunfish, 2.50 inches long.

Pieces of a crayfish and some small pieces of land and water beetles.

POND NO. 2.—This pond had been stocked with Bullhead catfish, sunfish and crappie.

Specimen No. 6—Pond No. 2.

Total length of specimen, 15 inches.

Food contents of stomach:

Five small sunfish, 1.50 to 2.50 inches in length.

No trace of any other food.

Specimen No. 7—Pond No. 2.

Total length of specimen, 15.75 inches.

Food contents of stomach:

One Bullhead catfish, about 5 inches in length.

Some pieces of hard parts of crayfish.

Specimen No. 8—Pond No. 2.

Total length of specimen, 13.25 inches.

Food contents of stomach:

One small crappie.

One crayfish.

Two water beetles.

Specimen No. 9—Pond No. 2.

Total length of specimen, 12.50 inches.

Food contents of stomach:

Two mole crickets.

Three water beetles.

Five brown cutworm moths.

Specimen No. 10—Pond No. 2.

Total length of specimen, 13.75 inches.

Food contents of stomach:

One partly digested crayfish.

Three mole crickets.

A small mass of partly digested water bugs and beetles.

Four buds that had fallen from a cottonwood tree, each about as large as a navy bean, were found in the stomach of this frog.

POND NO. 3.—The small young fish had been removed from this pond the previous fall. The pond was stocked with large crappie and Black bass. There were very few, if any, small fish in this pond for the bullfrogs to feed upon.

Specimen No. 11—Pond No. 3.

Total length of specimen, 12.75 inches.

Food contents of stomach:

Two large green bullfrog tadpoles (its own kind).

No trace of any other kind of food.

Specimen No. 12—Pond No. 3.

Total length of specimen, 13 inches.

Food contents of stomach:

This specimen had swallowed another bullfrog of its own kind, over half its own size. The food frog was partly digested, and we could not get its exact length. It was about 10 inches long.

One white moth and about a dozen snails, evidently taken for dessert, completed the breakfast of this specimen.

Specimen No. 13—Pond No. 3.

Total length of specimen, 11.25 inches.

Food contents of stomach:

Two dragon flies.

One mole cricket.

One black land beetle and a small mass of half digested snails, with fragments of insects.

Specimen No. 14—Pond No. 3.

Total length of specimen, 14 inches.

Food contents of stomach:

Three large bullfrog tadpoles.

No trace of any other food.

Specimen No. 15—Pond No. 3.

Total length of specimen, 14.50 inches.

Food contents of stomach:

One frog of its own kind, 9 inches long.

No trace of any other food.

POND NO. 4.—This pond had a variety of fish in it, such as bass, crappie, sunfish, catfish and goldfish.

Specimen No. 16—Pond No. 4.

Total length of specimen, 12.75 inches.

Food contents of stomach:

One goldfish, 2.50 inches in length.

Nine snails.

One moth.

One spider.

Some larvæ and small water insects.

Five pieces of gravel, size of wheat grains to peas, were in the stomach of this animal. These may have been taken with some kind of food; snails sometimes stick to pebbles.

Specimen No. 17—Pond No. 4.

Total length of specimen, 13 inches.

Food contents of stomach:

Two large water beetles.

Two dragon flies.

Three dragon fly larvæ.

Seven snails.

Some small insects and some vegetable matter. The latter was probably swallowed accidentally while feeding upon the water forms of animal life.

Specimen No. 18—Pond No. 4.

Total length of specimen, 10 inches.

Food contents of stomach:

Two water beetles.

Five snails.

Some small insects and larvæ.

Specimen No. 19—Pond No. 4.

Total length of specimen, 12 inches.

Food contents of stomach:

One crappie, 2.50 inches in length.

One large tadpole, with trace of snails and insects in stomach.

Specimen No. 20—Pond No. 4.

Total length of specimen, 12.50 inches.

Food contents of stomach:

One Bullhead catfish 3.50 inches in length, and a small mass of partly digested insects and snails.

POND NO. 5.—This pond had been stocked with goldfish the previous spring and had plenty of young goldfish in it.

Specimen No. 21—Pond No. 5.

Total length of specimen, 14 inches.

Food contents of stomach:

This frog had seven goldfish in its stomach, ranging in size from 1.50 to 2.50 inches in length.

No trace of any other food.

Specimen No. 22—Pond No. 5.

Total length of specimen, 12.50 inches.

Food contents of stomach:

One goldfish.

Two sunfish.

When the frog was cut open one of the sunfish was alive. It was placed in a bucket of water and soon began to move about. It finally became active and was returned to the pond in apparently good condition.

Specimen No. 23—Pond No. 5.

Total length of specimen, 11.25 inches.

Food contents of stomach:

Two red goldfish, each about 3 inches in length. One was pretty well digested.

No other food.

Specimen No. 24—Pond No. 5.

Total length of specimen, 11 inches.

Food contents of stomach:

Two mole crickets.

Three water beetles.

Two white moths and three cottonwood buds.

Specimen No. 25—Pond No. 5.

Total length of specimen, 12 inches.

Food contents of stomach:

Two whole and two partly digested water beetles.

Three spiders, parts of snails and insects, and several small pieces of gravel.

POND NO. 6.—There were crappie, sunfish, bullheads and some goldfish in this pond.

Specimen No. 26—Pond No. 6.

Total length of specimen, 14.50 inches.

Food contents of stomach:

One crappie 2.50 inches long.

One Bullhead catfish 3.50 inches long.

One crayfish.

Specimen No. 27—Pond No. 6.

Total length of specimen, 13.50 inches.

Food contents of stomach:

Three large tadpoles.

One half-grown crayfish.

Two water beetles and a bunch of half-digested stuff that showed traces of snails and insects.

Specimen No. 28—Pond No. 6.

Total length of specimen, 11.50 inches.

Food contents of stomach:

Two large water beetles.

One dragon fly and a mass of water larvæ and small insects partly digested.

Specimen No. 29—Pond No. 6.

Total length of specimen, 11.25 inches.

Food contents of stomach:

One mole cricket.

Three spiders.

One larva over two inches long of a water beetle, and some partly digested insects and snails.

Specimen No. 30—Pond No. 6.

Total length of specimen, 13.25 inches.

Food contents of stomach:

Four large blowflies.

One large black land beetle.

Three green land bugs, with traces of snails and insects.

The above specimens, as stated before, were all taken in the spring, on April 7 and 8, 1910, and from ponds where food conditions were limited and strained. It is noticeable that the food of specimens taken from certain ponds depended largely upon the nature of the food supply in those ponds. Fourteen of the specimens examined had eaten fish, and the total number of fish taken by the thirty specimens was thirty-two—an average of a little over one fish for each frog. A little figuring would show the damage a hundred or a thousand frogs could do the small fish in the Hatchery if other food became scarce.

Frogs taken from pond No. 3, where there were no small fish and where all kinds of food was comparatively scarce, owing to the fact that the pond had recently been drained and all small fish removed, had eaten tadpoles of their own kind, and had even turned cannibals and had eaten the smaller and weaker members of their own family.

Food of Specimens Taken from Other Waters.

Specimens taken at other times, and at different times of the year, and from various localities, show that bullfrogs will eat almost any live animals that they can find, or that come their way, provided the animals are not too large for them to swallow.

Our notes show that the food of frogs taken from natural lakes and ponds in Kansas varies with the season of the year. More than half of the food mass under such conditions is frequently made up of insects, and large water beetles in many instances make up a good part of this insect food. The large bullfrogs eat a good many young turtles, beginning to devour them when they are first hatched and keeping it up until they attain about the size of a silver half dollar. Specimens of bullfrogs taken from small streams and creeks were found to have fed largely upon crayfish, and at certain seasons of the year as much as 50 per cent of their food was furnished by these animals.

Judging from our own studies we would say that fish are seldom eaten by frogs that live in lakes and creeks where other kinds of food are abundant. Where they can be had, crayfish and insects make up the bulk of the bullfrog's food. However, as we said before, they will take almost any animal that comes along that is small enough for them to swallow. We have taken mice and birds, such as sparrows and thrushes, from the stomachs of bullfrogs. Snakes from a foot to fifteen inches in length have been found in their stomachs. We learned many years ago that when large and small frogs were shut up together in a live box and left for a few days, the larger specimens would swallow the smaller ones.

Natural History Notes.

During the summer of 1911, while the men at the Hatchery were working around one of the ponds, one of them, Mr. John French, saw a large bullfrog spring from the edge of the water and catch a chicken that was two weeks old and partly feathered out. The frog, with the chicken in its mouth, jumped back into the grass and weeds that grew in the edge of the water, where it proceeded to swallow the chicken. Meanwhile the old hen had made a great commotion and put up the best fight she could under the circumstances against the reptile, but it did not avail much. The men who were near by rushed to the scene of action and succeeded in capturing the frog by means of a rake. The poor chicken was all out of sight in the frog's stomach except its head, which had apparently caught in the corner of the frog's mouth. One of the men, Mr. John French, held the frog while his brother Henry squeezed the frog's stomach. Arthur Shaw took the chicken by the head and worked his finger around in the frog's throat to loosen up and dislodge the chicken. The combined efforts of the three men succeeded in getting the chicken out of the frog's stomach. The chicken, wet and covered with slime, made distressed comments in the way of little squawks and peeps when rescued. It was partly dried with a piece of burlap and wrapped up and placed in the sun where it might get dry and warm. It revived and was afterwards turned loose with the hen. The old bullfrog, with an empty stomach and a look of disgust and disappointment on his face, was returned to the pond, not however, until a little advice had been administered on the "Fish and Game Laws" and the "closed season on birds." Cases have been reported where bullfrogs caught and swallowed young ducks.

Last summer, while Mr. O. C. LeSuer, resident engineer and superintendent of the Hatchery, and myself were doing some repair work on the old Hatchery, we caught a bullfrog that was eighteen inches in length, as large a specimen as we have ever seen.* This animal had such a large stomach that we thought we would kill it and see what the frog had been eating. The stomach contained three large crayfish and four large water beetles. One of the crayfish was alive, and when we returned it to the water, it shot back by quick jerks of its tail, apparently none the worse off for its experience in whale frog's belly.

Last June, 1913, we took a garter snake that was 14.5 inches long from the stomach of a bullfrog that was 15.5 inches in length. In July, 1911, we took a bullfrog that was nearly a foot in length from a water snake that was about three feet in

* Since the above was killed, my son George, who was sent to Pond No. 3 to get six frogs for examination for food habits, brought in one that was 18.5 inches in length. I had instructed the boy to get large frogs with full stomachs, but I was sorry that Jumbo frog was killed.

length. It would seem from the above observations that when a large hungry bullfrog and a large hungry snake meet each other, they gaze and stare and stare and gaze at each other; and when they have finished gazing and staring and staring and gazing, and have finally sized each other up, one or the other (the one with the best nerve and with the largest mouth and digestive capacity) proceeds to swallow the other. Thus do animals in nature, guided by the laws of "natural selection" and the "survival of the fittest," love one another and get along with each other in peace and harmony.

Advisability of Placing in Ponds.

As there has been some discussion and some criticism concerning the advisability of placing bullfrogs in ponds and concerning their food habits, we hope the above notes and observations will be of some value to all persons who own ponds and desire to keep bullfrogs in them. We are the natural friend of the bullfrog, and do not desire to pass an unjust criticism on him or do him any injustice by giving unfavorable reports on his habits and life history.

Food for Man and for Fish.

The flesh of the bullfrog is considered by many as the most delicate and palatable that can be found in the animal kingdom. The bullfrog produces a very considerable number of eggs, which are usually spawned in May and June. These eggs develop into tadpoles, and at from one to two years of age these tadpoles develop into frogs.

We have been opening up fish and examining the contents of their stomachs since we were a small boy, and thus far we have never found a tadpole in the stomach of any fish. However, most of the game fishes are fond of frogs, especially the young Green bullfrogs. The Black bass and the catfish will swallow almost any frog they can catch, and we doubt whether a bullfrog ever grows so big that a large bass, when hungry, would not tackle and swallow him. At the Hatchery we have frequently placed several thousand tadpoles in ponds that have been stocked with Black bass for spawning purposes. In early summer tadpoles begin to change into frogs. This transformation continues all summer, and thus a constant supply of young frogs are furnished for the bass.

When one year old these frogs are large enough for table use, and at two years old are about half grown. When three years old they are about grown, and at four years old are big and full-sized specimens. However, the growth depends largely upon the food supply. We have had two-year-old specimens that were nearly full grown.

We think it is possible to fence a pond with wire screening, so that the bullfrogs can not get out of it. Ordinarily the fence should not be less than four feet high. We have not tried to

fence them in very much. Thus far our experience would indicate that the animals do not jump very high, though they can make long jumps. We have not noticed any of them climbing up the fence to look over or get out.* We would not undertake to say, however, just what they would do if food got scarce. Starving animals rapidly develop new and sometimes unexpected characteristics.

The ponds should be thoroughly stocked with goldfish and minnows, or any kind of fish that will eat waste and vegetable matter and increase the food supply for the frogs. Crayfish might also be raised for the frogs, but we are in doubt about the advisability of raising a lot of these animals in the same ponds with the fish. However, it might work all right, when we come to consider that we want to raise a crop of frogs and not fish. Of course the ponds should be well supplied with various kinds of aquatic plants to attract insects and to furnish the vegetable-eating fish with a constant supply of food. The tadpoles also get their supply of food from the vegetable matter that the ponds produce. A great many insects will be attracted by this vegetable matter, and especially to the semi-aquatic plants that should grow along the shores. These insects will furnish much food for the frogs, and when the insect food is not sufficient there will be a supply of young vegetable-eating fish in the water for the batrachians. Bullfrogs bring a very high price in the market. The dressed saddles were quoted this year at from fifty cents to a dollar per pound.

