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INSTITUTE FOR FISHERIES RESEARCH
DIVISION OF FISHERIES
MICHIGAN DEPARTMENT OF CONSERVATION
COOPERATING WITH THE
UNIVERSITY OF MICHIGAN

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ANN ARBOR, MICHIGAN

March 29, 1939

REPORT NO. 528

MINNOWS (CYPRINIDAE)

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Introduction

The minnow family, inhabiting the fresh waters of the Northern Hemisphere, is one of the largest families of fishes. It contains about 200 genera and well over 2,000 species, of which about 250 are found in North America. Most of the minnows are of small size. Some never attain a length of over three inches, and the majority never exceed a length of eight inches. A few species reach a length of from two to five feet and a weight of 80 pounds, but our largest native Michigan minnow (the horned dace or creek chub) seldom exceeds a length of 10 inches. The family contains the shiners, dace, chubs, carp and goldfish which are familiar to many. The carp and goldfish are not natives of North America, but were introduced from the old world.

Minnows are usually thought of as bait for fishermen. The name "minnow" is commonly but erroneously applied to small fishes of all species. The mud minnow and top minnow, two species of which are used as bait, belong to other families. Young specimens of game and food fishes, which should be called fry or fingerlings are often spoken of improperly as

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minnows, e. g., perch minnows and pike minnows. The true minnows are distinguished from all other fishes by their possession of the following characters:

1. There are no teeth on the jaws.
2. There are no scales present on the head.
3. There are no spiny rays in the fins.
4. The single dorsal fin has less than ten rays.

Each species of minnow seems to prefer a more or less definite habitat, and to require this habitat to satisfy its needs during various stages in its life history. For example: some species, such as the horned dace and the common shiner, require stream conditions for spawning, and therefore cannot be reared through their entire life cycle in ponds. Other species show a decided preference for rather large lakes, small ponds, or large rivers, and do not thrive in habitats which fail to meet their requirements. An illustration is the case of the lake emerald shiner, Notropis atherinoides. This minnow is almost incredibly abundant in the Great Lakes, where it is an important item in the diet of the lake trout and other predacious species. Efforts to establish the lake emerald shiner in small inland lakes have been uniformly unsuccessful.

Minnows are generally carnivorous, feeding upon insects and crustaceans (water fleas), but some species are omnivorous, and feed largely on vegetation (especially algae) or the organic slime found on rocks and on the bottom, as well as on insects and crustacea. None of the minnows is strictly herbivorous.

Minnows are adapted to a wide variety of conditions, spawning profusely and everywhere finding an abundance of food. While some species may prey on the eggs of game fishes, they also eat the eggs of noxious and less

desirable species, thereby holding them in check. The importance of minnows is not generally appreciated but the abundance and well-being of the larger food and game fishes in many waters seems to be conditional upon a permanent stock of minnows. Besides fishes, the fish-eating birds, turtles, and various other animals depend upon fish for food. If an abundant supply of minnows is present the predatory animals will probably eat fewer of the more important food and game fishes.

The carp is the only minnow of any direct importance as a food fish for man in America. Although all minnows are edible, their flesh is of inferior quality, and only the larger species are used as food. Minnows are, nevertheless, important links in the human food chain, for they convert organic matter and minute forms of plant and animal life into foods for other forms of life which eventually serve as food for man.

There are no fewer than 38 species of minnows in Michigan waters. The table below gives the distribution, habitat, spawning requirements and the maximum length attained by the most important bait species.

Distribution List of Common Michigan Minnows

Common name	General distribution and abundance in Michigan			Habitat preference in Michigan		Spawning requirements	Maximum length
	S. part of Lower Pen.	N. part of Lower Pen.	Upper Pen.	General	Specific		
River chub	C ¹	C	R	Creeks and rivers	Gravelly and weedy areas	Gravel in stream	10 in.
Northern creek chub (horned dace)	A ²	A	A	Small creeks	Moderate to rapid water	Gravel in stream	10 in.
Northern red-bellied dace	R ³	C	C	Lakes, ponds, and creeks	Boggy waters	Eggs scattered over aquatic vegetation	3 in.
Golden shiner	A	A	C	Lakes, ponds, and streams	Weedy waters	" "	10 in.
Common shiner	A	A	A	Creeks and rivers	Clear waters	Gravel nest Stream	8 in.
Blunt nosed minnow	A	A	C	Lakes and sluggish streams	Sandy shoals	Eggs laid on under surface of stones, boards, and other objects	4 in.
Northern fat-headed minnow	R	C	C	Ponds	Boggy waters	" "	3 in.

