# BEHAVIOR, ECOLOGY, GROWTH, AND INTERSPECIFIC RELATIONSHIPS OF THE YELLOW AND BLACK BULLHEADS

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by

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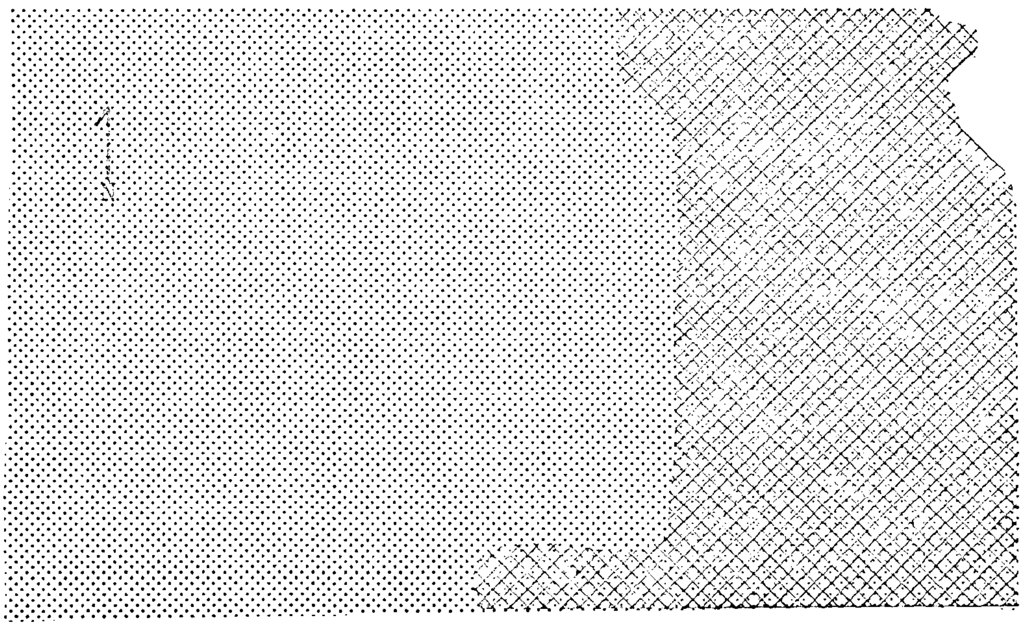
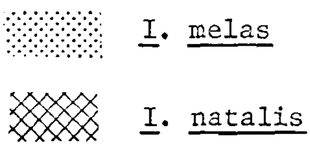


Figure 1. Distribution of the Yellow Bullhead, _I. natalis_, and the Black Bullhead, _I. melas_, in Kansas (After Cross, 1967).



from trapping and fishing at selected stations along a stream study area. The captured bullheads were examined, measured, tagged, and released. An attempt was made to compare distribution of the species in the stream and to compare their growth rate under field conditions.

Clear Creek, a small stream located in west-central Lyon County, was chosen for the field portion of this study. The habitat was varied along the creek's length and the distance from its upper branches to the point where it flows into the Neosho River is approximately 2.5 miles (straight line distance). I first observed the study species in Clear Creek at the time that the laboratory specimens were being collected.

## Literature Review

With such a large overlap in the ranges of *I. natalis* and *I. melas* it would seem probable that both species would be present in some of the same bodies of water. Many studies have shown this to be the case, but in this portion of the thesis I will refer only to those close to the study area. Elkin (1954) in Oklahoma, and Hall (1934), Minckley (1959), and Cross (1967) in Kansas, reported finding these two species coexisting.

Studies which concern some aspect of the life history of either *I. melas* or *I. natalis* are numerous, especially for the former. Forney (1955) studied the life history of

*I. melas* in one Iowa lake, Carlander (1969) compiled life history and ecological observations from many sources, but considerably more space was devoted to *I. melas*. Cross (1967) gave the Kansas life history for the two species, but again much more space was alloted to *I. melas*.

Esterly (1917) discussed species behavior and the relation between habits in nature and reactions in the laboratory. He said, "The actual mode of work is to learn what the particular organism does in nature and to discover by means of the laboratory the reasons for its behavior." Bardach and Villars (1970) studied the behavior, and Todd (1971) the chemical languages, of *I. natalis* in the laboratory. Darnell and Meierotto (1962) determined the feeding chronology of *I. melas* in laboratory studies.

## Taxonomy of the Species

According to Bailey (1956) the family name Ictaluridae is an amalgamation of Amiurus Gill (=*Ameiurus* Rafinesque) with *Ictalurus* Rafinesque. From this revision, the family name Ameiuridae was changed to Ictaluridae. *Ictalurus* was then adopted as the generic name of the bullheads and the larger, forktailed catfishes.

Cross (1967) and others (Harlan and Speaker, 1956; Clay, 1962; Breukelman, 1966; Trautman, 1957; and Eddy, 1957) relying on differences in color, body measurements, and qualitative body characters of *I. natalis* and *I. melas*, listed the following as characteristics of each species:

> *I. natalis* - Yellowish-brown to black; ventral surface of head and body bright yellow, yellow-white, or milk-white. Chin barbels unpigmented (white) or matching the underside of the head. Anal fin with 24-27 rays; vertebrae 42-45. The body is slender; caudal fin rounded outward and slightly notched above mid-point of its distal edge; anal fin long and low; band of teeth in upper jaw without any backward lateral extensions; pectoral spine saw-edged posteriorly; jaws nearly equal in length.

> *I. melas* - Yellowish-brown to black; ventral surface of head and body bright yellow, yellowish-white, or milk-white. Chin barbels pigmented and darker than skin on underside of head. Anal fin with 17-21 rays; vertebrae 39-40. Body usually more stout than that of *I. natalis*; caudal fin rounded inward, slightly notched and may appear almost square-tipped; anal fin short and rounded; band of teeth in upper jaw without any backward lateral extensions; pectoral spine smooth posteriorly (may be rough, but not toothed); jaws equal in length or the upper only slightly protruding.

## Description of Field Study Area

The drainage basin of Clear Creek includes approximately four square miles on the east escarpment of the Flint Hills Upland adjacent to the Neosho River in west-central Lyon County. The total drainage of Clear Creek lies in nine adjacent sections, 7-9 and 16-21 in T18; R10. The creek originates as a permanent spring 4.5 miles west and 1.0 miles south of Americus and flows into the Neosho River 2.5 miles west of the same city. The Neosho River is a part of the Arkansas River Basin. Numerous tributaries join Clear

Creek and most are of intermittent flow. The surface drainage is derived mostly from agricultural lands.

The field study area was primarily rolling bluestem prairie, broken by ridges and limestone outcrops (Hartman, 1960). The soils are dark grayish-brown and grayish-brown, limestone, calcareous shales, and loess. The bottom structure of Clear Creek is either clay, mud, gravel, or bedrock.

The normal growing season for the study area is 186 days. Seventy-two percent of the annual precipitation, 30 to 38 inches, falls within this period. Average temperature for July is 26.1°C as compared to an average January reading of -0.6°C (Breukelman, Eddy, and Hartman, 1961).

## CHAPTER II

## MATERIALS AND METHODS

### Laboratory Study

The laboratory study was conducted on the Kansas State Teachers College campus from October 1970 until November 1971.

The study species, *I. melas* and *I. natalis*, were maintained in glass aquaria measuring from 46 cm by 150 cm by 26 cm to 31 cm, by 60 cm by 26 cm. All sides of the aquaria were clear and kept clean of algae and fungi for the duration of the study. The glass sides were scraped and cleaned at the same time that the aquaria were drained and fresh water added (approximately once a week). The fresh water was tap water that had been allowed to age in tanks for a minimum of 24 hours. Bottom filters were used and covered with one inch of gravel. Air was supplied to the aquaria at all times.

Tiles were used in the aquaria to provide cover for the bullheads. Cuboidal construction tiles approximately 30 cm to a side and having four compartments were used in the larger aquaria. Cylindrical tiles, 30 cm in length and 10 cm inside diameter, were used in the small aquaria as the only cover and in the larger to provide additional shelter.

Observations were normally made during the daylight or early evening hours. Because classes were held in the study area, the bullheads were exposed to much human activity during portions of the day. Most observations were confined to the periods when few people were in the area and the light conditions could be altered at will.

The laboratory specimens were normally fed dry catfish pellets. Other foods used included liver (pork and beef), mealworm larvae, earthworms, and scraps of fish and crayfish. The time of feeding was varied to observe the responses at different hours of the day and evening.

The populations of study fish were arranged so that in some aquaria only one species was present, while in another both species were together. In this manner the specific behavior and ecology could be studied and, at the same time, the interspecific relationships. Some of the variables that were adjusted during the experiment were the size of the fish, comparative number of species, amount of food, shelter, and external stimuli produced by the researcher.

Notes in longhand were taken by the observer at each observation period. The times for observation were kept to a minimum of 30 minutes and lasted as long as two hours. Everything observed was recorded in the laboratory notebook as the events took place. Behavior observed was recorded in the notebook under the general behavior headings given by Scott (1958).

Drug-induced spawning was attempted. Injections of between 0.3 and 0.8 cc of Chorionic Gonadotropin were given to seven of the largest *I. melas*. No sex determination was attempted. The injections were given into the shoulder hump, anterior to the dorsal fin. *I. melas* were used to observe this behavior because of the greater availability of mature specimens.

