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SOME PROGRESS IN THE CONTROLLED CULTURE OF THE LARGEMOUTH BASS, *MICROPTERUS SALMOIDES*, (Lac.)[1]

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INTRODUCTION

More than 19 million largemouth bass, *Micropterus salmoides* (Lacepede), fingerlings were produced and distributed by federal fish hatcheries in 1967[2]. If state hatchery production were added to this total, the number supplied by public hatcheries is estimated to be well over 42 million. This estimate is based on the findings of Hagen and O'Conner (1958) who reported a ratio of state to federal bass production of 1.22 to 1.0. Largemouth bass are included in practically all of the 30,000 to 40,000 farm ponds stocked annually by the Bureau of Sport Fisheries and Wildlife (King, 1960). In the southeast, only the bluegill sunfish, *Lepomis macrochirus*, Rafinesque, approaches the largemouth bass in importance numerically, and the fact that more bluegills are distributed than bass is explained by the greater number stocked per acre rather than that more acres receive bluegills than bass.

There was a steady upward trend noted in the number of bass distributed by federal hatcheries during three decades starting in 1940 which reached a peak about 1965. Available information suggests that this high rate of demand can be expected

[1] Prepared for presentation at a meeting of the Southern Division of the American Fisheries Society held in conjunction with the 22nd. Annual Meeting of the Southeastern Association of Game and Fish Commissioners, Baltimore, Maryland, October 21-23, 1968.

[2] Annual Report - 1967. Division of Fish Hatcheries, U. S. Dept. of Interior, Bureau of Sport Fisheries and Wildlife, Washington, D. C.

to continue in future years. McBroom (1967), reporting on the results of a nationwide survey of needs for hatchery fish conducted in 1966-67 by the Bureau of Sport Fisheries and Wildlife, predicted an increase in warm-water fish habitat of more than 8 million acres by the year 2,000. Undoubtedly, a substantial part of this acreage will entail management programs where initial or corrective stocking of bass will be called for. This new water, along with the manageable waters currently requiring renovation, suggests that future production of largemouth bass will continue to be an important facet of warm-water fish husbandry.

In spite of the heavy demand for largemouth bass for stocking purposes, basic production methods have changed but little in the past 20 years. Methods described by Meehean (1939), Blosz (1947), and Topel (1949) are still being used with minor modifications by federal warm-water hatcheries. This fact is a tribute to the soundness of the procedures recommended by these workers, but indicates a lack of progress when compared to advances in other areas. Presently, varying numbers of adult fish are stocked in spawning ponds at about the normal spawning date for the species at a given latitude. Parent fish pair themselves and produce young during a 6-10 week long spawning season. At a suitable time the young are either harvested for distribution directly from the spawning pond or, more commonly, transferred to a fertilized rearing pond for further growth. After a relatively short (15-30 days) growing period the survivors are harvested for distribution at a size of 1.5-2.0 inches total length.

The relatively uncontrolled nature of the above method does not permit the fish husbandman to retain the initiative in conducting the operation. Once the fish are stocked in the spawning or rearing pond there are only a limited number of actions he can take to safeguard his stock and their offspring. A further disadvantage is the lack of knowledge which he generally has of what is occurring in the production ponds. Often the first warning he has of a crop failure is the absence of harvestable fish at the end of the production period. Obviously by this time it is too late to take corrective action.

For the past ten years, investigations at the Marion, Alabama National Fish Hatchery have been conducted into ways more control can be gained over the various steps involved in the production of several sizes of largemouth bass. This paper is in the nature of a progress report of what has been learned in this regard.

Controlling the spawning date

Largemouth bass spawn in the spring as water temperatures approach 65°F. Other factors also are probably involved in the exact time of spawning, including characteristics inherent in the individual fish. As a consequence, spawning usually extends over a 6-10 week period for a given lot of adult bass. For mass production of small bass under hatchery conditions, it is desirable to have as many of the brood stock in a given pond spawn simultaneously as possible. Also, it is advantageous to delay the first spawning until weather conditions stabilize and danger of cold temperatures is past (Jurgens and Brown, 1954).

A simple and effective technique has been developed to delay spawning of bass or other warm-water species. Prior to the time the earliest ripening fish begin egg-laying, the brood stock is sorted into two lots, one containing males, the other females. These lots are then held in separate ponds until spawning is desired. At that time they are reunited and heavy spawning can be expected in 24-48 hours provided that conditions are favorable. For largemouth bass at Marion, we sex and separate the fish when the male bass begin to sweep out nests. Depending upon the weather, the sexes are held separately for two to three weeks. In five trials during two spawning seasons in 16 ponds, the method has given good results in four trials with mediocre success in the fifth, due possibly to some errors in sexing or unexplained factors.

