PRODUCTION POTENTIAL OF CATFISH GROW-OUT PONDS SUPPLEMENTALLY STOCKED WITH SILVER AND BIGHEAD CARP

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Abstract: Three experimental ponds were stocked with a polyculture of channel catfish (*Ictalurus punctatus*), silver carp (*Hypopthalmichthyes molitrix*), and bighead carp (*Aristichthes nobilis*). Three control ponds were stocked with catfish alone. In 2 of the 3 sets of ponds, there was little difference in catfish production (less than 1 and 10% by weight) while total production in the polyculture ponds far exceeded the controls with catfish alone. In the remaining set, catfish production was less in the polyculture pond but total production remained higher as a result of the additional growth of the silver and bighead carp.

Lesser objectives were to refine artificial spawning methods and describe the difference in water quality resulting from the presence of the filter feeding Chinese carps. Successful hormone induced spawning techniques were developed and an improvement in pond water quality was noted.

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Since the silver carp and bighead carp were first imported into Arkansas in 1972, their efficient filter feeding mechanisms exposed several advantages for using these 2 species in polyculture. Intensive pond fish culture often results in low oxygen levels on a year-round basis. While there are several reasons for low oxygen levels, decomposition of metabolic wastes is probably the most important factor. As these waste products are broken down via bacterial degradation nutrients are released into the system that provide "fertilizer" for the production of phytoplankton.

The sudden mortality of the phytoplankton biomass, which often results from overpopulation, causes further problems since the dead plankton organisms also use oxygen. The loss of oxygen producing organisms and the subsequent increased oxygen demand often results in an oxygen depletion and loss of the crop of fish in the pond.

Over the years, the most widely used method of combatting reduced dissolved oxygen levels has been to pump fresh well water into the pond. This results in the addition of oxygenated water to the pond and flushing out organic wastes. This strategy can effectively solve the problem if the situation is closely monitored and fresh water added at the proper time. However, the increasing cost of energy to operate pumps and the decreasing level of the water table is making this method less and less acceptable to Arkansas' fish farming industry. An efficient and economical alternative is needed.

Feeding silver and bighead carp on plankton in the pond can be compared to continual grazing of cattle on a well fertilized pasture. the grass never gets too tall, but continues to grow. The same thing would be expected to happen as these fish "filter" the plankton from the water. Plankton growth is stimulated while the chance of overpopulation and die-offs is reduced resulting in continual daytime oxygen production and reducing the chance of oxygen depletion. Waste products from the metabolism of the silver and bighead carp would also return to the pond as an oxygen demanding substance, however, the partially digested plankton is more easily recycled into the sytem. The fact that a single silver carp has exhibited the capability of growing to 12 pounds in 1 year indicates there is a significant amount of nutrients available for producing more fish flesh.

Silver and bighead carp do not compete directly for food with many commercial species. Therefore, an increased yield is the net result that should be a welcome addition to a commercial fish culture pond. The primary purpose of this study was to determine the feasibility and effectiveness of polyculture using silver and bighead carp in catfish production ponds. Determination of spawning techniques capable of efficiently producing seed in quantities necessary for commercial use was a secondary objective and the improvement in water quality noted during this study could not be overlooked.

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SPAWNING OF SILVER AND BIGHEAD CARP

To be commercially useful, a ready supply of fingerlings must be available for that particular species. The natural spawning requirements of silver and bighead carp are relatively specific and limited to free-flowing streams. They have never been known to spawn successfully in a pond or static water environment. This sub-objective was to develop an acceptable and economically feasible method of artificially spawning these species for commerical use.

Methods

Based on previous successful experiences in Arkansas, a series of hormonal injections of Human Chorionic Gonadotropin and acetone-dried whole carp pituitary were used to induce egg maturation and ovulation in these species of Chinese carp.

INJECTION SERIES No. 1: The grass carp injection method was the first tried. This consists of an initial intramuscular injection of 220 IU of HCG/kg of body weight; followed in 24 hours with a second intramuscular injection of 1870 IU of HCG/kg of body weight; and 24 hours later an interperitoneal injection of 2.2 mg of whole carp pituitary per kg of body weight. Spawning is expected within 6 to 12 hours after the last injection.

Three silver and 2 bighead carp females were placed in holding tanks and the above dosage rate and injection regime begun. All fish except one of the bighead females unexpectedly released their eggs in the holding tanks prior to the scheduled time of the third injection. One female silver carp ovulated after the first injection and the remaining 2 silver carp and 1 bighead carp after the second. The remaining bighead female did not ovulate even after the entire series was given.

Since this "premature" release of the eggs was not expected, males were not readily available and no eggs were fertilized. Viability of eggs obtained in this manner remain in question.