The ecology portion of the laboratory study was confined to the effects of light, temperature (water and air), barometric pressure, turbidity, and human or mechanical stimuli affecting the bullheads. The lights used were the overhead fluorescent lamps (approximately two meters above the aquaria) and whatever light entered the room through the door or windows. Water temperature was measured with a mercury column, Celsius thermometer and air temperature with a mercury column, Fahrenheit thermometer. Barometric pressure readings were taken directly from *The Emporia Gazette*. The turbidity and human or mechanical stimuli were recorded as qualitative data.

## Field Study

A personal survey of Clear Creek was conducted after gaining permission to fish and trap from the landowners and the Kansas Forestry, Fish and Game Commission in Pratt, Kansas. The decision was made, after the initial survey, to trap in the main stream between its Neosho River outlet and as far upstream as sufficient water could be found within which the traps could be completely submerged. Thirty-seven collecting stations were selected (Fig. 2). During the initial collecting period, the following data were recorded for each collecting station:

a. date
b. pool length
c. pool depth
d. pool width
e. water turbidity
f. type of creek bottom
g. description of pool bank
h. water flora
i. water velocity
j. water temperature
k. remarks

These same data were again collected at the conclusion of the trapping program. The data from the two visits were used to form habitat descriptions for each collecting station.

The term "pool" is defined, for the purpose of this paper, as any stream area deep enough for complete submersion of the traps, and lying between two shallow areas of the creek.

Turbidity was measured by the use of a U. S. Geological Survey turbidity rod. The water temperature was taken by holding a mercury Celsius thermometer approximately 30 cm below the surface of the water for a minimum of one minute. The water velocity was approximated by allowing a fishing "bobber" to float a known distance (10-20 feet) and recording the number of seconds elapsed. The velocity procedure was run three times for each collecting station, and the average feet-per-second recorded.

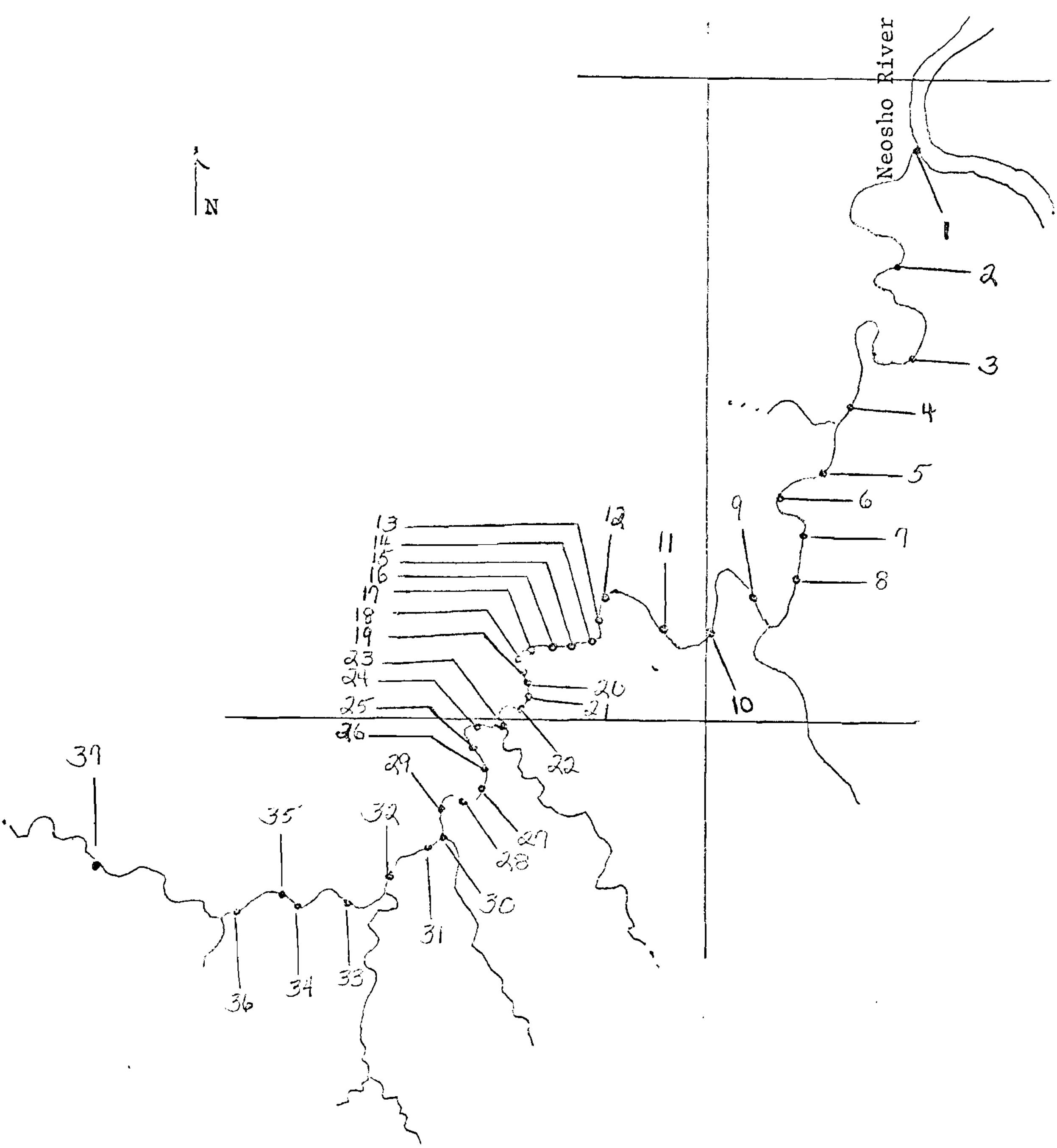



Figure 2. Map showing locations of collecting stations on Clear Creek, Lyon County, Kansas.

Climatic data were taken from the Federal Aviation Agency reports; as recorded in The Emporia Gazette. The Federal Aviation Agency weather reports for the Emporia area were taken at the Emporia Airport which is four miles south of Emporia or 13 miles southeast of the field study area. The climatic data required for each of the collecting periods were as follows:

a. high air temperature
b. low air temperature
c. barometric pressure
d. trend of barometric pressure
e. relative humidity
f. precipitation

The trend of barometric pressure is stated as either rising, falling, or steady.

The data for each bullhead captured were recorded in the field notebook under the following categories:

a. collecting station number
b. date
c. tag number
d. weight (grams)
e. total length (cm)
f. species
g. remarks

The traps used were cylindrical wire pots made of quarter inch hail screen, 75 cm long and 27.5 cm in diameter. The fish could enter the traps from either end through funnel shaped openings approximately five cm in diameter. Square doors (12 cm to a side), on the side of the cylinder, were used for fish removal and placement of the bait within the traps. The bait was contained in dog food cans with a plastic snap-on lid over one end. Holes in the metal allowed the bait to diffuse into the surrounding water.

The bait used in the traps was fresh liver (beef or pork). Earthworms or liver were used on the few days that hook and line was used for collecting.

The tags used were strap tags manufactured by National Band and Tag Company of Newport, Kentucky. The style was number 1005 and size 1. It measured 21 mm (9.4 mm clinched), by two mm by 0.3 mm and weighed only 0.0675 grams (Rounsefell and Everhart, 1953). The tags were normally attached to the left opercle of the study species. When clinched, the tag had an indentification number facing outward and the letters KSTC inward.

Length-frequency distributions were used to estimate age. The fish of each age group normally form a peak in the distribution curve.

Estimation of population densities were attempted by the mark and recapture procedure (Odum, 1966).

Absolute growth and length-weight relationships were determined graphically. Absolute growth was plotted as the average length for each age group.

The value of the condition factor, or the coefficient of condition, is interpreted as expressing the relative well-being of the fish (Carlander, 1969). This coefficient, K, is determined by the following formula:

$$K(TL) = \frac{W\,10^5}{L^3}$$

Where W = weight in grams

L = length in mm

and $10^5$ is a factor to bring the value of K near unity.

# CHAPTER III

## RESULTS AND DISCUSSION

### Species Behavior

#### Ingestive Behavior

Both I. melas and I. natalis fed in the same manner. The body was held, head down, at angles between 15 and 90 degrees. The head was pushed against the bottom with powerful thrusts of the caudal fin. The more vigorous the feeding, the larger the body angle and the more powerful the caudal thrusts.

I. melas always became conditioned to feeding, in the aquaria, before I. natalis. The shortest time between the placing of food in the aquaria and the fish actually feeding was 0 seconds for I. melas and 10 seconds for I. natalis. I. melas often rose toward the surface at my approach, and caught the food on its way to the bottom. I. natalis grabbed food on its way down, but not until they had been excited by food on the aquaria bottom. Many times, I. melas, when in separate aquaria, would feed for several minutes before I. natalis had left their shelter.

The smaller specimens of both species were usually the most active at feeding time and began feeding first.

The time of feeding made no noticable difference in the appetites of the study specimens.