- ¹/_v Common
- ²/_v Abundant
- ³/_v Rare

(After Hubbs and Cooper, "Minnows of Michigan" in pars.)

The culture of minnows by dealers is being encouraged by the Conservation Department. Besides furnishing the dealer with an adequate supply of minnows of all sizes at all times, propagation also promotes the interests of good fishing by conserving the natural food supply in our lakes and streams. This supply of food is needed by the game fish that occur in our waters. At the present time the supply of minnows in some of our lakes and streams is in a serious state of depletion. Fishermen and dealers waste thousands of minnows daily by careless handling and improper facilities for transporting and holding. At times when minnows are easily taken, fishermen and minnow dealers are prone to take more minnows than can be safely carried. This usually results in the loss of part or all of the minnows. The commercialization of the minnow resources of our inland waters is not in harmony with the present conservation program and steps have already been taken in some states to prohibit the use of natural supplies of minnows for bait purposes. The Conservation Department of the State of Michigan is willing to assist in all reasonable ways those who raise or desire to raise minnows or bait fishes.

All organisms are dependent upon a particular combination of factors for their existence and development. For the best results we must maintain a balance of these factors which will favor the propagation and growth of the fish and the organisms that enter directly or indirectly into their food supply. Just as cattle and sheep are dependent upon forage, so fish are dependent upon algae and other plants. But unlike cattle, fish do not usually consume plants directly. There are generally a series of smaller organisms that feed upon the plants or upon each other, which in turn are eaten by the fish. Thus, fish are the final link in the food chain.

General Suggestions on Minnow Culture

To avoid some of the difficulties experienced in the care and feeding of minnows, the following general suggestions are given.

The ideal location for raising minnows is an outside pond similar to state-owned bass or bluegill rearing ponds. The ponds should have a continuous supply of fresh water, although it need be no more than enough to maintain the proper level. A good crop of aquatic vegetation should be present in the pond. No definite sized body of water is required. The pond should be so built as to drain to the outlet end, in order to facilitate harvesting, sorting and distributing the crop of minnows and cleaning the pond. The physical requirements for the location of a pond of this type may be observed at any of the state hatcheries which rear warm water fish. Certain species are easily and inexpensively adapted to pond culture. Another valuable feature of rearing ponds is that the fish may be sustained in a large part by the natural food that is produced by the pond.

To increase the productivity of ponds, i.e. to increase naturally produced fish food organisms such as insects, water fleas, etc., each pond should be fertilized. Some investigators in minnow culture recommend applying horse manure at the rate of one ton per acre. Langlois of Ohio used one quart of superphosphate of lime and six quarts of sheep manure to each 100 cubic feet of water. Wiebe of the U. S. Bureau of Fisheries used a mixture of 11 pounds of soy bean meal and 5 ounces of superphosphate to each 500 cubic feet of water. Of course a great deal depends upon the kinds and proportions of chemicals present in the water. Under ordinary circumstances either horse or cow manure would be sufficient. The pond should be fertilized early in the spring. One fertilization should be sufficient if horse or cow manure is used. If commercial fertilizers are used, several fertilizations yearly may be necessary.

