FISHERIES SESSION

PROPAGATION OF BUFFALO FISHES*

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ABSTRACT

Intense interest in commercial fish farming in Arkansas, due to crop acreage controls and other factors, stimulated experiments in buffalo fish propagation at the Joe Hogan State Fish Hatchery, Lonoke, Arkansas.

A pond method of propagation was developed necessitating the use of over-wintering or brood ponds, spawning ponds, nursery ponds and growing ponds. The culture procedures are set forth in a step by step "cook book" fashion.

INTRODUCTION

In the Lower Mississippi River Valley, comprising the states of Arkansas, Louisiana, Mississippi and Tennessee, the buffalo fishes are highly prized as food, and the wild fishery is of considerable economic importance to the region. In 1957, a total of 5,984,000 pounds of buffalo were caught, valued at $897,000.00. or an average value to the fishermen of approximately seven cents (7¢) per pound in the rough (Mississippi River Fisheries, 1957). The chronic problem of this wild fishery is the annual cycle of over-supply and saturated markets followed by periods of scarcity.

Down through the years numerous attempts have been made to store the live fish in ponds during the period of over-supply and low prices, with the idea of putting them on the market when the price became more favorable. Most such attempts have proven unsatisfactory because of heavy mortality resulting from injuries received by the fish when they are caught and handled.

Another approach to solving this problem would be the establishment of bigger markets based on a steady, substantial supply of fish.

Artificial propagation (fish farming) has been offered as a possible solution to maintaining a steady supply of marketable buffalo fish. If fish farming proved to be profitable, it could become a supplemental farm enterprise where suitable soils and waters are available and the topography favorable.

Riggs (1957) states that the greatest production of fresh-water fishes by fish farming will come from raising fishes with short food chains. The buffalo fishes fall into this category as they are predominately plankton feeders (Moen, 1954).

The possibilities of fish farming in the Lower Mississippi River Valley are almost unlimited. Davison (1954) states that all riceland soil is suitable for fish production and gives the following statistics for the year 1952:

Total U. S. A. rice acreage	2,000,000 acres
Southeastern rice acreage	1,200,000 acres
Louisiana rice acreage	510,000 acres
Arkansas rice acreage	480,000 acres
Mississippi rice acreage	52,000 acres

The current over-production of certain basic crops and the resulting acreage controls has caused great interest in fish farming as a possible supplemental crop for the idle fields.

Surface water storage projects for crop irrigation and the construction of scores of "duck reservoirs" in Eastern Arkansas have resulted in further interest in the possibilities of artificial propagation of food fishes as a multiple use of

* Presented at the Eighth Annual Meeting of the Southern Division of the American Fisheries Society, held in conjunction with the Thirteenth Annual Conference of the Southeastern Association of Game and Fish Commissioners, Baltimore, Maryland, October 25-27, 1959.

these water areas (Hogan, 1953). According to Sturgis (writing in the 1957 Yearbook of Agriculture), there are five major problems involved in managing soils planted to rice. *Oryza sativa:* "The maintenance of soil organic matter and nitrogen and the aggregation necessary for desirable structure; the development of drainage that permits the rotation of rice with other crops; the development of more efficient methods for the application of fertilizers to rice and to crops rotated with rice; crop rotations; and the control of weeds." In recent years many Arkansas rice farmers have come to believe that a rice-fish rotation solves these problems more satisfactorily and economically than any other method of soil management available to them.

Almost daily we read articles in the newspapers quoting statistics on how the world's population is increasing and how there will be a great need in the not too distant future for additional high quality protein foods. Stern (1957) states: "It has been estimated that by 1975, there will be a shortage of approximately 1.5 billion pounds a year of edible fish in the United States alone." Therefore, it is not inconceivable that our public waters will someday be just as important as a source of food fish as sport fish. There is a supply of evidence in the literature to support the contention (Hulsey, 1958) that sport fish and certain species of food fish can be produced simultaneously in the same waters without seriously hurting the yield of the other.