Money in Raising Bullfrogs.

Many people have an idea that a very considerable amount of money can be made by raising frogs. Our experience here at the Hatchery is, that if we get too many tadpoles in any one pond they will get a disease and begin to die; but our greatest difficulty is when thousands of tadpoles begin to change into frogs. When these frogs are in the fish ponds the bass and catfish will take care of them, but when placed in a pond where there is nothing to destroy them it does not seem possible to supply or produce enough food in any one locality to feed a very great number of them; and so they also develop some kind of a disease, due, perhaps, to the fact that they are not properly fed, which kills them off. At such times the larger specimens feed upon the smaller ones. We have taken as many as five small frogs from the stomach of one large specimen.

Perhaps some enthusiast who desires to get into the bullfrog business and make it a paying proposition can solve some of these problems and work the proposition out on a paying basis. I imagine if one had from ten to fifty or more acres of swampy ground, mostly covered with water, that a goodly number of

* Bullfrogs can climb up almost any fence, but seldom do it when in ponds; a flat board projecting six inches from the top of the fence prevents them from climbing over.

bullfrogs could be raised, but I do not think it is possible to carry on the industry very extensively and successfully unless conditions more favorable for their production can be produced than those furnished by a few small ponds.

We know of no way to feed them on cheap artificial food. They do not care to eat anything that they do not catch alive, though they can be persuaded to grab a piece of red meat, or even a piece of red cloth, that is dangled before them on a string or hook.

We are just as glad as you are that this bullfrog story is finished. It has been written for the most part to supply information that the Department is called upon to furnish. We have tried to answer all intelligent questions that have been asked. It is simply impossible to answer all individual letters received from correspondents, giving the information they ask for or such part of it as they ought to have and are entitled to from the Department, without the use of bulletins and printed matter.

However, we are always willing to answer such questions as we are able to; so if there is anything you do not understand after studying the bulletins, or concerning which you want further instruction, please write us, addressing your communication to the Department of Fish and Game, Pratt, Kan.

Adult dragon fly, frequently called "snake doctor." It feeds largely upon mosquitos caught on the wing.

ENEMIES OF FISH. THE BIRDS.

The Kingfisher.

Another constant and persistent enemy of the fish at the Hatchery during the summer season is the kingfisher. These birds are present on the Hatchery grounds from spring until late in the fall, and they feed constantly upon small fish. Only yesterday, August 15, 1913, while we were writing this part of this bulletin, we saw a kingfisher dart into the water several times after small fish at a distance no greater than forty feet from the window where we were sitting.

After striking the water the bird, with a small fish in its beak, lit on the cement wall that inclosed this particular retaining pond. The bird placed the fish on the wall, and after looking about preened its feathers a little picked up the fish

A pair of kingfishers.

From specimens mounted by the author in Kansas University Museum.

and swallowed it. Almost immediately the bird dashed into the water again and came up with another small fish. It sat on the cement wall some little time, with the fish in its beak, and finally the fish disappeared down the bird's throat. In a few moments the bird dashed into the water and secured a third fish, which it placed on the wall. The kingfisher now preened its feathers as before, then picked the fish up, and after holding it in its beak for some little time swallowed it. We did not note the time that had passed, but all this happened in a very few minutes, about 10 A. M. Again the kingfisher

plunged into the water and came out with a stick a few inches in length, which it placed on the wall. Then it dove into the water for the fifth time and brought up a little twig that had two or three leaves on it, and placed this on the wall. Then the bird preened its feathers as before. It made one more trip into the water and brought up a little bunch of leaves and placed them on the wall. Then, after shaking itself and preening its feathers for a little while, the bird took its departure for some tall cottonwood trees that stood several rods north of the Hatchery building. After the bird had gone we examined the sticks and leaves that had been placed on the wall, but could discover no particular reason why they had been picked up by the bird and left as they were.

Examination of the stomachs of many kingfishers has shown nothing but fish food. The kingfishers that we examined seldom had more than one whole fish in the stomach, in addition to others partly digested, and a bunch of fine bones.

About the only successful way to get rid of kingfishers, so far as our experience goes, is to shoot them. They may be caught by placing a steel trap on the end of a pole that can be placed in or near the pond. Such a device is objectionable because other birds are frequently caught in the trap. It is hard to understand where so many kingfishers come from, especially in such an out of the way place on the western prairies as where the Hatchery is located. During the months of June, July, August and September we kill, on the average, about a dozen per week. My son, Lindsay, killed twelve last Wednesday morning before breakfast. He said he got them all. However, next day we noticed three or four flying over the ponds.

Ospreys or Fish Hawks.

As a rule, two or three pairs of ospreys, fish hawks or "fish eagles," as these birds are sometimes called, visit the Hatchery each year. They are very destructive to fish. When they are

Fish hawks. From specimens mounted by the author in Kansas University Museum.

there they can be seen hovering over the ponds almost any time of day, and when they drop, sometimes from a very considerable height, they strike the water with force enough to make a splash that almost or quite conceals them. In fact, they sometimes appear to go under the water. They are almost sure to rise with a fish weighing from one to two pounds.

As the bass are usually feeding in shallow water or near the surface, they are the fish most commonly taken by the osprey. The fish is usually carried to a convenient tree or post, where the fish hawk proceeds to eat a part of it. We followed an osprey one day to the spot where it had been eating a fish. The fish that the bird had taken was a bass of a pound or more in weight. A part of the body had been eaten. The insides or entrails were gone. Whether this part of the fish had been eaten by the bird or not we could not tell. The dissection of ospreys killed on the Hatchery grounds usually showed nothing but the lean flesh of the fish in the stomachs. The ospreys seem to return many times during the day for fish. They are constantly catching them and carrying them away. We know of no way to stop their depredations except to watch and shoot them. This we do as soon as we find that the birds are on the Hatchery grounds.

The Herons.

The herons are the most destructive of all birds that catch fish on the Hatchery grounds. The American bittern, the Little Green heron, the Night heron and the Great Blue heron

The herons. From left to right—the Black-crowned Night heron, the American bittern, the little Green heron, the Great Blue heron. This bird is frequently mistaken for the Blue crane.

are all very fond of fish, and at different times of the year visit the Hatchery ponds. The Great Blue and the Night heron are very destructive, but fortunately they are only present during the migratory season. The bittern and the Little Green heron both nest and rear their young in Kansas, and are present nearly the whole summer season, and are constantly stealing fish from the Hatchery ponds.

The herons eat frogs, snakes, crayfish, and insects such as grasshoppers. However, when they visit the Hatchery ponds

they feed upon fish almost exclusively. The ponds are full of fish, and it is easy for the herons to catch them in the shallow water near the shores.

A flock of about fifty Black-crowned Night herons visited the Hatchery grounds one night early in September two years ago, at a time when we had one of our bass ponds partly drained. Some of the birds fed upon the young bass during the night to such an extent that they became so full that it apparently made them sick. They spit or regurgitated many of the fish that they had swallowed. Next morning we found several small piles of fish that they had spit up. The number of fish in these little piles or heaps ranged from nineteen to thirty-seven, and the fish measured from two and one-half to four inches in length.

We are friendly to the herons and do not like to take their lives. We try to drive them away by shooting at them. We frequently take long-range shots at them with No. 10 or 12 shot. The Night herons and the Great Blue herons, as a rule, can be driven away without much trouble. It sometimes becomes necessary to "burn" the bittern and the Little Green heron with fine shot two or three times before they will take the hint and leave.

Fish Ducks.

The mergansers, or fish ducks, are very destructive to fish. Fortunately they only appear for a short time during the spring and fall migration. They are usually wild and can be put to flight without much trouble by firing a few shots. However, they sometimes come and settle on the ponds at night and do considerable damage before they can be frightened away. We took a sucker $12\frac{1}{2}$ inches long from the stomach of an American merganser that we killed several years ago while

Mergansers or fish ducks. From specimens in Kansas University Museum.
To left, the Hooded merganser; to right, the American merganser.

collecting birds for the Kansas University Museum. The tail of the fish was plainly visible in the mouth and throat of the duck when the bird was picked up. The fish was so long that it could not be completely swallowed.

Mud Hens.

There are usually a good many mud hens on the ponds, especially during the spring and fall or migratory season, but we have never found fish in the food contents of their stomachs, and we have opened up a great many specimens. These birds do damage, however, in the spring by puddling around the shores in places where fish spawn. Common wild ducks also bother us a good deal in the spring of the year by puddling along the shores of the ponds and in the shallow water where fish, especially the Black bass, are accustomed to make their spawning beds.

Grebes, Gulls and Terns.

The common grebes, dab chicks or hell-divers that frequent the ponds in this locality seldom catch fish, as shown by the examination of the contents of the stomachs of many specimens. Other birds, such as the gulls and terns, take a few fish during their migrating season, but as a rule do no great damage. However, the terns have bothered us by taking a good many small fish, especially at times when we lower the water in the ponds for the purpose of removing the fish.

The terns got so bold that they would fly within a few feet of us while we were working and pick up the small fish. They would carry them a few rods in their bills, when they would drop the fish and return for more. The fish dropped were found to have been pinched by the birds' mandibles until some of them were nearly cut in two pieces. The terns would sometimes fly so very near as to grab the fish that had been corralled by the minnow seines that were being used to catch them. The men handling the seine struck at the birds with the hand nets that they were using, and threw mud, sticks and bunches of wet moss at them. Most of these bold marauders could be scared away by shooting, but it became absolutely necessary to kill some of the most impudent before their depredations could be stopped.

ENEMIES OF FISH. MAMMALS.

The Muskrat.

The muskrat is considered by some to be an enemy of fish. It is pretty generally understood now among scientific men that the muskrat does not eat any kind of flesh except the meat of the clam. They sometimes dig up clams, carry them to an old log, and are supposed to pull or break the shell open near its edge with their teeth and eat a portion of the body of the

clam. We have found piles of clam shells at such feeding places, but as yet have never seen a muskrat open a clam shell or eat such food. This is most frequently done during the late fall, winter and early spring, when their regular food is not so easy to get. We have caught muskrats and cut them open for many years, and never found any meat in them, not even the flesh of the clam. We have had reliable trappers examine them for us during the season, and no one has ever reported having found any meat or fish in the stomach of a muskrat.

However, muskrats are enemies of the pond owner. They especially enjoy living in the banks of ponds, and they go from one pond to another and dig and burrow in the embankments, and continue to do damage in this way. The only way to keep

Muskrats. They do not eat fish, but do great damage by burrowing in the banks. They are very prolific and hard to keep down, as they migrate from place to place. Over 200 were killed in the new Hatchery grounds during the first year.

them out of the ponds that we know of is to shoot or trap them. As a rule, it is not hard to find them in the early morning or in the evening. A good shot gun with No. 5 shot is good medicine for them. A steel trap properly set in the water near the bank where they feed and travel is almost sure to catch them. A good bait for a muskrat is a piece of apple, parsnip or carrot. Place the bait on the end of a sharp stick and push the stick in the mud under the water about a foot from the edge of the shore, with the bait from six to ten inches above the surface of the water. Place the trap about two inches under water and between the shore line and the bait. Another good and perhaps a better way to use the bait is to throw a few small pieces or shavings of parsnips in the edge of the water near the trap. The trap should always be placed under the water and near the shore.

Another method is to dig out a small shallow pocket in the shore, extending it back into the bank about a foot from the water's edge. Pile the mud and freshly dug up dirt just back of the little water hole. Then set the trap about two inches under water in this prepared pocket and cover lightly with mud, or with a little decayed vegetation so as to partly conceal the trap. This sort of a place with a little bait seems to attract the attention of a muskrat. With the above suggestions and a little experience you ought to be able to catch the muskrats without much trouble.

As a rule it is a poor plan to set the trap in the burrow of any animal. Better set the trap in a near-by place that the animal frequents while traveling or feeding. The chain should be fastened to a stick that can be pushed into the ground in the deeper water. When the muskrat gets in the trap it will twist the chain around the stick (or perhaps it is better if two sticks are stuck a few inches apart) and soon drown itself. A wire fastened near the shore, with a stone, sand bag or some kind of a weight on the other end of it, thrown into the water, makes one of the very best devices for fastening the trap. As soon as the rat is caught it will plunge out into the deeper water; the ring on the trap chain will slip down on the wire into the deeper water, and in a very few moments the muskrat will be drowned, thus preventing any undue suffering from any injury that may have been inflicted by the trap. It is a good idea to make a little kink or bend in the lower part of the wire to prevent the ring on the chain from slipping back on the wire after it has once slipped down. When not drowned a muskrat will sometimes cut its foot off close to the trap and get away.

The high price of muskrat skins during the past few years makes it possible during the trapping season to get experienced trappers to catch the animals for their fur. However, care should be taken to shoot or trap any animals that may be left in the ponds in the early spring before they bring forth litters of young muskrats.

Muskrats, as we have stated before, are vegetable feeders and eat many kinds of aquatic plants, feeding for the most part upon the juicy and tender parts of the stems. They also eat the young growing tops and buds of certain plants. The bark of some of the willows, as well as some of the tender branches, are eaten. Small willows are frequently cut in early winter time and carried to their feeding places.

The Mink.