Whether minnows are produced in private rearing ponds or taken from public waters, a retaining tank or screen is necessary for holding them until needed. Fishes require oxygen (which is obtained from the water), and if a screen or live box is used it should be so constructed that water currents will pass through the box or screen. The live box should be large, at least 3'x3'x6'. If a tank or trough is used, the best means of aeration is a continuous flow of well aerated water entering the head of the tank. If this is not feasible a continuous fine, spray of compressed air introduced near the bottom of the tank will be sufficient. It is more satisfactory to have a natural flow of water through the tanks because the cost of installation of pumps or air compressors is usually prohibitive and there remains the possibility of breakdown. Troughs should be built under cover or in the shade in order to keep the temperature of the water as low as possible. Cold water will hold more dissolved oxygen than will warm water. The more oxygen, the more fish that can be held in a container of a given size. Avoid the use of city water, as it is usually chlorinated, and chlorine in sufficient concentration is lethal to fish. If possible, do not allow the water to run from one ^{trough} ~~trout~~ to another, as this warms the water and, in case of disease, will allow the water borne infection to spread to other troughs. If water is supplied under pressure, three-quarter-inch pipe drilled with 1/8 inch holes, 4 to 6 inches apart laid down the center of the trough, will insure constant aeration.

At all times crowding should be avoided. No more fish should be kept in a holding tank than can readily be disposed of in a few days. The ideal number of fish to carry per unit of space cannot be stated as conditions vary with the species and size of minnow, size of tanks, character of water, temperature and many other factors. The maximum number can best be determined by actual experience. A greater number of minnows can be

carried during cold weather than during hot weather. Tanks should be drained, dried and if of wood should be painted, at least once a year. At regular intervals of a week or two weeks tanks and dip nets should be sterilized with a concentrated solution of salt or of commercial copper sulfate (blue vitrol) which is a cheap and efficient disinfectant. However, care must be exercised in use of copper sulphate as it is toxic to fish in very small amounts. A good stock solution should be kept on hand. It can be made by placing several inches of copper sulphate in the bottom of a 2 quart fruit jar and filling the jar with water. Approximately one pint of this solution will sterilize a tank 2'x2'x10'. Screens should be cleaned daily, or more often if necessary. A common scrub brush fitted with a handle of convenient length makes an excellent screen brush.

The tank should be of wooden construction, or of smooth concrete, with the exposed surfaces painted with coal tar thinned with turpentine, or with asphaltum paint. These paints are economical and rather impervious to water. Many people find that large metal stock tanks (used for watering cattle) are suitable. The outline of the tank or trough should be rectangular rather than square, with the inlet at one end and the outlet screen at the other. Concrete tanks have proven to be very satisfactory, the most economical size being 12'x3'x2' deep. All tanks should slope slightly towards the outlet to facilitate cleaning.

Transportation of Bait Minnows

In securing minnows care should be exercised to avoid excessive handling or injury. When using a seine, be careful not to draw the bag too tightly, thereby entangling the fish in the debris, but rather leave sufficient room and depth of water for fish to be removed. It is best not to remove the net from the water while sorting out the fish. If

possible remove the fish with a small, shallow, fine-meshed scap, dip net, or enamel dipper, returning to the water alive the young game fish and other protected species or those not wanted. In transporting the minnows avoid excessive crowding, especially in hot weather. The water temperature should be kept below 70°F. Addition of small quantities of ice, or small quantities of cold water should accomplish this result. Aeration will be maintained by the splashing of the water during transit. Yet, if the containers are large this may not be sufficient, and hand-dipping of the water may have to be performed at short intervals. Presence of insufficient oxygen can be recognized readily because the fish will all be at the surface of the water, many upon their sides. The oxygen supply may be increased by adding small quantities of fresh water or by dipping out a bucket full and pouring it back, letting the water splash against the sides of the container. Small oil drums, or milk cans that are clean and sanitary are the most efficient containers for hauling fish. An old dipper, bucket or tomato can punched with holes makes a fine hand aerator. If the water is cold and the can is not overcrowded, hand aeration is not necessary. A large tank fitted with a water pump or other aerator is the most satisfactory arrangement. Cans and tanks should be sterilized before each trip.

Care should be taken to avoid sudden changes in the temperature of the water. A pocket thermometer is a necessary part of the equipment of every minnow dealer. Before placing the fish in tanks or ponds, compare the temperature of the water in the cans with that of the tanks or ponds. Try to get the temperatures approximately equal before the fish are changed. This can be accomplished by adding a bucket full of water from the pond or tank to the can, or by placing the can in the tank or pond. This operation should change the temperature gradually, allowing ten minutes for each two or three degrees change. When there is a difference of over 10 degrees, at least 20 minutes or more should be allowed for each

2 to 3 degrees change in temperature. Artificial aeration should be resorted to at this time if necessary. Sudden changes in temperature will kill every fish.

