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Feeding of Black Bullheads Ictalurus Melas (Rafinesque) in Experimental Cages

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FEEDING OF BLACK BULLHEADS ICTALURUS MELAS (RAFINESQUE) IN EXPERIMENTAL CAGES

BY

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FEEDING OF BLACK BULLHEADS ICTALURUS MELAS (RAFINESQUE)

IN EXPERIMENTAL CAGES

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

// Thesis Advisor Date

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ABSTRACT

Black bullheads, Ictalurus melas (Rafinesque), were grown experimentally from July 25, 1969, through October 21, 1969. The fish, collected from Lake Poinsett, were grown in five cages each with a water volume of 2.6 m^3 and five cages each with a volume of 3.86 m^3. The larger cages contained nearly 60 percent of the total 323 m^3 of water volume in the cages.

No significant difference in fish growth between the two cage sizes was observed. Fish in large cages gained 204.4 Kg and were fed 1550.8 Kg of food, for a food conversion factor of 6.60. Fish in smaller cages gained 133.5 Kg and were fed 924.5 Kg of food with a resultant food conversion factor of 6.92.

Over 75 percent of total gain occurred while water temperatures were between 23° and 24° C. More desirable food conversion factors were obtained when water temperature was above 23° C (2.3 - 9.0) than when water temperature was below 23° C (1.14 - 20.1).

One hundred seventy-two fish (3.6 percent) died in the larger cages while 137 (2.8 percent) fish died in the small cages. Of the 309 total dead, 76.3 percent died the first two weeks.

No significant difference in fish condition between the two cage sizes was observed. The mean condition factor was 1.784 for the fish in the smaller cages and 1.766 for the fish in the larger cages.

Fish were produced slightly more economically in the larger cages ($1.01/Kg) than in the smaller cages ($1.05/Kg).

ACKNOWLEDGEMENTS

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INTRODUCTION

The majority of small ponds in eastern South Dakota are reasonably fertile and are conducive to high fish production during summer months. Many ponds winter-kill, thus harvesting of the fish in fall is essential. Many ponds, where winterkill isn't a problem, have characteristics that provide extreme harvesting problems which could possibly be solved by growing fish in small transportable cages. The present project, designed to investigate this alternative, involved feeding black bullheads, Ictalurus melas (Rafinesque), in small cages, suspended in a pond.

Many species of fish have been reared in the United States specifically for food. Swingle (1956a) reared bigmouth buffalo, Ictiobus cyprinellus (Valenciennes), in Alabama and produced fish averaging 626.5 g at a cost of $.33/Kg. Tiemeier (1962) reported rearing channel catfish, Ictalurus punctatus (Rafinesque), in fertilized and unfertilized ponds by supplemental feeding of dry pelleted feed. He achieved gains of 260.5 Kg/Hectare at a cost of $.46/Kg. In Tiemeier's experiment the fish were fed at a rate of five percent of the total weight of the fish daily. A survival rate of 94.3 percent was obtained in his study.

Albaugh (1969) conducted an experiment with black bullheads in ponds partitioned with hardware cloth. The fish were fed a commercial fish food near dusk at a rate of two percent of the total weight daily.

Swingle (1954) reared speckled bullheads, Ictalurus nebulosus marmoratus (LeSueur), in Alabama for market at a cost of $1.05/Kg; however, it was pointed out that the elimination of feeding during the winter while water temperatures were below 60° F should result in more economical production. Swingle (1956b) produced gains at a cost of $.25/Kg in a later trial when fish were not fed at temperatures below 60° F.

Black bullheads are primarily omnivorous. Welker (1960) noted that crustaceans, plant materials, chironomids and small fish were found in the stomachs of black bullheads. Forney (1955) reported that adult black bullheads in Iowa feed predominately on chironomid larvae. Darnell and Meirotto (1965) noted that black bullheads appear to feed mainly after dark. The fish reach two feeding peaks--one shortly after dusk and the other before dawn.

Objectives of the present study were to determine if black bullheads in South Dakota could be grown economically in cages and to determine differences in growth, mortality, and cost of growing fish in two different size cages. Cages were used to rear the fish because of the ease in harvesting.

Black bullheads were selected because they were readily available, commonly found in farm ponds, and could be expected to accept a commercial fish food. This species is abundant in South Dakota, and they are desired by many people as food.

STUDY AREA

The pond in this study is located one-half mile north of Brookings, South Dakota. It has a maximum width of 62.2 m, maximum length of 121.9 m, and a surface area of .67 hectares. The bottom consists of sand and gravel grading to silt-covered clay. The pond is exposed to wind and has limited higher aquatic vegetation. Numerous microscopic organisms are believed to inhabit the pond because periodic plankton blooms occurred during the study period. The principal water source is College Creek which drains approximately 24,605 hectares to the location of the pond.

MATERIALS AND METHODS

Ten cages, suspended in a pond, were used to confine the fish during an experimental feeding study. Data collected included length and weights of fish, fish mortality, water temperatures, and amounts of food fed. Growth differences, mortality differences, and condition factor differences of fish between cage sizes were tested statistically. Feed conversion rates and condition factors were also calculated.

Fish Cages

Ten cages with redwood frames were constructed. The top and bottom edges were built with 1 in. x 2 in. lumber, while 2 in. x 2 in. lumber was used for the upright and bottom braces. Galvanized hardware cloth (1/4 in. mesh) was stapled to the sides and ends. Bottoms were covered with galvanized window screen (1/16 in. mesh). The widest strip of hardware cloth obtainable was 3 feet. This limited the size of the cages because of the overlap needed when two pieces of hardware cloth joined.

The larger cages had inner measurements of 2.48 m x 1.67 m and were 1.21 m in depth (Figure 1). The smaller cages had inner measurements of 1.72 m x 1.67 m and were 1.21 m in depth (Figure 2).

A styrofoam billet was attached with wire to each upper corner of the cage for floatation. Billets were positioned so that approximately 25.4 cm of each cage was above the water surface.