The method of actually ingesting the food varied between the field and the laboratory. In the field the bullheads (both species) gripped the bait between their jaws and moved for a short distance before swallowing. I observed this procedure several times, when fishing under a low water bridge on Clear Creek, and it never varied. The bullheads in the laboratory were hesitant only through the first day, but subsequently would swallow immediately upon biting the food substance.

One individual I. melas, maintained in another room and not one of the study specimens, would rise to the surface and take mealworm larvae or liver from the fingers. The fish could actually raise its head out of the water and gently take the food without biting any fingers.

The type of food would cause different reactions with the study fish. Mealworm larvae and earthworms were fed alive and their body motion caused great excitement and vigorous feeding. The catfish pellets and liver were both eaten readily, but not with as much vigor as with the earthworms or mealworms. When feeding on pellets or liver, the fish often fed until their abdomens were quite visibly swollen.

## Shelter-Seeking Behavior

The most frequently utilized form of shelter were the tiles. The fish also sheltered against the glass and in the open areas of the aquaria bottoms. I. natalis only infrequently left the tiles while I. melas could often be found some distance from the nearest tile.

Both species exhibited the same two body positions within the tiles. The head was usually within five cm of the opening. Position one was horizontal, with the fish completely at rest. The only body motions visible were the opening and closing of the jaws and operculum. Position two was "head up" at an angle up to 45 degrees. The caudal fin just touched the bottom of the tile and all fins were constantly in motion. The fish would drift slowly, vertically or horizontally, and touch the tile at the sides or top. I. natalis displayed this alert position much more then I. melas.

The horizontal position was also assumed when the fish were away from the tiles. All sizes of I. melas demonstrated this behavior, but only the dominated I. natalis. The usual choice of location was next to a tile or along the aquarium side. A position away from any solid object was usually assumed only by the larger I. melas.

One additional position that was assumed was the vertical. This position was demonstrated only by the dominated smaller fish of both species. The position was the same as the horizontal except that the ventral portion of the fish's body rested against an aquarium side or a tile. The caudal fin was against the aquarium bottom and slightly bent from the weight of the fish. This position was often assumed in the aquaria corners or between a tile and the glass aquaria side.

*I. melas* was often observed sheltering in aggregations. This occurred both in the tiles and on the aquaria bottoms. Bowen (1931) stated that, "Fishes in older stages which are not actively aggregating nearly always rest in contact with one another, with the tips of the barblets, the ends of the fin or the tail resting against a companion."

*I. natalis* was observed in aggregations only during periods of stress or excitement. Bardach and Villars (1970) stated that *I. natalis* band together when frightened.

## Agonistic Behavior

This type of behavior was never observed until after the fish had become accustomed to their new surroundings. At first all of the fish stayed together; either in a corner or in the same tile. After one or two days, a hierarchy usually was established and a dominance pattern observed.

Dominance was primarily based upon size. A fish that had been dominant in one group became a subordinate to fish larger than itself when added to an already established population. Dominance was very clear between the different size classes but not definite for fish of near equal size.

The largest *I. melas* was clearly the dominant fish in its population, but its influence was much less than that expressed by the largest *I. natalis* over its own group.

The *I. melas* tolerated much more physical contact and only rarely did it actually chase or bite others of its own species. *I. natalis*, on the other hand, did not allow any physical contact except for periods of stress. These periods were either during cleaning of the aquaria or just after the introduction to a new environment.

The largest *I. natalis* always commanded the preferred shelter. When in its shelter tile, and in the alert position, it always stood its ground if another fish tried to enter. At this time, it rapidly moved its head back and forth, laterally, and held its jaws wide open as though "roaring" at the intruder. Todd (1971) stated that mouth displays varied considerably in intensity. The roar, as I have called it, is labeled a "quiver" by Todd, who said it usually preceded either a mouth fight or a chase. The smaller fish always backed away from the larger and no biting was observed during these encounters.

Biting was observed in several separate laboratory aquaria. *I. melas* were observed biting only one time. In this case the fish were exhibiting sexual behavior and trying to establish their territories. The two victims were badly scratched and one died before the two could be removed. Most of the damage was caused by scraping against the tiles in trying to escape and not from the actual bites. With *I. natalis*, the most usual case was when two fish of near equal size were trying to establish dominance and claim the only tile shelter. In several instances larger _I. natalis_ were observed pursuing smaller specimens and even holding the caudal fin within their jaws. The damage suffered from the bites by the _I. natalis_ was serious. The caudal fins were eaten away and death resulted in three instances. The other fish that were damaged all recovered when moved to new aquaria.

## Sexual Behavior

No sexual behavior was observed with _I. natalis_. They were not injected with hormones to stimulate reproduction and exhibited no natural sexual behavior.

Seven of the largest _I. melas_ were injected with from 0.3 to 0.8 cc of Chorionic Gonadotropin on 24 May 1971. One aquarium contained four large _I. melas_, and it was with this group that the biting was recorded. The first scraping or damage was noted on 5 June 1971.

The two largest _I. melas_ did not feed at all on 7 June 1971. This was the first time this had happened since observations began. From 10 June 1971 until the morning of 14 July 1971 they fed but appeared very nervous.

On 8 July 1971 the two largest _I. melas_ were recorded staying very close to each other. They spent most of their time together and were constantly touching and circling each other. This activity continued until the afternoon of 14 July 1971 when eggs were first observed.

## Care-Giving Behavior

The eggs were laid in two masses. One mass was approximately 30 mm high and 20 mm in diameter at its base. The second was 10 mm high and 5 mm in diameter at the bottom. The aquarium where the eggs were laid had no gravel or bottom filter and the eggs adhered directly to the aquarium bottom.

Ulrey, Risk, and Scott (1938) stated that, "Because the eggs of the catfish are laid in a single large mass, it seems certain that they are all laid at one time." In the laboratory, however, the eggs were laid in two masses and this might indicate that they were laid at two different times.

The eggs were constantly fanned by the adult bullheads. No sexing of the two parents was conducted but one of the two fish did much more of the fanning. The two fish differed in that one had a notched adipose fin and was slightly larger in size. The rounded-adipose fin individual did by far the most fanning. The notched-adipose fin individual serated the eggs either by itself, for brief periods, or at the same time as the other fish.

The fanning was done by the pelvic and caudal fins. The fish used only their pelvic fins for short periods (up to one minute) and a rather gentle body motion. Between these periods there were brief (up to 15 seconds) flurries of activity in which both the caudal and anal fins were used. For the flurry periods the fish drifted downward until the eggs were between the caudal and pelvic fins and then with forceful lateral motions swept the eggs with their pelvic fins.

The fish constantly changed positions when fanning. The most frequent move was 180 degrees. When turning, the parents touched the eggs with their chin barbels, which dragged across the egg mass as they passed over.

The adult fish stopped fanning when I approached the egg masses closer than 30 cm. The adults did not flee but rather remained quietly on the bottom with their heads facing the disturbance. Only the notched-anal-fin individual stayed over the nest when an underwater object moved near the fanning fish. The other adult always retreated into a tile.

The notched-adipose-fin adult tried to defend the nest. When a pencil was first lowered, there was no reaction except that the fish turned slowly so as to keep facing the pencil. The fish only bit the pencil after it was tapped against the inside of the aquarium glass. The fish opened its mouth very wide and struck the pencil three times in succession, without the pencil having been removed from the water between bites.

The bites were vigorous and the pencil was moved sharply in my hand. Teeth were felt scrapping against the wood of the pencil.

The eggs were laid on 14 July 1971, and by 1100 hours on 15 July 1971 over half were missing. By 1500 hours, of the same day, the remaining eggs were recorded as no longer visible. A thorough search of the aquarium produced no sign of the eggs. There were no recorded disturbances that could explain the distruction of the eggs.

Both parents continued to fan the area where the eggs were laid. The adult with the notched adipose fin was the fish that did the most fanning, as was the case before the disappearance of the eggs. This behavior was last recorded on 27 July 1971.

## Eliminative Behavior

No behavior of this type was observed. The water became foul but no solid or liquid wastes were detected.

## Allelomimetic Behavior

Both *I. melas* and *I. natalis* displayed this behavior when first introduced into new surroundings. The fish crowded into one corner of the aquaria or one compartment of a tile. When venturing into the open, the smaller fish usually followed the larger or more aggressive fish. This behavior lasted up to two days for fish that had been just captured but never more then one day for fish transferred from one aquarium to another. Draining and cleaning the aquaria always caused the fish to group, but they stayed together an average of only two hours.

As stated in the Shelter-Seeking Behavior section, *I. melas* was often observed in aggregations. The aggregations in the tiles were constantly in motion and there was considerable shifting of positions by the individuals. When in the open, however, there were often periods when the fish would lie next to each other in the horizontal position. When one fish in the resting group moved, it caused the others to shift also.

Allelomimetic behavior was frequently observed when the fish were either searching for food or when actually feeding. At times of feeding, agonistic behavior was abandoned and only ingestive and allelomimetic behaviors were recorded.

The smaller fish were the most active and were usually feeding before the larger fish were out of their shelters. The activity of the smaller fish, either feeding or actively searching for food, was investigated frequently by the larger fish.

## Investigative Behavior

This behavior was observed when the fish were placed into a new environment and just after the cleaning of the aquarium.

When the study area was quiet and there were no disturbances around the aquaria, the fish left their aggregations, swam over the bottom and even part way up the sides and then returned to their group. This routine was followed until the fish became accustomed to their new or changed environment.