Very few animals of the mink or weasel kind bother the fish ponds. Both the mink and the otter are great fish eaters. Otters are very rare, if any are left in the state; and the mink, owing to the high price paid for its fur, is not common anywhere. We know of only one being taken on the Hatchery grounds during the past four years.

Many years ago, while watching for a squirrel to come out of a hole, we saw a mink come from a pile of driftwood on the bank of a creek and hop along on the ice to where there was some open water just above a riffle. The main part of the creek was frozen over and covered with ice and snow. The mink dove into the water and soon appeared with a small fish. This was eaten; then the mink dove again and soon appeared with another small fish. We wanted to shoot the mink, but thought we would take our time and see how many fish it would catch. We had a shotgun, and felt sure that we could get a shot before the animal could get back to the driftwood. The mink dove for the third time, and we never saw it again. It must have had an underground passage to its den.

This occurred during our boyhood days, and the disappointment of not getting the mink made us feel bad for a long time. We watched the place, after the mink disappeared, for an hour or more, and went back the next day and watched, but the mink never came back, at least while we were watching.

The Gopher.

Gophers burrow in the banks and have at times bothered a good deal on the Hatchery grounds. We have learned that no embankment should be built on ground that has gopher* holes in it. The ground should be plowed and scraped deep enough under the foundation of the embankments to destroy all gopher holes; otherwise there will be serious trouble when the water is turned into the pond. Water will run through gopher holes just about as freely as through iron pipes or tiling, and it is no easy matter to stop such leaks. It frequently necessitates draining the pond and doing a lot of work digging up the old gopher burrows.

Gophers may be trapped or poisoned. There are a number of different kinds of traps sold in the market. Small potatoes, or, better, sweet potatoes, or, better yet, raisins, can be poisoned and used with good effect in killing gophers. Find the gopher burrow by punching holes in the ground with a hard stick or with an iron rod. The rod should be about an inch in diameter, so as to make a hole large enough to admit the bait. If the poisoned potatoes are too large to be dropped into the gopher's burrow, they can be cut into pieces of sufficient size to be admitted. Such poison as "Rough on Rats," arsenic, strychnine, or the poison prepared at the Kansas State Agricultural College, can be used. If there are only a few gophers in the locality they may be trapped; but if there are very many, poisoning is by far the quickest and easiest method of getting rid of them.

*Gophers sometimes cut through the banks after they are built and before the water is turned in. It would be a good plan to kill the gophers on a piece of ground before the ponds are built.

The Crayfish.

It might not seem fair to place crayfish under the head of "Enemies of Fish." In one sense crayfish should be considered as an important element—as a good food for certain kinds of fish. The crayfish is eaten by the bass, the crappie, the sunfish, and the catfish. They are especially devoured when they are young. The large bass and catfish also feed extensively upon full-grown crayfish when the latter are present. Bass are very fond of them. Bullfrogs and turtles are also fond of crayfish, and many water birds, particularly the herons, feed upon them.

The crayfish themselves are rather omnivorous in their food habits. They are scavengers, and are fond of all kinds of meat and soft-bodied insects and larvæ. Crayfish also feed upon fish. They will devour any dead fish they can find. They also catch small fish when the latter are placed in an aquarium with them. We have seen them catch them on riffles in small streams, and also in the small streams that run over the ground from the water pipes while we are lowering the ponds at the Hatchery.

The crayfish caught in the nets with the small fish when we are seining at the Hatchery frequently kill the young fish by catching them in their pinchers, and sometimes become very troublesome. Thus far we have never taken a real good crop of young fish from a pond that had a great lot of big old crayfish in it. A certain number of them may be all right in breeding ponds. However, we would rather have them in stock and feeding ponds where there are fish large enough to handle them.

Make Holes in the Banks.

Crayfish sometimes become very troublesome by digging holes in the banks of the ponds. They also dig holes in the bottom of ponds. In some soils this makes it possible for the water to flow down and seep out through the lower strata or beds of sand and gravel on which the bottom of the pond rests. In sandy or loamy soil it is frequently necessary to puddle the bottom of a pond to make it hold water. In such ponds the crayfish can do much damage by making holes that will allow the water to seep out of the pond and flow away through the porous material that underlies the puddled or true bottom of the pond.

To Get Rid of Crayfish.

We know of no easy method of getting rid of crayfish when they once get in a pond. They migrate from place to place, and if they get in one pond they will soon be in all the ponds in the same locality. When they get too plentiful in any of the Hatchery ponds we usually stock such ponds with large Black bass. The bass are very fond of them, and when they once get

started to feeding upon crayfish they will take them almost exclusively in preference to other kinds of food. When we drain the ponds the large crayfish are removed and placed in ponds where they can be properly handled as food for fish. Crayfish placed in the ponds where the large Black bass are being wintered furnish the latter with a natural food that they seem to take as freely as any food that can be given to them. Bass thus fed are always in fine condition as spawners in the spring-time. Crayfish are all right in fish ponds if they are properly managed, but the chances are that the fish culturist will find that they are not easy to manage.

HOW TO STOCK THE FISH POND.

The Department is continually receiving letters of inquiry in regard to "how to stock a fish pond." Many people that we meet in our travels also ask the same question. Our first advice to all such persons would be to read our bulletins. If these bulletins have been read carefully, nearly all the information which is asked for will be found under the various topics discussed.

No one can tell how to stock a fish pond until the conditions of the pond are understood. Even then, perhaps, no two fish culturists would exactly agree upon just how it should be done. The size of the pond, the water supply, and the natural food supply are things of first importance. When these things are understood, then the kinds of fish that would naturally do best in the pond must be considered. This proposition must be worked out in its relations to the kind of fish that the pond owner really wants, and the kind that would really do best in the pond. A great many persons who write for fish, and who have not informed themselves very much upon the subject, desire to stock their ponds with Black bass or Channel catfish. It would make an endless chain of correspondence to undertake to furnish information that would give details of why certain things should be or should not be done. It takes a long time to explain to certain people why they should not do something that they really want to do.

Therefore we earnestly recommend to all persons who are interested in stocking their ponds with fish to read the bulletins on "Ponds," "Pond Fish," and "Pond Fish Culture." After this has been done, the Department will undertake to answer any questions that are in line with its work and which will in any way help people along who are undertaking to raise fish. However, we hope to supply most of this information in the future by issuing bulletins and circulars. The fact is that in the writing of these bulletins we have undertaken to answer all the intelligent questions that have come to us through our correspondence during the past four years. We tell a story or give an experience or an observation, but these stories, expe-

riences and observations are really intended to answer a certain line of questions which are continuously propounded to the Department by its correspondents. Read what the bulletin says before you stock your pond with Black bass or Channel catfish, or any other kind of fish; then, if you are in doubt, think it over and write us.

Birds Carry Fish Eggs, and Stock Ponds.

Certain kinds of fish, such as the sunfishes, the Bullhead catfishes, and some others, deposit, lay or spawn what are called adhesive or sticky eggs. Eggs of this character may adhere to material in the bottom of nests of such fish as make nests, or to other things when spawned by fish that do not make nest beds.

The fact that these fish eggs are sticky and adhere to various objects makes it possible for water birds, those that wade and paddle in such places as fish spawn, to get the eggs stuck to their feet and feathers. These birds fly from one body of water to another, carrying the fish eggs with them. In this way ponds and even streams that have no fish in them are said to be sometimes stocked with some of the common varieties of fish. This method of stocking ponds is supposed to account for the fish, and other aquatic life, found in many ponds that are miles from other bodies of water that have such forms of life in them.

Various plants, as well as various forms of animal life such as crustaceans, mollusks and insects, are frequently carried from one body of water to another by water birds. On several occasions we have found live snails sticking to the feathers of water birds. We have also found live aquatic stuff in the pouch that hangs from the lower beak of a pelican. The bird evidently does its share in distributing small water life over the country in the places that it frequents.

I WANT FISH.

We are continually meeting people in different parts of the state who inform us that they want fish. If these people will write to the Department and say that they want fish, their names will be entered in the proper books, blank application will be sent to them, and such bulletins, circulars and other information as they may need will be forwarded to them. The Department will be glad to coöperate with these people and assist them in every way possible not only to get started in the fish business but to make a success of it.

Applicants will receive all instructions necessary to put them in direct line for getting fish at the earliest possible date from the State Fish Hatchery. In the future we hope to keep the fish car on the road delivering fish almost continuously, except in midwinter and midsummer. This will make it possible for us to visit all the chief points in the state at least once a year,

Hatchery fish wagon, with a load of ten thousand yearling fish ready to be delivered to the fish car, Angler No. 1.
Car house and car in distance.

and deliver fish "alive and kicking" at your nearest railroad station, ready for your streams and ponds. You will understand that these fish are for brood-stock purposes. They should be protected and cared for until they have a chance to spawn and rear broods of young fish. In this manner we hope to stock and restock the streams and ponds of Kansas with good fish.

Fish from two to seven inches in length can be carried in the fish car in much greater numbers than fish of larger size. The capacity of our present fish car makes it possible to carry from five to twelve thousand fish from two to ten months old. When the fish are from one to two years old it is not possible to carry so many, and when the fish are from two to three years old the number that may be carried in the fish car ranges from 500 to perhaps 3000, depending upon kind and size. However, the Department believes in delivering good-sized fish. Two-year-old fish are of spawning age and size, and when placed in a pond or river in the spring of the year they will spawn during the season. The owner of a pond who receives such fish does not have to wait for them to grow to spawning size. He is immediately in the fish business, and a few pairs of such fish will soon stock a pond with thousands of young fish. If small fish are delivered, it is necessary to wait for them to grow to spawning size. Personally, if we were stocking a pond, we would much rather have twenty fish of spawning size than two hundred or even five hundred small fish, such as are ordinarily delivered from fish cars.

A greater number of small fish can be delivered, but these small fish run a great many chances before they reach maturity. If there are any old game fish in the bodies of water that are stocked with these small fish many of the young fish may be destroyed before they are large enough to spawn. However, it will be necessary for the Department to deliver fish of different sizes and ages, all the way from an inch in length to perhaps three pounds in weight. It is not always possible to load the car with just the kind of fish that one would like to handle. It will frequently happen that the car will be loaded with such fish as we have at the time and are able to handle most conveniently.

Again, the time of the year is an important factor when it comes to handling certain kinds of fish. Large fish can be moved best in early spring and late in the fall, when the weather and water is comparatively cool. The smaller fish can be handled almost any time.

Do not be afraid to write the Department for fish; write us also concerning your successes and your failures. We will be pleased to hear of your success; but if you have troubles and failures, let us know about them also; we might be able to assist and help you to that extent that you could succeed.

FISH CAR "ANGLER No. 1."

Before the fish car "Angler No. 1" starts for your particular locality with a load of fish you will receive a notification that will read something like the following:

KANSAS STATE FISH HATCHERY, PRATT, KAN.

DEAR SIR—The Kansas State Fish Car will pass through your locality in the near future for the purpose of distributing fish. Parties who expect fish should meet the train at station designated, with clean barrels, milk cans or some vessel in which live fish can be carried. The vessels should be about one-fourth full of pure fresh water. Fish should be taken to streams or ponds as quickly as possible. When long drives are to be made, a large dipper should be carried, to be used in lifting the water from the cans and pouring it back. By holding the dipper two or three feet above the can, a good supply of small air bubbles can be carried into the water for the fish to breathe. Ten gallons of water will serve 100 small fish from three to six hours when thus aerated.

The fish car will be the last or end car on the train. Please locate, with your cans, at the station as nearly as possible where the last or end car would naturally stand when the train stops. Do not wait at the station until the train pulls in and then make a grand rush for the last car, dragging the can at breakneck speed, spilling the water, getting out of breath and upsetting your natural good humor. We will write you later exact date and train to meet. If anything should happen to interfere with train program after we start, we will telegraph the ticket agent at your station of the change and give the exact date and time of train to meet.

Do not cover the cans that contain fish with anything heavier than one thickness of cheesecloth or burlap. Fish must have air and can not live in water that does not have small bubbles of air in it.

It is the purpose of the Department of Game and Fish to furnish brood-stock fish enough to properly stock streams and ponds. The fish when young must be protected and allowed to grow until large enough to spawn. In other words, we furnish the fish for brood-stock purposes, but you must raise the crop. It requires about 100 small fish, or from 20 to 50 large ones, to the acre to properly stock a pond. The number of fish that a pond will support depends largely upon the condition of the water, and especially upon the food supply.

L. L. DYCHE,

State Fish and Game Warden.

After the above notice has been received and read, and you get your mind in proper condition for receiving a consignment of fish, you will receive a card which will read something like the following:

FISH AND GAME DEPARTMENT, PRATT, KAN.

The fish car is coming to.....
(Name of station.) (Date.)

.....
(Name of railroad.)

.....
(Train No.)

.....
(Time of arrival of train.)

It will be the *last or end car* on the train. Meet it at above mentioned station, as per letter of instructions already sent. Locate, with cans one-fourth full of water, back far enough to be opposite the *last car* when it stops. *Be on time*, and at the *right place*, as the car only stops a *few minutes* at each station.

L. L. DYCHE,

State Fish and Game Warden.

This card *must* be presented at the car door to obtain fish.

If you have an application filled out and on file, which reads something like the following—

APPLICATION FOR FISH.

To the State Fish and Game Warden, Pratt, Kansas:

Name of applicant (write plainly).....

Post-office address, Town of....., County of.....

Date of application..... R. F. D. No.....