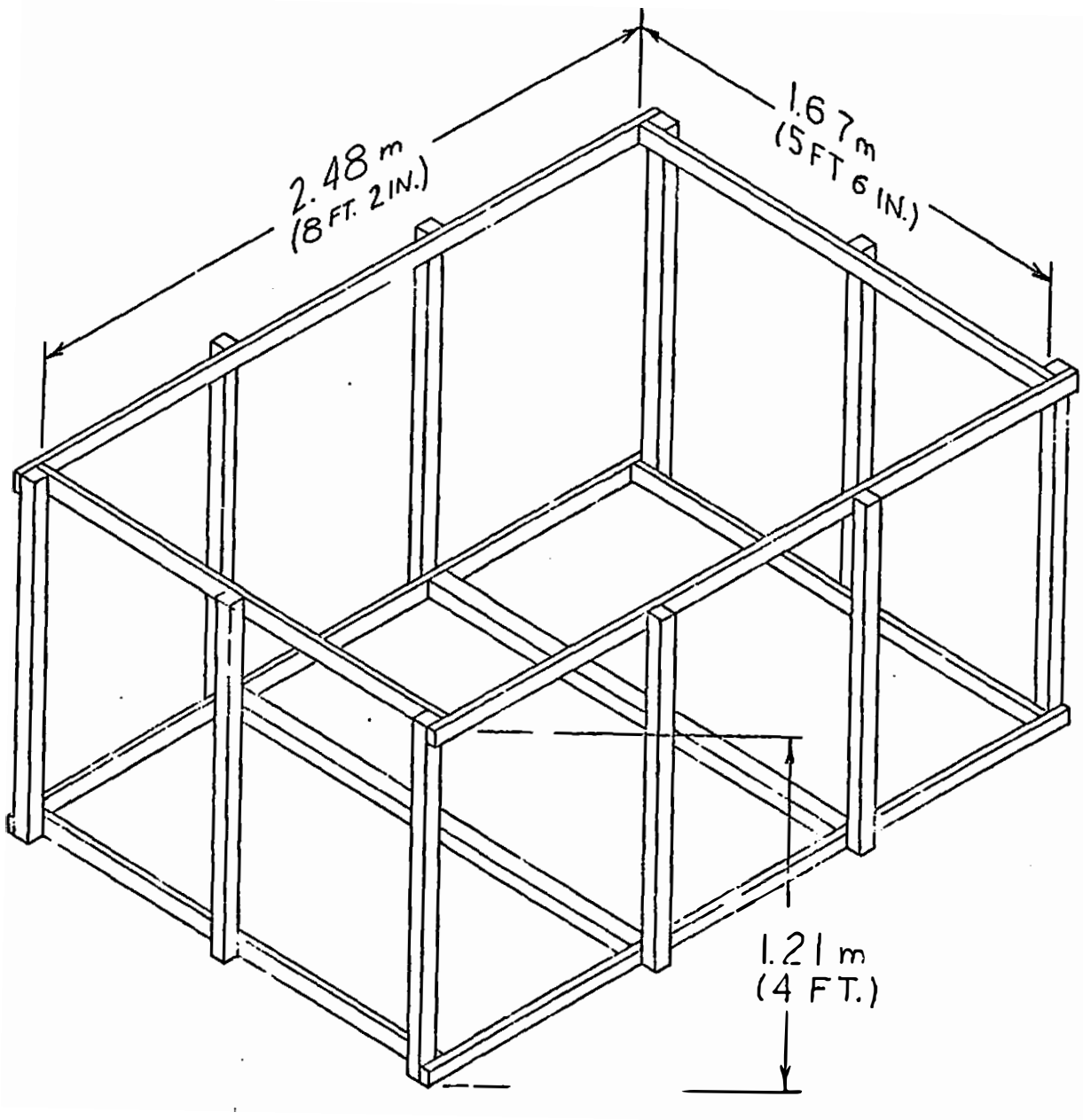

Figure 1. Diagram of large cage for growing black bullheads.

