actively growing—in May, June, and July. Apparently diuron remains toxic to aquatic plants for more than three weeks after application.

No fish kills attributed to diuron were noted. Concentrations used in the field trials were well below the mortality levels to fish reported by Siles (1964). Users of aquatic herbicides must always be on guard against oxygen depletions caused by decaying organic materials. Where heavy concentration of weeds occur in a pond only part of the pond should be treated to prevent oxygen depletion.

Under no circumstances should water that has been treated with diuron be used for irrigation during the season of application. Rice was successfully grown on a field that was treated with diuron to control aquatic weeds the previous year.

Diuron is in the category of compounds with very low toxicity to warm blooded animals. We have used diuron where livestock had access to the pond and have not heard of any complications.

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OBSERVATIONS ON CONTROL OF VEGETATION IN LAKE CATHERINE USING ISRAELI CARP AND A FALL AND WINTER DRAWDOWN[1]

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Arkansas Game and Fish Commission
Little Rock, Arkansas
1965

ABSTRACT

Due to a combination of factors, Lake Catherine, a 3,000-acre reservoir which had never known a vegetation problem, suddenly became congested with rooted aquatic vegetation in 1960. The vegetation, mostly coontail, *Ceratophyllum demersum*, and *Elodea* sp., could be controlled with chemicals and consequently various chemicals were used by the riparian property owners on small localized areas. However, for the larger, main body of the lake, chemical herbicides were considered too expensive to be practical.

In October 1960 the Arkansas Game and Fish Commission was petitioned both by the sportsmen in the area, the riparian property owners, and the Arkansas Power and Light Company (owners of the dam and reservoir), to advance a plan for the control of the vegetation.

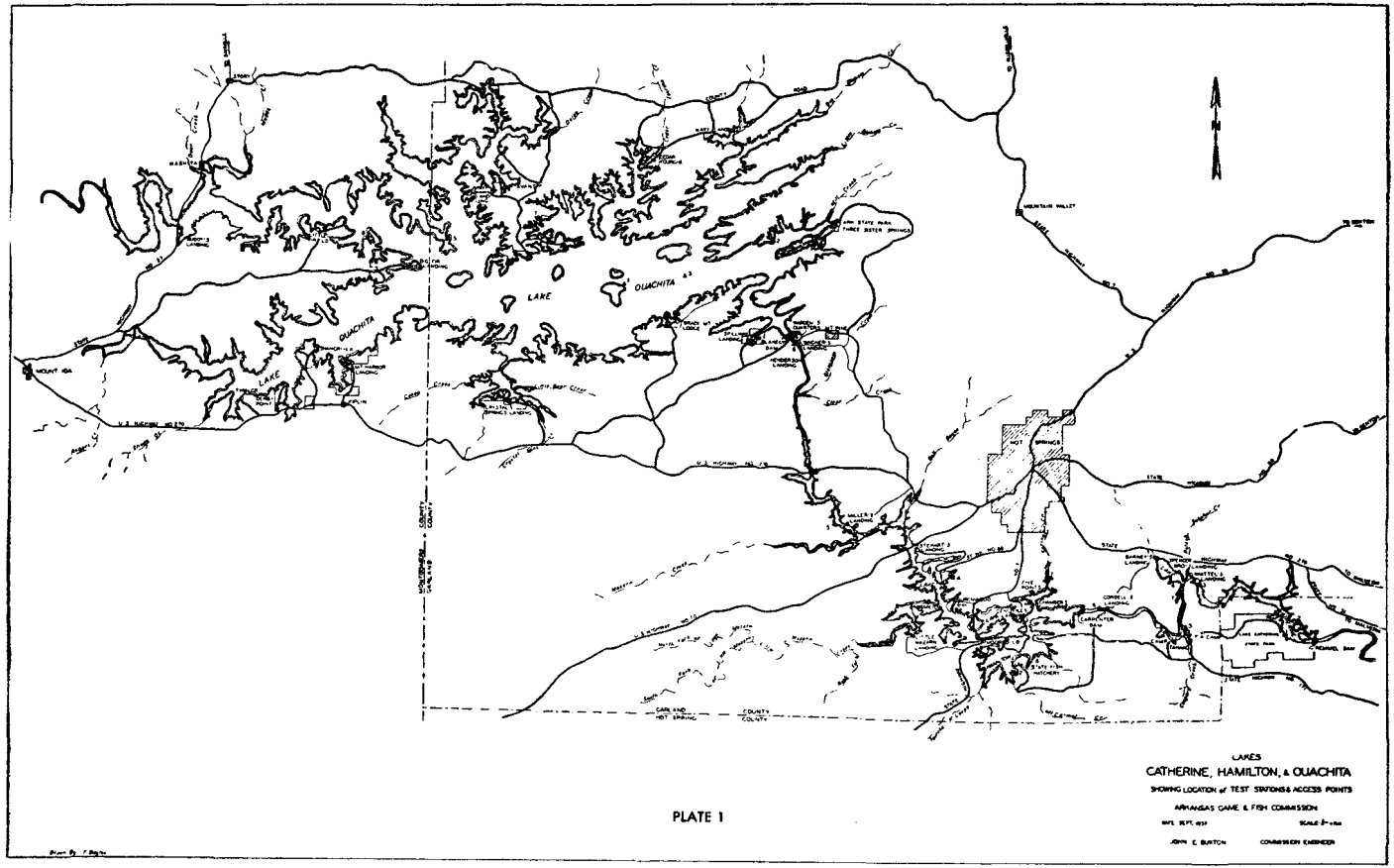
The formulation and the carrying out of that plan is discussed, with emphasis on the combination of two biological methods of control.

