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Interactions of Intensive Cultures of Channel Catfish With Largemouth Bass and Bluegills in 1-Acre Ponds

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DEVELOPMENT of techniques for the pond culture of channel catfish (*Ictalurus punctatus*), and increasing use of the species in both tropical and temperate climates, have stimulated interest in the feasibility of combining channel catfish production with other pond cultures. In an earlier study (Buck et al. 1972) we examined the compatibility of channel catfish and golden shiners (*Notemigonus crysoleucas*) in combined cultures. In the study reported here we have attempted to measure the nature of the interactions when intensive cultures of channel catfish were superimposed upon existing populations of largemouth bass (*Micropterus salmoides*) and bluegills (*Lepomis macrochirus*).

DESCRIPTION OF PONDS

The ponds used in these studies were originally constructed to be 100 feet (30.5 meters) wide and 436 feet (132.9 meters) long, and to provide a surface area of 1.0 acre (0.4 hectare) when maintained at maximum depths of 7 feet (2.13 meters). In the present study maximum pond depths fluctuated between 6 and 7 feet (1.8 and 2.1 meters), and average depths between 3 and 4 feet (0.9 and 1.2 meters). Because of shoreline erosion over the period since the date of pond construction (1963), it is believed that areas of 1.0 surface acre (0.4 hectare) were very closely approximated at the levels over which the depths fluctuated during the period of study. Water was supplied to the ponds by gravity from a 585-acre (236.7-hectare) reservoir. Drainage valves were contained in cement headwalls which supported short walkways out over the deepest parts of the ponds.

1970 EXPERIMENTS

Materials and Methods

In April and May, 1970, six 1-acre (0.4-hectare) study ponds were each stocked with 635 3- to 6-inch (7.6- to 15.2-centimeter) bluegills and 305 largemouth bass of mixed sizes and ages, including mature adults. We hoped that the initial stock could be sufficiently large to permit both species to attain carrying capacities by fall.

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In May and June we superimposed channel catfish populations of two types (all caged; and half caged, half free) upon four of the bass-bluegill populations. The other two ponds were maintained as controls having only bass and bluegills. Two additional ponds were also maintained as controls with catfish only, half caged and half free. Thus, we had eight ponds — two with bass and bluegills only, two with catfish only, and two sets of two ponds each in which the catfish were combined with the bass and bluegills in two different ways.

Each catfish population was composed of 1,600 5-inch individuals of which 850 were stocked on May 14 and 750 were stocked on June 11. In one of the two types of catfish populations 800 of the fish were released into the pond while the other 800 were confined to cages; in the second type all 1,600 catfish were confined in two cages at rates of 800 per cage. As a convenience, each pond containing catfish was considered to have two population units, those stocked at a rate of 800 free in the pond, or those stocked at rates of 800 per cage.

Cages used in this study were constructed by lacing ½-inch (1.27-centimeter) mesh hardware cloth to a frame of thin-wall electric tubing of ½-inch (1.27-centimeter) diameter. Each cage was 4.5 feet (1.37 meters) long, 4 feet (1.22 meters) deep, and 4 feet (1.22 meters) wide, and was floated by Styrofoam to provide a water depth of about 3 feet (0.9 meter) and a water volume of about 2 cubic yards (1.5 cubic meters). Thus stocking was at a rate of 400 catfish per cubic yard (523 per cubic meter). Each cage was provided with a plywood cover having a "feeding ring" in the center. The "ring" had rectangular dimensions of 11.25 x 22.5 inches (28.6 x 57.15 centimeters) enclosing a water surface of 1.76 square feet (0.16 square meter), and extending about 16 inches (40.6 centimeters) below the water surface. The ring was designed to control the rate of feeding activity and to prevent the feeding fish from splashing the floating food out of the cage. Cage design is shown in the cover photo.