Normal investigation of the open area in the aquaria occured daily. It was usually observed when the lights were either low or off, the water was turbid, or there was no human activity other then myself, in the study area.

The fish used their eyes for investigations. Except when the water was very turbid or the lights were off, they were able to discern a moving object. Moving objects beside the aquaria frightened the fish but not as much as when above the aquarium.

The chin barbels were used constantly. They were always in motion except when the fish were resting in the horizontal position. The barbels were extended and just touched the bottom as the fish swam forward. Any object that the fish came upon was examined by moving the barbels over and around the subject.

The bullheads were highly sensitive to touch on their bodies. They would examine any object that was touched. When food particles hit a fish on the dorsal surface, it would immediately turn and bite the particle. Objects not of food value were not swallowed but were held in the mouth and then spit out.

### Escape Behavior

This particular behavior does not include fleeing from other fish or outside disturbances. It was observed only with *I. natalis* and in this case, refers to any attempt for escape from the confinement of the aquarium. Two freshly captured *I. natalis* did escape from their aquarium the first night after capture, and were found dead on the floor in the morning. Screen tops were then placed on the aquarium and there were no more escapes. One of the larger remaining *I. natalis* was observed trying to push the screen top off its aquarium. The screen was approximately 10 centimeters above the water and the fish thrashed violently for periods of up to five seconds. This action was observed with only one individual fish and recorded seven times within two days.

## Interspecific Relationships of the Laboratory Specimens

Two experiments were conducted in which the study specimens were nearly equal in size. The dominant individual in each case was a *I. natalis*.

One *I. natalis* and two *I. melas* were maintained in aquarium A. The *I. natalis* killed both of the *I. melas* in 13 and 22 days, respectively. Both individuals had their caudal fins eaten away and the bones exposed. The individual that died first had a hole eaten into the top of its head, behind the eyes.

Two I. natalis and I. melas were housed in aquarium B. The dominant specimen was the larger of the two I. natalis. The smaller I. natalis and the I. melas had their caudal fins eaten away and the damage was done, presumably by the dominant individual. Both survived the damage and eventually their wounds healed over.

Both aquarium A and B contained only one cylindrical tile shelter. The dominant I. natalis specimens used the inside of the tile shelter and the subordinate fish, the outside. The two subordinate I. melas in aquarium A stayed in close contact before their deaths. The subordinate I. melas and I. natalis specimens in aquarium B, however, stayed on opposite sides of the tile. The subordinate I. natalis in aquarium B had what appeared to be the least preferred shelter position, which was between the tile and the front glass.

Two experiments were conducted for testing interspecific relationships between specimens of unequal size.

Aquarium C contained six I. natalis and six I. melas. The 12 fish were all placed in the aquarium at the same time. The I. melas usually fed first but were observed being chased away from the feeding area by the larger I. natalis. When the two species fed together, the I. natalis were more aggressive and the I. melas moved aside. The largest I. natalis was observed chasing a smaller I. melas out of a tile opening with the caudal fin of the smaller fish in its mouth. Two of the smaller I. melas suffered caudal fin wounds but this was the only evidence of physical damage suffered by any of the 12 fish. Three of the four tile compartments were usually occupied by individual I. natalis. The fourth compartment was usually shared by the two or more I. melas.

Aquarium D contained seven I. melas and one I. natalis. The I. natalis was the same specimen that killed the two I. melas in aquarium A. The I. natalis was introduced into an already established population and was approximately equal in length to the median-sized I. melas. The I. natalis, when released into the aquarium, swam into one of the lower compartments and would not allow any of the I. melas to enter its compartment, regardless of size. The I. melas were nipped around the caudal fin area when fleeing but were not bitten when face to face with the I. natalis.

Within one week of introduction, the I. natalis in aquarium D had changed its shelter location. It moved from one of the lower compartments to an upper one. The movement or traffic of _I. melas_ was much less in the upper compartments. After the _I. natalis_ moved upward, the _I. melas_ again utilized the lower compartments.

## Ecological Relationships and Distribution

### Laboratory Study - Both Species

The amount of light in the study area greatly influenced the activity of the study species. The fish were much more active when the overhead lights were off. Enough light came in through either the shaded windows (during the day) or the open door (at night) to make observations. When the overhead lights were turned on, the fish retreated to their tile shelters. The lights did not influence the bullheads when hungry, and they were constantly in motion until their appetites were sated.

The air temperature in the study area was held constant $23.9 \pm 2.7$°C by thermostat and did not vary from these limits throughout the year. The water temperature was approximately 5.5°C lower than the air temperature.

Changes in barometric pressure had no noticeable effect upon the laboratory specimens. The fish fed when the barometric pressure was rising, falling, or steady.

Increased activity was noted when the aquaria water became turbid with dissolved food particles and body wastes.

External stimuli almost always frightened the study fish. When people were in the room, the fish ventured away from their shelters only during periods of feeding or hunger. Vibrations transmitted through the aquaria stands were detected when created within five meters of the aquaria. Movement of a hand or arm was detected within two meters.

## Field Study

Eighty-four *I. natalis* and 79 *I. melas* were captured at 30 of the 37 collecting stations on 77 collecting days, between 10 August 1971 and 26 November 1971 (Table I). *I. natalis* were captured at 26 collecting stations and *I. melas* at 21. Both species were found together in 17 of the 30 pools in which bullheads were captured.

Metcalf (1959), referring to a Kansas portion of the Arkansas River basin, reported that *I. melas* were found at every station where *I. natalis* were captured and were usually several times more abundant.

Clarke, Breukelman, and Andrews (1958) gave the relative abundance in Lyon County as "abundant for *I. melas* and common for *I. natalis*."

The collecting station pools varied greatly in size. Table II shows the length, width, depth, and area for each station. The range was from two to 840 $m^3$, with a mean of 176.1 $m^3$.

TABLE I. *I. natalis* and *I. melas* captured at the Clear Creek collecting stations between 10 August 1971 and 26 November 1971.

| Collecting Station | *I. natalis* | *I. melas* |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | 3 | 1 |
| 7 | 4 | 2 |
| 8 | 9 | 1 |
| 9 | 9 | 3 |
| 10 | 1 | |
| 11 | 5 | 3 |
| 12 | 4 | 3 |
| 13 | 3 | 5 |
| 14 | 4 | |
| 15 | 2 | |
| 16 | 2 | 1 |
| 17 | 4 | 14 |
| 18 | 1 | 2 |
| 19 | 3 | 3 |

TABLE I. (Continued)

| Collecting Station | *I. natalis* | *I. melas* |
|---|---|---|
| 20 | 4 | 4 |
| 21 | | 8 |
| 22 | 4 | |
| 23 | 1 | |
| 24 | | 4 |
| 25 | | |
| 26 | 1 | |
| 27 | 3 | 14 |
| 28 | 2 | |
| 29 | 2 | |
| 30 | | 2 |
| 31 | | |
| 32 | 1 | 1 |
| 33 | 3 | 4 |
| 34 | 1 | 2 |
| 35 | | 1 |
| 36 | 4 | |
| 37 | 4 | 1 |

TABLE II. Pool size for each of the Clear Creek collecting stations.

| Station | Length m | Width m | Depth m | Area $m^3$ |
|---|---|---|---|---|
| 1 | 30 | 2 | 0.5 | 30.0 |
| 2 | 10 | 2 | 0.4 | 8.0 |
| 3 | 65 | 4 | 0.4 | 104.0 |
| 4 | 30 | 3 | 0.6 | 54.0 |
| 5 | 15 | 2 | 0.5 | 15.0 |
| 6 | 70 | 4 | 1.2 | 336.0 |
| 7 | 20 | 3 | 1.2 | 72.0 |
| 8 | 30 | 2 | 0.5 | 15.0 |
| 9 | 65 | 5 | 2.0 | 650.0 |
| 10 | 10 | 3 | 0.8 | 24.0 |
| 11 | 60 | 3 | 0.9 | 162.0 |
| 12 | 20 | 15 | 1.5 | 450.0 |
| 13 | 50 | 4 | 0.8 | 160.0 |
| 14 | 50 | 3 | 0.8 | 120.0 |
| 15 | 40 | 8 | 0.8 | 256.0 |
| 16 | 40 | 4 | 0.9 | 144.0 |
| 17 | 25 | 15 | 2.0 | 750.0 |
| 18 | 10 | 2 | 0.8 | 16.0 |

TABLE II. (Continued)

| Station | Length m | Width m | Depth m | Area $m^3$ |
|---|---|---|---|---|
| 19 | 15 | 3 | 1.5 | 67.5 |
| 20 | 10 | 3 | 1.0 | 30.0 |
| 21 | 40 | 4 | 1.5 | 240.0 |
| 22 | 2 | 2 | 0.5 | 2.0 |
| 23 | 15 | 5 | 1.0 | 75.0 |
| 24 | 60 | 4 | 0.8 | 192.0 |
| 25 | 20 | 4 | 0.8 | 64.0 |
| 26 | 100 | 5 | 0.5 | 250.0 |
| 27 | 5 | 3 | 0.4 | 6.0 |
| 28 | 5 | 3 | 0.4 | 6.0 |
| 29 | 20 | 2 | 0.4 | 16.0 |
| 30 | 35 | 4 | 1.0 | 140.0 |
| 31 | 60 | 4 | 1.2 | 288.0 |
| 32 | 40 | 4 | 1.5 | 420.0 |
| 33 | 25 | 7 | 1.0 | 150.0 |
| 34 | 12 | 5 | 1.0 | 60.0 |
| 35 | 80 | 7 | 1.5 | 840.0 |
| 36 | 45 | 5 | 1.2 | 270.0 |
| 37 | 40 | 2 | 0.4 | 32.0 |

Depth was more important than area when considering the pool sizes. The average depth for the collecting stations was 0.9 meters. The average depth for the 17 pools where both species were collected was 1.1 meters. 1.2 meters was the average depth for the four pools where only I. melas were captured. The average depth for the nine pools, where only I. natalis were collected, was 0.7 meters. This last figure would appear to indicate that I. natalis was found in pools of less depth than I. melas. The range for the pools where only I. natalis were captured was 0.4 to 1.2 meters while that for I. melas was 0.8 to 1.5 meters.