DESCRIPTION AND HISTORY OF LAKE CATHERINE

Lake Catherine is the oldest of three lakes located in series on the Ouachita River near Malvern and Hot Springs, Arkansas (Plate 1). The dam was completed in 1923 by the Arkansas Power and Light Company, and the 3,000-acre reservoir filled the same year. The reservoir was impounded for hydroelectric power and recreational purposes. The installed hydroelectric capacity is approximately 10,000 kilowatts.

Lake Catherine is not as well developed commercially as is Lake

[1] Paper presented at the 19th Annual Meeting of the Southeastern Association of Game and Fish Commissioners, Tulsa, Oklahoma. 1965.


LAKE
OUACHITA
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LAKE
CATHERINE, HAMILTON, & OUACHITA
SHOWING LOCATION of TEST STATIONS & ACCESS POINTS
ARKANSAS GAME & FISH COMMISSION
JOHN E. BURTON
COMMISSION ENGINEER

PLATE 1

Hamilton located directly above it. However, along its shores are a number of permanent residences, summer cottages, youth camps, a state park, several public boat landings and a large steam generation plant which obtains its cooling water from the lake. Prior to filling, the lake area was cleared of timber and all was burned or removed (Stevenson and Hulsey, 1958). The top of the gates is at elevation 305 feet (m.s.l.). On occasional floods, the lake elevation at the dam sometimes gets as high as 309. At 305, the area of the lake is approximately 3,000 acres.

Because of its proximity to both Hot Springs and Malvern, Lake Catherine is of considerable economic importance to the region from a recreational and tourist viewpoint.

The Ouachita River rises in Polk County, Arkansas, and flows in a general southeasterly direction through Arkansas and Louisiana. It is joined by the Tensas and Little River at Jonesville, Louisiana, below which place it is called the Black River. The Black River continues flowing south and enters the Red River 34 miles above its mouth. The Ouachita River is about 500 miles long and the Black River 57 miles long, a combined length of about 557 miles. Remmel Dam, which forms Lake Catherine, is located at about mile 450, and Carpenter Dam, impounding Lake Hamilton, at mile 461. Blakely Mountain Dam, forming Lake Ouachita, is located at approximately mile 480. At maximum power pool storage level, Lake Ouachita extends upstream to about mile 532. During certain high water periods, backwater from the downstream lake reaches to the control structure of the upstream lake.

A cursory examination of the above information will show that most of the water in both Lake Hamilton and Lake Catherine comes from Lake Ouachita. The direct flow of water is from the lower reaches of Lake Ouachita through Lake Hamilton where it slides beneath the surface and proceeds almost unchanged to Carpenter Dam (Stevenson and Hulsey, 1961). This cold, clear water is then used to generate power and is discharged into Lake Catherine. As a consequence, there is a constant exchange of water in Lake Catherine, however, day-by-day variations in water level are very small, about 1.5 feet over a year's operation (Arkansas Power and Light Company — Personal Communications).

In 1958 a rough fish removal was recommended and subsequently carried out on Lake Catherine by the Arkansas Game and Fish Commission (Mathis and Hulsey, 1959). In this fish kill, the population of rough fish was drastically reduced. As a consequence of this kill, and in combination with the inflow of cold, clear water coming from hydroelectric generation at the Blakely Mountain Dam upstream, the lake cleared up considerably.