1. Name of body of water to be stocked.....

2. In what county?..... 2a. Near what P. O. (town)?.....

3. If a stream, give idea of depth and width.....

4. Where does it empty?.....

5. If a lake or pond, give area in acres.....

6. If a lake or pond, give source of water supply.....

7. Give greatest depth of water..... 7a. Is it clear or muddy?.....

8. Is bottom sand, mud or gravel?..... 8a. Does it ever go dry?.....

9. What kind of fish does the water now contain?.....

10. Have fish ever been planted in it before?.....

11. When?..... 11a. What kind?.....

12. Have the planted fish or any others ever been successfully raised in this water?.....

13. Does any substance empty into the water that would pollute it?.....

14. What is the sentiment in the locality in regard to laws for fish protection?

15. Are the laws well enforced?.....

16. Who is your fish and game warden?.....

17. Is his work satisfactory?.....

18. What is your nearest railroad station?.....

19. On what road?.....

20. How often do you receive mail?.....

21. Will you meet the fish car at the railroad station to get fish for the above-described water?.....

22. How long does it take to drive from station to water to be stocked?.....

REMARKS: (Make remarks on other side of this sheet.)

you will be in line to receive a brood stock of fish such as the state is supplying for all the public waters, and for private ponds so far as it is possible to do so.

Interior of the Kansas fish car "Angler," showing living room and office.

Interior of the Kansas fish car "Angler," showing fish tanks.

A REQUEST.

Our request is that you interest yourself in fish and fish culture. We believe that fish enough can eventually be produced in the state of Kansas to make it quite an important factor in the home supply of food products. As we have stated before in this bulletin, the prices of beef and pork and mutton have been going higher and higher for a number of years. We have no information that will lead us to think that such meat products will ever be very much, if any, cheaper. We know of no good reason why the ponds, reservoirs and streams of Kansas can not be made to yield a good supply of fish food.

There is no more healthful or more tasteful food than fresh fish. In this connection we desire to put the emphasis on the word "fresh." The sooner a fish is eaten after it has been taken from the water, and killed, the better it is. Fish should always be killed and bled, and not allowed to die, either in or out of the water. If the fish are allowed to die without being killed and bled, as hundreds of fishermen allow them to do, they lose a good part of their flavor. And if they are dead very long, the flesh soon becomes insipid and even tainted; this is especially true where the fish have not been properly killed, bled and dressed. A fish that dies, either in or out of the water, has no chance to bleed, and consequently all the blood is coagulated in the arteries and veins; this not only helps to spoil the flavor of the fish, but invites early decomposition and decay. If the fish are killed, properly bled, dressed and packed on ice, they can be kept for some length of time. Even then, in three or four days they will lose much of their flavor.

Our experience in keeping fish for a day or two teaches us that the fish should be killed, properly bled, and then wiped dry with a cloth, or with clean grass or leaves. If the fish are to be put on ice, wrap them in paper or put them in a porcelain or granite-ware dish. Do not place the fish in direct contact with the ice. If fish are kept in this way, it will be found that they will retain their flavor much longer than when washed and placed directly on the ice. However, if bloody they may be washed in clear, cool water, which should be allowed to drain from them a few minutes before they are placed on ice or cooked. Some very common and coarse fishes, such as carp, buffalo, redhorse and quillbacks, are better when taken directly from the water, dressed and cooked immediately than many of our most prized fishes that have been kept for several days on ice. Fish should never be frozen, as freezing destroys their flavor.

A FURTHER REQUEST.

The further request is that you continue to interest yourself in this fish business, and that you help the Department of Fish and Game to educate the people in your locality concerning the importance of fish as a food. It is easy to interest a

great many persons in fishing, because most people, especially young people, enjoy fishing where it is possible for them to catch a mess of fish. It is a pleasure and a sport which should not be overlooked in an agricultural state like Kansas. There are thousands and thousands of people in our state who enjoy fishing and like fish. We meet and hear from more or less of these people nearly every day. The general interest in the subject encourages us to do everything we can to make fish more common in our streams and ponds, the fishing better, and the supply of fish for food greater.

To repeat, "a further request" of the Department is that you do all you can to cooperate with us in carrying out these ideas. You can do a great deal of good, if you are successful, by showing other people in your locality how to succeed.

THE FISH LAWS.

The Kansas state fish laws as at present written apply to creeks, streams, rivers and bodies of water connected with such public streams, and not to private ponds. The owners of private ponds can manage them as they see fit and take the fish out of them by any method that may seem advisable.

It is not possible for the legislature to make a law that is satisfactory to all the people in the state, as conditions in different localities are not the same. Every fish and game law seems to be a compromise. It was after much discussion that the fish and game committee of the legislature agreed upon the measures of the present law. This law may be changed by any future legislature.

One of the apparent important provisions of the present law is that it provides that any citizen may obtain a permit from the Fish and Game Warden by putting up a fifty-dollar bond with two sureties, to use a seine with meshes three inches square. This makes it possible during certain seasons of the year for the owners of such seines to catch many of the larger and coarser fish for food. The lawful owner of such a seine can take a number of persons with him to help operate the seine. The idea of a three-inch-mesh seine is that fish weighing from three pounds upwards may be caught. After fish reach this size it is proper that they should be caught and used for food. Many of the larger fish, such as the buffalo and the carp, rarely bite a hook, and when they do they are hard to land. By the use of a seine they can be taken readily and lawfully.

A seine with meshes three inches square makes it possible for the young fish up to three pounds to pass through its meshes, and as most fish spawn at least once by the time they reach the weight of three pounds, this provision of the law guarantees a continual supply of fish in the streams. It seems to us a wise provision of the law that protects the young fish until they can spawn at least once before they can be taken

with any kind of a net or seine. After the fish have reached a size larger than three pounds it seems not only legitimate but advisable to allow them to be caught by use of a seine and used for food.

At first people were inclined to make light of this provision of the law. However, letters received from persons who have used these seines indicate that many owners of such seines are pleased, and they pronounce the law a good one, as it works for the benefit of both the fish and the fisherman. One correspondent writes that the farmers in his locality are pleased with the law. He said that "the farmers do not have time to fish with hook and line, and when they do they seldom catch anything." "This law," he continues, "makes it possible for the farmers to get fish without violating the law."

You can especially help the interests of this Department and your own interests by using your influence, not only for the enactment of good laws for the management of the fish business in the state, but also for their enforcement. It is no easy matter to frame a law that will apply with equal fairness to the different localities of the state. In fact, it can not be done. The present law may be improved, and should be changed as conditions change. We can never have a good supply of fish in our streams if nets and traps are used to catch the small and undersized fish. The experienced and intelligent fishermen of the state are, so far as we know, all agreed that the smaller and younger fish should be left in the streams until they are of a reasonable size before they are taken out. By reasonable size we mean that the different kinds of fish should be left in the ponds and streams until they are large enough and old enough to have spawned at least once before they are taken for food.

In 1911 the legislature passed a law that would prevent the using of all kinds of traps and nets except seines with meshes three inches square. A seine with meshes three inches square will not hold fish, as a rule, that weigh less than three pounds. This was rather a crude way of fixing the law, but it was the best law that the committee on fish and game, coöperating with the warden, could get at the time.

THE HOOK-AND-LINE FISHERMAN.

The present law places no restrictions on the hook-and-line fisherman other than that he can have but one hook on a line. We have fished for a lifetime, and never cared to use any kind of contraption or artificial lure that had more than one hook on it. So far as this Department is concerned, there would be no objection to using more than one hook on a line, if these hooks were used for legitimate fishing and not used as grab hooks for snagging small and undersized fish, or any kind of fish in their winter quarters.

The Fish and Game Committee of the legislature found it a difficult task when it undertook to make a law that would allow hook-and-line fishermen to use a number of hooks on a line and at the same time prevent an arrangement that might be used to snag and grab fish. The committee had an abundance of evidence that a number of hooks could be arranged in a bunch or so strung on a line that fish could easily be snagged or grabbed, especially in the winter time when the water is cold and when fish naturally congregate in schools in certain places in the streams and ponds.

It is possible, with a bunch of hooks properly arranged as a grab, or properly strung on a line, to snag or grab a great number of fish. Some good fishermen reported to the committee that catching fish by this method was a common practice. They further reported that this method of fishing caused more or less fish to be injured to such an extent that they would probably die. So the idea of using one hook on a line was not intended so much to prevent three or four hooks being used legitimately on a line as to prevent bunches of hooks from being used to snag fish where they congregate below dams and in certain favored localities, such as their protected bedding grounds, during the winter season. The law does not prevent the hook-and-line fisherman from using several lines with a single hook on each. This method of fishing is, in our judgment, much more satisfactory, and also more humane. A trotline can be used with twenty-five hooks. The Department recommended that fifty hooks be allowed on a trotline, but the Fish and Game Committee thought twenty-five was enough, under the present condition of the streams, for one fisherman, in connection with the single lines that he might use.

It is our purpose to stock all Kansas waters with good fish, with the idea of making fishing better and fish more plentiful. With the help of the law-abiding citizens who are interested in fish, either for sport or food, we believe that a good supply of fish can be produced in all the streams and ponds in Kansas where fish can live. If you will do your part toward enforcing the laws and creating a sentiment favoring the protection and propagation of fish in your locality, the Department will do everything in its power to assist and encourage you in your work, and will visit your locality as often as possible, and supply you with fish from time to time, for stock purposes, giving you as many as the state can afford and at the same time be fair to other people in other localities.

We would ask you to bear in mind that there are a great many streams and ponds in Kansas, and consequently a very great many localities where the people want fish. However, with the new fish Hatchery which has been completed and is now in operation, we think it will be possible to keep the streams and ponds of the state well stocked with a supply of

good fish, and make hook-and-line fishing good for all persons who may have an opportunity to take a day off now and then for this kind of enjoyment. We know of no more satisfactory or more delightful recreation for an outing party than catching a mess of fish with hooks and lines. We are always wanting and planning "to go a-fishing," and always have a good time when we do go, whether we catch fish or not. However, we have the best time when we catch a mess, and the best of all times when the catch is large enough in size or quantity to show and brag about. We hear a robin singing. Spring is here. Let's go a-fishing.

SPECIAL ARTICLES.

POSSIBILITIES OF AN ACRE FISH POND.

This article was read by the author of this bulletin before the forty-third annual meeting of the American Fisheries Society, in Boston, September 9, 1913. It will be published in the proceedings of that society. We also desire to publish it in this bulletin, believing that by so doing the article will meet with a wider circulation and fall into the hands of those specially interested in pond fish culture.

The work covered by this paper was carried on partly as an experiment and partly for the purpose of raising a good lot of fish for brood-stock purposes, to be used in stocking ponds in the new Hatchery. Another experiment might not come out so well; in fact, this one exceeded our most sanguine expectations. However, it will give an idea of what the possibilities of an acre pond may be under the most favorable circumstances. We really got three or four times as many fish and three or four times as many pounds of fish from the pond as we expected, and we expected a good yield from the pond, inasmuch as we watched it and gave more or less time and attention to caring for it.

Three years ago an acre pond was stocked with several kinds of fish at the Kansas State Fish Hatchery. The exact size of this pond, which is No. 214 in the old series, was one and sixteen one-hundredths (1.16) of an acre when the pond was at standard height, but as the water usually stood a little below standard, the pond was almost an exact acre in size. After the pond was stocked but little attention or care was given to it for a period of three years, other than to see that the water supply was good and that the fish had food, natural or artificial, when they needed it. The pond was stocked as an experiment and with the hope of raising some good brood fish that could be used in the future to stock a then proposed new Fish Hatchery. The pond is nearly circular; however, shape makes but little difference. Near the edge of the pond the water is shallow, but the ground or bottom surface, in a general way, is basin-shaped and gradually slopes to the deepest place, which is about thirty feet from the east shore line. At the bottom of this deepest place, or kettle, there is a drain pipe which is used when it is desirable or necessary to lower the water or drain the pond. When the pond is full of water, or at standard height, it is six feet deep in the deepest place.

This pond has a soft mud bottom, except for a few spots where the ground is rather hard and covered with a little sand and gravel. The water was carried into the pond through two three-inch pipes that connect with other ponds. However, just enough water was allowed to run into the pond to keep it at a certain height. Usually the water stood about five feet deep in the kettle in the summer time and six feet in the winter

time, the idea being to keep the pond supplied with water, but not to have any overflow or waste. There are many ponds in the country that are fed from windmill pumps or from springs or small streams. Under such conditions there is little or no water to spare. When there is an extra supply it is usually needed either for stock or for small garden irrigation, or for both purposes.

VEGETATION IN AND AROUND THE POND.

This acre pond had in previous years been thoroughly stocked with water plants, including various kinds of "mosses," principally *Chara* and one kind of water lily (*Castalia odorata*). There are several patches of these lilies, and we estimated that about one-fifteenth of the surface of the lake was covered with lily pads. The north and east banks above the water line are covered with swamp grass, with a few rushes along the water line. Higher up the bank small willows are growing, and some of them hang over the water. A number of large cottonwood trees stand on the southwest and west shores of the pond. They furnish some shade, but we do not consider them of any particular value in connection with fish production. There are other ponds that do quite as well, and even better, in producing fish, that have no trees around them. We do not advise having trees right up against a pond. A grove of trees should be a little distance from a pond, so as to reduce the number of leaves that would fall and blow into the water. The leaves are of no value to the fish and frequently color the water, and in some instances have been known to damage the water, when the pond was low, to the extent that it was rendered unfit for fish to live in.