The turbidity of the collecting station pools was quite low. Except for periods of up to seven days following heavy run-off, the turbidity readings were less then 2 ppm. This was the smallest ppm measurement which could be read on the U. S. Geological Survey turbidity rod. The platinum needle was visible to the creek bottom.

Cross (1967) stated that the characteristic turbidity is "high" for I. melas and "clear" for I. natalis. Clay (1962) reported I. natalis as largely a creek species that is not as tolerant of turbidity as I. melas. Hubbs and Ortenburger (1929) found that, "These records indicate that Ameriurus natalis in the Southwest as well as in the North inhabits cleaner and swifter water than A. melas." Trautman (1957) often found I. natalis present in small low-gradient brooks which contained normally clear waters and some aquatic vegetation.

The range for the water temperatures throughout the study area was slight. In August, the range was between 22.0 and 26.0°C, with a mean of 24.0°C. When the study ended in November, the same readings ranged from 3.9 to 6.7°C, with a mean of 5.0°C.

Table III shows the bottom description for each of the collecting stations.

Fifty-nine I. melas were captured in pools with mud bottoms, as compared to 54 for I. natalis. I. natalis, however, was found in 19 of the 29 mud-bottomed pools and I. melas only 15.

Thirty-five I. natalis were captured in pools containing large rocks. Only ten I. melas were found in pools with the same type of cover. Eight pools contained the large rocks and I. natalis were found in seven and I. melas in five.

Except for the mud and large rocks there was no evidence found to indicate any preference, by either species, for any particular bottom type.

Cross (1967) stated that, "The yellow bullhead is principally a stream-fish, and is most common in clear permanently-flowing tributaries that have rocky bottoms. Thus its distribution complements that of the black bullhead, which seems best adapted to ponds and muddy intermittent

TABLE III. Bottom description for each of the collecting stations.

| Station | Bottom Description |
|---|---|
| 1 | mud |
| 2 | mud |
| 3 | mud |
| 4 | mud |
| 5 | mud, silt, and large scattered rocks |
| 6 | mud, silt, and large scattered rocks |
| 7 | rock and much debris |
| 8 | rock and much debris |
| 9 | mud, gravel, large rocks, and much debris |
| 10 | mud and gravel |
| 11 | mud, clay, and rock |
| 12 | gravel, silt, and large and small rocks |
| 13 | silt, gravel, much debris, and fallen tree |
| 14 | clay, silt, and large rocks |
| 15 | mud, silt, and large rocks in center |
| 16 | rock |
| 17 | mud and silt |
| 18 | mud, gravel, and clay |
| 19 | mud, clay, logs, and fallen tree |

TABLE III. (Continued)

| Station | Bottom Description |
|---|---|
| 20 | mud, rock, and logs |
| 21 | silt, gravel, and logs |
| 22 | silt, gravel, and dead trees |
| 23 | mud, gravel, and rocks |
| 24 | mud, rocks, and clay |
| 25 | mud, rocks, and gravel |
| 26 | rock and some mud |
| 27 | mud and gravel |
| 28 | mud and some rocks |
| 29 | mud and gravel |
| 30 | mud, rocks, and gravel |
| 31 | mud, shale, rocks, and gravel |
| 32 | mud, shale, rocks, and gravel |
| 33 | mud and debri |
| 34 | mud, rocks, and gravel |
| 35 | mud, shale, rocks, and gravel |
| 36 | mud, shale, and gravel |
| 37 | mud, gravel, and silt |

creeks. These habitats are not fully discrete, however; both species are found at many localities." The last sentence of the quote would apply to I. natalis and I. melas in Clear Creek.

Hall (1934), in Kansas, and Larrabee (1926), in Iowa, reported finding I. melas and I. natalis in habitats with muddy bottoms. Hall listed both species as being common in a Kansas lake and creek. Minckley (1959) reported that, "The yellow bullhead inhabited the muddy-bottomed streams and the upland, gravelly creeks, usually occurring in the headwaters." Clear Creek would fit this habitat type.

Table IV shows the approximate velocity for each collecting station.

I. natalis were more numerous at each of the five velocities except .08 ft/sec. A single I. natalis was the only bullhead captured in the .25 ft/sec. pools. Table V shows the per cent of each species captured in areas with each of the velocities.

Both species were most numerous at the .08 and .13 ft/sec. velocities. This would indicate a preference for a slower current and would agree with statements by Dolan (1960), for I. natalis, and Hubbs and Lagler (1958), for both species. It would not agree, however, with a statement by Hubbs and Ortenburger (1929) that I. natalis inhabited swifter waters than I. melas.

TABLE IV. Water velocity for each of the Clear Creek collecting stations.

| Collecting Station | Velocity in ft/sec. |
|---|---|
| 1 | .13 |
| 2 | .25 |
| 3 | .13 |
| 4 | .13 |
| 5 | .25 |
| 6 | .13 |
| 7 | .13 |
| 8 | <.08 |
| 9 | .13 |
| 10 | .25 |
| 11 | .17 |
| 12 | .13 |
| 13 | <.08 |
| 14 | .13 |
| 15 | .13 |
| 16 | .17 |
| 17 | .13 |
| 18 | .13 |
| 19 | .13 |

TABLE IV. (Continued)

| Collecting Station | Velocity in ft/sec. |
|---|---|
| 20 | .17 |
| 21 | .08 |
| 22 | .08 |
| 23 | .17 |
| 24 | .08 |
| 25 | .08 |
| 26 | <.08 |
| 27 | .08 |
| 28 | .08 |
| 29 | .08 |
| 30 | .08 |
| 31 | .08 |
| 32 | <.08 |
| 33 | .08 |
| 34 | .08 |
| 35 | <.08 |
| 36 | .08 |
| 37 | .08 |

The velocity is expressed in ft/sec. and is the mean of two readings for each collecting station.

TABLE V. Per cent of I. *melas* and I. *natalis* captured for each velocity at the collecting stations on Clear Creek between 10 August 1971 and 26 November 1971.

| Velocity | Per Cent (%) I. *natalis* | I. *melas* |
|---|---|---|
| .08 | 14 | 8 |
| .08 | 30 | 47 |
| .13 | 41 | 35 |
| .17 | 14 | 10 |
| .25 | 1 | 0 |

Velocity is expressed in ft/sec.

Table VI shows the pool-bank description for each collecting station.

Seventy-one per cent of the bullheads were captured in pools with some undercutting. When broken down to species, however, the figures are 76 per cent for I. *natalis* and 65 for I. *melas*.

The type of bank did not noticeably influence the number of bullheads in the pools. Both species were represented almost equally with the different bank types.

Table VII shows the aquatic flora for each collecting station.

Eighty-six per cent of the I. *melas* and 78 per cent of I. *natalis* were captured in pools containing coontail

TABLE VI. Bank description for each of the Clear Creek collecting stations.

| Station | Undercutting | Description |
|---|---|---|
| 1 | | dirt |
| 2 | X | dirt and tree |
| 3 | X | dirt and tree |
| 4 | | dirt |
| 5 | | dirt |
| 6 | | dirt |
| 7 | X | dirt and tree |
| 8 | X | dirt |
| 9 | X | dirt, gravel, and tree |
| 10 | X | dirt and bridge |
| 11 | X | dirt and tree |
| 12 | | dirt |
| 13 | | dirt |
| 14 | X | dirt and tree |
| 15 | X | dirt |
| 16 | | dirt, shale, and seep |
| 17 | | dirt |
| 18 | X | dirt and grass, gravel |

TABLE VI. (Continued)

| Station | Undercutting | Description |
|---|---|---|
| 19 | X | dirt |
| 20 | | dirt and grass |
| 21 | X | grass and gravel |
| 22 | X | dirt and grass |
| 23 | X | dirt, bridge, and grass |
| 24 | X | dirt and grass |
| 25 | | dirt |
| 26 | X | dirt and woody shrubs |
| 27 | X | dirt, grass, and tree |
| 28 | X | dirt and grass |
| 29 | X | dirt, gravel, grass, and ws* |
| 30 | X | dirt, grass, and ws |
| 31 | X | dirt, rock, grass and ws |
| 32 | X | dirt, grass and ws |
| 33 | X | dirt, grass and ws |
| 34 | X | dirt, grass and ws |
| 35 | X | dirt, grass and ws |
| 36 | X | dirt, grass and ws |
| 37 | X | dirt, grass and ws |

* The letters ws denote woody shrubs.