In the population sample reports of 1959 there were remarks about the increasing amounts of vegetation. Previously the lake was relatively free of vegetation. The usual amounts of *Chara* and *Nitella* in the shallow water with a band of smartweed (*Polygonum* sp.) around the margins of the shallower bays, this was the vegetation picture prior to 1959. These reports cited the emergence of coontail *(Ceratophyllum demersum)* and *Elodea* sp. as a distinct detriment to rotenone sampling and consequently to sport fishing (Progress Reports on Dingell-Johnson Project F-5-R).

The fishermen gradually adjusted to the situation, seeking "holes" in the dense vegetation and there catching sunfsh, or bream, and bass. The fishing improved greatly during this period as shown by creel census (F-5-R-5 Progress Reports), but the number of fishermen declined in spite of the good fishing.

The vegetation problem increased greatly in the spring and summer of 1960. The state park swimming area was completely choked, and a swimming pool was considered. The area around the FFA Camp and the Church Camp was completely useless. These two camps were "vegetated in" even though they were in the channel area and were subjected to a brisk current. The waterweed began to move into the deeper areas of the lake. One area, with water 33 feet in depth, was completely impassible to boats. Other areas were also so congested as to

make the lake inaccessible to boats. About this time the Arkansas Power and Light Company began to have trouble keeping the intake screens on their steam generating plant free of the vegetation.

At this point, the Malvern Chamber of Commerce petitioned the Arkansas Game and Fish Commission by letter for a meeting to discuss this growing problem. This meeting was arranged for October 5, 1960 at Malvern. Mr. Andrew H. Hulsey, Chief of Fisheries, represented the Arkansas Game and Fish Commission at this meeting. The vegetation was recognized as a major problem by all agencies concerned and ways and means to control it were discussed. The use of a fall and winter drawdown to maintain a balanced fish population had already been proposed (Stevenson and Hulsey, 1958). The Arkansas Power and Light Company agreed to try a maximum drawdown of three feet for a period of three years. The experimental stocking of 50 Israeli Carp per acre over a period of years was also agreed upon. The rate of 50 carp per acre was based on experiments conducted in fish farming reservoirs in Arkansas by the Soil Conservation Service (Wright—Personal Communication). The three-foot drawdown was carried out in the fall and winter of 1960-61 (Table 1). In addition, during the month of July 1961, the Arkansas Power and Light Company carried out experiments which were designed to determine just exactly how much drawdown they could give without endangering the operation of their steam electric plant. As a result of these experiments, a drawdown of five feet was agreed upon for 1961-62. This brought the lake level to approximately 300′ m.s.l. at the bottom of the drawdown. The extent of the drawdown was later lowered to 298′ m.s.l., giving a drawdown of seven feet. The drawdown has been carried out every year since its inception.

The actual stockng of the carp took three years and was completed January 12, 1963 (Table 2).

Providing the carp presented somewhat of a problem in that they were to be stocked in an established fish population. This called for fish large enough to escape predation (Plate 2). In order to produce this size fish, rearing ponds were stocked at the rate of 5,000 to 10,000 fingerling carp per acre in mid July. By cold weather we would harvest approximately 750-1,000 pounds of "hand size" carp per acre. A total of 30 acres of rearing ponds were used to produce the carp needed.

The survival of the carp was excellent, and bait fishermen began to catch them in 1962. At first the fishermen were reluctant to keep the carp, but word rapidly got around that they were comparable to the buffalo fishes in eating quality. After this, the fishermen actively sought the carp for food as well as sport. The carp were not so easily caught until the vegetation began to get scarce. The most common method used was to motor over the area until clumps of floating vegetation were found. There the fishermen, both sport and commercial, caught fish ranging from 8 to 18 pounds in size. The most common bait was worms or doughballs. It was even reported that good catches were made on a treble hook using filamentous algae for bait.

RESULTS

The property owners on the lake reported a measure of control along the shoreline in the spring of 1961. This after one three-foot fall and winter drawdown! At the same time the fishermen reported seeing carp actively over the lake. This degree of control was maintained throughout 1961. The fall and winter drawdown of five feet in 1961-62 increased the zone of control greatly. During the summer of 1962 large patches of floating vegetation were observed and the commercial fishery developed. In the fall and winter of 1962-63 the drawdown was increased to seven feet, giving a greater area of control on the margin of the lake and in the shallow bays. The maximum carp activity was also observed during 1963. The drawdown of 1963-64 was carried out on schedule. During this drawdown, efforts were made to find any remaining shreds of the vegetation. A few strands were observed in isolated areas. After the 1964-65 drawdown was completed and the