Feeding Minnows

Fish held in tanks or troughs for more than a few days should be fed, because undernourishment reduces their vitality. Underfeeding is not as harmful as overfeeding, because the latter tends to make the fish sluggish. No more food should be given than can be eaten at a single feeding, as surplus food becomes sour, decays, and uses up oxygen, thus polluting the water and inviting an epidemic of disease. All of the uneaten food should be removed shortly after feeding. Most species of minnows can be kept for a limited time by feeding bread and cracker crumbs. A definite type of food cannot be prescribed for any species. The use of finely ground oatmeal or other cereal will usually suffice. If the fish are to be fed over long periods of time it is best to use a balanced diet consisting of vegetable, meat and mineral materials. Cooked oatmeal and finely ground meat scraps are good. The amounts of either can best be determined by experimentation. Dog rations such as "Balto," or "Rowena Dog Biscuits" are sometimes used, and may be mixed with raw beef liver or other ingredients. A mixture of clam or fish meals with oatmeal or some other cereal is also good. The occasional feeding of earthworms or Daphnia (water fleas) or other aquatic organisms seems to be of value. (These organisms may be obtained from lakes with the use of extremely fine meshed cone-shaped nets, towed behind a boat.) (Data on methods of Daphnia culture will be furnished upon request.)

Diseases

Some of the most common diseases of minnows are fungus and tail rot. White fungus results from lack of oxygen, sudden changes in temperature,

decaying food in the water or other unsanitary conditions, or from rough handling which may knock scales off fish or remove the protective coating of mucous. Excrement from healthy fish is dark, and when either white or yellow indicates overfeeding. Illness is shown by bloodshot fins, drooping dorsal fin, fish resting on bottom or lack of appetite. If only one fish is affected, this condition may safely be assumed to be overfeeding or constipation; if many show disease symptoms, it may be assumed that something is **wrong** either with the food, water, oxygen supply or temperature conditions.

Infected fish should be removed immediately and either destroyed or placed in a separate tank to avoid spread of the infection. Diseased fish should be dipped in a strong solution of salt, potassium permanganate, or copper sulphate until the fish shows signs of acute distress, when they should be removed to a separate tank with fresh water. Repeat dippings daily. Twelve ounces of salt per gallon of water, or approximately one teaspoonful of copper sulphate per gallon should be sufficient for dipping. If after several treatments the condition does not improve, it is best to destroy the fish. In many cases transferring the fish to fresh running water is sufficient. Weekly salt baths of about 3 ounces of salt per gallon of water for healthy fish often proves beneficial in correcting constipation and improving their appetites. Leave the fish in the bath for a half an hour or until distress is noted, aerating the water constantly during treatment. Small amounts of epsom salts are sometimes used in bath or in food.

Habits and Culture

Following is a description of the habits and the culture of several species of minnows which have proven of value as bait.

Blunt-nosed Minnow (Hyborhynchus notatus)

This minnow has a wide distribution over the entire state of Michigan. It is found in lakes and streams with sand- or gravel-bottomed shoals. The minnow attains a maximum length of 4 inches and a maximum age of 4 years. It is thick bodied, broad and flat between the head and the dorsal fin, where the scales are small and crowded. The snout is rounded and protrudes beyond the small mouth, which is on the under surface of the head. A prominent black spot is present at the base of the tail fin. In breeding males there are three rows of large calcareous tubercles across the snout. The head and upper part of the body are bluish black; the skin on the back in front of the dorsal fin is soft and spongy. The spawning season extends from May to the latter part of August, at water temperatures of about 70° F. or higher. By preference the eggs are laid on the flat and smooth lower surface of submerged objects, close to the bottom (1 inch or less). Almost any object such as logs, rocks, slabs, tin cans, crock, tile, etc. may be utilized. The blunt-nose rarely spawns where the bottom is thick mud. It prefers water 6 inches to 3 feet in depth for spawning. Because of the protracted spawning season all sizes of young are obtained. Some reach maturity by the beginning of the second summer; others later in their second summer or first part of third, depending upon when they were hatched, and upon the water temperature. The blunt-nosed minnow is a general feeder upon all small organisms and is partially herbivorous.