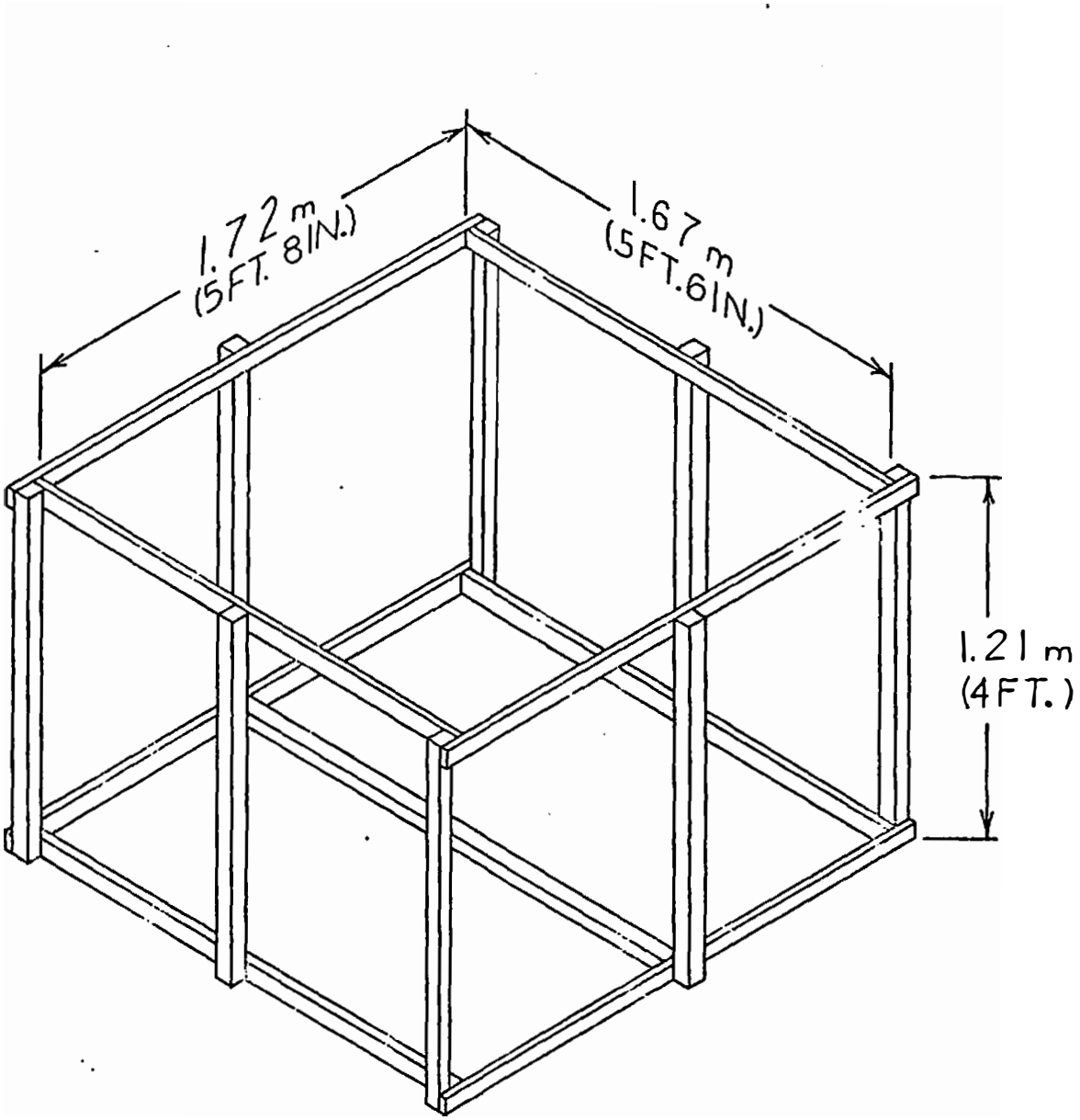

Figure 2. Diagram of small cage for growing black bullheads.

Billets used on the large cages measured 30.4 cm x 27.9 cm x 20.3 cm. Small cages were floated with billets measuring 30.4 cm x 20.3 cm x 20.3 cm.

Each cage was anchored to steel posts so that the bottom of each cage was approximately 30 cm from the bottom of the pond. Two sizes of cages alternated around the edge of the pond and were numbered from 1 to 10 (Figure 3). The smaller cages received numbers of 1, 3, 5, 7, and 9; while the larger cages received numbers of 2, 4, 6, 8, and 10. The larger cages had water volumes of 3.87 cubic meters while the smaller cages had water volumes of 2.61 cubic meters. The larger cages cost $31.72 each resulting in a cost/unit volume of $8.21/m^3. The smaller cages cost $24.34 each or $9.36/m^3.

Stocking

Black bullheads were collected from Lake Poinsett using frame and hoop nets. The fish were kept in the cages and fed a commercial ration before the study began. Stocking in all cages was at a rate of 17.50 Kg fish/m^3 of water. Nearly 57 Kg were placed in each larger cage, while each smaller cage received 42.2/Kg. The average lengths and weights of the fish in large cages were 199 mm and 120 g respectively with a range of 108 to 288 mm and 60 to 310 g. The small cages received fish with average lengths and weights of 202 mm and 128 g ranging between 112 to 295 mm and 72 to 324 g respectively (Table 1).

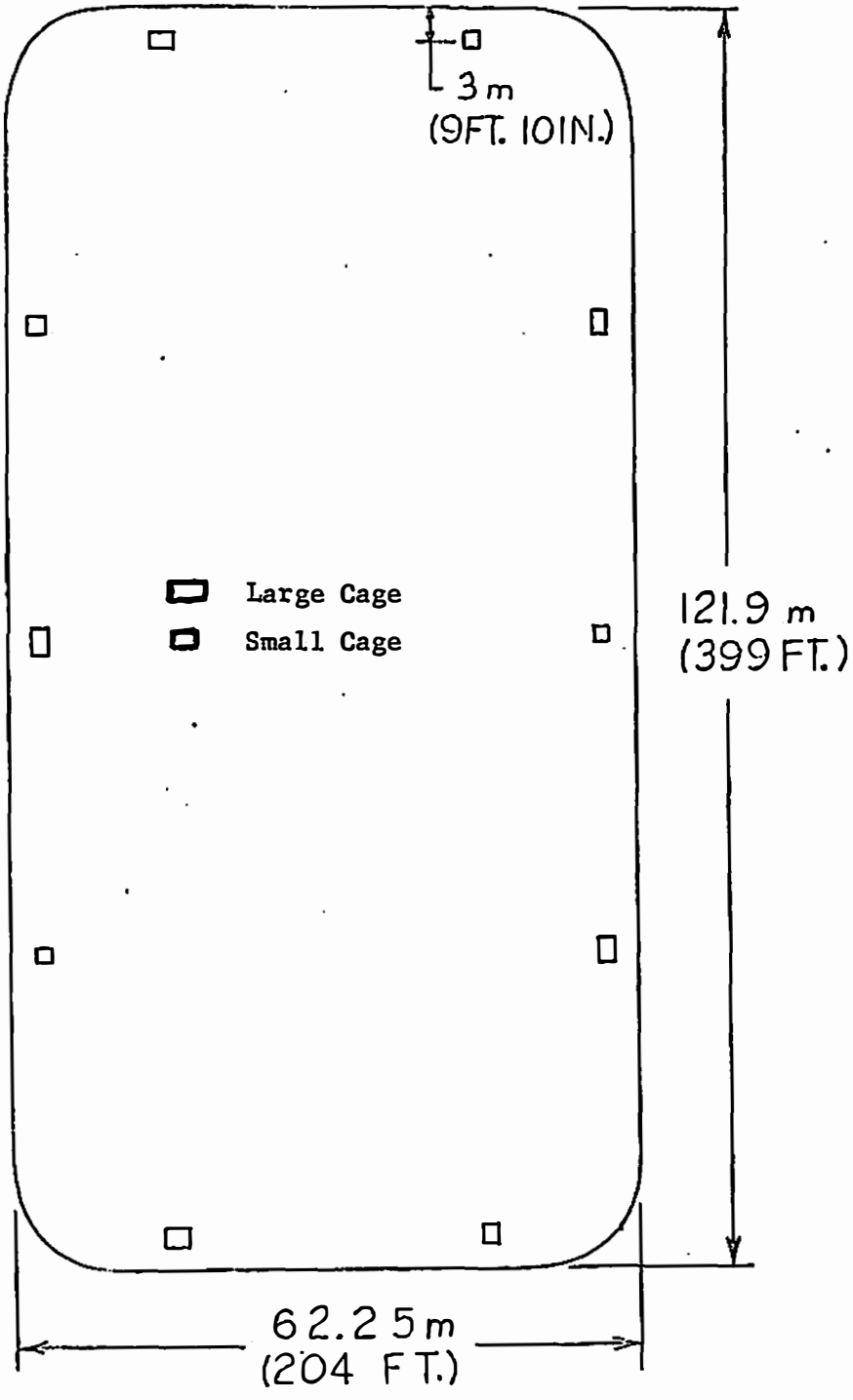

Figure 3. Study pond and location of cages.