STOCKING THE POND.

Three years ago, in the spring of 1910, this pond was stocked with about 10,000 yearling fish that had been raised in it. All the larger fish were removed, together with 20,000 yearlings. The fish that were allowed to remain were Black bass, crappie, Blue-gill sunfish, common Green sunfish, Bullhead catfish, a few Hickory shad, German carp, and about 300 goldfish. Many of them were small and only fit for food for the larger bass. In the fall of 1910, a few months after the above stocking, about a thousand more small fish of various kinds were added to this stock, including 200 Black bass that were from four to six inches long. These bass had been hatched in the spring and were unusually large and fine for their age. They were cannibals, and we put them in this pond because we had no other convenient place for them. We usually distribute such fish, as soon as possible after getting hold of them, in the larger creeks and rivers.

In the spring of 1911 about 1500 two-year-old crappie were added to the stock of this pond. These were a fine lot of fish, and many of them had spawn in them. However, they were the same size and age as the yearling crappie that had been left in the pond in 1910. At this time 2000 Bullhead catfish one and two years of age were added to the stock; also 192 Channel catfish that would weigh from one to two pounds each. The Channel catfish were placed in the pond by mistake, due to a misunderstanding of orders. About one-half of them were caught at the feeding station and removed during the summer and fall of 1912. They did not breed in the pond, at least no young fish were found. We considered it a misfortune to have them in with the other fish, which they continually fed upon. During the spring of 1912 about a thousand more one- and two-year-old fish, a miscellaneous lot, were placed in this pond. They were mostly small fish that we had no particular place or use for. They were thrown into pond No. 4, as it was called, with the idea that they might, for the most part, serve as food for other fish. Altogether, about 15,000 fish were placed in the pond; however, many of them were only considered as food fish for the others.

FOOD FOR THE FISH PRODUCED IN THE POND.

Around the shores of this pond during the spring and summer of the years 1912 and 1913 there were thousands and thousands of young fish to be seen, frequently appearing in clouds or bunches several feet long. Among these young fish we noticed bass, Bluegills, sunfish, carp, goldfish, shad and bullheads. It was very apparent that many of the fish in the pond had spawned and that great numbers of the eggs had hatched. This crop of young fish served for the most part as food for the older and larger fish.

This pond, from the time it was first stocked, was allowed to stand practically undisturbed. Most of the food supply for the fish was produced in the pond. The dense growth of vegetation was not disturbed, except that boats were sometimes run through it to open up channels of water. The *Chara* "moss," lilies and other water plants grew to that extent that the surface of the water during part of the summer months was almost completely covered with vegetable matter; and at times only small patches or lanes of water could be seen. On two or three occasions during the hottest part of the summer the water went down until the deepest basin was not over four or four and one-half feet in depth. This was due to growths of vegetable matter that partly stopped up the water pipes. However, we made it a point to watch the water pipes and keep them open.

TEMPERATURE OF WATER.

The temperature of the surface of the water, taken twelve feet from the shore, where the water was four or five feet deep, during the month of August, at 8 A. M. and 5 P. M., ranged from 70 to 91 degrees Fahrenheit, the usual temperature varying somewhere between 80 and 86. The temperature taken at the bottom of the pond was from one to three degrees lower than at the surface, but never as much as four degrees. The temperature of the air for the same month, taken in the shade at 8 A. M. and 5 P. M., ranged from 70 to 95 degrees Fahrenheit, but on a few occasions was over 100 at some intervening time during the day.

HOW THE FISH WERE FED.

The fish in this pond when fed were given liver, chopped-up fish, corn chop and some small quantities of other kinds of fish material. They were fed from a platform that was built about fourteen feet from the east shore and near the deepest basin in the pond. A board walk led from this platform to the shore. On the platform there was a chopping block, and during the summers of 1911 and 1912 about 500 pounds of liver and 500 or 600 pounds of fish, mostly German carp, were chopped up and fed to the fish. When the chopping began, the fish would appear, the bass first, and then the Channel catfish. The bass would take the first food that was thrown on the water. It was necessary to satisfy them before any of the other fish would have a chance to get any food. The Channel catfish would feed next. The Bluegills and Green sunfish would feed around the edge of the general mass of fish, grabbing and darting away with anything they could get. The bullheads would come last and stay longest, and would take food from the surface of the water. No crappie were ever seen to come near the feeding station. If they fed at all it was so deep under the water that they could not be seen. About 200 pounds of corn chop were thrown in on the feeding grounds and perhaps as much as fifty pounds of kafir corn. The catfish, carp and goldfish took most of this. However, the Bluegills and sunfish took some of it. When bread was thrown in, the goldfish, carp and bullheads and Bluegills would take it.

REMOVING THE FISH FROM THE POND.

About the middle of April, 1913, we began to lower the water in this pond. From April 25 to April 30 the fish were removed and placed in other ponds. Most of the fish were used to stock the ponds of the new Hatchery. After the water had been lowered, the large fish were rounded up by the use of seines with meshes one inch square. Minnow seines were used to capture the small fish. The fish were removed from the water to the tubs and transfer tanks by the use of hand nets ranging in size from eight to twenty inches in diameter. A

stream of fresh water was allowed to run through the pond until all the fish were removed. This prevented the water from getting so muddy that it would injure the fish.

SIZE AND WEIGHT OF FISH TAKEN FROM THE ACRE POND FROM APRIL 26 TO APRIL 30.

The fish were removed by the use of seines and hand nets.

No. specimens.	KIND AND SIZE OF FISH.	Total pounds.
280	Black bass (large), 2½ lbs. each.....	700
310	Black bass (one and two years old), 1 lb. each.....	310
95	Channel catfish (large), 4 lbs. each.....	380
1,986	Bullheads (large), 1 lb. each.....	1,986
630	Bullheads (yearlings and two-year-olds), 8 to 1 pound...	79
350	Crappie, dark (calico bass), 1¾ lbs. each.....	612½
500	Crappie (one and two years old), not estimated.	
1,490	Bluegills (large), ½ lb. each.....	745
1,100	Bluegills (two years old), 6 to 1 pound.....	183
650	Goldfish (large), 1½ lbs. each.....	975
	Goldfish (young), very few.	
27	Carp (large), 6 lbs. each.....	162
	Carp (young), very few.	
103	Hickory shad (large), 1½ lbs. each.....	154½
227	Hickory shad (two and three years old), ½ lb. each....	123
700	Green sunfish (large), 3 to 1 pound.....	233
1,000	Green sunfish, 6 to 1 pound.....	156
5,000	Green sunfish (one and two years old), not estimated.	
12,000	Bass, crappie and Bluegills (yearlings), not estimated.	

Total number of pounds of fish taken out of pond.... 6,780

Total number of fish taken out of pond, 26,448.

The above list is about as nearly correct as it could be made, under the circumstances. Mr. O. C. LeSuer, superintendent of the Fish Hatchery, had charge of the work of removing the fish, and kept the records. We could not weigh all the fish, but fish of a certain size and length could be measured and weighed. There were two Large-mouthed Black bass that were over twenty-two inches in length, and each weighed a fraction over six pounds. They were females and heavy with spawn. There were many crappie that would weigh over two pounds, and bullheads that weighed over two pounds. The carp would weigh from five to twelve pounds. There were many Channel catfish that weighed from four to eight pounds.

There were 1986 large bullheads, but only a very few yearlings and two-year-olds, 630 all told. There were only 350 large crappie, though 1500 fine two-year-old specimens were put in the pond in the spring of 1911. They were undoubtedly devoured by the larger bass and Channel catfish. Only a few one- and two-year-old specimens were found. There were 1490 large Bluegills, and only a few young fish; 650 large goldfish, and almost no young; 27 large carp, and less than 100 young fish. There were many more young of the Green sunfish, and of Bluegill sunfish in the pond than of any other variety, or of all others combined.

While the Channel catfish were being handled, in the transfer tanks, they would spit up fish that they had swallowed. Sunfish, Bluegills, crappie, goldfish and gizzard shad were most common among the ejected fish. The ejected fish would range in size from one ounce to one-half pound each. The bullheads spit up the same varieties of fish, but of course the average size of the specimens was smaller.

About 16,000 young fish were placed in the pond (as counted). About 27,000 of all ages and sizes were taken out. Estimated weight of fish placed in pond, not to exceed 700 pounds. Estimated weight of fish removed from pond, 6780 pounds. This did not include many of the small fish.

The total number of fish that weighed one pound or over was 3801, and their total weight was 4279 pounds. Black bass, crappie and catfish made up 3088 pounds of this weight.

There were 978 pounds of Bluegill and Green sunfish that averaged one-third pound each, making, in all, 5257 pounds of good food fish, and about 1500 pounds of carp, goldfish and gizzard shad.

Amount of food fed to the fish:

500 pounds chopped-up liver and meat.

600 pounds chopped-up fish (mostly German carp).

200 pounds corn chop.

50 pounds kafir corn.

50 pounds miscellaneous stuff (bread and table scraps).

THE PRIVATE FISH POND.

A Neglected Resource, by C. H. TOWNSEND.

This article on "The Private Fish Pond" was read by Mr. Townsend before the American Fisheries Society in Boston, September 9, 1913. It will be published in the proceedings of that society. Mr. Townsend, connected with the United States Fisheries for years, is now director of the New York Aquarium, and was president of the American Fisheries Society when this article was read. His wide experience and great knowledge of the fish business in general lends a special value to his article on "The Private Fish Pond." We are glad we are able to produce this article with the consent of the author in this bulletin, believing that it will be of much interest and value to its readers.

The possibilities of small fish ponds as sources of food for the people have received little consideration in this country, and the actual breeding and maturing of fishes in such ponds is an art which we have yet to put in practice. While certain foreign countries have long profited by the art of private fish culture, and have furnished notable examples, our own facilities for this industry have been neglected. It is probable that our resources in this respect are greater than those of other countries, as the United States already lays claim to the most extensive fish cultural operations carried on in the world, and nowhere is there so large a body of professional fish culturists

as that connected with our national and state fishery commissions.

In these times when the value of running streams for water power is being widely considered, the possessors of brooks, springs, and small lakes should be awakened to the value of their home resources for water farming. At a former meeting of this society I had the privilege of describing at considerable length approved methods for the construction and care of small fish ponds.* The matter is recorded in the printed transactions of the society, and it is unnecessary at the present time to reconsider the methods of pond management, but it is always desirable to keep the subject of private fish culture before the public.

It is gratifying to note that trout culture in the hands of the private citizen is making some progress in Massachusetts and adjacent states and the advertisements of successful trout raisers may to-day be found in American journals devoted to fish and game. Trout culture is, however, a branch of the work which requires special conditions, such as purity of water, comparatively low temperature, the construction of buildings and artificial fertilization. The possibilities for the private or commercial culture of many other kinds of fishes, which are more widely distributed than the trouts and can be cultivated by simpler methods, should receive serious consideration. North America is abundantly supplied with hardy fishes which are available for this purpose. There are no serious difficulties in the way of obtaining them for breeding, and under cultivation they would yield a food supply which would supplement to an important degree that derived from the public fisheries.

In Europe the cultivation of carp is carried on extensively. This fish is now abundant in American waters, and while not comparable to many of our native species, has already contributed annually many millions of pounds to our market supply. Despised by many, it is nevertheless marketed more profitably each year in most of our large cities, and there is no doubt that the carp is destined to supply a considerable amount of our fish food. The methods of carp culture as practiced in Europe have been frequently published in this country and are available for use. It is unquestionably the easiest of all fishes to raise, and it is only necessary to turn to the weekly New York market reports for assurance as to its money value and extensive use. But it is our native fishes which I wish to consider especially in this connection, as many of them have been proved available for cultivation and are more acceptable as food to our people than the carp. Among them may be men-

* Transactions of the American Fisheries Society, 1907, "The Cultivation of Fishes in Small Ponds," by C. H. Townsend, pp. 128-139. (NOTE. For sale at the Aquarium, New York; pamphlet, 25 cents.)

tioned the various species of basses, perches, sunfishes and catfishes, which are well distributed in our eastern states, and there are other species inhabiting our western and southern states which are also available for pond culture.

My connection with a public aquarium has brought me into correspondence with many persons who have desired to undertake the raising of fishes, but whose efforts have been limited to the mere stocking of natural ponds. Comparatively few have realized the necessity of proper equipment and actual cultivation, which involves the complete control of the water and of the fishes contained therein. Very little can be accomplished with a single natural pond; it is necessary to have several artificial ponds which can be readily controlled, while the various operations of pond culture require frequent attention and considerable actual labor.

The requirements for the successful management of several kinds of pond fishes have already been worked out at public fish hatcheries and there is more or less official information on the subject. It is not necessary at present to give instances where success has been achieved; my object, as already stated, is to keep before the public the fact that success in private fish culture is possible and that considerable fish food may be produced with the same amount of labor and intelligent effort that is necessary for the raising of fowls. There has been much agitation over the high cost of living, and it is time to consider what the individual citizen can do in the way of assisting in the production of fish food.

In some of the countries of central Europe the cultivation of fishes in private waters has been going on for centuries. In Austria and Germany fish farming, as it is often called, is a common industry. While it is much practiced by small landowners, there are many large estates which maintain hundreds of ponds in active cultivation. Much of this private fish culture is based on the various forms of the carp, but other European fishes are also cultivated for sale, such as the tench, ide, rudd, bream, perch and pike. Some European fish culturists are now raising American basses and perches. There are many villages in Austria where fish ponds are maintained at the expense of the community. In view of these facts, it is remarkable that immigrants from Europe have neglected to practice their ancient art of pond culture in this country.