Thus a variety of circumstances have cumulated to cause an intense interest in the artificial propagation of buffalo fishes in Arkansas, and it behooves a governmental agency, such as the Arkansas Game & Fish Commission, to investigate and be prepared to serve in a changing world. Therefore, beginning in the spring of 1953, experiments in buffalo fish culture were begun at the Joe Hogan State Fish Hatchery, Lonoke, Arkansas. This report is the result of our work at the Hatchery and with cooperating farmers in the surrounding area during the past six years and should prove of value to anyone interested in the controlled propagation of buffalo fishes in ponds.

BUFFALO FISHES PROPAGATED

Canfield (1922) states: "There are three species of buffalo fishes in the United States—the razorback, smallmouth or current buffalo fish (*Ictiobus bubalus*); the gourd-head, stub-nose, or bigmouth buffalo fish (*Ictiobus cyprinella*); and the mongrel, sheep's-nose or blue-rooter buffalo fish (*Ictiobus urus*). The following obvious characters serve to differentiate the different species: *I. bubalus* has compressed body, elevated back, pointed nose and turned-down mouth; *I. cyprinella* has an elliptical robust body, blunt nose and turned-up mouth; and *I. urus* has an elliptical robust body and a turned-down mouth. All three species thrive in rivers, but *I. bubalus* predominates, *I. cyprinella* ranks second and *I. urus* third. In northern lakes, *I. cyprinella* is found almost exclusively, while in southern lakes, *I. urus* and *I. cyprinella* occur, the former predominating".

In Arkansas we find the bigmouth buffalo to be the predominate buffalo fish in natural lakes. In fact, it is commonly called "lake buffalo" by the commercial fishermen. All three species are propagated in Arkansas (Stevenson, 1957).

From our experience with buffalo fish in ponds at the Joe Hogan State Fish Hatchery, Lonoke, Arkansas, we prefer the bigmouth buffalo because they have grown faster, become sexually mature younger and produce more fry and fingerlings as compared with smallmouth and black buffalo.[1]

SELECTING AND HANDLING BROODFISH

One should select clean, fast growing, disease free and uninjured fish for broodstock. Fish that are reared in ponds or reservoirs of known age are the best since they will be of uniform age, size and condition and will likely be easier to obtain without injury to the fish. The broodfish should be caught and handled a few at a time to help avoid excitement and injury. We find it

[1] Nomenclature recommended by the Committee on Common and Scientific Names of Fishes, Spl. Pub No. 1, American Fisheries Society, 1948.

advantageous to place a cloth covering over the tubs while handling the fish as they will quickly calm down in the darkened tub.

We prefer and recommend the smaller size fish for broodstock, i e., fish in the three to eight pound class. The smaller fish are easier to handle and transport, with less danger of injury to the fish. Satisfactory spawn can be obtained from a two-year-old bigmouth buffalo weighing 1½ pounds, but buffalo weighing at least three pounds or more give best results. It is unwise to attempt to spawn one-year-old buffalo even though they may weigh 1½ pounds. Numerous one-year-old buffalo in the one to 1½ pound class have been disected. In most cases the males are mature while the females are immature.

WINTERING PONDS FOR BROODFISH

Wintering or holding ponds are needed for the parent fish. A well fertilized one-acre pond will easily accommodate 400 to 600 pounds of broodfish without feeding. Over-crowding will cause the fish to lose weight, break out with disease and parasites or even die. You cannot expect satisfactory spawning unless the fish are in good shape. Our wintering ponds are ¾-acre ponds having a maximum depth of six feet and an average depth of 3½ feet.

Broodfish should be placed into the wintering pond at least six weeks before the spawning season—earlier if possible. Also, close to the maximum number of pounds should be carried in the wintering pond. At first this may seem strange, but we have found and others also (Swingle, 1956) that buffalo fishes produce a repressive "substance" which prohibits spawning. This is very desirable because it enables you to control spawning. We have held buffalo a full month past the regular spawning season and then, by draining the pond and refilling it with fresh water, obtained a tremendous spawn. Conversely we have observed spawning in wintering ponds where the fishes had only remained a short time, were sparsely stocked or where heavy rainfall had freshened the water.