Fish can readily be separated as to sex just before spawning using the technique described by Snow (1963a). Doubtful individuals can be identified by use of an otoscope (Driscoll, In Press). Some training is required in applying the techniques, although with practice the average fish culturist can achieve a high level of accuracy, especially if the operation is performed before the bass have spawned.

Use of artificial rations

Our progress in rearing large bass fingerlings for special purposes has been detailed elsewhere (Snow, 1960, 1963b, In Press-a, In Press-b). The method developed entails training 1.5-2.0 inch pond-started fingerlings to take a suitable size food particle in concrete holding tanks. The best size bass to train appears to be one of about 500 fish per pound. It is essential that the fish in a given lot be uniform in size and be moderately crowded. Rates of 0.2-0.5 pound of fish per cubic foot of tank volume seem most desirable. A period of 7-14 days for tank training has proven to be ample, after which the fish are returned to earthen ponds for rearing to whatever size is desired. A stocking rate of 20,000 fish per acre seems about right to obtain fish of 6-8 inches total length in a growing period of about 90 days (July 1 – October 1).

The most effective ration tried so far has been the Oregon Moist Pellet (Hublou, 1963). In spite of a relatively high cost of $0.21 per pound delivered to Marion, Alabama, it has been possible to grow largemouth bass to a size of 6-8 inches for a feed and labor cost as low as $0.32 per pound in one pond and an average cost of $0.46 in three ponds. The highest yield was 3,283 pounds of bass per acre and feed conversions ranged from 1.33 to 1.85 on an all-pellet diet.

Inclusion of ground frozen fish during the training period apparently improves the palatability of the ration as a higher percentage of the bass learned to take the ration when this was done. About 25 percent of the ration by weight seems to be an ample quantity of fish. It can be discontinued after 2-3 weeks as best conversions were obtained when an all pellet diet was used.

Some preliminary work has been done in the artificial feeding of smaller size bass. Snow (1960) was not very successful in feeding bass smaller than 1.5 inches. Hawkinson[3] did better, however, rearing 17 percent of the swimup fry to advanced fry which he started in troughs stocked at a rate of 2,100 fry per trough and fed three different starting rations. After examining his results and studying the particle size as compared to the mouth size of the fish, he was of the opinion that most of the feed he supplied was too large for the small bass to swallow.

Ostergaard[4] gathered data on the gape (mouth size) of bass fry as they developed beyond the swim-up stage to a total length of 43 mm. From his measurements, he concluded that particle size of commercial trout diets of "starter" size was too large for the first feeding of largemouth bass.

Feeding beyond a 6-8 inch size

Once largemouth bass become accustomed to taking an artificial ration they can be maintained on it for an extended period. Also, evidence exists that they will revert to a natural diet when hand-feeding ceases and forage fishes are again available (Snow, 1963b, In Press-a).

During 1966-67 a 0.1-acre pond was stocked with 400 8-inch bass reared to that size on a mixture of equal parts ground frozen fish and dry pelleted trout feed (Table 1). During the period October 14, 1966 to April 6, 1967, the fish gained 69.4 percent in weight with a feed conversion of 4.6. Numerous fish developed sexually and spawned successfully at one year of age.

A more extensive trial was conducted in 1967-68. In October 1967 three 0.1-acre ponds were each stocked with 225 eight-inch bass which had been reared to that size from a size of two inches on a diet of Oregon Moist Pellet. Four other ponds were stocked with similar fish except that the previous ration had been a mixture of 50 percent trout feed and 50 percent ground frozen fish. These latter fish were changed to a diet of pelleted trout feed while the first three lots were continued on Oregon Moist Pellets.

Feeding was done once or twice daily except when water temperatures dropped to the point where the fish would not take feed. This generally occurred at about

[3]Hawkinson, J. S. Unpublished Report. A study of rearing largemouth bass fry, *Micropterus salmoides* (Lacepede), on artificial diets in a controlled environment.

[4]Ostergaard, D. E. Unpublished Report. Relationship of total length and gape of largemouth bass fry. Term Problem Report, Warm-water Inservice Training School, Marion, Alabama.

8°C. A rate of 2.0 percent of the body weight per day was fed initially with increases being made when it became obvious to the fish culturist that the lot would consume more.