Feeding

The fish were fed every evening approximately one hour before sunset by scattering feed in the cage. The feed used, purchased for seven cents per pound, was Purina Fish Chow, Number 5120; but Purina Catfish Chow, Number 5140, was used for seven days when the former could not be obtained. The guaranteed analysis and ingredients of each food is as follows:

Purina Fish Chow - No. 5120

Guaranteed Analysis

Crude protein not less than	35.0%
Crude fat not less than	2.5%
Crude fiber not more than	8.0%

Ingredients

Fish meal, soybean meal, ground yellow corn, ground grain sorghums, wheat middlings, meat and bone meal, Vitamin A supplement, D activated animal sterol, calcium pantothenate, folic acid, niacin, riboflavin supplement, menadione sodium bisulfite (source of Vitamin K activity), methionine hydroxy analogue, calcium, iodized salt, iron oxide, manganese sulfate, manganous oxide, copper oxide, cobalt carbonate, zinc oxide.

Purina Catfish Chow (FR) - No. 5140

Guaranteed Analysis

Crude protein not less than	32.0%
Crude fat not less than	2.5%
Crude fiber not more than	8.0%

Ingredients

Soybean meal, ground yellow corn, fish meal, meat and bone meal, dried whey, brewers' dried yeast, wheat middlings, iodized salt, iron oxide, manganese sulfate, manganous oxide, copper oxide, cobalt carbonate, zinc oxide.

All fish were fed at the same rate during each two-week period. The fish were fed three percent of their body weight/day from July 25 to August 7. Four percent of the body weight/day was fed from August 8 to September 4. Three and one-half percent of body weight/day was fed from September 5 to October 2. Three percent of the fish weight/day was fed the remainder of the experiment. Feeding rates were changed to achieve a high rate of gain and obtain a desirable food conversion factor.

Mortality

Dead fish were collected each evening by dipping the dead fish out of the cage. They were counted and recorded daily for each cage.

Sampling

One large cage and one small cage were chosen at random every 14 days (July 25 to October 16). One hundred bullheads from each cage were measured to the nearest millimeter and weighed to the nearest gram. It was assumed that one cage was representative of the others of that cage size. It was also assumed that the same conditions prevailed in each cage size because stocking and feeding rates were similar. After individual measurements and weights were completed, 45.4 Kg of fish were collected from each cage and the number of individuals was counted in the sample.

The bottom of a larger cage deteriorated, releasing an estimated 93 Kg of fish into the pond on October 2, 1969. When this occurred, lengths and weights were taken from the remaining fish. The total weight gains in larger cages from October 2 until the study terminated on October 16 are predictions, assuming no fish were lost.

Water temperatures were obtained daily from a maximum minimum thermometer suspended approximately .9 m below the water surface. They were assumed to be relatively constant at cage depth throughout the pond, but no verification of this assumption was made.

Statistical Procedures

The least significant difference, determined by a computer, was used to determine fish gain differences between cage sizes at the .05 level using 6 degrees of freedom. The percent mortality, weight gains, condition factors, and food conversion ratios were determined with a desk calculator. Condition factors of the fish were calculated for each 14-day feeding period with the formula, (Carlander 1969):

$$K = \frac{W \times 10^5}{L^3}$$

where: W is the weight of the fish in grams

and L is length in millimeters.

The Chi Square test at the .05 level and 1 degree of freedom was used to compare fish mortality differences between cage sizes, fish condition differences between cage sizes, and differences in fish condition before and during the study.

RESULTS AND DISCUSSION

Black bullheads gained 338.04 Kg from July 25, 1969, to October 16, 1969. Fish in the large cages weighed 335.01 Kg on July 25 (Table 1) and increased to 539.49 Kg on October 16, 1969. The fish in the small cages increased from 234.41 Kg on July 25 to 367.98 Kg on October 16, 1969. The fish in the large cages each grew approximately 33 mm (119 to 232 mm) and gained 82 g (120 to 232 g), while the fish in small cages each grew approximately 26 mm (202 to 228 mm) and gained 100 g (128 to 228 g).

The fish in both cage sizes gained rapidly for the first six weeks, then experienced a slower growth between the sixth and eighth week (Figure 4). Over 75 percent of the total weight gain (Table 2) occurred in the first six weeks. The amount of gain was nearly equal for the periods August 8 to August 21 and July 25 to August 7. Five percent of the total weight gain occurred during the last two weeks of study. The weight gain of the fish in larger cages increased from August 7 to August 21 (Figure 5), while the fish weight gain in smaller cages (Figure 6) decreased. A marked decrease in gain was observed in both cage sizes from August 21 to September 4.

No significant difference in weight gain was observed in fish between the two cage sizes. Fish in each large cage gained a total of 24 to 31 Kg (Table 3). This amounted to an increase of 60.2 percent and 59.7 percent respectively, assuming no fish were lost October 2, 1969.

Table 1. Initial and final lengths and weights of black bullheads in cages.

Cage Size	Initial				Total Weight	Final				Total Weight
	Length (mm)		Weight (g)			Length (mm)		Weight (g)		
	Mean	Range	Mean	Range		Mean	Range	Mean	Range	
Large	199	108 to 288	120	60 to 310	335.01	232	170 to 305	205	80 to 462	*539.49
Small	202	112 to 295	128	72 to 324	234.41	228	175 to 312	203	95 to 470	367.98

*Predicted weight assuming no loss of fish on October 2, 1969.