TABLE VII. Aquatic flora found in each of the Clear Creek collecting stations.

| Station | Aquatic Flora |
|---|---|
| 1 | none |
| 2 | filamentous algae |
| 3 | filamentous algae |
| 4 | filamentous algae |
| 5 | filamentous algae |
| 6 | filamentous algae and coontail |
| 7 | coontail and filamentous algae |
| 8 | filamentous algae |
| 9 | filamentous algae and coontail |
| 10 | filamentous algae |
| 11 | filamentous algae |
| 12 | filamentous algae and coontail |
| 13 | coontail |
| 14 | coontail |
| 15 | coontail |
| 16 | duck weed and coontail |
| 17 | coontail |
| 18 | coontail, sedge, and grass |

TABLE VII. (Continued)

| Station | Aquatic Flora |
|---|---|
| 19 | filamentous algae |
| 20 | coontail, sedge, and grass |
| 21 | filamentous algae, coontail, grass, and duckweed |
| 22 | filamentous algae |
| 23 | coontail and filamentous algae |
| 24 | coontail, filamentous algae, sedge, and cattails |
| 25 | filamentous algae |
| 26 | filamentous algae and coontail |
| 27 | filamentous algae and coontail |
| 28 | sedge and coontail |
| 29 | sedge and coontail |
| 30 | sedge, coontail, and filamentous algae |
| 31 | sedge, coontail, and filamentous algae |
| 32 | coontail and filamentous algae |
| 33 | coontail and filamentous algae |
| 34 | filamentous algae, coontail, and duckweed |
| 35 | filamentous algae, coontail, and sedge |
| 36 | filamentous algae, coontail, and sedge |
| 37 | filamentous algae, coontail, sedge, and duckweed |

(Ceratophyllum Sp.). Even though more I. melas were captured in the pools with coontail, only I. natalis were captured in the three pools that were choked with that plant. Seventy-six per cent of the I. natalis and 63 per cent of the I. melas were found in pools with filamentous algae. The other species of aquatic flora, present in the stream, did not appear to affect the number of individuals or species found in the different pools.

Hubbs and Lagler (1949) reported I. natalis as being more common than the other bullheads in clean waters with a growth of aquatic vegetation. Clear Creek would fit this category and I. natalis was indeed more numerous than I. melas. Both species were found frequently (Hall, 1934) in weedy habitats, in a Kansas lake and creek.

Table VIII shows the climatic data for each of the collecting days.

Both of the species were captured in greater numbers when the daytime high temperature was above 15.6°C. I. melas was captured more frequently than I. natalis above this temperature but were outnumbered after the temperature dropped below 15.6 degrees. No bullheads were captured the one day that the high temperature was 2.2°C or the three days that the low temperatures were below -1.1°C.

Both species were captured on 57 per cent of the days that the barometric pressure was falling and 39 per cent of

TABLE VIII. Climatic data for each collecting day on Clear Creek between 10 August 1971 and 26 November 1971.

| Date | Temperature Noon | Temperature Low | B.P. | B.P. Trend | R.H. | Precipitation |
|---|---|---|---|---|---|---|
| August | | | | | | |
| 10 | 27.8 | 20.0 | 29.97 | Down | 52 | |
| 11 | 31.7 | 20.0 | 30.08 | Steady | 35 | |
| 12 | 32.8 | 16.7 | 29.99 | Steady | 48 | |
| 13 | 31.7 | 20.0 | 30.02 | Steady | 20 | |
| 14 | 33.3 | 17.8 | 30.09 | Up | 28 | |
| 16 | ---- | 18.3 | 30.19 | Down | 59 | |
| 17 | 31.7 | 15.0 | 30.13 | Down | 45 | |
| 18 | 31.1 | 15.6 | 30.02 | Down | 45 | |
| 19 | 31.7 | 22.6 | 30.05 | Down | 37 | |
| 20 | 33.3 | 20.0 | 30.03 | Down | 32 | |
| 21 | 33.3 | 20.6 | 29.93 | Steady | 63 | |
| 23 | ---- | 18.9 | 29.92 | Down | 54 | |
| 24 | 33.3 | 21.7 | 30.04 | Steady | 43 | |

TABLE VIII. (Continued)

| Date | Temperature Noon | Low | B.P. | B.P. Trend | R.H. | Precipitation |
|---|---|---|---|---|---|---|
| 26 | 36.1 | 17.8 | 30.05 | Up | 47 | |
| 27 | 33.3 | 15.6 | 30.11 | Down | 49 | |
| 30 | ---- | 12.8 | 30.10 | Down | 46 | |
| 31 | 29.4 | 13.3 | 30.03 | Down | 42 | |
| September | | | | | | |
| 1 | 30.0 | 17.2 | 29.95 | Steady | 41 | |
| 3 | 33.3 | 20.6 | 29.83 | Down | 52 | |
| 4 | 32.8 | 24.4 | 29.83 | Down | 70 | |
| 7 | ---- | 21.7 | 29.94 | Down | 54 | |
| 8 | 33.9 | 22.8 | 29.95 | Down | 50 | |
| 9 | 36.7 | 16.1 | 30.00 | Down | 49 | |
| 10 | 35.0 | 18.3 | 29.95 | Down | 46 | |
| 13 | ---- | 15.0 | 29.95 | Down | 38 | |
| 14 | 31.7 | 18.9 | 29.71 | Steady | 37 | |

TABLE VIII. (Continued)

| Date | Temperature Noon | Temperature Low | B.P. | B.P. Trend | R.H. | Precipitation |
|---|---|---|---|---|---|---|
| 15 | 32.2 | 15.6 | 30.03 | Down | 36 | |
| 16 | 30.0 | 8.3 | 30.06 | Steady | 47 | |
| 17 | 22.2 | 11.7 | 30.28 | Down | 41 | Trace |
| 21 | ---- | 5.0 | 30.22 | Down | 16 | |
| 22 | 22.2 | 10.6 | 30.20 | Down | 57 | Trace |
| 23 | 22.8 | 8.9 | 30.40 | Down | 44 | |
| 24 | 21.1 | 10.6 | 30.26 | Down | 70 | |
| 25 | 18.9 | 13.3 | 29.96 | Steady | 87 | .90 |
| 27 | ---- | 21.1 | 29.76 | Down | 42 | |
| 28 | 30.6 | 21.1 | 29.90 | Up | 57 | |
| 29 | 32.2 | 20.0 | 29.99 | Down | 53 | |
| 30 | 29.4 | 20.0 | 29.92 | Down | 50 | |

TABLE VIII. (Continued)

| Date | Temperature Noon | Low | B.P. | B.P. Trend | R.H. | Precipitation |
|---|---|---|---|---|---|---|
| October | | | | | | |
| 1 | 30.6 | 19.4 | 29.89 | Down | 56 | |
| 2 | 29.4 | 16.7 | 29.91 | Up | 81 | .08 |
| 4 | ---- | 6.7 | 30.12 | Down | 25 | |
| 5 | 22.8 | 10.0 | 30.15 | Steady | 29 | |
| 6 | 26.7 | 8.3 | 30.23 | Down | 44 | |
| 7 | 28.3 | 12.2 | 30.04 | Down | 36 | |
| 8 | 26.7 | 13.9 | 30.08 | Steady | 37 | |
| 9 | 30.6 | 3.3 | 30.18 | Steady | 43 | |
| 11 | ---- | 10.0 | 30.01 | Down | 23 | |
| 12 | 25.0 | 6.7 | 29.83 | Down | 23 | |
| 13 | 24.4 | 6.7 | 30.04 | Down | 40 | |
| 14 | 30.0 | 8.9 | 29.84 | Steady | 40 | |
| 15 | 21.1 | 1.1 | 29.87 | Down | 54 | |

TABLE VIII. (Continued)

| Date | Temperature Noon | Temperature Low | B.P. | B.P. Trend | R.H. | Precipitation |
|---|---|---|---|---|---|---|
| 16 | 27.2 | 16.1 | 29.98 | Down | 90 | |
| 18 | ---- | 17.2 | 29.81 | Steady | 87 | .31 |
| 19 | 25.0 | 10.0 | 30.01 | Steady | 53 | .33 |
| 20 | 17.2 | 1.1 | 30.02 | Down | 93 | .26 |
| 21 | 13.9 | 12.2 | 30.19 | Down | 87 | |
| 22 | 14.4 | 11.7 | 30.08 | Steady | 66 | |
| 23 | 15.0 | 11.7 | 30.09 | Steady | 88 | |
| 25 | ---- | 8.9 | 29.99 | Steady | 75 | |
| 26 | 20.6 | 14.4 | 29.72 | Down | 73 | |
| 27 | 24.4 | 11.1 | 29.65 | Up | 50 | .04 |
| November | | | | | | |
| 3 | 19.4 | -0.6 | 30.31 | Down | 34 | |
| 4 | 16.7 | 2.8 | 30.04 | Down | 33 | |
| 8 | ---- | -0.6 | 30.07 | Down | 76 | .14 |