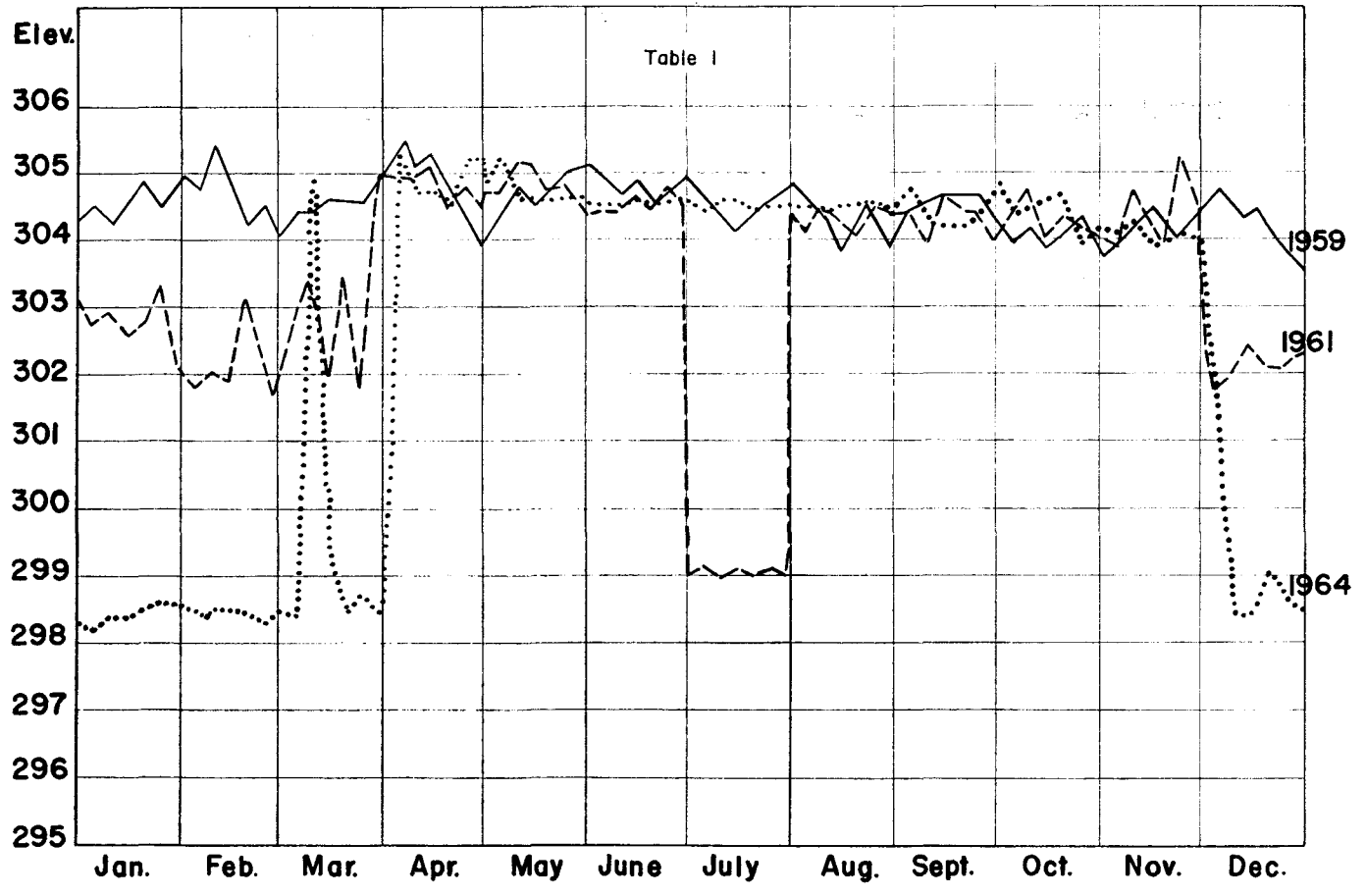
Table I
Elev.
306
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300
299
298
297
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295
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
1959
1961
1964