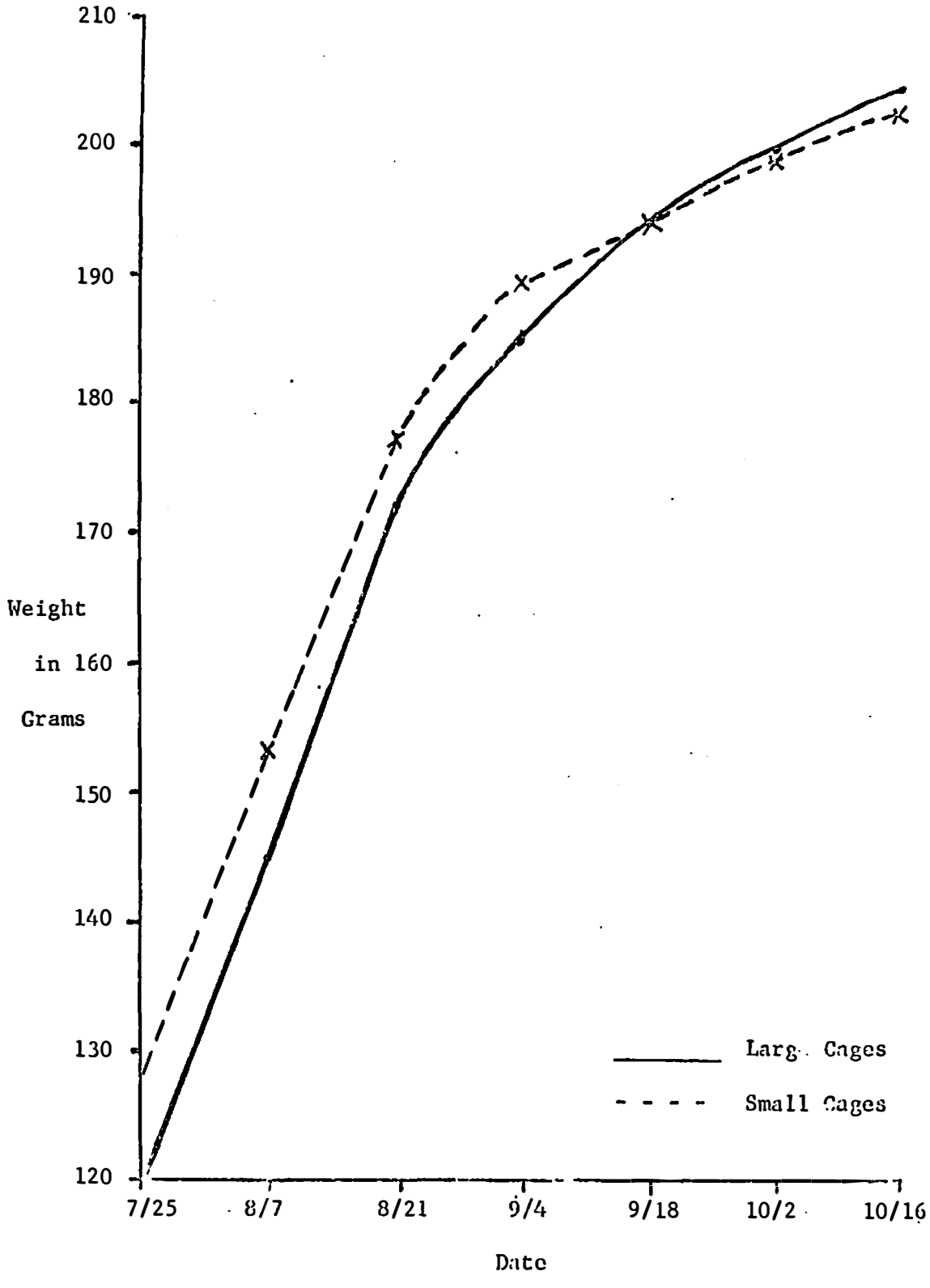

Figure 4. Average weight of black bullheads in large and small cages from July 25 to October 16.

Table 2. Weight, gain and percent of total gain of black bullheads in cages from July 25 to October 16.

Period	Large Cages			Small Cages		
	Weight (Kg)	Gain (Kg)	% of Total Gain	Weight (Kg)	Gain (Kg)	% of Total Gain
July 25 - Aug. 7	395.59	60.57	29.662	280.31	45.40	33.994
Aug. 8 - Aug. 21	460.71	65.12	31.847	323.17	43.32	32.437
Aug. 22 - Sept. 4	491.84	31.13	15.225	342.96	19.78	14.817
Sept. 5 - Sept. 18	513.31	21.47	10.501	342.83	8.95	6.705
Sept. 19 - Oct. 2	527.61	14.29	6.989	360.87	8.95	6.705
*Oct. 3 - Oct. 16	539.49	11.89	5.814	367.98	7.15	5.355
Totals	539.49	204.48		367.98	133.57	

*Predicted gain and weight assuming no loss of fish on October 2, 1969.