The blunt-nosed minnow is a very important forage and bait fish and is readily adapted to pond culture. Artificial spawning devices may be installed by merely pushing small boards or shingles into the sides of the pond just above the bottom, especially in sandy areas. The shingles can be placed fairly close together and may be staggered one above another.

The adult males will then work out the sand and gravel beneath the shingles, constructing a small excavation extending several inches into the bank. Flat rocks and broken pieces of tile placed on sandy bottoms may also be used. With this method it is possible to obtain a production of 100,000 or more fish per acre by the end of one season.

Artificial feeding methods should be attempted if the pond is overcrowded. Any food will be eaten, but it must be finely ground. The food may be scattered over the pond or placed in small containers upon the bottom of the pond.

Fat-headed Minnow (Pimephales promelas)

The fat-headed minnow occurs over the entire state of Michigan. It is most abundant in sluggish, boggy streams and small lakes. This minnow seldom reaches a length exceeding 3 inches and a maximum age of 4 years. It greatly resembles the blunt-nosed minnow in having a prominent black spot on the base of the dorsal fin, about half way up. The fat-headed minnow is deeper bodied than the blunt-nose, and the mouth is small and located at the end of the snout. Breeding males are blackish on the head and back. They have three rows of large tubercles across the snout, other large tubercles on the chin, and a prominent spongy area on the back between the head and dorsal fin.

The spawning habits of the fat-headed minnow are very similar to that of the blunt-nosed minnow. The spawning season extends from the latter part of May into August. The eggs are deposited on the lower surface of submerged objects, which may be of almost any kind of material, if they are of suitable shape and size. Maturity is reached during the second year. This minnow feeds on all types of food, but it is believed that algae make up the bulk of the diet.

This fish is much hardier than the blunt-nose, and is able to withstand crowding in small containers. Pond culture methods for this fish are similar to those for the blunt-nosed minnow.

Golden Shiner (Notemigonus crysoleucas)

The golden shiner occurs abundantly throughout most of Michigan. It shows a decided preference for weedy lakes, but is common in some of the larger rivers. It prefers shoals where vegetation is moderate to dense. The body is very deep and flatly compressed. The head is short, low, and flattened; the mouth is small and oblique. The sides of the body are silvery, with golden reflections. The fins are yellowish. In some localities and especially during the breeding season the fish are of a brilliant golden color.

The golden shiner has a long spawning season, extending from May until late August. The eggs are adhesive and stick to aquatic plants, roots and to filamentous algae. A length of 3 inches may be attained by the end of the first year, but due to the protracted spawning season fish of all sizes are likely to be encountered. Maturity is reached at the age of one or two years. A maximum length of 10 inches has been recorded for this species in Michigan. The golden shiner feeds mostly upon animal plankton (water fleas and allies), occasionally taking insects and algae.

The golden shiner is easy to raise. Any small weedy pond is well suited to its life and reproduction. It is possible to produce at least 100,000 golden shiners per acre the first summer.

Horned Dace or Creek Chub (Semotilus atromaculatus)

The horned dace is one of the most abundant stream fish in Michigan, living in most of the small streams in the state. It is one of the largest of Michigan minnows, males commonly reaching a length of 8 inches. The color is olive above and light gray below. The body is robust; the head large and broad with a large mouth reaching to the level of the eye. The scales are crowded toward the head and are much smaller than in the horny-headed chub (river chub). There is a conspicuous black spot at the base of the dorsal fin, in front, and a dark bar at the shoulder. Breeding males have two rows of large tubercles along side of head, one row on each side.