Table 2

FISH DISTRIBUTED TO LAKE CATHERINE FROM JOE HOGAN STATE FISH HATCHERY

DATE	NUMBER OF FISH	LOADS	YEARLY TOTAL
July 1, 1960 to June 30, 1961 Stocking Report			
June 15, 1961	4,700 Yearling Israeli Carp	---	4,700
July 1, 1961 to June 30, 1962 Stocking Report			
November 1, 1961	3,000 Yearling Israeli Carp	---	
November 2, 1961	3,000 Yearling Israeli Carp	---	
November 8, 1961	14,000 Yearling Israeli Carp	---	
November 12, 1961	7,000 Yearling Israeli Carp	---	27,000
July 1, 1962 to January 30, 1963 Stocking Report			
November 30, 1962	750 Yearling Israeli Carp	1	
December 27, 1962	11,000 Yearling Israeli Carp	3	
December 31, 1962	3,100 Yearling Israeli Carp	1	
January 2, 1963	12,000 Yearling Israeli Carp	3	
January 4, 1963	13,000 Yearling Israeli Carp	3	
January 7, 1963	14,000 Yearling Israeli Carp	3	
January 8, 1963	9,660 Yearling Israeli Carp	2	
January 9, 1963	10,100 Yearling Israeli Carp	2	
January 10, 1963	8,900 Yearling Israeli Carp	2	
January 11, 1963	11,500 Yearling Israeli Carp	3	
January 12, 1963	19,320 Yearling Israeli Carp	3	113,330
	TOTAL STOCKED =		145,030
	APPROXIMATE WEIGHT =		22,000 Pounds

Plate 2

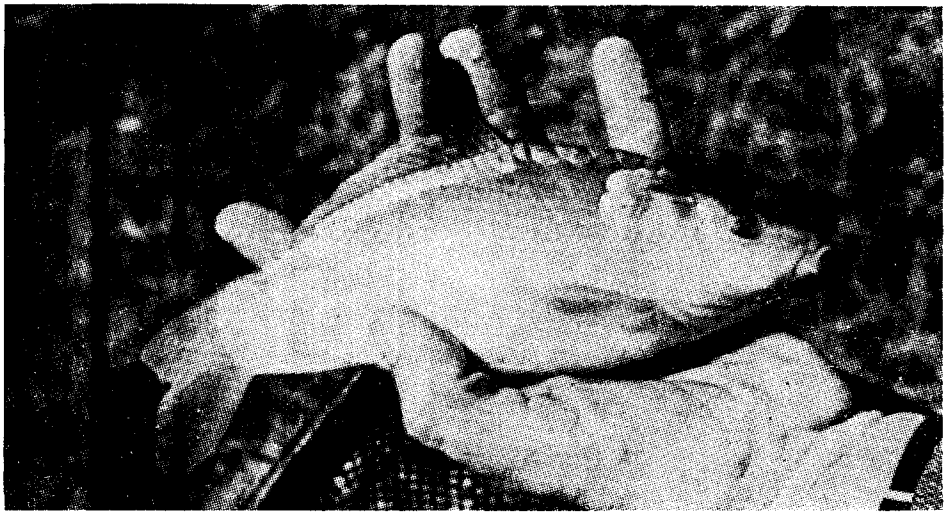
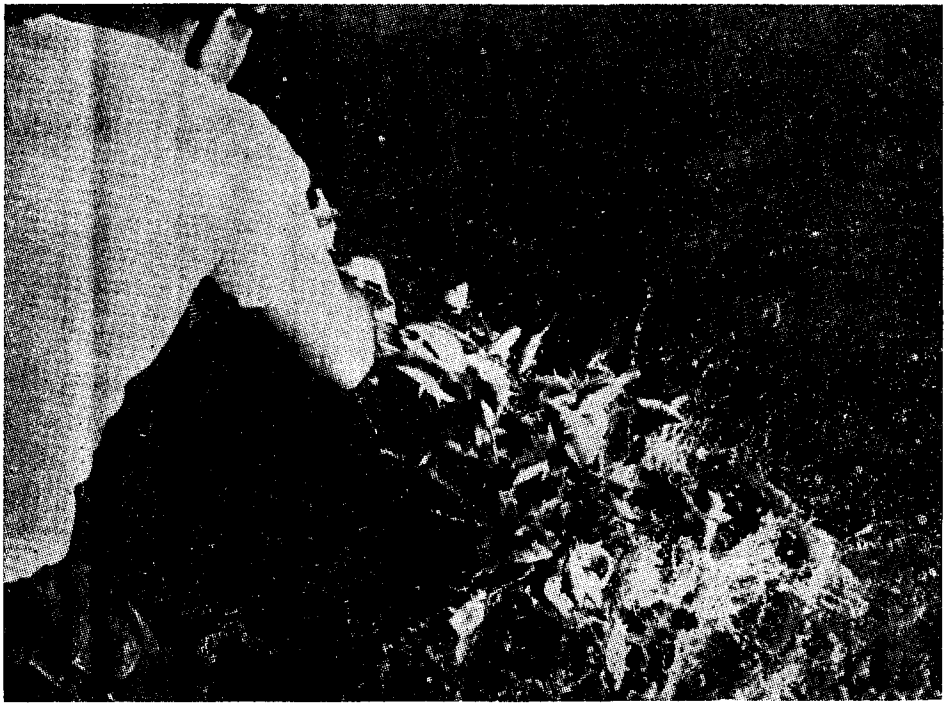