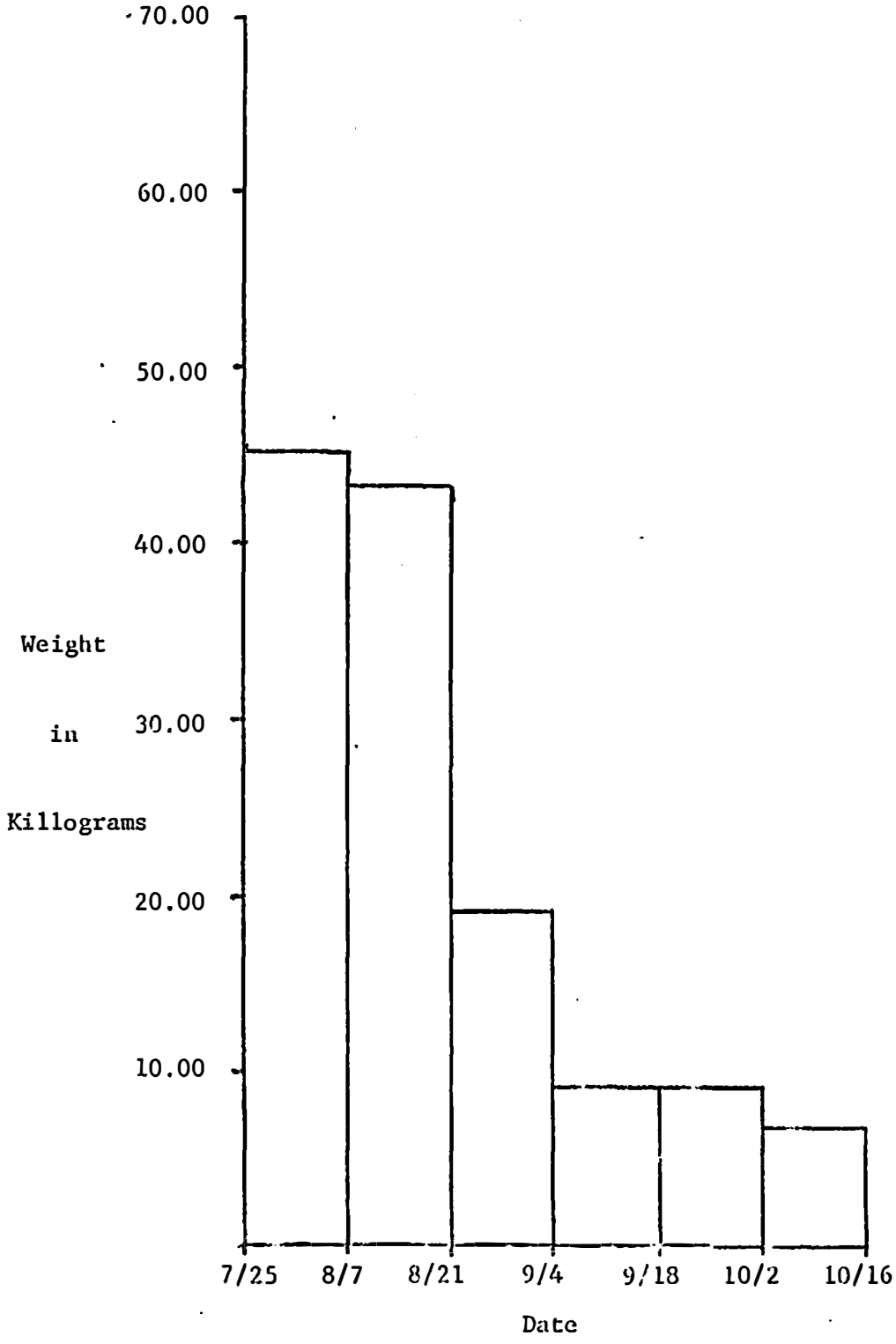

Figure 6. Total weight gain of black bullheads in small cages from July 25 to October 16.

Table 3. Initial and final total weight of black bullheads in each cage.

	Cage Number	Initial Weight (Kg)	Final Weight (Kg)
Large Cages	2	67.0	107.9
	4	66.8	104.8
	6	67.1	103.7
	8	66.9	*14.2 **107.2
	10	66.9	112.2
Small Cages	1	47.2	75.0
	3	46.8	70.2
	5	46.6	73.5
	7	46.9	76.9
	9	46.2	77.6

*Final weight after approximately 93 Kg of fish lost on October 2, 1969.
**Final weight assuming no loss of fish on October 2, 1969.

A least significant difference test revealed no significant difference of fish growth between cage sizes. The absence of significant growth difference between bullheads from large and small cages is probably due to the fact that all cages were stocked at equal densities and all fish were fed at the same rate.

Food conversion rates for bullheads differed slightly between cage sizes. Fish in large cages achieved food conversion rates of 2.37 for the first two-week period (Table 4), and fish in small cages achieved a food conversion of 2.27 (Table 5). More weight was gained by fish in large cages during the second period when the feeding rate was increased to four percent (of total fish weight/day) but, because of increased feed, the food conversion was 3.39. Feeding rates were decreased after September 4, but food conversion values increased to a maximum of 18.94 for the final period.

Water temperatures appeared to influence rate of fish gain and food conversion in that there was a direct relationship between rapid gain in both cage sizes and higher water temperatures. Food conversion values of fish in both cage sizes greatly increased from September 4 to October 16, when water temperatures decreased (Figure 7).

Shrable, Tiemeier and Deyoe (1969) found the optimum temperature range for most rapid rate of digestion by channel catfish was 26.6° C to 29.4° C but was only slightly less at 21.1° C to 23.9° C.

Tiemeier (1962) stated, with respect to his catfish feeding, that "The water temperature of farm ponds in east central Kansas decreased during late August and early September, and apparently

Table 4. Food conversion of black bullheads in large cages from July 25 to October 16.

Date	Weight Gain (Kg)	Feeding Rate % of Total Fish Weight/Day	Food Fed (Kg)	Food Conversion
July 25 - Aug. 7	60.57	3.0%	143.64	2.371
Aug. 8 - Aug. 21	65.12	4.0%	221.10	3.395
Aug. 22 - Sept. 4	31.13	4.0%	261.21	8.389
Sept. 5 - Sept. 18	21.47	3.5%	244.30	11.376
Sept. 19 - Oct. 2	14.29	3.5%	255.31	17.864
Oct. 3 - Oct. 16	11.89	3.0%	225.28	18.947
Totals	204.48		1,350.36	

Table 5. Food conversion of black bullheads in small cages from July 25 to October 16.

Date	Weight Gain (Kg)	Feeding Rate % of Total Fish Weight/Day	Food Fed (Kg)	Food Conversion
July 25 - Aug. 7	45.40	3.0%	103.48	2.279
Aug. 8 - Aug. 21	43.32	4.0%	155.58	3.591
Aug. 21 - Sept. 4	19.78	4.0%	178.90	9.040
Sept. 5 - Sept. 18	8.95	3.5%	166.60	18.604
Sept. 19 - Oct. 2	8.95	3.5%	170.24	19.010
Oct. 3 - Oct. 16	7.15	3.0%	149.68	20.929
Totals	133.57		924.50	