Spawning occurs in clear streams, on a bottom of coarse gravel, usually at the head of rapids. The male guards and builds the nest. Spawning usually extends from the latter part of April to July. The diet of the horned dace is largely carnivorous. The list of organisms eaten by the horned dace includes insects, crayfish, earthworms, snails, small fish and some aquatic plants. With such a versatile appetite, the creek chub finds suitable food in most aquatic habitats. Its ability to eat rather large fish makes it undesirable to leave adult horned dace in the same pond with young. This fish is one of the best bait minnows; it is extremely hardy and an active swimmer. Its large size makes it an excellent pike bait.

It has been found that the creek chub will not spawn in the still water of ponds. Perhaps with a slight current of water at one end of a pond, flowing over gravel (place the inlet pipe flush with the pond bottom), spawning might be induced. A small section of stream would be ideal for this species. It has been found that artificial propagation can be carried on successfully, the eggs and milt being stripped as in trout culture. The eggs of several females should be stripped into a clean,

shallow pan. The milt of a male should then be stripped into the same pan, and with a gentle rotary movement the eggs and sperm should be mixed. After this has been repeated several times a small amount of clean, fresh water should be added. After thorough and careful mixing, the water should be poured off. Repeat the operation until all surplus milt has been washed away and eggs are clean. After setting a few moments, the eggs should be gently poured into a bucket of water and allowed to harden, which takes approximately one to two hours, the water being changed, carefully, at intervals. After the eggs are hardened they should be removed to trays, made of cheese cloth tacked on to wooden frames, and placed in troughs or tanks where a weak current of water can pass over them. Dead eggs show up white and should be picked off daily to prevent the growth of fungus. Hatching should take place within two to three weeks, depending upon water temperatures. After hatching, the fry should be removed to a pond. The horned dace attains a length of between 2 and 4 inches by the end of the first year. These fish can be fed any of the diets named previously. They feed readily, churning the water in a manner similar to trout.

Common Shiner (Notropis cornutus)

The common shiner is found over the entire state of Michigan. It is one of the most abundant of Michigan minnows, being dominantly a stream species, but it is occasionally found in lakes. Large males often attain a length of 8 inches. The body is short, robust, deep, and flattened from side to side. The head is large. ~~The~~ Exposed portions of the large scales are about three times as deep as they are broad. Dark stripes run between the scale rows on the back. The body colors are olive green to gray above, grading through silver along the sides to white below. Breeding males have large tubercles on the top of the head, and the body and fins are brilliantly colored in various shades of orange and pink.

Spawning, so far as is known, occurs only on stream riffles over gravelly bottom, although it may take place on gravelly shoals in lakes. The spawning season extends from the latter part of May into June, at water temperatures that are over 65°F. A total length of approximately 2 to 3 inches is reached by the end of the first year. Between 2 and 3 years are necessary for the species to reach maturity. Food studies indicate that equal amounts of plant and animal material are eaten. It has also been shown that they feed generally from the stream bottom, to the water surface.

Very little work upon the artificial propagation of this fish has been attempted. One writer found that they would not spawn in ponds. Knowledge is not available as to whether or not stripping can be carried out successfully. If artificial propagation is attempted, the pond used should have a stream entering so the fish could ascend to spawn. Artificial stream conditions could be imitated by creating a current of water to wash over gravel at the head of the pond (similar to that described for the horned dace).

Horny-headed Chub or River Chub (Nocomis biguttatus)

The river chub lives in the larger creeks and smaller rivers in Michigan. It is seldom found in stagnant waters. Its form is robust and only slightly compressed, bearing some resemblance to the creek chub in this respect, but differing by lacking the black spot at the front part of the dorsal fin. Adult breeding males have the entire upper part of the head covered with large tubercles, and display a large vermilion spot on either side of the head, behind the eye. The mouth is large and almost terminal and does not reach to the level of the eye. The scales are large and are not crowded together near the head. The color is bluish olive, with coppery reflections. The fins are pale orange and unspotted.

The river chub prefers swift-water streams with gravel bottoms. Spawning occurs during the latter part of May and the first part of June, and takes place over gravel riffles in water between one and two feet deep, with a temperature of 65° F. or more. The male builds and guards the nest. The males, which exceed the females, in size, may attain a length of 10 inches. Two or more years are required for the species to reach maturity. The diet includes the larval and nymphal stages of insects, smaller crustacea (water fleas), earthworms, terrestrial insects, algae and occasionally small crayfish, and small fish. The river chub is a fairly hardy fish in minnow pails and storage tanks, and is a lively and excellent bait minnow.