Plate 3



lake returned to normal level, periodic checks were made of the lake. There is a complete absence of *Elodea* and *Ceratophyllum*, almost a complete absence of *Polygonum*, and a significant reduction of *Nitella* and *Chara*.

That the vegetation control program on Lake Catherine is a success, there is not a doubt. It was successful beyond our greatest expectations. The amazing thing was the speed with which the vegetation was eliminated.

SUMMARY

1. What are the problems encountered in the use of Israeli Carp for vegetation control?
   (a) Public relations—The need for drastic action must be apparent to all concerned. A drastic drawdown was impossible on Lake Catherine, therefore, other methods had to be devised. Public acceptance of the carp as a sport fish and a commercial fish was a must.
   (b) Raising and stocking—As discussed above, the big problem is obtaining the size fish desired. This was accomplished by thinning the fingerling fish out into rearing ponds to obtain the desired growth in one summer. We were fortunate, in that our hatchery system is large enough to produce the poundages of fish required for such grandiose management projects. No problems were encountered in stocking (Plate 3).
2. How do these fish aid in controlling vegetation?
   (a) The presence of a bony plate set in an elastic cartilaginous socket in the soft palate, with two sets of enameled teeth which worked on this plate with a grinding action, enables these fish to eat vegetation as a ruminant does.
   (b) The rooting and feeding activity of these fish uproots vegetation, allowing it to float to the surface where it shades out some additional growth.
   (c) Increasing the turbidity. The above-described method of feeding increases the turbidity by stirring up the bottom mucks, and by the decay of the uprooted vegetation.
3. Can a fishery be developed for these fish?

   Experience gained on Lake Catherine tells us that fishermen will utilize this fish both commercially and as a sport fish.
4. Do these carp spawn under these conditions?

   No spawn has been observed when these fish are stocked in an established fish population. This is our observation and also that of the Soil Conservation Service biologists (Grizzell and Neely, 1962).
5. How does the stocking of these fish affect the resident fish population?

   There is reason to believe that the effects of these fish are nothing but beneficial. The increase in turbidity is not great enough to impair the feeding of the bass, but is adequate to insure good crappie survival. Population samples indicate an overall increase in total pounds per sample, with the largest increase being in the predator group.

ACKNOWLEDGMENTS

The author wishes to acknowledge the Arkansas Power and Light Company, Mr. Clinton Richards, Manager of the Lake Hamilton State Fish Hatchery and Mr. Raymond Martin, District Fishery Biologist, for providing data and records.

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UTILIZATION OF CASEIN AND SOYBEAN PROTEIN BY CHANNEL CATFISH, *ICTALURUS PUNCTATUS* (RAFINESQUE)

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ABSTRACT

This research was conducted at the Fisheries laboratory at Auburn University Agricultural Experiment Station to determine the comparative value of casein, soybean protein, and a 1:1 combination of these two proteins in diets of channel catfish. The proteins or combination of proteins were fed at a 5 or 30 per cent level. The comparative values of the proteins were evaluated by growth rate of lots of 10 channel catfish held in troughs and fed the purified diets during a 10-week period.

The growth rate data indicated that diets containing casein and the protein combination produced approximately equal growth and that both of these protein sources produced better growth than soybean protein alone. Fish receiving diets containing 30 per cent protein gained at a significantly higher rate than fish receiving diets containing five per cent protein. The relative order of growth rates for the three sources of protein was the same at both levels of protein in the diet.

INTRODUCTION

The channel catfish is one of the most promising species of fish in the United States for culture in ponds. Results of experiments conducted by the Farm Ponds Project of Auburn University Agricultural Experiment Station showed that the channel catfish can be cultured profitably both as a commercial fish and as a sport fish (Swingle, 1956, 1958; Prather, 1959). These experiments also demonstrated that supplemental feeding is necessary to obtain high production.

Some research has been conducted at Auburn to provide information on which to base an adequate program of supplemental feeding

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