In earlier experiments (Buck et al. 1973) we had fed both caged and uncaged catfish populations a floating ration formulated as a supplemental food for catfish free in ponds and found that this ration was inadequate for catfish that were confined to cages, and resulted in high mortalities. In the present experiments all feeding was with Purina trout chow,

COVER PHOTO: Illustration of catfish cage design with "feeding rings."

a more complete diet, which eliminated fighting and high mortalities. The catfish were fed twice daily for 5 days each week. Daily rations were 3 percent of body weight per day from the start of the first feeding period of June 15 until September 2, and were then increased to 3.5 percent until the time of census in October. Ration amounts were determined from the weighing of 300 catfish from each cage every 14 days; the uncaged catfish were not sampled. Actual computation of the ration was based on an average of all cage samples so that all populations received the same daily ration, both those in cages and those free in the pond. We now know that determination of the rations from cage samples only meant that the faster-growing uncaged fish were receiving less food per unit of body weight than were the caged catfish.

All populations were censused by pond drainage in October, 1970, at which time the bass and bluegills were returned to their ponds and the catfish were pooled in one pond and held overwinter for redistribution in the spring.

Results

Gross census data for 1970 (and 1971) are shown in Tables 1 and 2. Standing crops for both individual and combined species are shown in Table 3. Recoveries of all sizes of fish were believed to be gen-

TABLE 1.—Fall standing crops after one and two growing seasons for largemouth bass (LMB) and bluegill (BG), when in the stocking combinations shown. Listed weights represent averages for two populations of each of the types indicated. (CC = channel catfish.)

Species Measured	Original Stock, Spring, 1970		Fall Standing Crops in Kilograms Per Hectare	
	Number	Kilograms	1970	1971
LMB (when in pond with BG)	308 ^a	3.63	33.88	72.23
LMB (when in pond with BG and caged CC)	308	3.60	39.66	80.68
LMB (when in pond with BG, caged and free CC)	308	3.80	36.88	80.14

BG (when in pond with LMB)	635 ^b	12.67	67.76 ^c	232.56
BG (when in pond with LMB and caged CC)	635	13.11	79.11 ^c	204.37
BG (when in pond with LMB, caged and free CC)	635	12.96	99.16 ^c	301.95

^a Bass populations all included 104 Age 1 fish stocked on 4/10/70, 4 adults stocked on 6/12/70, and 200 Age 0 stocked on 6/25/70.

^b Total lengths of bluegills ranged from 7.6 to 15.2 centimeters; all were stocked within the period 4/7/70 to 5/12/70.

^c Standing crops of bluegills for 1970 are incomplete because of the stranding and loss in drainage of small but unknown weights of young-of-the-year in small sizes.

erally quite complete, with the exception of the young-of-the-year bluegills stranded in the dewatered vegetation (mostly *Najas* spp.) which was quite abundant in most ponds in 1970. Although quite small in terms of total standing crops, the weights of the stranded fish were not estimated and the totals listed for bluegills in 1970 must be recognized as incomplete.

In the fall of 1970 the standing crops of bluegills older than Age 0 (original stock) were quite uniform from pond to pond, ranging from 257 to 335 in number, and from 50.20 to 76.63 pounds (22.77 to 34.76 kilograms) in weight. Survivals among populations of these older bluegills ranged from 40.5 to 53.2 percent. Age 0 bluegills were abundant in all ponds, but were mostly quite small and contributed relatively little to the total weights. In those ponds containing bass and bluegills, standing crops of channel catfish averaged 25 percent less in weight than the catfish in those ponds containing no bass and bluegills. These differences were due in part to predation on catfish by bass, and probably had no relation to the presence or absence of bluegills.

Age 0 bass contributed very little to the fall standing crops in 1970. No natural reproduction was observed, and the few surviving young-of-the-year originated from the 200 fry stocked in each pond on June 25, 1970. Survivors of this stock numbered 0 in three ponds, and 3, 5, and 22 in the remaining three ponds. Survivals among populations of older bass ranged from 31.5 to 75.0 percent, and weights ranged from 26.13 pounds (11.85 kilograms) to 41.58 pounds (18.86 kilograms).

As mentioned above, standing crops of channel catfish averaged less in the presence of bass and bluegills. It is probably significant that the poorest survival of channel catfish was associated with the largest survival of bass. In one pond, in which only 34 of the 108 older bass survived (31.5 percent), the survival among 800 channel catfish released into the pond was 658 (82.2 percent), a figure quite close to that for the caged population in the same pond (689); however, in its replicated pond the survival of 81 bass older than Age 0 was the highest of any pond (75.0 percent), and the survival among the 800 catfish released into the pond was only 371, by far the lowest of any population, caged or otherwise. It seems apparent that some predation of channel catfish by bass must have occurred in this first season when many of the catfish were still small enough to be eaten by the larger bass.