SPAWNING PONDS

The spawning ponds should be small, easily handled ponds. We use ¾-acre ponds for spawning. These ponds can be drained into a harvest basin and there is a supply of fresh water which discharges directly into the harvest basin. We can completely fill one of these ponds with fresh well water in about 24 hours. The ponds have a maximum depth of six feet and and average depth of 3½ feet.

SEXING BROODFISH

Buffalo fish that are sexually mature are very easily sexed at or near spawning time, e. g., the vent (genital) of the female is larger, redder and more protruding than that of the male. A slight pressure near the vent of the male fish will produce a small amount of the white milt. About the easiest way to sex buffalo fish during the spawning season, and it has been used often (Walker and Frank, 1952) is by running the hand lightly over the body and head of the fish. At spawning time the female buffalo is relatively "smooth feeling" while the male buffalo has a "sandpaper feel."

FLOODING AND STOCKING SPAWNING PONDS

In the spring when water temperatures rise to between 65° and 70° F. and remain so for several days, it is time to stock the spawning ponds. Usually at this time there have been numerous reports of buffalo fishes spawning in the wild, maybe for the last two or three weeks. We prefer to wait until all danger of cold snaps has passed or about April 10th in Arkansas (Table I).

For best results, the spawning ponds should have been laid out and kept dry until immediately before use. As the ponds are being filled with fresh water from a source unpolluted with buffalo fishes or their wastes (spring or well water preferred) select and stock eight to ten pairs of broodfish per acre. We use equal numbers of males and females. Use only one species of buffalo fish in each pond.

Although not as satisfactory as the above method, we have obtained varying amounts of spawn in ponds that had been filled with water for several days to several weeks before the introduction of the broodstock. The main drawback to this method is that the aquatic insects and other animals have had a chance to build up in numbers. These animals will prey on the buffalo eggs and fry thereby reducing production. In order to combat the insects, the ponds should be treated with a mixture of one quart of cheap motor oil and five gallons of kerosene or diesel fuel oil per surface acre of pond. Such treatments should be carried out on days when there is just enough wind to move the mixture slowly across the pond.

Eggs are usually laid within 24 hours after stocking the broodfish and free-swimming fry will be seen along the banks in about seven days. From 20,000 to 100,000 fingerlings measuring in length from one-half to one inch may be expected per acre, however, as many as 400,000 per acre have been produced at the Joe Hogan State Fish Hatchery.

TABLE I

AIR AND WATER TEMPERATURES TAKEN DURING THE BUFFALO SPAWNING SEASON. JOE HOGAN STATE FISH HATCHERY, LONOKE, ARKANSAS. APRIL, 1955

Date	*Pond Number*	*Air Temp. Degrees F.*	*Water Temp. Degrees F.*	*Time of Day*
April 5	1	83	75	1:00 P. M.
April 5	2	83	72	1:00 P. M.
April 5	51	83	72	1:00 P. M.
April 6	1	62	64	8:00 A. M.
April 6	2	62	68	8:00 A. M.
April 6	51	62	68	8:00 A. M.
April 6	1	62	67	5:00 P. M.
April 6	2	62	68	5:00 P. M.
April 6	51	62	68	5:00 P. M.
April 7	1	59	58	8:00 A. M.
April 7	2	59	62	8:00 A. M.
April 7	51	59	63	8:00 A. M.
April 8	1	58	60	8:00 A. M.
April 8	2	58	62	8:00 A. M.
April 8	51	58	64	8:00 A. M.
April 8	1	78	76	5:00 P. M.
April 8	2	78	72	5:00 P. M.
April 8	51	78	72	5:00 P. M.
April 10	1	67	67	8:00 A. M.
April 10	2	67	68	8:00 A. M.
April 10	51	67	68	8:00 A. M.
April 10	1	68	68	5:00 P. M.
April 10	2	68	68	5:00 P. M.
April 10	51	68	68	5:00 P. M.
April 11	1	63	65	8:00 A. M.
April 11	2	63	66	8:00 A. M.
April 11	51	63	66	8:00 A. M.
April 11	1	80	76	5:00 P. M.
April 11	2	80	74	5:00 P. M.
April 11	51	80	74	5:00 P. M.
April 12	1	70	71	8:00 A. M.
April 12	2	70	71	8:00 A. M.
April 12	51	70	71	8:00 A. M.
April 12	1	66	71	5:00 P. M.
April 12	2	66	71	5:00 P. M.
April 12	51	66	71	5:00 P. M.
April 13	1	66	66	8:00 A. M.
April 13	2	66	68	8:00 A. M.
April 13	51	66	68	8:00 A. M.
April 13	1	70	72	5:00 P. M.
April 13	2	70	72	5:00 P. M.