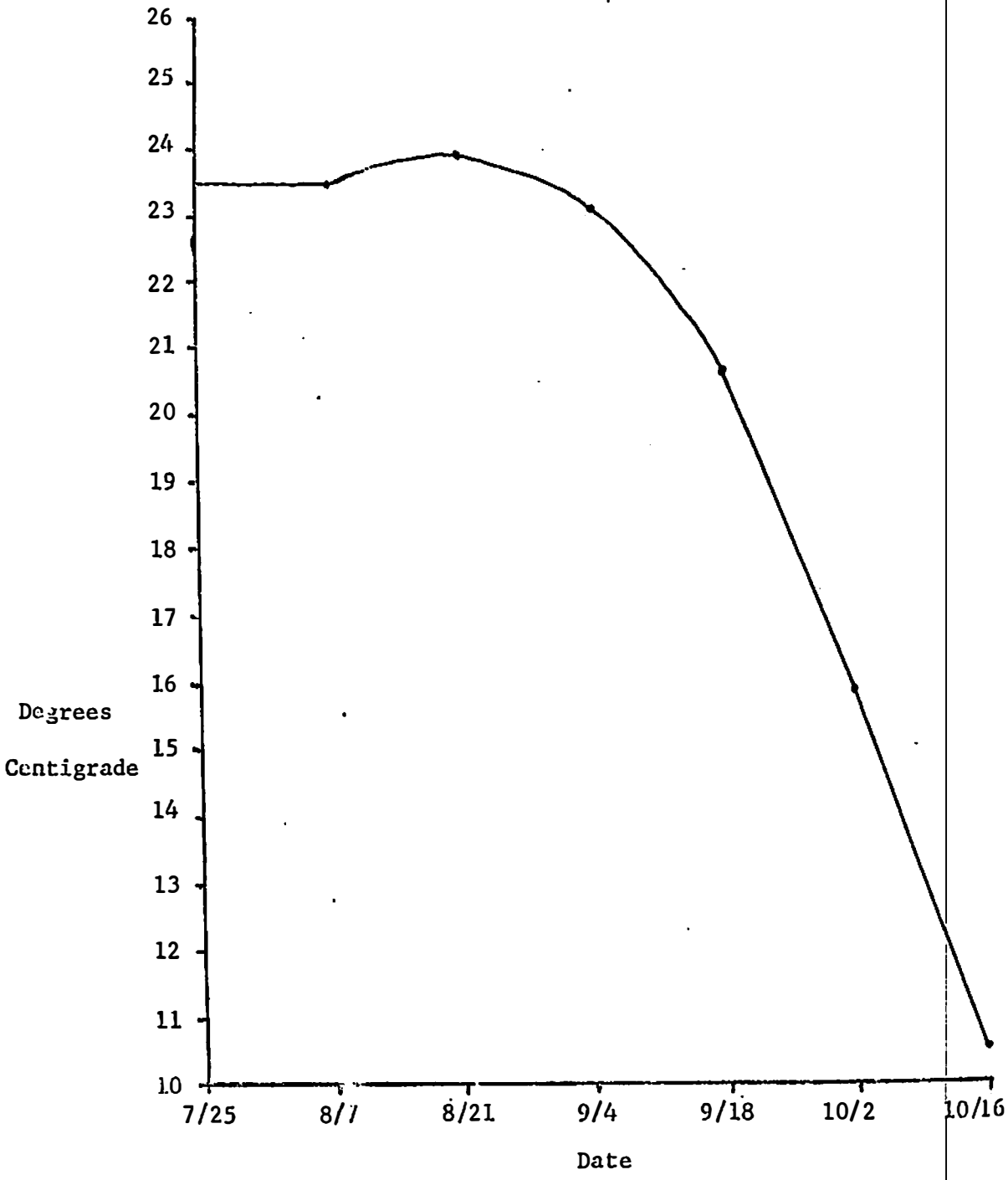

Figure 7. Mean water temperatures of study pond from July 25 to October 16.

channel catfish decreased their rate of feeding at the same time, so conversion values were poor." His fish achieved conversion values from 2.47 to 3.84 during June, July, and August. Food conversion values in September increased to 14.7, thus increasing the average conversion value for his study to 5.02. He suggested that the fish be removed in September to obtain a desirable conversion value. Seventy-three percent of Tiemeier's fish gain occurred in July and August.

Results of this study follow those of Tiemeier's. Conversion values obtained in all cages averaged 2.31 during the first two weeks and increased to 3.40 from August 8 to August 21. Food conversion values increased to an average of 8.7 on September 4. Approximately 76 percent of the total weight gained was obtained from July 25 through September 4, 1969.

Known mortality (Table 6) during the current study was 309 fish (6.6 percent). During the first two-week period the mortality was 236 (4.9 percent), while during the remaining ten weeks 73 fish (1.6 percent) died. Seventy-eight percent of the total number of mortalities died within the first two weeks. The high initial mortality was probably due to injuries the fish received while being captured, transported, and placed in cages. Tiemeier (1962), when feeding channel catfish in ponds, observed mortality rates from 6.4 percent to 10.5 percent with a total average mortality of 8.4 percent.

One hundred seventy-seven fish died in large cages from July 25 to August 7 (Figure 8), while 109 died in the small cages during the

Table 6. Known mortality of black bullhead population in large and small cages from July 25 to October 16.

Date	Dead		Alive
	Total Number	% of Total Population	Total Number
July 25	0	0	4775
Aug. 7	236	4.946	4539
Aug. 21	22	.484	4517
Sept. 4	23	.509	4494
Sept. 18	17	.378	4477
Oct. 2	4	.089	4473
Oct. 16	7	.156	4466
Totals	309	6.562%	

Table 7. Chi Square values from mortality comparisons of black bullheads between large and small cages from August 7 to October 16.

Date	X^2 Values for Mortality	X^2 Value at .05% level, 1df
Aug. 7	.01655	3.84
Aug. 21	.04805	3.84
Sept. 4	.08096	3.84
Sept. 18	.16834	3.84
Oct. 2	.17256	3.84
Oct. 16	.06078	3.84