We may consider the catfish in four categories: those either caged or free in the ponds with bass and bluegills, and those caged or free in the ponds without bass and bluegills. Standing crops of catfish free in the ponds averaged heavier than those populations confined to cages, and catfish in ponds alone consistently outweighed those populations sharing the ponds with bass and bluegills (Table 3). However,

TABLE 2.—Fall standing crops after one and two growing seasons for channel catfish (CC), both caged and free in ponds, when in the stocking combinations shown. Listed weights represent averages for two populations of each of the types indicated, except as noted.

Species Measured	Standing Crops Per Unit of Catfish ^a				Standing Crops Per Hectare			
	1970		1971		1970		1971	
	Number	Kilograms	Number	Kilograms	Number	Kilograms	Number	Kilograms
CC caged (when in pond with free CC)	764	83.64	698	319.44	•	•	•	•
CC caged (when in pond with BG and LMB)	783 ^b	71.36 ^b	695 ^c	274.96 ^c	3,870	352.66	3,412 ^d	1,423.67 ^d
CC caged (when in pond with BG, LMB and free CC)	704	73.55	686	278.59	•	•	•	•
CC free (when in pond with caged CC)	794	100.54	676	357.53	•	•	•	•
CC free (when in pond with BG, LMB and caged CC)	515	76.30	654	361.50	•	•	•	•

^a Catfish were Age 1, 12 grams in average weight, and numbered 800 per stocking unit (1,600 per pond) when stocked in 1970; the same fish averaged 96 grams and numbered 700 per stocking unit, or 1,400 per pond, when stocked in 1971.

^b Average of four, rather than two units of caged catfish. These averages are high because one of the four units was inadvertently stocked with 900, rather than 800 fish.

^c Average of three, rather than two units of caged catfish.

^d For one pond only due to loss of fish by asphyxiation.

^e Could not be accurately computed because half of the catfish in any individual pond were caged and half were free.

TABLE 3.—Average standing crops in kilograms per hectare after one and two growing seasons for two populations of each of the combinations indicated.

	Channel Catfish		Bass	Bluegills ^b	All Species Combined
	Caged	Free			
1970	206.70	248.48			455.18
1971	789.45 ^a	883.59 ^a			1,673.04 ^a
1970	181.71	188.56	36.88	99.16	506.31
1971	688.50	893.39	80.14	301.95	1,963.98
1970	352.91		39.66	79.11	471.68
1971	1,423.67 ^a		80.68	204.37	1,708.72
1970			33.88	67.76	101.64
1971			72.23	232.56	304.79

^a Data from one pond only.

^b Standing crops of bluegills for 1970 are incomplete because of the stranding and loss in drainage of relatively small but unknown weights of young-of-the-year in small sizes.

in the later evaluation of data from both years we will see that the differences were probably not significant.

There was a surprising difference in production in the two ponds which contained catfish only. Caged populations had similar survivals (98 and 93 percent) and weights (181 and 187 pounds) (82.1 and 84.8 kilograms) in the two ponds, but the populations of unconfined fishes showed marked differences. In one pond the total weight of the free catfish was less than that of the caged fish, and this was associated with very clear water (average turbidity 10 ppm) and heavy weed growths (mostly *Najas* spp.). Observations made at the time of drainage disclosed a marked scarcity of damselflies and burrowing mayflies. In the replicate pond the standing crop of free catfish exceeded the weight of the caged population by almost 100 pounds (45.36 kilograms), or slightly over 50 percent, and this greater weight was associated

with a higher average turbidity (35 ppm), an absence of weeds, and an abundance of those natural foods observed to be scarce in the other pond.

1971 EXPERIMENTS

Materials and Methods

Numbers and weights of bass and bluegills restocked in October, 1970 to establish the 1971 populations are shown in Tables 4 and 5, along with standing crops recovered in the drainage censuses of October 1971.