TABLE I—*Continued*

AIR AND WATER TEMPERATURES TAKEN DURING THE BUFFALO SPAWNING SEASON. JOE HOGAN STATE FISH HATCHERY, LONOKE, ARKANSAS. APRIL, 1955

Date	*Pond Number*	*Air Temp. Degrees F.*	*Water Temp. Degrees F.*	*Time of Day*
April 13	51	70	72	5:00 P. M.
April 14	1	64	65	8:00 A. M.
April 14	2	64	68	8:00 A. M.
April 14	51	64	68	8:00 A. M.
April 14	1	80	76	5:00 P. M.
April 14	2	80	72	5:00 P. M.
April 14	51	80	76	5:00 P. M.
April 15	1	70	68	8:00 A. M.
April 15	2	70	70	8:00 A. M.
April 15	51	70	72	8:00 A. M.
April 15	1	86	79	5:00 P. M.
April 15	2	86	76	5:00 P. M.
April 15	51	86	79	5:00 P. M.
April 16	1	72	72	8:00 A. M.
April 16	2	72	72	8:00 A. M.
April 16	51	72	72	8:00 A. M.
April 18	1	78	76	9:00 A. M.
April 18	2	78	76	9:00 A. M.
April 18	51	78	78	9:00 A. M.

NOTE: Ponds number 1 and 2 are ¾-acre ponds, however, pond No. 1 was not completely full of water. Pond No. 51 is a 3-acre pond.

FACTORS CAUSING A DELAY IN SPAWNING AND SUGGESTED REMEDY

After checking the spawning pond closely for a period of ten days or two weeks without observing any young fish, it is possible that the fish failed to spawn. Two factors could have prevented the fish from spawning: (1) the fish being in poor condition; or (2) a sudden drop in water temperature. Begin feeding the broodfish a well-balanced high protein feed at a rate of approximately four percent (4%) of body weight per day. After a period of one week to ten days, if the fish have still failed to spawn, lower the water level in the pond to about one-half or one-third and then refill rapidly. Oil for insects, if needed.

CARE OF SPAWNING POND AFTER STOCKING

The pond should be fertilized immediately after the fish have spawned. If a good plankton bloom is not obtained within eight or ten days, the newly hatched fry will starve to death. The pond should be checked daily and treated with the oil mixture every few days or as the insects build up. Preliminary experiments with benezene hexachloride show promise in controlling predacious insects, however, we cannot recommend its use for this purpose as yet.

Light feeding should begin in about ten or fifteen days after the broodstock have spawned. As soon as the little buffalo are observed feeding, the amount fed should be increased so as to keep the fish growing fast and in good shape. If it is noticed that the little buffalo are swimming in a broken or continuous school around and around the shore of the pond, all going in the same direction, it could mean that they are hungry and on the verge of starvation. We have observed severe outbreaks of disease at this stage, believed due to the fishes growth being halted. It is hard to handle the fingerling fish until they are about 1½ inches in total length. During this period they must not be allowed to lose weight or heavy loss is likely to occur. At this time a few days can make a lot of difference.

HANDLING OF THE FINGERLINGS

There are two ways of raising and handling buffalo fingerlings: (1) leave them in the spawning pond with the parent fish until fall harvest, and (2)

remove them to larger nursery ponds. If plan No. 1 is used, only two or three pairs of broodfish should be stocked per acre. When plan No. 2 is to be followed, eight to ten pairs of broodfish may be stocked. Plan No. 2 is a more controlled operation and will result in more fingerlings being produced.