TABLE VIII. (Continued)

| Date | Temperature Noon | Temperature Low | B.P. | B.P. Trend | R.H. | Precipitation |
|---|---|---|---|---|---|---|
| 9 | 6.1 | 1.1 | 30.32 | Down | 38 | |
| 10 | 5.6 | 2.2 | 30.15 | Down | 22 | |
| 11 | 14.4 | 0.0 | 30.14 | Down | 22 | |
| 12 | 18.3 | 7.8 | 29.84 | Down | 38 | |
| 15 | ---- | 12.2 | 30.05 | Down | 59 | |
| 16 | 23.9 | 12.8 | 30.05 | Down | 93 | .22 |
| 17 | 23.3 | 12.2 | 29.77 | Down | 70 | |
| 18 | 15.6 | 2.8 | 30.05 | Up | 73 | Trace |
| 19 | 18.9 | -3.3 | 30.06 | Down | 41 | |
| 20 | 7.7 | 4.4 | 29.89 | Steady | 30 | |
| 22 | ---- | -3.8 | 30.13 | Down | 82 | |
| 23 | 6.7 | -1.1 | 30.13 | Down | 82 | Snow-4.0 |
| 24 | 2.2 | -1.7 | 30.25 | Down | 89 | |

The letters B.P. = Barometric Pressure and R.H. = Relative Humidity.
The Precipitation is in inches.

the days that it was steady. When it was rising, however, *I. natalis* were captured on 40 per cent of the days and *I. melas* on 49 per cent. Sixty-two per cent of the *I. natalis* and 68 per cent of the *I. melas* were captured when the barometric pressure was in the thirties.

When the barometric pressure was in the twenties, the fish-per-day amounted to 0.92 for *I. natalis* and 0.87 for *I. melas*. 0.89 *I. natalis* and 1.02 *I. melas* per day were captured when the reading was in the thirties.

Forty-eight per cent of the collecting days had relative humidities in the forties and fifties. Sixty-two per cent of all the bullheads were captured during these days. The percentage of total fish captured increased as the relative humidity rose to the forties and decreased after the relative humidity reached the fifties. The one exception was when the relative humidity was in the sixties, (which was recorded on only two days) when three per cent of the bullheads were captured. There was no discernible pattern for the number of either species captured at the different humidities.

Eighty-two per cent of the bullheads were captured on the days with no precipitation. These days accounted for 85 per cent of the collecting days. Five per cent of the days had only a trace of moisture and on these days seven per cent of the study species were captured. Ten per cent of the days had more than a trace of moisture and eleven per cent of the fish were captured on these days. More I. melas than I. natalis were captured on the days with only a trace or no precipitation. I. natalis, however, outnumbered I. melas for the days with more than a trace of precipitation.

Toth (unpublished research problem, 1968) reported finding leeches (Myzobdella moorei) on specimens of I. melas. No leeches were found on any I. melas during this study but four I. natalis were captured with leeches (species unknown) attached.

The four I. natalis that were infested with leeches were collected at stations 32, 33, and 36. These captures took place between 4 October 1971 and 13 October 1971. Two of the fish were in age group III, and one each were in age groups II and IV.

Twelve attached leeches were observed in all. This would agree with the one to three-per-host intensity as given by Harms (1960). All of the leeches were attached to the skin at the base of the chin barbels.

When the leeches were pulled off of the fish a small circular wound was left. One I. natalis was captured at station 33 that had small circular scars around its chin barbels. The scars were completely healed and matched the wounds that were left when the leeches were pulled off.

# GROWTH

## Length-frequency Distribution

The estimated ages of the captured bullheads were obtained by plotting length-frequency distributions. Figure 3 illustrates the length-frequency distributions for the 79 *I. melas* and 84 *I. natalis* captured from the Clear Creek collecting stations between 10 August 1971 and 26 November 1971.

Four age groups were obtained for each of the two species. The peaks in the distribution curves appear to indicate that *I. melas* attains a slightly greater length during the first year, but that *I. natalis* is longer at ages II and III. The peaks for the age group IV individuals were at 25.0 centimeters for both species.

Frequency distributions for the captured bullheads showed a normal decreasing frequency for *I. melas* (Fig. 4), but a high second year frequency for *I. natalis* (Fig. 5). A frequency distribution similar to that shown for *I. natalis* was reported by Schoffman (1955). In that case, however, it was the age group III that was high.

## Population Estimates

All of the captured bullheads were marked and released. Nineteen of the 79 *I. melas* and 12 of the 84 *I. natalis* were

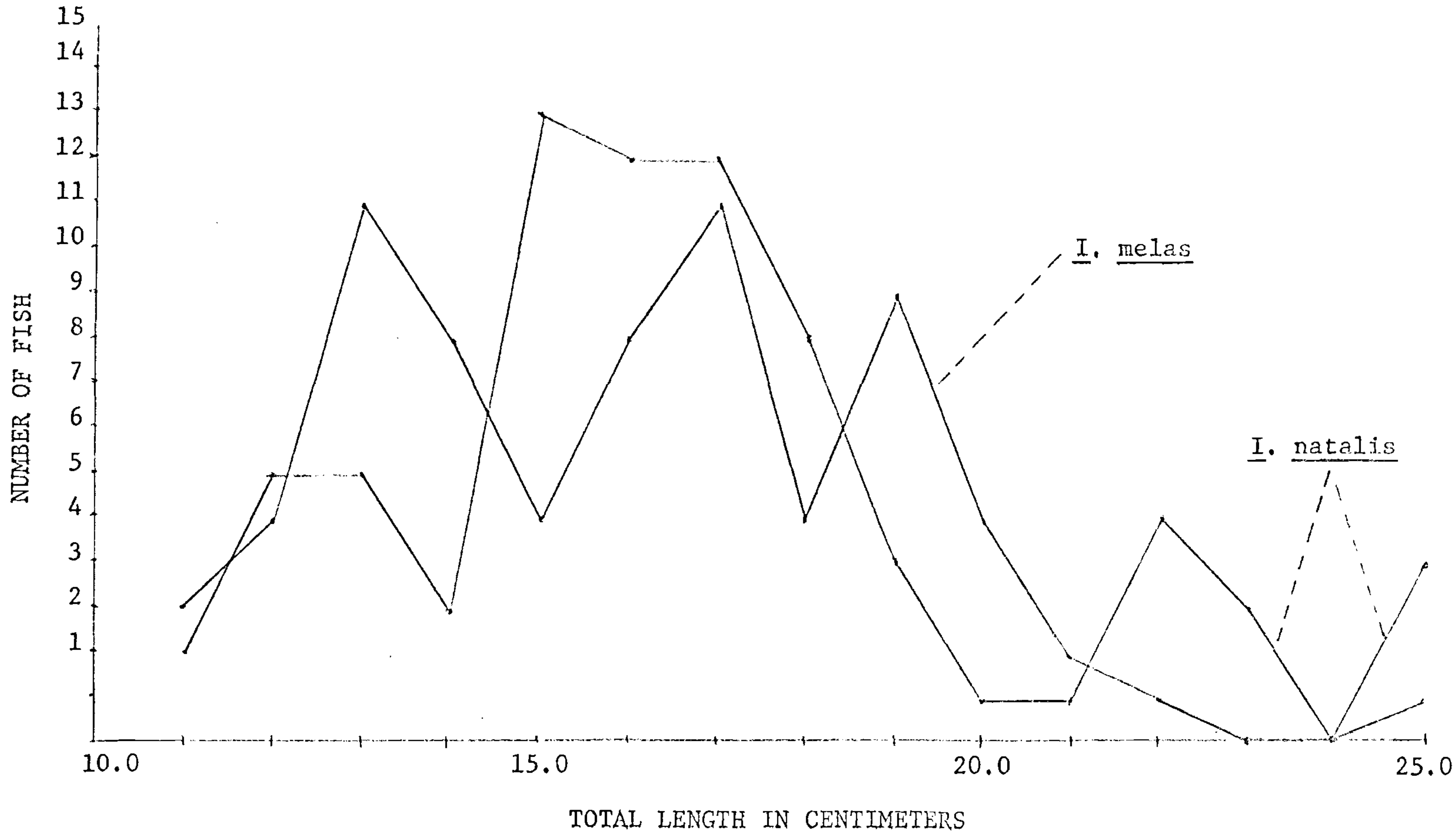



Figure 3. Length-frequencies of 79 _I. melas_ and 84 _I. natalis_ captured from Clear Creek between 10 August 1971 and 26 November 1971.