It has been found that this fish will not spawn in ponds. Natural spawning takes place only in running water over a gravel bottom. If the culture of the river chub is attempted, a section of suitable stream should be available. Most desirable would be a pond fed by a small, gravel-bottom stream. After the naturally spawned eggs hatch the young fry would find their way into the pond. Artificial stripping would probably be successful, using the same methods described for the horned dace, in which case natural spawning facilities would not be essential.

Northern Red-bellied Dace (Chrosomus eos)

There are two species of red-bellied dace. One is a northern form, C. eos; the other, C. erythrogaster, is found only in the southern part of the lower peninsula of Michigan. The northern red-bellied dace is found in bog ponds, where it is usually abundant, and in sluggish streams and in lakes. This fish reaches a maximum length of three inches. The color is olive to dusky above, and white below with two broad, black bands extending along each side of the body. In breeding males the abdomen is a brilliant red, and the fins are highly colored with red

and yellow. The mouth is small and terminal. The spawning season extends from the latter part of May into August. The eggs are deposited in masses of filamentous algae. Maturity is reached at the end of the first year by some individuals, but not until the second by those hatched late the preceding summer. Food studies indicate that this fish is mainly herbivorous. It is a fine bait for such fishes as perch, crappie, and rock bass. It is extremely hardy and is long lived in crowded minnow pails.

Experimental evidence shows that it is possible to rear the red-bellied dace in small, weedy ponds. A production of well over 100,000 per acre has been attained. Fertilization to insure a luxuriant growth of algae is advisable.

Further General Suggestions on Culture

For the person just starting out to culture minnows for commercial purposes, it may be advisable to mention a few problems that may develop. It would be well to have plenty of pond space, and a small section of stream, with gravelly bottom. Each year a certain number of adults must be held over for use as breeders the following year. It would also be wise to allot a certain number of fish each year to a pond to provide a supply of bass and pike minnows. Most dealers raising their own bait find that they have a sufficient supply of small minnows, but not enough of the larger ones. Three to four years may be required before an ample supply of larger minnows will be available for sale.

It is possible to obtain an excellent yield of minnows the first year. A small percentage of these will be lost due to predation and natural causes. The numbers decrease appreciably each successive year that the fish are kept. Fish like the blunt-nosed minnow and the fat-headed minnow do not live more than two to three years, frequently dying after their first spawning. Species similar to the horned dace will eat smaller fish.

If poor natural food conditions prevail, the cost of feeding the fish may be prohibitive, but fertilization of the pond would probably increase the amount of natural food.

An epidemic of disease may kill off all of the fishes in one pond or trout, as it occasionally does even in our best regulated hatcheries. All equipment should be sterilized at frequent intervals.

Until a person becomes experienced in fish cultural work, the fish, ponds, etc. must be given constant attention. Fish culture does not consist merely of placing a certain number of adult breeders in a pond, and reaping the harvest several months later. Disease, undernourishment, over-feeding and its consequences, must be spotted immediately, and a remedy prescribed. After several years of experience in fish culture the sign of trouble can be readily observed.

In removing fish from lakes, ponds and streams it is much more desirable to use traps rather than seines. Do not handle the fish any more than is necessary. Excess handling knocks scales off the fish, and removes the mucous layer covering the body, thereby leaving these spots open for infection.

Preserving Minnows for Bait

1. Take one part of formalin (formalin can be obtained at any drug store) and add 29 parts of water. Place the minnows in a container that can be sealed tightly, add enough solution to cover the minnows and place in a dark place (to retain natural colors and silvery hues) until ready to use. When ready to use soak the fish in water overnight to remove the formalin and add a few drops of rhodium to disguise the pungent odor of formalin.

2. Freezing method. Place dead minnows in small containers (ice cream cartons are inexpensive and easy to obtain). Place in the freezer of your mechanical ice box. Before using, thaw the minnows out by placing in water.