THE NURSERY POND

Our nursery ponds have a maximum depth of six feet and an average depth of about 3½ feet. The nursery ponds can be of almost any size desired. The important thing is that they be completely free of all other species of fish, especially predacious species such as bass, crappie and green sunfish. For purposes of experimentation, we have stocked thousands and thousands of small, one-inch buffalo in bass ponds, or ponds containing a mixture of several species of game fish. Very few of these little buffalo ever survived the predation.

When the little buffalo are about 1½ inches long, they can be seined and stocked in the nursery ponds. The rate of stocking is dependent upon several factors, the most important of which are: (1) the length of time they are to be left in the pond; (2) the size of fingerlings desired for market or for stocking in the growing pond or reservoir; and (3) the management the pond will receive. Ordinarily 2,000 to 10,000 fingerlings are stocked per acre.

YIELDS FROM THE NURSERY PONDS

Fertile waters grow about 500 to 1,000 pounds of bigmouth buffalo per acre per year. The nursery pond should be stocked with this in mind. For example, if 1/5-pound fingerlings are desired for stocking a reservoir containing a mixture of adult fishes of various species (bass, crappie and sunfish), only about 5,000 fingerlings at the most could be produced per acre, and in stocking the nursery pond this would have to be taken into account.

Mortality rates vary greatly in the nursery ponds where a 50% mortality rate is not uncommon. In a 0.75-acre nursery pond at the Lonoke Hatchery stocked with an estimated 2,000 fingerling buffalo fish per acre, we produced 920 fish averaging 1¼ pounds each in eight months without feeding or fertilizing. About the maximum growth we ever obtained on a bigmouth buffalo from an egg in the spring to a fish in the fall was 1½ pounds. However, the raising of such large fingerlings is impractical, as a production of 3,000 to 4,000 fingerlings per acre per year would be required for a profit.

THE GROWING POND

Before the growing pond can be intelligently stocked, we first have to have an idea of just how fast a buffalo can grow. We have already stated that they are capable of reaching a weight of 1½ pounds from the egg the first summer. Numerous experiments were set up to test the maximum growth capabilities of the buffaloes. It was soon found that the female fish (Table II) usually outgrew the male fish. Gains of as much as six pounds in one season were obtained and an average gain of as much as three pounds could be expected. Just as important as the determination of how fast a buffalo can grow is the determination of how many buffalo should be stocked per acre in order to efficiently utilize the food resources of a pond.

Generally speaking, we found (in our unfertilized but old hatchery ponds) that fingerling buffalo stocked at the rate of 500 per acre would weigh about a pound at the end of the first summer, or we would get a total gain in weight of about 500 pounds per acre. We could then take these pound size buffalo and stock them at the rate of 250 per acre and obtain a three pound buffalo at the end of the season. Here again we get an average gain in total weight of around 500 pounds per acre. Of course, there is a limit to the total pounds of fish an acre of water can support and there is a point of diminishing returns as the total pounds of fish in the pond builds up. It is illogical to expect an additional gain of 500 pounds per acre per year in a population of fish already weighing 750 pounds per acre. Therefore, after several years of experimentation and taking into account the particular situations found in the fish farming areas

of Arkansas, we finally decided that somewhere around 100 buffalo fingerlings should be stocked per acre in the growing pond. These fingerlings need not weigh over one-fourth (¼) pound each. Large fingerlings (¾-pound to 1-pound) are harder to handle, fewer can be transported in a given volume of water and it is not economical to raise them to this size or buy them at this size for stocking growing ponds. Fairly small fingerlings can be used in "clean" growing ponds, however, for stocking lakes and reservoirs containing adult predatory fish (bowfin, bass, etc.) the fingerlings must be too large for these fish to conveniently swallow.