Injection Series No. 2: As reported in the literature (Lin, 1965), the Chinese and Japanese have successfully spawned these fish with carp pituitary alone. Two silver carp females were injected with 3 mg carp pituitary alone. Eggs were obtained but percent hatch was extremely low, less than 1%.

Injection Series No. 3: This method was described to the author by Dr. S.Y. Lin of Taiwan (personal communication). The method consists of an initial interperitoneal injection of 100 IU of HCG mixed with 1 mg of whole carp pituitary per kg of body weight. This is followed in 6 hours with a second injection of 500 IU of HCG mixed with 3 mg carp pituitary per kg of body weight. Spawning is expected within 6 to 12 hours after the second injection. Over the last 2 spawning seasons, over 20 silver and bighead carp have been successfully spawned using this method. This amounts to over 90% of the fish tried.

Fertilized eggs are hatched in McDonald type hatching jars with constant flowing water sufficient to keep the eggs in motion. At water temperatures between 22-24C, hatching takes place in 24 to 36 hours.

Conclusions

While all methods produced eggs, the first 2 described resulted in unpredictable spawning times and apparent low production of viable eggs. The third method utilizing the mixed injections is recommended. Over 2 separate spawning season, it has produced effective and efficient results with relatively high percent hatch. It could easily be utilized to produce fish of sufficient numbers for widespread commercial application.

POND SPAWNING OF SILVER AND BIGHEAD CARP

One of the reasons that several potentially valuable species of fish are not utilized in pond culture is due to their spawning habits. If the fish have the capability of spawning within the grow-out pond, then harvesting and sorting becomes a costly, time consuming effort. This is not a serious concern with the silver and bighead carp since these species do not reach maturity until 3-4 years and eligible spawners would not be used in annual production. However, since these are not native species, as much as possible, should be determined about their reaction to their new environment.

The objective of this part of the project was to determine if certain natural occurrences would be sufficient to stimulate spawning of these fishes in ponds. One of the methods commonly used to induce spawning of some native fishes in ponds is to rapidly exchange the water in the pond by pumping in fresh water. This often triggers spawning as a result of sudden water level increases, temepratur fluctuations, or by some other subtle effect that is not clearly understood.

Methods

Two small 0.3 ha ponds with a plentiful water supply and adequate drainage facilities were used to allow rapid exchange of pond water. During April, 10 pairs of silver carp brood stock were placed in 1 pond and 10 pairs of bigheads placed in the other. This allowed for 3 to 4 weeks of acclimatization in the ponds prior to water temperatures reaching the natural spawning level for these species. All fish were old enough to be safely considered mature adults and no mortalities were noted as a result of handling during stocking. Fish ranged in size from 4.1 to 6.8 kg.

A 6.25 cm hose was placed parallel to and just below the water surface of the pond containing the silver carp. A 1.5 horsepower electric pump was used to circulate water in the pond and establish a circular current. While this did not simulate the actual intensity of flow reported in natural spawning areas, it did produce a noticeable and continuous movement of the water within the pond.

As the water temperature in the ponds rose to and surpassed the optimum spawning temperature for thse species (22-24C), these ponds were intermittently lowered and "freshened" by pumping ground water through them. The current in the silver carp pond was also maintained. The ponds were observed daily and regular checks were made with a small mesh seine to see if eggs or fry could be found. This was continued for approximately 5 weeks until the pond water temperature reached and maintained itself consistently above 27C.

This segment of the project was begun in late April and the final checks were made in mid-July. At no time during this period was any activity noted that could be construed as courting or spawning behavior. During the period, no eggs or fry were located in either of the ponds.

Conclusions

These fishes could be stocked in static water ponds without fear of reproduction.

POLYCULTURE OF CHANNEL CATFISH WITH SILVER AND BIGHEAD CARP

The objective of this section of the project was to determined the production potential of channel catfish grow-out ponds when supplementally stocked with silver and bighead carp. This included total production of all species present as well as noting increases or decreases in the production of the primary crop, channel catfish.

Six ponds located on the Joe Hogan State Fish Hatchery were used for the test. Three ponds, approximately 2.9 ha each, were used as experimental ponds and stocked with both catfish and carp. One hectare ponds were used as controls and stocked with catfish alone. Due to different water flow patterns supplying these ponds, a control pond was paired with each experimental pond. Both experimental and control ponds were treated as though catfish alone were present following accepted fish culture methods.

The stocking of the experimental ponds was plagued with difficulties from the beginning. The silvers and bigheads were held in the same pond before stocking. Inexperience in handling these species and the hand-sorting and counting of the mixed species resulted in large mortalities after stocking. Also, a mix-up on the part of a truck driver resulted in 2,000 extra fish being stocked in 1 pond and 2,000 less fish than planned stocked in another. These stocking errors resulted in some changes from the rates that were originally planned, however, since each experimental pond and its respective control were treated as separate units the results are comparable. Each set of ponds will be presented separately.