Two of the ponds were harvested on April 9, 1968 and yield data obtained. The pond where the commercial trout ration was fed produced 223 fish ranging in size from 0.15 to 0.38 pound and averaging 0.239 pound. Where the Oregon Moist Pellet was fed, 193 fish were recovered ranging in size from 0.19 to 0.48 pound and averaging 0.285 pound. Conversion on OMP was 3.75 with a return of 551 pounds per acre. On the dry trout feed, conversion was 4.50 and a yield of 533 pounds per acre was noted.

TABLE 1

Growth of largemouth above fingerling size.

Pond No.	*Ration*	*Lbs. fed*	*Wt. Gain (Lbs.)*	*Conversion*	*Days fed*	*Mean water temp. °C.*	*Percent survival*	*Average weight (lbs.)*
C-20	Mixed*	342.0	74.2	4.6	174	14.0	92.4	0.49
C-11	Trout pellets	155.5	45.3	3.4	264	17.0	87.6	0.43
C-12	Trout pellets	156.5	46.0	3.4	264	17.0	81.8	0.46
C-13	Trout pellets	231.2	84.2	2.7	317	17.9	89.3	0.61
C-10	Trout pellets	64.8	14.4	4.5	181	11.7	99.1	0.24
C-22	Oregon Moist Pellet	207.3	73.0	2.8	264	17.0	77.8	0.63
C-23	OMP	67.9	18.1	3.8	181	11.7	85.8	0.28
C-24	OMP	206.6	76.0	2.7	264	17.0	83.6	0.60

*Mixture of equal parts ground frozen fish and commercial pelleted trout feed fed during 1966-67. Other trial was run in 1967-68.

The remaining five ponds were maintained on feed for a total of 264 days, after which the two remaining OMP and two commercial trout feed ponds were harvested. Yield data are shown in Table 1 and a length-weight relationship shown for a population on each ration in Figure 1. Oregon Moist Pellet appeared to be the superior ration in this trial. While not spectacular, growth on each ration was steady and increased noticeably after the spawning season in the ponds which were continued for the longer growing period.

The superiority of OMP as a growing ration for larger bass is further verified by these data. While the 2.4 conversion is higher than the figure obtained when smaller fish were fed, consideration must be given to the effects of slow growth during the cool months, reduced growth or a possible weight loss during spawning and increased maintenance requirements of the larger fish.

By spawning time an average size of about 0.3 pound was reached by both the fish fed the dry diet and those receiving the moist diet, while those on the mixture of fish and dry pellets the previous year exceeded this figure. Many fish examined from these ponds were sexually mature and the fish in the ponds during the spawning season spawned heavily even though stocked at rates of about 2,000 per acre. The lots fed beyond fingerling size for 264 days had been on artificial food for a year or slightly longer when the experiment was terminated. They were started on feed in June 1967 and harvested on July 15, 1968.

Control of eggs and fry

The logical time to train young bass to take an artificial ration seems to be at the time they first begin to feed. To test this assumption it is necessary to have the fry

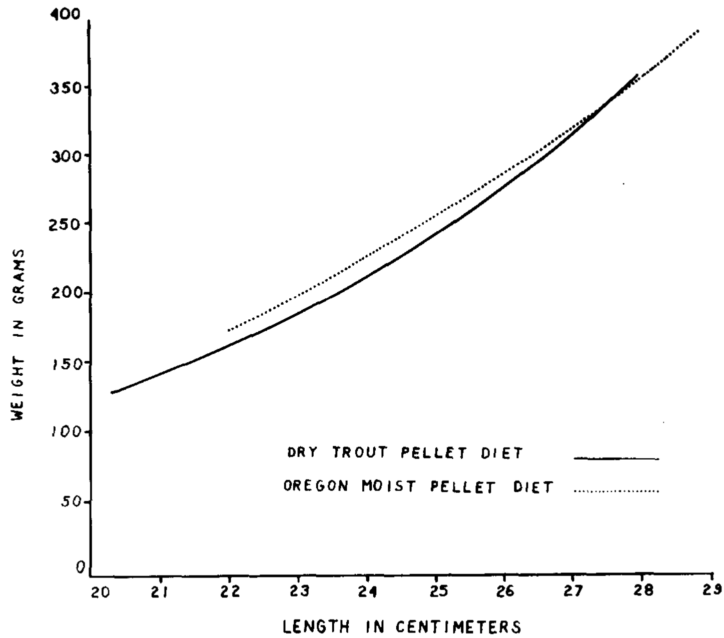

FIGURE 1. LENGTH-WEIGHT RELATIONSHIP FOR LARGEMOUTH BASS FED TWO PELLETED RATIONS (STOCKING RATE 2,250 FISH PER ACRE)