TABLE II

SHOWING WHAT MIGHT BE CALLED MAXIMUM GROWTH POTENTIAL OF BIGMOUTH BUFFALO AS DETERMINED AT THE JOE HOGAN STATE FISH HATCHERY, LONOKE, ARKANSAS, IN ¾-ACRE PONDS IN 1955. FISH USED WERE TWO-YEAR-OLDS AT TIME OF STOCKING. THESE PONDS WERE ALSO STOCKED WITH LARGEMOUTH BASS, HOWEVER, INTERSPECIFIC COMPETITION SHOULD BE INSIGNIFICANT

STOCKING

Pond No.	*Number Male*	*Number Female*	*Date Stocked*	*Species*	*Total No. Stocked*	*Average Length Inches*	*Average Weight Pounds*	*Total Weight Pounds*
13	5	2	4-6-55	Bigmouth	7	13.93	1.6	11.2
3	–	2	4-6-55	Bigmouth	2	13.93	1.6	3.2
11	5	–	4-6-55	Bigmouth	5	13.93	1.6	8.0
12	–	6	4-6-55	Bigmouth	6	13.93	1.6	9.6
10	–	4	4-6-55	Bigmouth	4	13.93	1.6	6.4
4	3	–	4-6-55	Bigmouth	3	13.93	1.6	4.8

HARVESTING

Pond No.	*Date Harvested*	*Total Months in Pond*	*Avg. Length Inches*	*Avg. Weight Lbs.*	*Total Weight Lbs.*	*Total Weight Gain Lbs.*	*Avg. Weight Gain Lbs.*	*Avg. Length Gain Inches*	*No. Harvested*	*Percent Mortality*
13	9-14-55	5.23	19.07	4.54	31.8	20.6	2.94	5.14	7	0.0
3	2-29-56	10.77	23.25	7.75	15.5	12.3	6.15	9.32	2	0.0
11	2-23-56	10.57	....	4.50	22.5	14.5	2.90	...	5	0.0
12	3-15-56	11.30	22.00	6.95	41.7	32.1	5.35	8.07	6	0.0
10	3-13-56	11.23	22.00	6.25	24.9	18.5	4.65	8.07	4	0.0
4	3-22-56	11.53	19.67	4.07	12.2	7.4	2.47	5.74	3	0.0
				Total Weight Gained.....		105.4				
				Overall Average Weight Gained.....			3.90			
				Total Number Harvested.....					27	

Our growing ponds have a maximum depth of six feet and an average depth of 3½ feet. Size, depth and shape of the growing ponds on the fish farms vary greatly according to the topography of the land and the resources of the farmer. A 20-acre growing pond seems relatively small while 200-acre ponds are not uncommon. We recommend a minimum depth of at least 18 inches but prefer two feet or more. Two-thirds (2/3rds) or more of the pond should be two feet deep or deeper.

There are various methods of managing the growing pond (Stevenson, op. cit.; Hulsey, 1957) but the usual and seemingly best practice is to keep it in fish for two years, drain, and if it is a rice field, plant it to rice for one or two years. A six pound or heavier buffalo fish is desired by the market and this is what the fish raiser shoots for.

FEEDING BUFFALO FISHES

We have felt that it would not be economical to try and feed out buffalo fishes for the food market. Feeding has been limited to the over-wintering pond, the spawning pond and sometimes the nursery pond.

There is no doubt that a lot is to be learned about the proper feed for buffalo fishes, and it is hoped that the U. S. Fish and Wildlife Service Fish Experiment Station that is to be set up near Stuttgart, Arkansas, will answer some of these questions. The food formula used at the State Hatchery varies somewhat according to the prices and availability of the various ingredients (Table III).

TABLE III

BUFFALO FISH FEED FORMULA

Rice Bran (Not Hulls)	600 Lbs.
Cottonseed Meal	600 Lbs.
Dehulled Soybean Meal (Fine Ground)	300 Lbs.
Poultry By-Product Meal	200 Lbs.
Wheat Shorts (Fine Grade)	50 Lbs.
Ground Yellow Cornmeal	50 Lbs.
Dry Whey or Other Dried Milk Product	100 Lbs.
	1,900 Lbs.
Pure Vitamin B-12	25 Milligrams Per Ton
Pure Vitamin A	10,000 Units Per Lb. Finished Feed
Pure Vitamin D	4,500 Units Per Lb. Finished Feed
TM-10	4 to 20 Lbs. Per Ton Finished Feed*
Salt	40 Lbs. Per Ton
Di-Calcium Phosphate	40 Lbs. Per Ton

* Sometimes fed only when disease outbreak is feared.