The number of catfish available for stocking in the spring of 1971 was reduced below the 1970 level by intervening mortalities. The number recovered on April 13 from the overwinter holding pond was sufficient to provide only 662 in each population unit, or 1,324 in each of the six ponds. These were stocked on April 13 and 14. In an effort to achieve a random distribution of fishes of equal sizes, the fish to be stocked were pooled in a large holding tank and were netted, weighed, and stocked in consecutive lots of 50 to each unit until each had received nine lots totaling 450 fish, then in lots of 40 until each had received an additional 120, and in progressively smaller lots until each unit contained 662 fish. On May 19, 1971, 38 additional fish were stocked in each unit which brought the totals to 700 per unit, or 1,400 catfish in each 1-acre (0.4-hectare) pond.

In 1971 in one pond, which happened to be completely weedless, it was possible to make a complete recovery of all of the bluegills including the smallest of the Age 0 fish. Numbers and weights of stranded small fish were estimated in all other ponds. The estimates were based upon complete counts of small fish stranded in randomly chosen sample areas. We

TABLE 4.—Numbers, ages, and total weights in kilograms of bluegills restocked following the 1970 fall census, with numbers, ages, and weights recovered in the fall census of 1971.

Pond Number	Stocked in October, 1970					Recovered in October, 1971				
	Age 0		Older		Total Weight	Age 0		Older		Total Weight
	Number	Weight	Number	Weight		Number	Weight	Number	Weight	
1	13,456	2.39	324	34.61	37.00	13,343	85.05	308	54.64	139.69
2	3,133	1.97	256	22.69	24.66	15,471	74.00	252	38.01	112.01
3	14,631	7.23	264	26.33	33.56	41,768	42.86	251	43.26	86.12
4	6,151	2.01	264	27.76	29.77	14,937	37.30	244	41.97	79.27
6	6,560	0.88	338	25.36	26.24	56,538	31.32	304	44.87	76.19
7	6,827	2.87	293	31.46	34.33	19,199	59.25	266	45.42	104.67

TABLE 5.—Numbers, ages, and total weights in kilograms of largemouth bass restocked following the 1970 fall census, with numbers, ages, and weights recovered in the fall census of 1971.

Pond Number	Stocked in October, 1970					Recovered in October, 1971				
	Age 0		Older		Total Weight	Age 0		Older		Total Weight
	Number	Weight	Number	Weight		Number	Weight	Number	Weight	
1	5	0.32	34	13.74	14.06	644	6.48	39	19.39	25.87
2	3	0.09	50	15.47	15.56	2,519	9.87	61	23.46	33.33
3	20	0.68	56	18.54	19.22	263	14.85	55	27.87	42.72
4	0		59	12.47	12.47	1,132	4.82	59	17.76	22.58
6	0		53	11.85	11.85	129	2.12	49	23.00	25.12
7	0		79	15.39	15.39	2,564	10.32	68	28.67	38.99

believe that the standing crops listed in 1971 are reliable and complete for all species.

With few exceptions, operating procedures in 1971 were much the same as in the previous year. The caged channel catfish populations were sampled only every 30 days in order to minimize loss of fish through handling in hot weather, and because it was not essential to our primary interest to achieve the most efficient feeding regime. Rations were increased on the basis of anticipated rates of conversion. An additional change in 1971 was that all cages were relined with nylon netting to prevent loss of fish through deterioration of the original wire netting.

Results

Standing crops of all three species were much larger in this second year (Tables 1 and 2), clearly establishing the hypothesis that carrying capacities had not been achieved in the first growing season.

For bluegills, substantial increases occurred in the weights of both Age 0 and older fish. Largest weights of both groups of bluegills occurred in the weedless pond where they were associated with caged and uncaged channel catfish. Table 6 shows that standing crops of bluegills in 1971 averaged highest in those ponds containing both caged and uncaged catfish, were intermediate when with bass only, and lowest when with bass and caged catfish; however, the dif-

ferences were not significant at the .05 level. The only observable interaction between bluegills and catfish involved uncaged catfish and Age 0 bluegills. Table 6 shows that the lowest average number but the highest average weight of Age 0 bluegills occurred in those ponds where they were intermixed with uncaged catfish, suggesting that substantial numbers of young bluegills were eaten by the catfish. Table 6 also shows that only very minor differences occurred in either number or weights of older bluegills in the three types of populations. It appears evident that the association with catfish placed no serious limitations upon bluegill production, and that poundages may actually have been increased either through (1) thinning of the young, (2) utilization by the survivors of food intended for the catfish, or (3) enrichment of the environment through the addition of the catfish food.