under controlled conditions before the yolk sac has been absorbed. Use of nylon felt spawning mats (Chastain and Snow, 1966) for deposition of the bass eggs and subsequent removal for incubation under controlled conditions offers one means of accomplishing this. Repeated trials with the nylon felt spawning mats in spawning ponds indicate that bass in the Marion National Fish Hatchery brood stock will utilize them as spawning sites sbout two-thirds of the time. Once laid, eggs can be removed from the pond and separated from the mats for jar hatching or incubated by suspending the mats in a tank of suitable size or placing them in a nursery pond to hatch and continue development there. All of these methods have been employed successfully in recent studies at this station. Results to date favor suspending the mats in a tank supplied with a small flow of fresh water and aerated with an electric agitator.

Removal of the eggs from the matting is rather tedious, damages embryos when they near the hatching stage and incorporates considerable amounts of detritus in the eggs which appears to be undesirable in the hatching jar. Transfer of the mats bearing eggs directly to the nursery pond for incubation exposes the eggs and newly-hatched fry to insect predation, disease conditions or other stresses which may take a toll before the embryos develop to a point where they can fend for themselves. In six trials where mats were incubated in nursery ponds, two were considered to be highly successful, two were partially successful and two were failures. With precautions taken to guard the eggs and embryos from insects, this approach might offer more consistent returns.

Extensive testing of incubating bass eggs on mats in tanks was done during the 1968 spawning season. Three 0.1-acre spawning ponds, each stocked in October 1967 with 225 yearling bass 7-8 inches in total length, were used as a source of eggs. Nylon felt spawning mats were placed in the ponds as described by Chastain and Snow (1966), after extensive nesting activity commenced. A considerable amount of spawning is believed to have occurred prior to mat installation in one of the ponds (C-11) with lesser amounts in the other two. The brood fish had been reared from a size of two inches to spawning size (average about 0.33 pound) on artificial food. Fish in two ponds received an Oregon Moist Pellet diet and the third received a commercial trout feed[5] After installing the mats, observations were made almost daily with eggs being removed prior to hatching in a majority of cases.

The mats bearing eggs were incubated in three fiberglass tanks holding about 70 gallons or two 50-gallon aquaria. Aeration was provided with an electric agitator and a small trickle of fresh water was also maintained. The 18 x 32-inch spawning mats of nylon felt were suspended on edge 2-3 inches apart. The agitator occupied the center of the container. No treatment was given the eggs or fry although this could have been done had the occasion demanded it. Upon hatching, the embryos dropped to the bottom of the tank where they remained until swim-up. At the prevailing water temperature of 68 to 75 degrees F. about five days were spent in this stage. Eggs hatched well under these conditions with only a small amount of fry mortality being observed in one of the aquariums which may have been stocked with too many mats.

Rearing fry in nursery ponds

Within 24 hours after swim-up, the recently hatched fry were transferred to fertilized rearing ponds which had been freshly filled at about the time the eggs were removed from the spawning pond. Fertilization was continued at weekly intervals until the ponds were harvested, usually from 20-35 days. Yields from six nursery ponds treated in this fashion in 1968 and one in 1967 are shown in Table 2. The

TABLE 2

Results of stocking artificially incubated swim-up bass fry in small ponds.

Pond Number	*Est. stocking rate per acre*	*Yield at Draining Per acre Number*	*Yield at Draining Per acre Weight (lbs.)*	*Est. percent survival*	*Days in production*
C-1*	113,000	43,230	120	41	32
C-6*	150,000	25,120	67	17	26
C-8	250,000	25,940	54	10	33
C-10**	150,000	115,380	65	77	35
C-19	120,000	42,900	30	36	19
C-23	200,000	70,000	55	35	22
C-24	250,000	151,200	105	60	24
C-9***	150,000	110,000	27	73	14
Average		72,970	65	43.6	25.6

*Pond sterilized with calcium hypochlorite instead of being drained prior to beginning production cycle.