This feed has been manufactured in both a meal and pellet form. We prefer pellets for buffalo fish as they feed readily on the pond bottom and the pelletted feed sinks to the bottom. Swingle (1958) states that a maximum of 30 pounds of pelletted feed can be fed channel catfish per day in "dead water" ponds. Our maximum rate of feeding per acre per day has been 20¼ pounds per day.

FERTILIZING

Fish pond waters are fertilized for three reasons: (1) to increase fish production; (2) to aid in the control of aquatic weeds and "moss"; and (3) make possible one standard rate of stocking fish (Hogan, 1946; Davison, 1955).

We recommend that the wintering pond, the spawning pond and the nursery pond be fertilized and maintained at high levels of fertility. The growing pond or reservoir is a different matter. Each growing pond should be regarded as an individual problem, and in event fertilizer is used, we feel it should be only after a soil test has been made. The growing pond should be fertilized according to the results of the soil test with the following crop of rice, or the particular desires and capabilities of the pond owner in mind.

DISEASES AND PARASITES

Buffalo fishes, like all other animals, have their share of diseases and parasites. We have experienced bacterial infections, fugus infections and infestations of the anchor parasite, In the spring, we have occasionally noticed ulcers on the gill covers of the broodstock buffalo. Generally speaking, our work has involved the development of a pond method of propagation with little attention given to diseases other than the trial use of treatments recommended by others (Stevenson, 1954; Davis, 1953; Dobie, *et al.*, 1956; and Prather, *et al.*, 1953). The control of diseases and parasites is very important in the culture of any organism and it is hoped that the new U. S. Fish and Wildlife Service Fish Research Station that is to be installed near Stuttgart will undertake such work. Treatments we have used with varying degrees of success are listed below (Table IV).

TABLE IV

DISEASES AND PARASITES OF BUFFALO FISH AND TREATMENTS TRIED

Disease and/or Parasite	*Treatments Tried*
Fungus Infections	3% SALT Dip. 4 Parts Per Million POTASSIUM PERMANGANATE in Troughs. 2 Parts Per Million POTASSIUM PERMANGANATE in Ponds. 0.10 Parts Per Million PHYGON-XL in Ponds.
Bacterial Infections	1 Part Per Million ACRIFLAVINE in Hauling Water. 190 Milligrams TERRAMYCIN Per Gallon Hauling Water. Addition of TERRAMYCIN to Feed (See Table III). 2 Parts Per Million POTASSIUM PERMANGANATE in Ponds. 0.5 Parts Per Million COPPER SULFATE in Ponds.
Anchor Parasite Infestation	1.0 Parts Per Million LEXONE (or Other Similar Preparations) in Ponds, Repeated Every 7 Days for 3-5 Weeks, or 0.5 Parts Per Million Repeated Every 4 Days for 3-5 Weeks.

There is one fundamental principal that should be kept in mind, i. e., that no amount of treatment will take the place of fast growth, proper hatchery sanitation and proper handling of the fishes themselves.

PREDATORS AND COMPETITORS

Cranes, herons, snakes, frogs, raccoons and other such animals are at times important predators, especially during draining and harvesting operations. We have already discussed the harm caused by predacious aquatic insects. "Wild-fish" such as bream, shad and green sunfish are the most obvious problem faced by the commercial fish producer. It seems that no pond or reservoir is ever completely free of wild fish. Wild fish are important predators on the small buffalo in the spawning and nursery ponds. In the growing pond they become important competitors for the available food supply. Many farmers have drained their growing ponds only to discover that they have raised an excellent crop of gizzard shad, bullhead catfish, carp or "bream". Even though state law allows the sale of any fish produced in private ponds, most of the wild fish are of a species or size little desired by the market.