Total weights of bass showed an average increase of more than 100 percent in 1971 over 1970, again emphasizing that carrying capacities had not been achieved in the previous growing season. Age 0 bass were present in all populations, and increases occurred in weights and numbers of both Age 0 and older fish. In 1971 the average difference in standing crops of bass sharing ponds with bluegills only, and of bass in ponds with bluegills and both caged and uncaged catfish was 7.06 pounds (3.20 kilograms), and in all

TABLE 6.—Fall standing crops by age groups in numbers and kilograms per hectare for largemouth bass (LMB) and bluegills (BG) after two growing seasons in the stocking combinations shown. Listed weights and numbers represent averages for two populations of each of the types indicated.

Species Measured	Age 0		Age 1 and Older		Total Weight
	Number	Weight	Number	Weight	
LMB (when in pond with BG)	3,272	14.83	136	57.40	72.23
LMB (when in pond with BG and caged CC)	1,725	24.30	141	56.38	80.68
LMB (when in pond with BG, caged and free CC)	3,963	20.76	133	59.38	80.14
BG (when in pond with LMB)	88,968	130.14	687	102.41	232.55
BG (when in pond with LMB and caged CC)	70,060	99.05	613	105.32	204.37
BG (when in pond with LMB, caged and free CC)	40,206	178.31	709	123.64	301.95

types of bass populations the difference was not significant at the .05 level. The results suggest that coexistence with a rather intensive culture of channel catfish had no measurable influence on the production of bass.

It was of further interest to observe that adults of both bass and bluegills were fatter in the presence of uncaged catfish than when separated from them. Bluegills intermixed with both bass and catfish had an average coefficient of condition (C) of 8.57; bluegills with bass only had an average condition of 7.41. For bass the averages were 5.07 when with both bluegills and catfish, and 4.74 when with bluegills only.

In 1971, mortalities averaged 1.0 percent in caged catfish populations and 5.4 percent in free populations. Among caged populations the difference between the highest and lowest rate of survival was only 12 fish (less than a 2-percent difference); among the uncaged populations the difference was only 26 fish, or less than a 4-percent difference. Average rates of survival of the two types of populations differed by less than 5 percent. Differences in weights, however, were considerably larger. Among the caged catfish the greatest weights were in those populations sharing the pond with uncaged catfish and in the absence of bass and bluegills. Among the uncaged catfish populations the greatest weights were made in those ponds containing bass and bluegills, but these were only slightly larger, and not significantly different from weights of those populations sharing the pond with caged catfish. Between caged and uncaged populations there was an average difference of 153.5 pounds (69.6 kilograms), or more than 19 percent. In terms of individual weights, uncaged catfish averaged about

0.29 pound (131.5 grams) heavier than those confined to cages.

Standing crops of bluegills in the ponds were considerably larger than those in a sampling of other unfertilized Illinois waters, and standing crops of bass were somewhat above average. At the end of two growing seasons our six populations of bluegills had standing crops ranging from 168 to 308 pounds per acre (188.3 to 345.3 kilograms per hectare), with an average of 219.7 (246.3) (Table 7). This compares with an average of 123.1 pounds per acre (138 kilograms per hectare) of bluegills obtained in seven censuses of bass-bluegill populations in 16-acre (6.5-hectare) Ridge Lake in central Illinois (Bennett et al. 1969); with 104.9 pounds per acre (117.6 kilograms per hectare) of bluegill obtained in three censuses of mixed populations (predominantly bluegill) in 2.6-acre (1.05-hectare) Arrowhead Pond (Bennett 1971), also in central Illinois; with 168 pounds per acre (188.3 kilograms per hectare) obtained in three ponds in southern Illinois (Hansen et al. 1960) which averaged 0.53 acres (0.34 hectares) at the time of census; and with 125.3 pounds per acre (140.5 kilograms per hectare) obtained by Buck & Thoits (1970) in four single species populations in 1-acre (0.4-hectare) ponds in northern Illinois.