Aside from commercial trout raising, which is practiced to a limited extent, we have nothing of such pond culture in America. Our numerous fish hatcheries, maintained under the direction of state commissions, are devoted almost entirely to the stocking of public waters with young fishes. Very little of the product is reared to maturity and none of it is sent to market direct. If our fish culturists could be commanded to

bring their annual yield of fry to maturity, and deliver it to the market, they would be at a loss how to proceed; we are really not fish raisers, but producers of fry. At that stage our efforts cease. The rest is left to nature and negligently cast into waters that we imperfectly protect and utterly neglect to keep pure. While our achievements in public fish hatching are notable, private fish culture has made no headway. A few of our state commissions are making efforts in pond culture for the benefit of farming communities, notably in Kansas, and it will be interesting to observe what progress can be made. Perhaps the vast natural yield from our coast, lake and river fisheries is responsible for the lack of private effort.

Our fish supply in general is large and well distributed, but we could consume a much greater supply, especially in view of the fact that in some sections the natural supply is being depleted by over-fishing and the pollution of waters. There are many sections of the country inadequately supplied with fish food, which could be produced locally by pond cultivation, and such supplies would find convenient home markets.

It is possible for the private citizen to obtain pond fishes for breeding purposes, but he needs assistance and direction. Object lessons on approved methods of fish culture could be obtained by visiting public hatcheries, but this he is not likely to undertake. It would be advantageous to the country if state fish commissions generally could supply the coarser fishes for cultivation in private waters, and furnish the public free information as to the methods to be followed.

We should not rest content with the mere fact that such information exists in public documents. The editions of state documents are neither large nor well distributed and rural population may remain unaware that useful fishery information may be had for the asking. State fish commissions should not only prepare inexpensive pamphlets on the cultivation of common fishes, but see that they reach many communities and be announced and reviewed by the rural press everywhere. Model ponds distributed about the state for demonstrative work would of course be educational, like agricultural colleges and state experiment farms. I am not prepared to set forth the best means of doing this work; perhaps no two states would undertake it the same way.

I am convinced that some of the energy put into the production of fry is misdirected. The output is amazing; 6000 million last year by the National Bureau and perhaps as much more by the states. Practically all of it is hurried into the nearest river and none of it raised. We are all doing about the same thing and have settled into the rut of fish hatching in hatchery buildings. No one is doing anything new except as connected with the competition for increased output.

Having practiced these wholesale methods for two or three decades, let us now consider whether we might not profit by a little less fish hatching and a little more fish raising. Does salvation lie only in a multiplicity of expensive federal and state hatcheries? If our fishery establishments were equipped to raise and market one per cent of the fry now being hatched and liberated, might not the quantity of food thus produced exceed that which eventually reaches market by way of the public waters. Let us simplify our art and teach it to the people, for they can surely help in the production of fish food.

FISH AND FISH CULTURE ON THE FARM.

The following article, contributed by Major W. L. Brown, of Kingman, Kan., speaks for itself. Major Brown has been raising fish for years, in his farm ponds, and speaks from a knowledge gained by experience. He has built ponds and raised a good supply of fish; he is willing to "stand right up in meetin'" and testify to the fact that with him the business has been a success, looked at from the standpoint of both pleasure and profit; and being convinced that it is a good thing, he does not hesitate to say to others, "Go and do likewise."

"Write an article," says Professor Dyche, "for the bulletin, giving your experience in fish culture and your ideas of the benefits derived from being the possessor of ponds well stocked with fish."

Like a good soldier, I will comply with the request, but am aware of the fact that I probably will get in deep water with the professor, in regard to minor matters, such as the proper tone a bullfrog's voice should be pitched, and the wrangle, as old as the Darwinian theory, as to the value of the carp as a food fish.

Leaving out those two matters, which might cause the discussion, I will simply say that in my opinion there is no branch of our state government that is doing more, not only for the present generation, but for the generations yet to come, than is the Fish Hatchery, in its development of the fish interests of the state, and in its distributions of the finny tribe that it is making, one of whose recipients I have been.

No man should make an assertion unless he can back it up with proof. Hence my plea for the fish pond, well stocked, is based on several tenable reasons. First, I am a great believer in irrigation in Kansas, which belief has been emphasized by the season of 1913, and am satisfied, from the attitude of our people, that in a very few years there will be hundreds of thousands of acres of land irrigated, especially in the localities known as the shallow-water districts.

In my judgment, in order to get the best results from irrigation it is necessary to have a reservoir where the water can be stored and tempered by the elements, and where a larger head can be secured than by direct pumping. Granted that

my theory is correct, you have the fish pond. How to make it has been well told by Professor Dyche in a former bulletin. I followed his directions, and now have four large ponds. It is true my ponds are fed by springs. Yet it is also true that my neighbors and friends who have engines for hoisting water, or even the pioneer windmill, could have ponds nearly or equally as good as mine, if they would only build the reservoir. From my personal knowledge I know that enough water has been wasted by running down the ditches and ravines from the windmills of Kansas during the past season, had it been properly stored and conserved, to have not only made it possible to irrigate the home garden, but also to have raised an abundance of fish.

No man in country or city, when he turns back the well-thumbed pages of memory, can find an incident in his life—not even the sensation produced by his first pair of red-topped boots—that filled his heart with more pride and pleasure than the landing of his first fish.

I further assert that in this day and age of the world, when we are trying to keep the boys and girls on the farm, there is nothing that will come nearer bringing the desired result than the possibilities of a good fish pond. Many of you who read this article may have passed the three-score-year mark, yet you will admit that when you, as a boy, were given the privilege of going to town, and perhaps loafing around, you preferred staying at home, provided you could go fishing. Hence the first plea I make for a well-stocked pond is in the interest of the boys, especially of Kansas. This may be sentiment, but I have no fears; it will appeal to every man whose mind will go back to his boyhood days.

Second, as an economic proposition. Located as many are on the farms of Kansas where it is not possible to get fresh meat except on rare occasions, the old diet of salt pork, so much prized in pioneer days, becomes monotonous, and should give way many times during the year for a luxury that can be so easily produced on the farm. When we come to consider the pleasure and sport that one receives in procuring this fish delicacy for the table, and its wholesomeness and healthfulness, it has more of value than can be figured or estimated in dollars and cents.

We desire to add, what you all know, that we are living in a day of high cost of the necessities of life. We believe that a well-managed fish pond can be made to do much to lighten this burden. I will now proceed to give you some of my own experience in successfully raising fish.

Some one at sometime has said there is a great deal in a name, and hence when you read natural history or the effusion of some learned professor of fish culture you are attracted by the names. Let me say, first, do not despise the humble bullhead on account of its common name, especially the Yellow

cat, which belongs to the bullhead family, and which I have successfully raised in a short time to the weight of two and two and a half pounds.

No doubt many of you have cracked a smile when you have read of corn for the catfish, but your bullhead enjoys a feed of corn, wheat or other grain fully as well as your hogs and cattle. He will thrive upon the diet, and will soon learn, when feeding time arrives, to be at the proper place to receive his rations.

Next, do not overlook the sunfish. Like the bullheads, they are very prolific, and though small are really a good farm fish for the table. The catching of a mess will furnish your grandchildren excellent sport; the young of these fish furnish a very large per cent of the food for other and larger fish.

Another fish which has given me great satisfaction is the Channel catfish. I take them from a stream when they are two or three inches long, and place them in a pond. In a short time they are large enough for the skillet. In little better than two years I have caught them out of my ponds that weighed five pounds.

Now I desire to say a word about the kinds that the Hatchery distributes. My choice of all for the small farm pond is the bullhead and the Bluegill sunfish. The latter is not only very prolific and a rapid grower, but is among the gamiest of the small game fishes. Next, the crappie; and last, the Black bass.

A word in regard to this favorite of the Kansas sportsman, by one who appreciates his gameness, his splendid table qualities, and his general beauty. However, there is a reverse side to the good showing of the picture when you come to study the life history of this fish. I would not put bass in a small pond and expect to get many fish of any other kind out of it. These fish not only devour all the other fish in the pond that it is possible for them to swallow, but turn cannibals and eat up each other. If the people of Kansas had appetites according to their size as has the Black bass, a hundred-million-bushel wheat crop would be consumed at home in six months. I am not making this assertion from what I have heard people say, but from my actual experience in raising this fish in my farm ponds. I have paid for that experience, not alone along the Black bass route, but in trying to raise fish which were not adapted to our waters.

Fourteen thousand Rainbow trout were placed in my ponds two years ago. So far as I know, there is not one to be found to-day. I have found out by experience that they are not adapted to Kansas waters. A thousand Yellow perch were planted in my ponds, and there may be a few left, but they are not a fish for Kansas waters. Hence my experience and belief is, that in stocking Kansas ponds you should use native Kansas fish, and not spend time experimenting with fancy varieties

not adapted to our climate and conditions. I believe that all of you will agree with me that the fish I have enumerated, and which I am raising successfully, are good enough for even an epicure's table, and, in addition, they are gamey enough to satisfy the desires of the most ardent angler.

This article would be too long were I to go into my personal ideas regarding fish culture. As a member of the legislature, I have supported all the measures for the development of a Fish Hatchery, which to-day makes it possible to restock the streams and ponds of Kansas.

Every man, it is said, is more or less cranky on some subject, and one of my subjects is irrigation and fish culture. It has been said that "the man who causes two blades of grass to grow where but one grew before is a benefactor of his race." Agreed. But I also believe that the man is a greater benefactor, and is worthy of consideration, who stocks the streams and ponds of Kansas with good native varieties of fish, and thus makes it possible to add millions of pounds of good, wholesome fresh fish food to our now too limited diet, especially on the farm.

To sum up my experience, I would like to say that I have never made an investment that has given me more pleasure and profit than my fish ponds. The investment was a small one. During the fall and winter, when the teams on the farm were not very busy and labor was plentiful and cheap, the ponds were built without any outlay worth speaking of.

If there is anything I enjoy more than another it is to take the grandchildren and go and sit on the banks of the ponds, watch the cork bobble, and pull out the fish. Under such circumstances one can easily imagine that time has rolled backward and that once more he is a barefooted boy with cheeks of tan, fishing in the old swimming hole and having the real time of his life.

A visit to the Hatchery will convince the most skeptical that the state, under the direction of Professor Dyche, is able to take care of all who apply for fish for ponds and the restocking of the streams. The fish raised at the Hatchery belong to all the people of Kansas. I hope that the farmers especially will build ponds and will avail themselves of the opportunity of getting these fish to properly stock them. If they will do it I am sure that later on they will become as enthusiastic as I am over the results. They will find that it will pay not only from the standpoint of pleasure and profit and good living and the entertainment of friends, but also from the standpoint of interesting the boys in farm life and making the old farm home, with its surroundings, more satisfactory, more interesting, and the best place on earth to live.

WATER-STORAGE POSSIBILITIES AND SOIL FERTILITY.

INTRODUCTORY NOTE.

During the past few years the Department of Fish and Game has given considerable time and study to the water supply and to the water conditions of the state of Kansas, having in view primarily the idea of increasing and improving the water acreage of the state, and of stocking the ponds, lakes and streams with food and game fishes. This finally led to the publication of the present bulletin on "Ponds," "Pond Fish," and "Pond Fish Culture."

While collecting information and getting material together for the bulletin, a number of things had to be considered and investigated. One of the principal ones was the water-storage possibilities of the state. This involved a study of the rainfall, the run-off water, the streams, the leaching of the soil, erosion, and soil fertility.

The article that follows was prepared for and read before the fortieth annual meeting of the Kansas Board of Agriculture, by the author of this bulletin. The article is published here because its contents are closely allied to the subject matter of the bulletin, and because we have had many requests for this special article. We hope it may be of some value to its readers.

NATURAL RESOURCES.

Water is a natural resource and, in Kansas, as essential to life as the light and heat of the sun. The general need of water for agriculture and domestic purposes is universally recognized; this need gradually increases with the growth and development of a country. While the land area and natural water supply of any country or locality remain practically constant, yet it is a proposition easy to demonstrate that the demands made upon both constantly increase with the growth and development of civilized ideas in any community. While it is true that the stock of water received directly from rain and snow, for any given country or locality, remains constant for given periods of time, it is also true that man, in his development of the country, makes many special uses of water, decreasing or augmenting the local supply, and making it solve or help solve many problems in the interest of mankind.

Good sunshine, good air, good soil and good water may be considered four of the most important things in the world, and they may also be considered the four primary natural resources that constitute the only foundation upon which a good country, with good institutions, controlled by good citizens, living in good homes, can be founded.

In a known acreage of fertile land, with a definite supply of water, a vast heritage has come to us from nature; do not the laws of nature and humanity make it incumbent upon us to determine its possibilities by intelligent forethought and scientific investigation? In taking charge of this heritage, should

we not remember that it was not intended for this generation alone, but for the generations that are to come as well; should we not take thought in this matter, lest by our improvidence we commit sins that will be visited upon our children for many generations to come?

In the general treatment of this subject we desire to base our conclusion upon facts ascertained by investigation, so far as it is possible to do so; in some cases where scientific work and investigation has not been carried on extensively it has been necessary to draw conclusions based upon our knowledge of conditions as we found them.

KANSAS WATER SUPPLY.

Almost the sole source of water supply for the state of Kansas comes from the snow and rain that fall on the prairies and woodlands of our own state. The Arkansas and Republican rivers are the only streams of any size that bring waters from other states within our borders, and the amount actually received from these sources is comparatively small.