Ponds 59 and 59A

Pond 59 was the 2.8 ha experimental polyculture pond and Pond 59A was a 1.0 ha pond designated as the control pond. the channel catfish fingerlings used as the primary crop were smaller than what is usually stocked to produce a marketable 0.34 to 0.45 kg fish in one growing season. Refer to Table 1. for complete stocking and harvest information.

TABLE 1. Stocking and harvest rates for Chinese carp-channel catfish polyculture ponds.

	STOCKING			HARVEST			
Pond No.	Species	Size	No./ha	Av. Weight	Av. Length	No./ha	kg/ha
59 (2.8 ha)	ch. catfish	33/kg	4,591	0.13 kg	24.1 cm	3,144	408.72
	silver carp	5-7.5 cm	1,908	0.5 kg	33 cm	1,750	875
	bighead	10-12.5 cm	300	0.76 kg	35.5 cm	281	213.5
	TOTAL						1,497.22
59A (1.0 ha)	ch. catfish	33/kg	4,995	0.3 kg	30.5 cm	3,510	1,053
60 (3.0 ha)	ch. catfish	60.kg	4,574	0.68 kg	34.3 cm	4,374	2,974
	silver carp	5-7.5 cm	480	3.36 kg	68.6 cm	530	1,780.9
	bighead	10-12.5 cm	120	6.3 kg	33.8 cm	184	184
TOTAL							5,914.1
60A (1.0 ha)	ch. catfish	60/kg	5,000	0.63 kg	35.5 cm	5,490	3,458.7
61 (2.9 ha)	ch. catfish	7.7/kg	7,200	0.32 kg	30.5 cm	6,353.4	2,033
	silver carp	5-7.5 cm	523	1.18 kg	45.7 cm	171	201.8
	bighead	10-12.5 cm	480	1.77 kg	55.8 cm	351	621.3
	TOTAL						2,856.1
61A (1.0 ha)	ch. catfish	7.7/kg	7,500	0.34 kg	30.5 cm	6,177	2,100

These ponds were stocked in June, 1976, and the fish were fed throughout the growing season until water temperature dropped low enough to cause the fish to cease feeding. A 33% crude protein (minimum 10% by weight fish meal) sinking pelletized diet was used. The fish were fed 3% of body weight 5 days per week as the weather allowed. The feeding schedule was revised upward at approximately 2 week intervals to allow for growth of the catfish. Both ponds were sampled at 4 week intervals and the feeding rate adjusted based on the actual weight gain of the fish. The interim adjustment of the feeding rate made between the actual samplings was calculated assuming a 2 to 1 feed conversion rate. These ponds were fed a total of 104 days from time of stocking until feeding was stopped in early December of the same year. The fish were harvested during the first week of March, 1977, without the feeding program being resumed.

A total of 1,503 kg of feed was used in Pond 59A producing a food conversion ratio of 1.43 for the catfish in this pond. A total of 3,056 kg of feed was used in Pond 50 producing a food conversion ratio of 2.6 for the catfish and a coversion ratio of 0.72 when total production of both catfish and carp species are considered.

This discrepancy in feed conversion between these 2 ponds at first glance would be attributed to competition from the carp for the pelleted food. This conclusion, however, is not substantiated by results obtained in the other ponds in this study nor were the carp observed utilizing the pelleted feed during the study period. While it is not verifiable at this time, it is thought that the difference is due (at least in part) to (1) errors in estimating the number of fish initially stocked and (2) the fact that total standing crop remained low and the maximum feeding rate never exceeded 32.7 kg/ha/day. Feed distribution at this low rate is less efficient in the larger polyculture pond than in the smaller control pond.

Ponds 61 and 61A

Pond 61 is a 2.9 ha pond that was used as the polyculture pond and pond 61A is a 1.0 ha pond used as the control. The channel catfish fingerlings stocked as the primary crop in these ponds averaged 7.7 fish/kg. Refer to Table 1 for complete stocking and harvest information. The type of feed and the method of determining the feeding rates were the same as described for Ponds 59 and 59A.

These ponds were also stocked in June, 1976, and fed 104 days until cessation of feeding in December. The fish were harvested from these ponds during the last week of February, 1977, without feeding being resumed.

A total of 4,307 kg of feed was used in Pond 61A producing a food conversion ratio of 2.07 for the catfish in the control pond. A total of 14,610 kg of feed was used in Pond 61 yielding a food conversion ratio of 2.49 for the catfish alone and a conversion ratio of 1.77 when the total production of both catfish and carp species are considered. A maximum feeding rate of 71.6 kg/ha/day was reached in Pond 61A at the end of the growing season. In Pond 61, a feeding rate amounting to 88.9 kg/ha/day was reached prior to the end of the feeding period.