Our six bass populations averaged 69.3 pounds per acre (77.7 kilograms per hectare), compared with 40.2 (45.1) in nine censuses of Ridge Lake; 27.5 (30.8) in three censuses of Arrowhead Pond; 70.0 (78.5) in Hansen's three ponds in southern Illinois; and 75.3 (84.4) in 11 single species populations in northern Illinois.

Our standing crops of channel catfish ranged from approximately 1,200 to 1,600 pounds per acre (1,345 to 1,794 kilograms per hectare), with an average of about 1,370 (1,536). These fell somewhat short of the range of 1,500 to 2,000 pounds per acre (1,652 to 2,242 kilograms per hectare) as predicted by Lewis (1969), because numbers stocked in our ponds were reduced to 1,400 per acre (3,459 per hectare) in 1971, and the fish were fed only 5 days each week. For the production of food fish in Illinois, Lopinot & Fisher (1969) have suggested stocking 1,500 fish per acre (3,707 per hectare) and feeding 6 days each week.

As pointed out earlier, all units of population, both caged and uncaged, received the same ration, but the amount of the ration was determined from sampled weights of caged catfish only. Thus the faster-growing catfish free in the ponds were given less food in terms of percentage of body weight than were the caged individuals. It is therefore interesting to observe that the uncaged individuals had not only a markedly greater average weight by 0.29 pound (131.5 grams), but a more efficient rate of conversion. Among the caged fishes, conversion rates for individual populations ranged from 1.41 to 1.77, with an average of 1.56; for the fish free in the pond the

TABLE 7.—Comparison of standing crops of bluegills and largemouth bass in kilograms per hectare after two growing seasons in our ponds with standing crops measured in a cross section of other unfertilized Illinois waters.

Location	Average Size (Hectares)	Source	Bluegill		Largemouth Bass	
			Number of Ponds or Years	Average Per Hectare (Kilograms)	Number of Ponds or Years	Average Per Hectare (Kilograms)
Our ponds	0.4		6	246.3	6	77.7
Dundee ponds	0.4	Buck & Thoits (1970)	4	140.5	11	84.4
Hansen's ponds	0.34	Hansen et al. (1960)	3	188.3	3	78.5
Arrowhead Pond	1.05	In Bennett (1971)	3*	117.6	3	30.8
Ridge Lake	6.48	Bennett et al. (1969)	7	138.0	9	45.1

* Computed from years 1950, 1952, and 1953.

range was from only 1.16 to 1.27, with an average of 1.24. Thus it is clear that the uncaged fish made efficient use of the pond's natural foods, and made significantly greater gains than the caged fish while receiving proportionately smaller rations. For example, when the final census weights were used to compute the percentages of total weight contained in the daily ration, the caged fish were receiving 1.31 percent of their weight, while the heavier and faster-growing uncaged fish were receiving a daily ration equivalent to only 1.03 percent of their weight.

DISCUSSION

It is widely accepted that the elimination of pre-existing pond fishes is a prerequisite to the successful production of channel catfish in commercial quantities. It is believed that the companion fishes will utilize food intended for the catfish, and might further reduce the potential for catfish production through competition for oxygen and space. While this might very well be true for certain types of companion fishes, such as bullheads (*Ameiurus* sp.), or one of the carps (*Cyprinus* sp.), it may not be true for others. An earlier study (Buck et al. 1972) produced evidence that commercial quantities of both channel catfish and golden shiners can be raised in combined culture, and results of the present study suggest that channel catfish can be raised in commercial quantities in ponds containing established populations of bass and bluegills without detriment to either culture. Such a combination could retain the recreational aspects of a pond through angling provided by the bass and bluegills, while the catfish could provide additional angling pleasure and food for the table as well as a cash crop.

It should be recognized, however, that the combining of such species presents certain problems, and would require certain precautions. A primary precaution would be to avoid overstocking and overfeeding to the point that accumulated organic wastes would cause a depletion of the supply of oxygen.