SOURCE AND DISPOSITION OF WATER SUPPLY.

Using as data a number of calculations that have been made, based upon the best information obtainable, of a rainfall that is well known over an area drained by certain well-known rivers and the amount of water discharged by these rivers, we have roughly calculated that about two-sixths, or one-third, of the water that falls on Kansas soil is carried out of the state by creeks and rivers; about one-sixth is directly evaporated within a few days after it falls, either from surface water or from water-soaked soils; and about three-sixths, or one-half, soaks into the earth, to be given up more slowly for the continuous growth of vegetation and for the supplying of the deeper strata of earth and rocks. It is from this latter source that springs and wells draw their supply of water.

NATURE'S METHODS.

By carefully studying nature's water system and the laws by which it is governed man has not only been able to make many special uses of the system, but has adapted it to his purposes in developing many human interests and industries. Man as an agriculturist soon learned that when the soil was properly loosened up and cultivated it would hold more moisture and give it up more slowly, two things essential to a good growth of vegetation, and when considered together constitute the basis of a good agricultural system. This idea, when properly developed and put into execution, will give a system of agriculture that would conserve much of the water that was formerly not only allowed to evaporate rapidly, but to run off the lands in their uncultivated condition.

It is one of the objects of this paper to show how much of the rainfall and snowfall water that now runs out of the country can be retained in ponds, lakes and reservoirs and be used afterward for various purposes at times when most needed. While collecting material for the bulletin before mentioned it was necessary for the writer to study water conditions in the state, giving attention to the subject of water in creeks, lakes, rivers and ponds, and especial attention to the water-storage possibilities of artificial ponds. Different parts of the state were visited in order that all the information available on the subject might be collected directly from the owners and builders of ponds; every published article on ponds and kindred subjects that could be gotten hold of was read and considered. From this study of ponds we learned a number of things; and the one thing that especially impressed us was that every owner of a pond, with few exceptions, was not only enthusiastic about its use and value, but was, as a rule, either figuring on improving it by making it larger and better or was planning to build more ponds.

Our primary interest in the study of ponds was their value and adaptability for fish-culture purposes. However, we find that ponds may have a permanent value, not only to their individual owners, but to a people and a country, aside from their ability to produce fish, which in itself would make them paying propositions.

In the preparation of Part I of the bulletin before mentioned we had occasion to consider the possibilities of water conservation by storage in artificial ponds on farms and ranches, not taking into account, however, what might be done by the building of large reservoirs for general storage, for irrigation and other purposes. After examining a number of ponds on ranches and farms that were considered not only valuable by their owners, but an almost indispensable part of the farm or ranch, we made some calculations as regards the water-storage possibilities of ponds and lakes that might be constructed on farms and ranches in the state.

A POND ON EVERY FARM.

If there were a pond or a lake of the average size of an acre on each square mile or section of land in the state of Kansas, it would amount to 82,144 acres of water. If there were a pond or a lake of the average size of an acre on each quarter section it would amount to 328,576 acres of water. If there were, on the average, an acre pond on each forty-acre tract of land in the state it would in the aggregate amount to 1,314,302 acres of water, or an average of four acres of water for each quarter section of land—enough water to cover 2000 sections or over 8000 quarter sections of land. In surface area this water, if combined in one body, would be equal to a lake 400 miles long

and over five miles wide—a body of water large enough to reach across the state from east to west; a body of water with a surface area five times as large as that of the Dead Sea and as large as Great Salt Lake. By figuring the volume of water that one acre would conserve at an average depth of three feet, which would amount to 130,680 cubic feet, it is easy to estimate the quantity of water—157,270,400,000 cubic feet, or about one-twentieth of the rainfall of the entire state for one year—that it would be possible to hold in the state if ponds of the average size of one acre could be conserved on each forty-acre tract of land. This amount of water would just about equal a rainfall of one inch over the entire state. Of course there can not be an acre pond on each 40 acres or on each 160 acres, yet it does not seem unreasonable to consider this proportion as among the possibilities of the future development of parts of the state, particularly in the central and western areas, where the contour of the gradually sloping land makes it possible to build ponds and reservoirs for holding surface water at no great expense, and that too in a section of the state where the soil is very rich and productive and where the influence of permanent sheets of water would be to the advantage of the country in various ways.

If such an amount of water could be stored in ponds and reservoirs it would undoubtedly, in connection with the planting of trees and the cultivation of the soil, do a great deal to modify and regulate both flood and general water conditions. The evaporation from these bodies of water would surely exert a more or less beneficial influence on atmospheric and climatic conditions in general, and the amount thus stored and evaporated would equal from one-sixth to one-third of the amount annually carried out of the state by the Kansas river.

ADVANTAGES OF A FARM POND.

These small lakes and ponds would be of value in a number of ways to the farmer, who, in a new country, is not only an agriculturist but frequently a horticulturist and stock raiser as well. Groves of both forest and fruit-bearing trees might be planted around them. These would serve various purposes, and while serving as windbreaks and furnishing shade, would grow into trees that would produce wood, posts, and even lumber. Groves around bodies of water always attract flocks of song and insect-eating birds. Many of these birds would remain throughout the summer season, not only enlivening the spot with their songs and bright plumage, but also rearing their young and waging a perpetual warfare on the injurious insects of the neighborhood.

Again, these ponds could be made to supply the stock of the farm with water; and in many places where the water supply was sufficient could be used to irrigate gardens, berry patches,

and orchards. The shady groves about the ponds where song birds live and where the wild flowers bloom, might be made a source of much pleasure for family gatherings and neighborhood picnics. If the pond or lake were an acre or more in size, there might be an ice house near the shore where a supply of ice sufficient to last through the summer season could be put up at a small expense. A boat could be kept on the water, and a small building might be constructed in a grove near the shore, where the boat and such articles as fishing tackle, bathing suits, skates, etc., could be housed for protection and safe-keeping. Such an arrangement of things would add much to the interest, enjoyment and value of everyday life on the farm and help materially to solve the problem that we are all trying to work out.

With such a system of ponds and with the streams cleaned, improved and put in good condition for sanitary, industrial and economic purposes, the fish products of the state might become of great value, and the benefits realized from the conservation of water could hardly be measured in dollars and cents.

HIGH PRICE OF MEATS AND THE VALUE OF FISH FLESH AS A FOOD PRODUCT.

Why should we be concerned about water conservation and food products? Because the present high prices that all the staple kinds of meat products command make it necessary for the great mass of the people to look not only for a cheaper meat food, but for more economic methods of producing it than have heretofore been devised. Even now men who are working for a wage of from \$1.35 to \$2 per day and who have families to support, can scarce afford to eat beef, pork or mutton once a day. It takes the best of grass and hay and the best of grains to produce good meats, and as the amount of land capable of producing the best of food materials is limited, and as the number of people is constantly increasing, there is little hope that good meat products will ever be much, if any, cheaper. Many people, and we might say the mass of the people, must have something that will in a measure take the place of, or at least answer in part as a substitute for, high-priced beef, pork and mutton. The possibility and value of fish as a good and wholesome food product for the people of Kansas should receive more serious consideration than has heretofore been given to it. If each family in the state could have fish on an average of once a week, it would not only be a most pleasing and satisfactory change in the regular bill of fare, but it would be an item of large economic importance. As there are over 300,000 families in the state, it would mean that over 300,000 messes of fish would be consumed each week. The value of the fish thus consumed, allowing an average of twenty-

five cents, or about one-half of its actual value, for the mess of fish consumed by each family each week, would amount to \$75,000 for one week, and 52 times \$75,000 or \$3,900,000 for one year. If fish were eaten twice a week, the value of the amount consumed would be \$7,800,000 per year. And if the fish were placed at their true value the amount consumed would be worth more than ten million dollars. The above figures are only suggestive, but furnish some idea of what might be done in localities where fish can be raised.

WITH STREAMS IMPROVED AND PONDS CONSTRUCTED.

Is it not possible, in connection with the future development of Kansas, to bring about results in many parts of the state as great as those indicated, by improving our natural streams and ponds for fish-culture purposes, and more especially by the building of artificial ponds and reservoirs adapted for the rearing of food fishes? At the present time our rivers, streams and creeks are much abused. Little or no care is given to them, and it is a most lamentable fact that many of them are used for sewage purposes. At present all kinds of filth is either thrown into the streams or allowed unheeded to run into them.

ROBBING OUR OWN FIELDS.

As a people we are skimming the cream from our fields, taking all we can get in corn, wheat and alfalfa, and returning almost nothing to the soil. The time will come when it will be necessary to put fertilizer on what are now known as the most productive soils; the time will come when all the sewage and garbage that is now being poured into the streams will be badly needed as fertilizer for the impoverished farm lands; the time will come when every stream in the state will be badly needed for water supply and fish-culture purposes; the time will come when it will be unlawful to pollute any public stream with sewage and garbage; the time will come, and ought to be here now, when the wastage, sewage and garbage that now go into streams will be converted into a fertilizer that will be indispensable for the production of crops. The ponds and streams of the state, instead of being foul mudholes and sewer channels, bearing all kinds of disease germs, should and will be improved and made to become a source of pleasure and great profit.

A FISH POND ON EVERY FARM.

In order to give some idea of the value of a small pond to a farmer, especially in central and western Kansas, we desire to give a brief account of one described on page 32 of the bulletin before mentioned as "The Sam Bailey Pond." Mr. Samuel Bailey lives on the uplands north of the valley of the Ninnescah, one-half mile northeast of the State Fish Hatchery grounds. He has built a pond almost on a hilltop, and its sole

supply of water is from a well. We have visited this pond a number of times, and have given it more than usual attention. It is such a complete success, considering the purpose for which it was constructed, that we desire to give special account of it, believing that the information may be of value to many persons who may be in position to build small ponds for irrigating, fish and other purposes. This pond covers an area of less than one-fourth of an acre, and is circular in shape. It was built by Mr. Bailey at an expense, allowing fair wages for labor, not to exceed a cost of \$25, or from five to seven days' work for a man with a good team, plow and scraper. Of course, this does not include the cost of a good pump and windmill, which were installed at a cost of \$95, making a total of \$120. The windmill that supplies the water for this pond works a pump with an eight-inch stroke in a tubular well with a three-inch casing and a two-inch point. The water is lifted thirty-five feet, from a well that is seventy feet deep. The water in the well usually stands within about thirty-two feet of the surface. For five years Mr. Bailey has irrigated a three- or four-acre garden patch from this pond. The water supply seems to be ample, for during a considerable portion of the time, even during a hot, dry summer like the past one (1910), the pond was full of water, and the mill was running only a part of the time. Unfortunately, Mr. Bailey has not kept an exact account of the amount of garden stuff raised and sold, and its value. This spring, from March 28 to May 18, he sold over \$100 worth of rhubarb from a patch of five rows, each 230 feet in length, and only a part of the crop was marketed. Better and finer rhubarb we have never seen anywhere. The hills were from twelve to twenty inches in diameter, and contained when examined from fifteen to forty good stalks each. Mr. Bailey gave us a half dozen stalks pulled from one of the first hills we came to. One of the stalks, stripped of its elephant-ear leaf, weighed fourteen ounces. There were other stalks in the patch that would undoubtedly have weighed a pound or more.

A bed of asparagus, three times as large as the rhubarb patch, furnished an abundance of one of the best early vegetables that can be grown in any country, both for private table use and for the market.

In this garden we saw sweet potatoes growing at their best. Mr. Bailey dug a hill for us September 2 that contained fifteen potatoes; another hill dug a week later contained twenty-one potatoes that weighed eleven pounds; and one hill, dug about the middle of October, contained thirty potatoes—a third of a bushel—that weighed eighteen pounds.

Grapevines, berry patches, and fruit trees that had been planted around the edge of the garden in order that they too might be irrigated when water could be spared, were all doing well.

Judging from Mr. Bailey's experience with his garden, and his own estimates of its money value, it is reasonable to suppose that such an irrigated garden patch would easily make returns of from three to five hundred dollars per year, if properly cared for, besides furnishing an abundance of fresh vegetables and fruits for family use. Mr. Bailey says that it takes some time to care for the pond and garden. Admitting that it does take some time, it surely pays to have one of the best vegetable gardens in the country, and that, too, in a locality where little or no garden stuff can be raised without irrigation. Such a garden is possible for any one who can secure a good well near a piece of fertile ground that has grade sufficient to admit of irrigation.

Mr. Bailey has recently stocked his pond with crappie and Bull-pout catfish, two of the best varieties of pond fish in the country. They are doing well, as several schools of hundreds of the young fish have been seen feeding near the shore.

We believe that we speak advisedly when we say that the products raised this year on Mr. Bailey's small irrigated garden patch would have sold, if placed on the market, for more money than was received for the crops he raised on some of the near-by eighty-acre tracts of land that were farmed in the usual manner, or, in fact, almost any eighty-acre farm in the adjoining country that was not sown to either wheat or alfalfa.

EVAPORATION OF RUN-OFF WATERS.

We have already called attention to the fact that in the storing of these small bodies of water the state at large would derive many advantages in addition to those directly enjoyed by the individual owners of the ponds. The amount of water evaporated from these ponds would probably equal or exceed the amount that was stored each year, and the amount that would naturally be carried out of the country during flood-water periods would be diminished by this amount. Heavy rainstorms cause the water to flow freely over sloping grounds; this water is collected by hundreds of small rivulets that unite to form creeks and rivers. These creeks and rivers carry thousands of tons of rich soil that have been eroded from the fields, as well as a great amount of rich fertilizing material that has been leached from the soils by the water soaking through them. By storing flood and storm waters in ponds and reservoirs, not only would flood conditions be reduced, but much of the soil erosion and leaching which damage the country beyond all reasonable calculation could be prevented. All material washing into the ponds could from time to time be restored to the fields by draining and cleaning the pond basins.