Ponds 60 and 60A

Pond 60 is a 3.0 ha pond that was used as a polyculture pond and Pond 60A is a 1.0 ha pond that was used as the control. The channel catfish fingerlings used as the primary crop in these pond were very small, averaging 50 fish/kg. Refer to Table 1 for complete stocking and harvest information. Type of feeds and methods were the same as described previously.

At the time of harvest of the other 4 ponds in early 1977, it was noted that due to the small initial size of the catfish fingerlings the catfish in Ponds 60 and 60A had only attained a size of 0.1 kg per fish. At that time, the project was amended to continue feeding these ponds through a second growing season so that the standing crop could be increased to a level more comparable to a commercial production pond. On 24 March 1977, feeding was resumed in these 2 ponds and they were not harvested until December, 1977.

These ponds were fed 104 days during the 1976 season and 130 days during the 1977 season until feeding was stopped in mid-October. This is a total of 234 feeding days from the time of stocking to harvest. A total of 7,514 kg of feed was used in Pond 60A, producing a food conversion ratio of 2.15 for the catfish in the control pond. A total of 22,636 kg of feed was used in Pond 60, yielding a food conversion ratio of 2.53 for the catfish alone and a conversion ratio of 1.27 when the total production of both catfish and carp species are considered.

Water Quality Variations

Daily observations of the ponds during the latter months of this study when feeding rates and standing crops were relatively high, revealed some rather obvious differences in water quality between the polyculture and monoculture ponds. In Ponds 59 and 59A, the standing crop of fishes and the feeding rate remained relatively low throughout the project period.. At no time were significant water quality differences noted between either of these 2 ponds.

During the hot summer months, a dense blue-green algae bloom appeared in Pond 61A. This same occurrence did not take place in Pond 61 where the silver and bighead carp were present. A relatively heavy phytoplankton bloom developed in Pond 61, but the population was predominantly green species and no mats or odors were formed. On 3 different occasions from mid-July to mid-September, the channel catfish in Pond 61A were found piping at the surface during early morning hours due to low oxygen levels. As a result, the wells were used to pump fresh water into the pond to alleviate the problem; no mortalities occurred as a result. While dissolved oxygen levels fluctuated widely in Pond 61 (polyculture pond) and relatively low oxygen levels were noted in early morning hours, no problems were encountered throughout the season.

During the latter part of the second feeding season, Pond 60A (channel catfish monoculture) was being fed at a rate of 78.5 kg/ha/day by late August and the pond had developed a dense, blue-green algae bloom. the well had to be used periodically begnning in July to prevent the loss of fish to oxygen depletion. An almost continual supply of incoming water taken from the draining of other ponds was necessary to continue advancing the feeding rate through August and September.

Pond 60 (polyculture pond) maintained adequate oxygen levels while the feeding rate was advanced up to 120 kg/ha/day. This system reached its limit on the morning of October 24 when an oxygen depletion occurred. The addition of potassium permanganate, superphosphate, and fresh water prevented severe losses of fish.

These obvious differences in water quality were believed to have occurred as a result of the feeding activity of the filter feeding carps. Recently completed studies have verified this by showing that the cuture of the silver and bighead carp in extremely fertile ponds results in a stable phytoplankton population, reduction of oxygen demand by 37% and reduction of total suspended solids in the form of phytoplankton by as much as 86% (Henderson, 1978 and 1979).

Conclusions

From past experience, a common practice on the Joe Hogan Hatchery is to not exceed a feeding rate of 38 kg/ha/day during the hotter months of late summer. This is considered a safe feeding level to avoid creating an overfertile situation, increasing the possibility of oxygen depletion and the necessity of pumping fresh water into the ponds. The average cost of operating one of the electrically powered wells on the hatchery at about 3,000 liters/minute is approximately $2.50 per hour of operation. When used for extended periods, this becomes a very significant operating expense for the fish farmer.

The lowered feeding rate would lessen the likelihood of operating the well but would also decrease production. Thirty-eight kg/ha/day would be little more than a maintenance diet in a heavily stocked production pond.

It is apparent that the stocking of silver and bighead carps in polyculture with channel catfish could allow for the same yield of channel catfish as a monoculture and improve the pond water quality. This would allow for a more intensive feeding program with less likelihood of costly pump operation being necessary. This fact alone would make polyculture systems a worthwhile method and the possibility of significant increases in total fish production with the same amount of feed makes it even more attractive. In one set of ponds in this study, total fish production in the polyculture was 44% greater than catfish monoculture while feed use efficiency decreased less than 15%. In similar silver carp-catfish polyculture studies at Auburn University, it is reported that catfish production was slightly increased and net income was $1,080/ha higher with the polyculture as compared to the catfish monoculture (Dunseth and Smitherman 1977).

This is not to say that this is the ultimate system for food size channel catfish production, but should suitable markets be developed for the silver and bighead carp, this would certainly provide a needed boost to the channel catfish production industry.

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