A second precaution would be the stocking of feeder fish of sufficient size to prevent excessive predation by the larger bass. In 1970 we suspected

that poor survival of catfish in one pond may have been due to such predation. In this instance the catfish had an average total length of 5 inches (127 millimeters) when stocked, and the bass population contained eight individuals sufficiently large to prey upon catfish of this size; however, survival of catfish was almost twice as high in the replicate pond where the potential for predation was similar. When restocked in 1971, the catfish had an average total length of between 9 and 9.5 inches (228.6 and 241.3 millimeters), and predation was not a problem, although the bass were larger. The use of cages would, of course, permit use of smaller catfish and totally eliminate the predation problem. An additional precaution against predation would be to remove the larger bass at harvest time, along with excessive numbers of bluegills. Selected bass and bluegills might then be returned to the pond to preserve the angling population. While the sorting out of the bass and bluegills during the catfish harvest would constitute a considerable nuisance, it might be worth the effort. Additional cash income could well be realized through the sale of excessive bluegills and the larger bass since a ready market now exists for both species, in Illinois as well as elsewhere.

Harvesting of catfish could be simplified by confining them to cages, but our study showed greater gains on a lesser amount of feed by catfish when they were free in the pond to supplement their ration with natural foods. Elimination of cages would also obviate the labor and cost of their construction, and lessen food costs. As shown in a companion study (Buck et al. 1973), caged catfish require a more complete and much more expensive feed because they have only a very limited access to natural foods.

Further mention should also be made of the apparent interaction between the uncaged catfish and bluegills in 1971 wherein the smallest numbers but the greatest weights of Age 0 bluegills were found in those ponds containing uncaged catfish. The data suggested that the catfish production was improved through predation of the small bluegills, and that the population of bluegills was in turn improved through a beneficial thinning of their numbers by

the catfish. At the same time the presence of catfish had no apparent influence on the bass population.

Utilization of catfish food by bass and bluegills was not a problem in our trials. Bass were never observed to take pellets, and only a few of the larger bluegills were observed to converge around the cages, or to intermingle with the free catfish at feeding time. On the other hand, consumption of pellets by bluegills would be advantageous if it produced a larger, more marketable size of bluegill, as it well should.

In conclusion, it appears that combining of the species would have at least as many potential advantages as disadvantages, and could be of particular interest to a pond owner wishing to retain the recreational aspects of his pond while at the same time utilizing it as a source of income.

SUMMARY OF FINDINGS

1. The bass and bluegills in our experimental ponds failed to achieve carrying capacity in the first growing season; the standing crops after two seasons more than doubled the weight of those recovered after the first season.
2. After two growing seasons the standing crops of bluegills were heaviest in those ponds containing both caged and uncaged catfish, were intermediate when the bluegills were combined with bass only, and least when they were combined with bass and caged catfish.
3. The lowest number, but greatest weight, of Age 0 bluegills occurred when the bluegills were intermixed with uncaged catfish, suggesting that the catfish may have effected a beneficial thinning of the small bluegills.
4. Association with catfish placed no obvious limitations upon bluegill growth, and may have increased production through thinning of the young.
5. Spawning by both bass and bluegills appeared to be normal, and Age 0 fish of both species were abundant in the final censuses.
6. Coexistence with an intensive culture of channel catfish had no measurable influence upon the production of bass because no significant difference existed between final weights of bass stocked only with bluegills and bass stocked with bluegills and both caged and uncaged catfish.
7. In 1971, mortalities averaged 5.4 percent among the uncaged catfish, and only 1.0 percent among the caged populations.
8. Caged catfish populations attained the greatest total weight when sharing a pond with only uncaged catfish, but the uncaged catfish populations attained greatest weights when associated with bass and bluegills.
9. Weights of the uncaged catfish populations averaged 153.5 pounds (69.6 kilograms) heavier than the caged populations, and uncaged individuals outweighed caged individuals by an average of 0.29 pound (131.5 grams).
10. Final standing crops for the six populations of bluegills averaged 219.7 pounds per acre (246.3 kilograms per hectare), which was substantially higher than standing crops measured in any of a cross section of other unfertilized Illinois waters.
11. Final standing crops in our six populations of bass averaged 69.3 pounds per acre (77.7 kilograms per hectare), which was higher than the average for a cross section of other Illinois waters.
12. The data suggest that channel catfish can be produced in commercial quantities in ponds containing better-than-average standing crops of bass and bluegills without loss in production of any of the three intermixed species.
13. The combining of intensive cultures of channel catfish with fishable populations of bass and bluegills could retain, and perhaps even enhance, the recreational aspects of a pond while the pond was being used as a source of income.

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