FLOOD WATERS.

To make what has already been said more apparent, during the past few years Kansas has suffered great losses by the destruction of crops, buildings, bridges, live stock, fences, and other visible property by means of uncontrolled flood waters; and yet if all the damage done in these lines could be figured in dollars and cents it would be but a small item, a drop in the bucket, as compared with the much more serious damage done by the erosion and leaching of rich soils and the consequent loss of their fertility. Thousands of tons of the best soils, rich in fertilizing material, have been carried by the flood waters into the creeks and rivers, to be floated away and forever lost to the state of Kansas. As an evidence of the truth of this statement we would call your attention to certain small protected fields that had flood-water sediment deposited upon them. They were enriched even to a degree beyond their original fertility.

POOR SOIL THE HOME OF POOR PEOPLE.

Why so much concern, we are asked, about the conservation of water and soil fertility? Because a study of the history of agricultural conditions in the world, both past and present, goes to show that a poor soil produces a poor people, and both are found in the same localities; and further, because poorly fed, poorly clothed and poorly housed people have always been ruled or dominated over by the well-fed races, and in many cases reduced to conditions that we, as an American people, have always fought against and hope in the future to avoid.

CONSERVATION OF NATURAL RESOURCES.

Thinking men and students of economic conditions tell us that we should immediately take steps to preserve for proper use for the whole people what remains of the billions of tons of coal, the great forests, the waterpower and other natural resources, lest private interests and corporate greed, linked with our extravagant, wasteful and most destructive methods, may produce conditions that will make poverty not a condition but a dire necessity for our descendants.

WHAT THE RECORDS SHOW.

Again we ask, Why so much concern about the conservation of soil fertility? We read, and have been reading for some time, in the national and state agricultural reports that the land area in the United States specially adapted to the growing of cereals, and wheat in particular, has rapidly marched from the Atlantic to the Pacific; and that the acres adapted to the production of food in our country are well known; and that many of our fields are already showing signs of decreased soil fertility by yielding crops reduced in yield per acreage. On the other hand, recent census tabulations go to show that the

population of our country is rapidly increasing, and men wise in business calculations, including the railroad magnate, Mr. J. J. Hill, tell us that within fifty years the population of the United States will reach 200 million. This seems possible, as the increase during the past ten years has been more than 16 million.

Why so much concern about conservation and soil fertility? By examining the above-mentioned reports further, we learn that there is a great waste in soil fertility to the state and country, partly due to natural causes, but largely to the improvident methods employed in connection with agricultural pursuits.

COST OF PRODUCTS MEASURED IN FERTILIZING MATERIALS.

It costs to produce 20 bushels of wheat \$5.79 worth of fertilizer—nitrogen, phosphorus and potassium.* To produce the ton of straw on which this wheat grew \$3.66 worth of fertilizer is used, or a total of \$9.45 for the wheat and straw. To produce 65 bushels of corn, a good acre yield, it costs in fertilizer \$9.38, and \$9.32 to produce the 3000 pounds of stalks on which the corn grew, or a total of \$18.70 in fertilizer for what might be taken from a single acre of ground in corn products. Again, four tons of alfalfa removes from an acre of ground 13.75 pounds of phosphorus worth \$1.10; 200.80 pounds of potassium worth \$12.09; and 85.44 pounds of calcium worth 42 cents, or a total of 300 pounds of fertilizer worth \$13.19. The removal of the phosphorus is most damaging as it is an element rare even in good soils the world over, and should be conserved in farm lands as it will be difficult and expensive to replace when once exhausted.

CROP ROTATION AND SOIL FERTILITY.

The idea of crop rotation so much advertised and advised in agricultural journals and societies is a good one. By this means, through the agency of bacteria, nitrogen can be restored to the fields; but no amount of crop rotation will restore phosphorus. Once removed from the fields this element can be returned to the soil only by some mechanical means, and the same thing is true of potassium and other mineral matters. The idea held by many persons that the growing of alfalfa on ground enriches it is an erroneous one; while the growing of alfalfa, clover, and other such plants, adds to the nitrogenous compounds, it robs the soil of the very mineral elements that constitute a good part of its crop-producing substances.

SPECIAL VALUE OF FERTILIZERS.

We are told that the wheat crop of 1909—in round numbers 82 million bushels—took from Kansas fields 160 million pounds of rich fertilizer which would cost over 26 million dollars if it

* See Bulletin 169, page 76, Kansas Agricultural Experiment Station.

had to be purchased in the market and restored to the fields. The straw—4,500,000 tons—that produced this wheat, represents over \$16,000,000 worth of fertilizer in nitrogen, phosphorus and potassium alone. In view of this fact it seems uncommonly strange that an article, a half column or so in length, given out by a city farmer, we are told, should appear in our leading newspapers, advising farmers to burn or dispose of their straw stacks and raise a few more grains of wheat on the ground where the straw stacks stood. By such an operation the wheat farmers would not only destroy or lose thousands of tons of fertilizer, but in the case of burning the straw on the ground would bake the latter to a cinder, rendering it unfit to produce crops for years to come unless fertilizers should be added.

This reminds one of Horace Greeley's definition of an agriculturist and a farmer. An agriculturist, Mr. Greeley said, was a person who lived in the city, and who out of his city business could make money enough to enable him to own and operate a farm and, incidentally, had time enough to advise the country farmers in general how to operate and manage farms. On the other hand, a farmer, Mr. Greeley said, was a man who lived in the country on his farm, and run and managed it successfully enough to enable him to support himself and family and, incidentally, to produce surplus enough to support the city.

In 1909 Kansas produced 147,005,120 bushels of corn at a cost of about the same number of pounds of fertilizer, worth in the market over 21 million dollars. The stalks that produced this corn contained about the same amount of fertilizer as the corn itself and was worth about the same amount of money, 21 million, or a total of over 40 million dollars' worth of fertilizer.

It takes \$3.25 worth of fertilizer to produce a ton of alfalfa hay, each ton taking from the soil over fifty pounds of phosphorus and potassium. Figuring on this basis, it would take eleven and a half million dollars' worth of fertilizer to produce the three and a half million tons of alfalfa raised in Kansas last year (1910).

From the same bulletin, referred to above, we get figures showing the value of the wastes from domestic animals to be as follows:

Wastes from a horse for one year	\$28.86
Wastes from a cow for one year	40.49
Wastes from a sheep for one year	2.58
Wastes from a pig for one year	3.34

In view of the above facts it is hard to explain why so many barns and stockyards are built on sloping grounds that permit the water from every rain to wash the fertilizing materials into ravines and creeks, to be carried away and to be lost forever to the farm.

CROPS AND SOIL FERTILITY IN OTHER COUNTRIES.

Why so much concern about the conservation of soil fertility? And that, too, in a new country, when other nations that depend upon soil fertility have existed for centuries?

Time forbids the discussion of this interesting subject, except to glance at it for a moment. By examining some recently published statistics we learn that the average yield of wheat per acre in Germany for a number of years past has been 29 bushels, and in England for the past ten years it has been 31.39 bushels, while in Kansas it has been less than 15 bushels. But what has Germany been doing? asks the statistician. She has been importing wheat and other grains rich in fertilizing material and exporting articles like sugar, which takes little or nothing out of the country except sunshine with carbon and water gathered for the most part through plants from the air. England is importing foods and feeds rich in fertilizers from various countries. In England, throughout the agricultural districts, every particle of fertilizing material is not only saved, but carefully stored and put in proper condition to be spread on the cultivated fields at the proper time.

Some published statistics also go to show that Denmark imports wheat, corn, oil cake and bran, but exports such materials as butter, bacon, and eggs. In 1909 the butter alone that Denmark sent to the United Kingdom amounted to 197,571,124 pounds, and valued at 30 cents per pound was worth \$59,271,307.20.* And this fifty-nine million dollars' worth of butter carried fertilizing elements that would impoverish the soil of Denmark less than the removal of one thousand tons of Kansas hay would impoverish Kansas soil, which hay, valued at \$12 per ton, would amount in comparison to the paltry sum of \$12,000; and just such hay as carries from \$3 to \$5 worth of fertilizer per ton from the soil, and the kind that is being shipped from Kansas farms by the thousands of carloads every year.

WHY SHOULD WE BE CONCERNED ABOUT THE CONSERVATION OF SOIL FERTILITY?

Because the mass of the people are indifferent and apathetic and do not seem to realize when or where their own interests are at stake, and this too in the face of the fact that the United States Department of Agriculture, and all the state departments of agriculture, and the experiment stations, as well as thousands of writers in the newspapers and magazines, including scientists and agriculturists of great ability, are continually giving out information concerning the vital importance of conserving the fertility of the soil. The above-quoted facts, which all point in the same direction, and teach that any soil, no

* Notes taken from Doctor Robertson's address at Ottawa, Canada, on Conservation of Natural Resources.

difference how rich, may be depleted of its productive qualities and eventually become almost worthless—a thing that has happened in many parts of the Old World, and in some places in the eastern parts of our own country—do not seem to have made any very serious impression on the minds of our people, or at least to have received the intelligent attention and consideration of the majority of the people that till the soil in our state, especially in the central and western parts of it. This is all the more strange and difficult to understand when we consider that Kansas farmers, as a class, are the best-informed people in the country.

There seems to be a tremendous and almost inherent temptation for farmers in a new country to become placer or surface miners and to make themselves rich by stripping the soil of its most valuable materials by the quickest methods known to agriculturists and in the shortest time possible.

Why this concern about conservation of soil fertility? Because we are forced to admit that we as a people are somewhat extravagant, somewhat careless, somewhat indifferent, and not altogether unselfish. We need to be watched and we need to watch ourselves, lest we forget the history of the past and take not sufficient thought for the future.

Of late we have been noticing the reports that are gradually being published concerning the census returns. Every state, city and village in the Union is losing no time, if the returns justify it, in boasting of its increase in population and its consequent growth and development. Why this tremendous and almost insane interest in the increase of population? Is it a deep-rooted desire to do something to improve the mental strength, moral soundness and religious condition of humanity, or is it an interest with no broader or deeper foundation than commercialism—the getting of dollars and cents? The sum and substance of twenty answers from business and professional men living in cities would indicate something like this: More population, more city; more city, more business; more business, more dollars and cents; more dollars and cents, more business. The sum and substance of twenty answers collected from rural districts would indicate the same tendency of thought and spirit. Seventeen answers referred to the value of land, and a summary would run like this: More population, the more valuable becomes both land and land products; hence, more money and more business; more valuable the land and land products, more money and more business.

After having visited the oil, gas, and coal fields in southern Kansas, we were thoroughly convinced that all the oil, gas and coal in the state would be taken out of the earth in a comparatively short period of time, if the prices only justified the action. Double the price and triple the profits on oil and gas and

coal, and thousands of men would hasten to convert material on which the happiness and comfort of our people largely depend, and which it has taken nature's forces many centuries to prepare—and that, too, presumably, for the special use of mankind—into money, an absolutely worthless thing when it can not be exchanged for bread, or when compared with the mental, moral and religious worth in human life.

Why this concern about conservation and soil fertility? We are concerned in the conservation of soil fertility because it is the greatest natural resource and the most important heritage nature has to bestow upon her children. While considering the natural resources of the country, President Taft in a former message expressed our sentiments when he said: "The feature that transcends all others, including woods, waters, materials, are the soils of the country. . . . Their productive powers should have the attention of our scientists, that we may conserve the new soils, improve the old soils, levee river overflow soils, grow trees on thin soils, pasture hillside soils, rotate crops on all soils, discover methods for cropping dry-land soils, find grasses and legumes for all soils, feed grains and mill feeds on the farms where they originate, that the soils from which they come may be enriched."

This quotation covers the ground so completely that we desire to add but one thought, namely, that every bushel of Kansas wheat should be ground in Kansas mills, and every pound of by-products or mill feeds resulting therefrom, together with every ton of Kansas hay, should be fed to Kansas animals on Kansas lands, and all wastage returned to Kansas fields, that the soils from which they came may not be impoverished.

We are concerned in water storage and soil fertility because we believe that it is incumbent upon us to encourage by every available means the conservation of both water and soil, the two things more than any others on which depends health—riches more to be enjoyed and more conducive to happiness than any other form of wealth.

We are concerned in soil fertility because we desire to elevate the standard of living of the masses of the people by making the necessities and comforts of life cheaper and better, the minds and hearts of the people larger and more charitable, and by this means promote good citizenship and good government. We are concerned in soil fertility because it is the basis of the future of human life in our country, and we not only have hopes, but a serious care, in our minds and hearts for the welfare of the boys and girls, our sons and daughters, who are to be the men and women of the future.

We are concerned in soil fertility because many of us believe that there is something in life, and in business too, beyond the ever-greedy and selfish spirit of financial gain, a

something that will produce a national strength and greatness based on the good that is being developed in human life. And further, we are concerned in soil fertility because we desire to be temperate in our dealings with nature, and conserve all the natural resources necessary, not only for the development, but for the preservation of the most precious thing in the world—human life—believing, as most of us do, in the creative power of the universe, and in a life beyond that dependent upon material things.

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