**Stocked with 10 spawns on nylon felt mats instead of swim-up size fry.

***1967 production season, remainder in 1968.

variability is thought to be related to the failure to harvest two of the ponds promptly when food ran out and use of fry of three ages in the third. In spite of our failure to follow sound bass cultural principles in these instances, the average yield per acre in all ponds was better than average yield from the regular production ponds on the Marion National Fish Hatchery. For 1968 the production hatchery yield was 61,412 fish weighing 55 pounds per acre. From the ponds where swim-up fry were stocked, the yield averaged 72,970 fish weighing 65 pounds per acre.

[5]Silver Cup brand manufactured by Murray Elevators, Murray, Utah.

Difficulty in controlling a dense growth of net algae in one rearing pond (C-8) was the main production problem encountered. Some embryos were lost in the spawning ponds because they hatched before removal of the mat could be effected. Several hatched in the process of being removed and during transfer to the incubation tanks. Water temperature in the range of 68 to 75° F made it necessary to move the mats within 36 hours after spawning to avoid this. Several nesting sites were used rather continuously during the collecting period. On one site, spawning and subsequent egg removal took place three successive days. Several sites yielded spawns on two successive days and still others were used three times in four days. It was not determined whether the same male fish was producing daily spawns, although this was suspected.

Discussion of results

Several applications may possibly be made of these findings. Further investigation of the possibilities associated with intensive egg production in small ponds seems indicated. It appears that eggs are more likely to be placed on spawning mats under such conditions. Crowding the brood fish may reduce the number of eggs produced per brood fish, but it could well increase the number obtained per acre. This would save pond space and enable the bass culturist to concentrate his efforts on a limited area, thus making better use of his knowledge and skill.

Control of the eggs and fry makes it possible to treat either stage for disease control if such is a problem. Embryos may be protected from predators and adverse environmental stress such as weather conditions (Jurgens and Brown, 1954). Test animals can be made available in quantity for research requiring earlier stages of development than those ordinarily employed. Protection can be given to the embryo during critical stages of development and knowledge as to the degree of spawning success is available on a current basis. This latter fact alone is quite valuable, as the fish manager can ready nursery ponds according to the production of eggs and fry rather than try to estimate requirements several weeks in advance as must be done with present methods. Control of sac fry also will permit extensive investigation into the use of artificial food for developing embryos in controlled rearing.

Successful feeding of fingerling and adult bass enables the bass culturist to produce any size fish desired under intensive and controlled conditions. All of the advantages, along with the disadvantages of controlled cold-water fish husbandry, appear applicable to the largemouth bass. Furthermore the strongly piscivorous food habits of the largemouth bass makes it mandatory that the fish stock be well fed at all times. Of particular interest is the possibility that disease control can be effected by incorporating medication into the ration as has been done so successfully with domestic animals and to some extent with cold-water species of fishes.

Investigation into the feasibility of a raceway type environment and automated feeding devices now appears to be possible. The relatively low production costs obtained for 6-8 inch bass suggests that further work be done in corrective stocking of this size bass in situations where forage fishes are crowded with a size which can be swallowed by the bass. Maintenance of the hatchery brood stock on an artificial diet will eliminate infestations of the bass tapeworm. Further refinements in feeding techniques and an improved ration conceivably may make "put and take" bass fishing justifiable in areas where heavy use and limited water area makes availability of bass fishing low.

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CULTURE OF PENAEID SHRIMP IN BRACKISH-WATER PONDS, 1966-67[1]

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ABSTRACT

Young shrimp have shown rapid growth in brackish-water ponds which had been fertilized, but to which no supplemental feed was added. In 1966, white shrimp *(Penaeus setiferus)* were stocked at the rate of nine shrimp per square meter of bottom in a pond that had been fertilized with chicken manure. In 1967, brown shrimp *(P. a. aztecus)* were stocked at a rate of 22 shrimp per square meter of bottom in one pond that was fertilized with rice husks and in another that was not fertilized. In both experiments initial growth was rapid; the shrimp attained bait size (75 to 93 mm total length) in 5 to 7 weeks. This rapid growth was followed by a period of slow growth. In 1967, supplementary feeding produced additional gains after growth had nearly ceased.

Survival of the white shrimp was 84 percent, whereas survival of the brown shrimp was 23 percent in the untreated pond and 31 percent in the fertilized pond. Oxygen deficiencies caused by dense blooms of phytoplankton during the 1967 experiment resulted in serveral mass mortalities.

INTRODUCTION

Experimental rearing of penaeid shrimp continued in 1966-67 at the Bureau of Commercial Fisheries Biological Laboratory, Galveston, Texas. Our investigations are

[1]Contribution No. 278 from the Bureau of Commercial Fisheries Biological Laboratory, Galveston, Texas.