A constant fight against wild fish must be carried on. Rotenone, lime and sodium cyanide are chemicals commonly used to poison pot holes and borrow ditches before the ponds are filled with water. Whenever possible ponds are initially filled with well water in an attempt to avoid wild fish.

Once a pond becomes infested with unwanted wild fish, remedial steps must be taken. Recently, selective kills of "bream" and bullhead catfish have been carried out successfully in nursery ponds using the chemical Lexone at a concentration of approximately 1.0 parts per million. It seems that buffalo fish can withstand higher concentrations of this chemical than "bream" and catfish. In growing ponds we have been carrying out selective kills of shad for several years using rotenone at a concentration of approximately 1/200ths part per million. Heavy stocking with largemouth bass is also a technique used to control the competitors in growing ponds.

HANDLING AND HAULING

"Understanding the factors which cause death or distress to fishes during transport is basic to improving present transport methods. Several variables can become lethal agents during transportation. These can act individually, or more likely, in combination, and thus with increased possibilities of causing mortality. The most obvious factors which may become lethal are: temperature, oxygen tension, waste product levels, carbon dioxide tension, and pH." (McFarland and Norris, 1958).

Heavy mortality rates experienced in some of the newer fish farming areas appear to be due to injuries received by the fry and fingerlings during seining,

hauling and stocking procedures. It does little good to raise a crop of fry or fingerling fish if they are to be killed by the rough handling of inexperienced persons. We rate this problem second only to the wild fish problem. It should be remembered that the gills of a fish take oxygen out of the water the same as our lungs take oxygen from the air. When large numbers of fish are crowded into a small water area, they soon deplete the water of all oxygen.

It seems that most reservoir owners would do well to purchase their fingerling buffalo fish "f.o.b. destination" from commercial hatcheries, thereby having them delivered and stocked by experienced fish culturists. Such a procedure would, no doubt, eliminate much of the "hidden" mortality which is not discovered until one or two years later when the reservoir is drained for the purpose of putting the fish on the market.

ACKNOWLEDGMENTS

The authors wish to extend thanks to Mr. Joe Hogan, Supervisor of Fisheries, for making ponds available for the carrying out of this work.

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THE USE OF HOBBLED GILL NETS IN A COMMERCIAL FISHERY OF LAKE CARL BLACKWELL, OKLAHOMA

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ABSTRACT

A modified gill net known as a hobbled gill net was utilized in a commercial fishery in 3,300-acre Lake Carl Blackwell in Central Oklahoma from September, 1957 through December, 1958. A total of 3,200 fish weighing 20,252 pounds was taken in 1,085 net days, a net day being 300 feet of net fished 24 hours.

Non-game fishes represented 97 percent by weight of the total catch. Hobbled gill nets proved particularly effective in taking flathead catfish, which comprised 63.4 percent by weight of the total catch. The average catch of flathead catfish increased from 4.9 to 13.0 and 14.6 pounds per net day for 3.0-, 3.5- and 4.0-inch bar mesh nets respectively. In general, the catch of all other species decreased as the mesh size increased from 3 to 4 inches. Hobbled gill nets may be an efficient modification over standard commercial gill nets and a more selective gear for large flathead catfish than other entanglement gears.

INTRODUCTION

A commercial fishery was conducted in 3,300-acre Lake Carl Blackwell, Payne County, Oklahoma, from September, 1957, through December, 1958, utilizing a modified gill net known as a hobbled gill net. This net is being used by many Oklahoma commercial fishermen and it is believed that the net represents an efficient modification of regular gill nets. It is not known who first designed the hobbled gill net, although it is reported to have been originally used in Oklahoma by fishermen in Grand Lake in 1955-56. A description of the hobbled gill net, a discussion of its efficiency and the commercial harvest from Lake Carl Blackwell are herein reported.

Descriptions, use and efficiency of much of the freshwater commercial fishing equipment used in the Mississippi River have been discussed by Starrett and Barnickol (1955). Houser (1957) described the gear used in Lake Texoma during 1952-53. White (1955, 1959) discussed the commercial fishing gears used on T. V. A. lakes in Alabama. Two of the most widely used entanglement

* Data collected as a graduate student at Oklahoma State University.