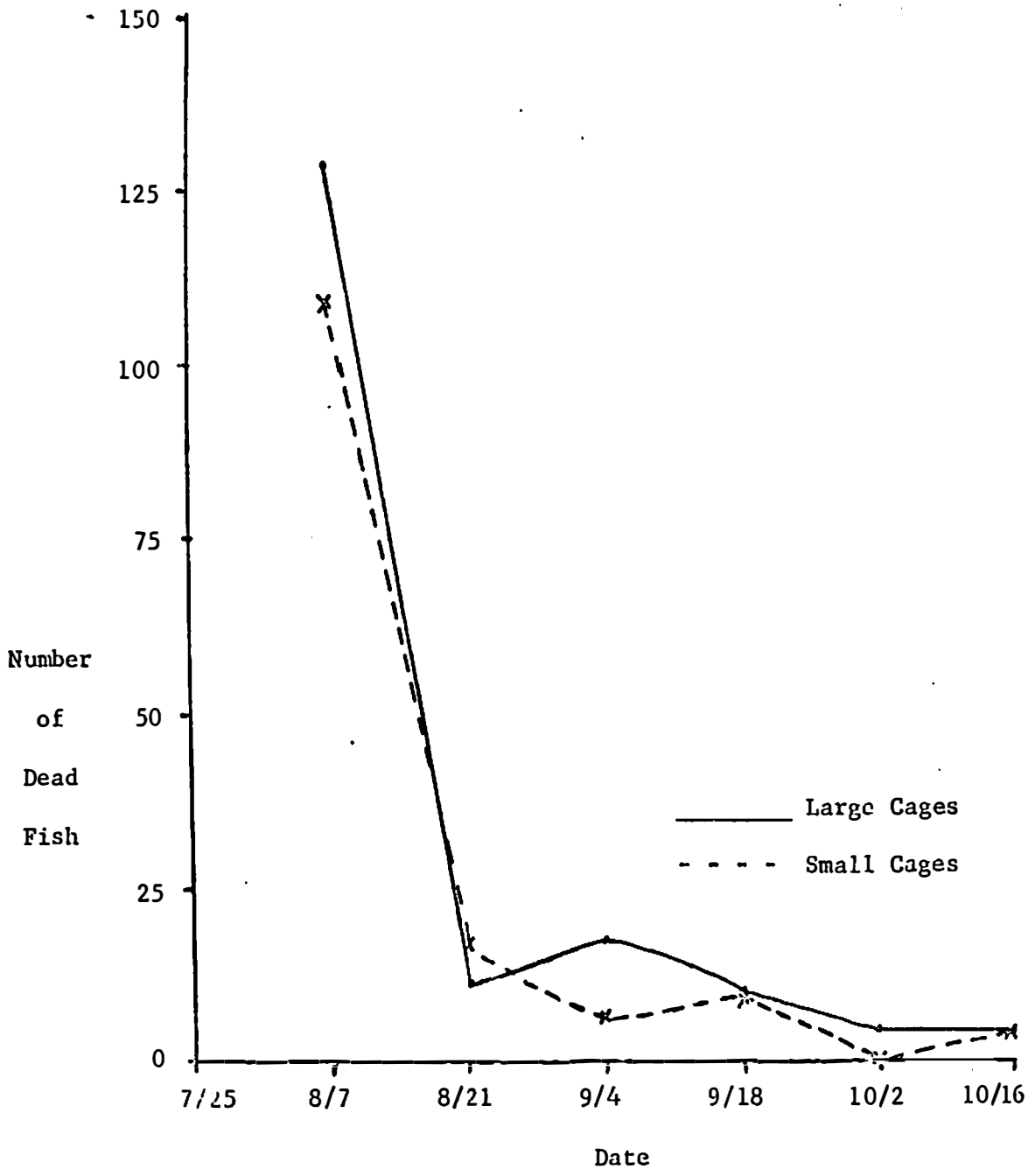

Figure 8. Total mortality of black bullheads in large and small cages from August 7 to October 16.

same period. Fewer fish died in large cages than in small cages from August 7 to August 21. The Chi Square value to determine differences in mortality due to cage sizes for each date was consistently lower than the X^2 value of 3.84 (Table 7). The Chi Square test results indicate that there is no significant difference in mortality between cage sizes for each date. This could be expected as there were no large differences in density, feeding rates, or handling.

No significant difference was revealed by the Chi Square test for the condition (plumpness) of fish between the two cage sizes (Table 8). This test did reveal a significant difference between fish condition on July 25 and fish condition on October 16. The better fish condition on October 16 could possibly be explained by the increased food consumption by fish when food was abundant.

Black bullheads in large cages appear to have gained slightly more economically than those in small cages. Fish in larger cages were fed food costing $208.28 and produced a total gain of 204.4 Kg at a cost of $1.01/Kg (Table 9); and fish in smaller cages produced gains for $1.05/Kg, but no significant cost difference was revealed using the Chi Square test.

Swingle (1954) produced speckled bullheads at a cost of $1.05/Kg but pointed out that elimination of feeding during the winter while water temperatures were below 60° F should result in more economical production. If the cage-grown bullheads of this study had not been fed at water temperatures below 60° F, then feeding would have

Table 8. Condition values for black bullheads in cages from July 25 to October 16.

Date	Condition Value	
	Larger Cages	Smaller Cages
July 25	1.522	1.552
Aug. 7	1.759	1.820
Aug. 21	1.857	1.806
Sept. 7	1.835	1.824
Sept. 18	1.773	1.773
Oct. 2	1.732	1.770
Oct. 16	1.641	1.712

Table 9. Cage costs, food cost, and production costs of black bullheads in cages.

Cage Size	Total Cost of Food Fed	Gain Cost	Cage Cost	Unit Volume Cost
Large	$208.28	$10.1/Kg	$31.72	$8.21/$m^3$
Small	$142.55	$1.05/Kg	$24.34	$9.36/$m^3$

stopped September 8, 1969. This would have resulted in greatly reduced mean conversion values. The fish would have gained 295.7 Kg and would have been fed 1476.6 Kg of fish food. The cost of bullhead production would have been $.78/Kg.

Swingle (1956b) later reared speckled bullheads at a cost of $.25/Kg when feeding stopped at water temperatures below 60° F. His fish food was prepared at a cost of 4.3 to 5.0 cents/pound. Costs in the present study would have been lowered to nearly $.41/Kg if fish food could be obtained for 4.3 cents/pound.

The cages, made from redwood for longevity, were rather expensive, costing $31.74 and $24.34 each for the larger and smaller cages respectively. The cost per unit volume is lower with the larger cages than with smaller cages (Figure 9).

Loss of Fish

Two great blue herons, Ardea herodias (Linnaeus), were observed on several occasions perched on cages catching and eating bullheads. It was not determined how many fish they caught and what percent of those caught were dying. It was possible they were consuming some dead fish each day before the cages were checked. A mink, Mustela vison (Schreber), was observed eating bullheads inside a cage on one occasion. Predation might have been decreased by providing a covering for cages in the form of netting. Lagler (1939) suggests covering screens and wires as methods to stop predation from fish production ponds.

CONCLUSIONS

Experimentally fed black bullheads will gain weight in cages during summer in eastern South Dakota. Fish in this study gained 337 Kg of weight from July 25, 1969, to October 16, 1969.

This study revealed no significant difference in fish growth between two cage sizes.

Results of this study indicate a direct relationship between water temperature and growth rate of fish. The best food conversion was obtained when the water temperatures were between 23^{o} and 24^{o} C.

No significant difference in mortality rate between cage sizes occurred in this study. The Chi Square test at the .05 level and 1 degree of freedom indicated no significant difference in fish mortality between cage sizes. Condition of fish did not significantly differ between cage sizes but differed significantly before and during the feeding study.

The results obtained from the study indicate the use of cages for rearing black bullheads might have economic importance in ponds where harvesting costs are prohibitive.

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