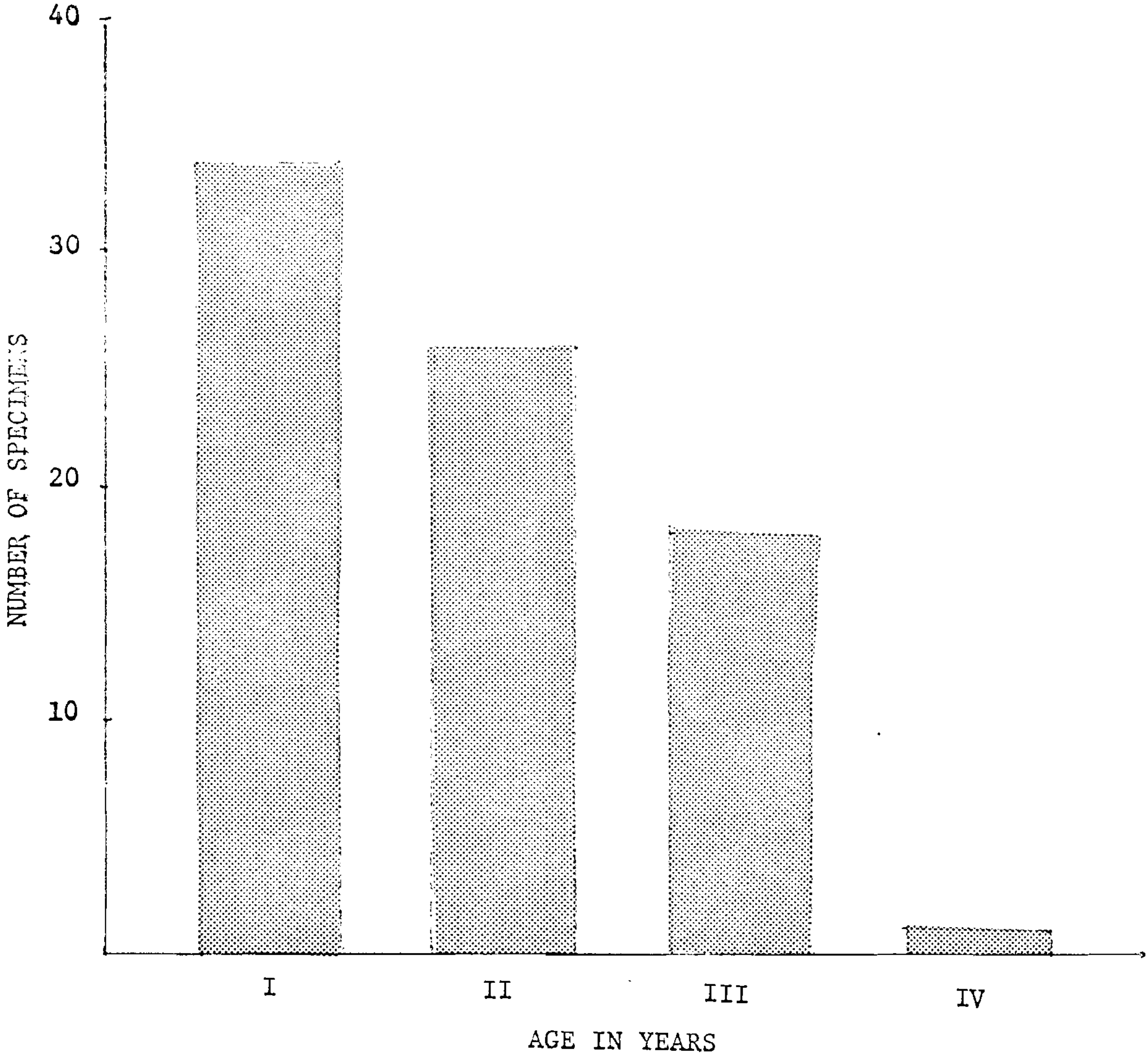



Figure 4. Frequency distribution of 79 I. melas grouped into age groups.

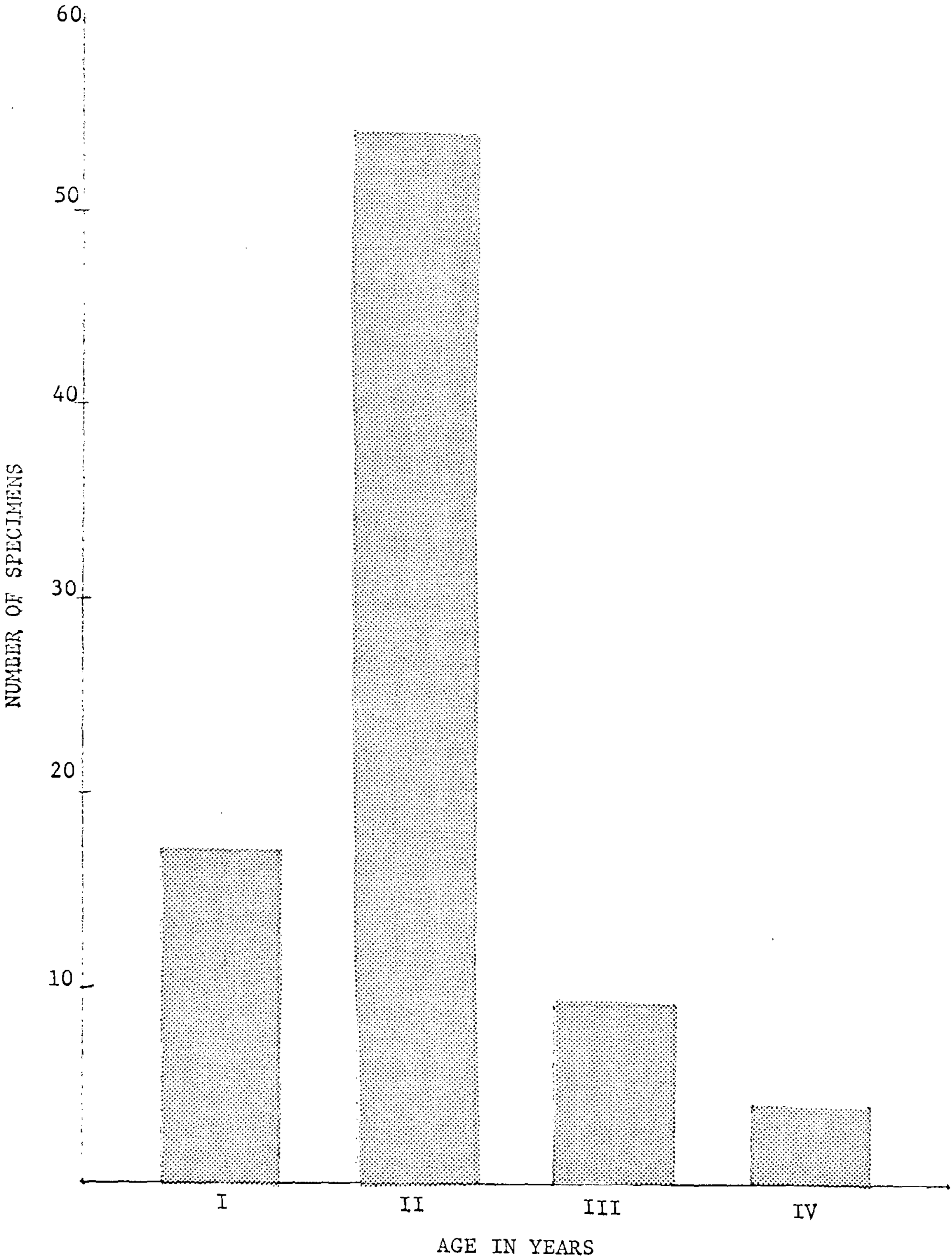



Figure 5. Frequency distribution of 84 I. *natalis* grouped into age groups.

recaptured. Using the mark and recapture procedure (Rousefell and Everhart, 1953) resulted in population estimates of 328 I. melas and 588 I. natalis for Clear Creek.

Cross (1967) in referring to I. melas stated, "The species is not abundant in large streams where bottoms are rocky or sandy, nor in small streams that have a permanent flow of clear water." Clear Creek fits the latter portion of the statement by Cross and is a possible explanation for the difference in estimated populations.

## Absolute Growth

The average total lenghts and weights for each of the age groups of I. melas and I. natalis are shown in Tables IX and X.

The average length of I. melas for age groups I-IV was higher than the average found by Houser and Collins (1962) for 19 Oklahoma streams. Their study found that in Oklahoma the averages for streams were considerably lower than those of other waters. However, except for age group I, the average length for all Oklahoma waters was higher than that for Clear Creek.

Lewis (1949) determined the age of 218 I. melas from an Iowa stream. Vertebral ring counts were made to determine age and this showed agreement with a length frequently distribution chart for the first three age groups. The length

TABLE IX. Average total lengths and weights for each age group of *I. melas* captured from Clear Creek between 10 August 1971 and 26 November 1971.

| Age in Years | Average Growth Length (cm) | Average Growth Weight (g) |
|---|---|---|
| I | 12.8 | 29.4 |
| II | 16.4 | 51.3 |
| III | 19.2 | 100.8 |
| IV | 24.2 | 173.0 |

TABLE X. Average total lengths and weights for each age group of *I. natalis* captured from Clear Creek between 10 August 1971 and 26 November 1971.

| Age in Years | Average Growth Length (cm) | Average Growth Weight (g) |
|---|---|---|
| I | 12.2 | 16.9 |
| II | 16.2 | 47.6 |
| III | 21.7 | 128.0 |
| IV | 24.6 | 196.8 |

averages obtained for *I. melas* from Clear Creek were higher than that found by Lewis, but within the range of lengths for age groups I, II and III. No individual fish captured by Lewis was as long as the average age IV fish from Clear Creek.

Sandoz (1960) calculated growth rates for both *I. melas* and *I. natalis* from a reservoir drainage system in Oklahoma. The average lengths for the age groups were below those found for Clear Creek. Sandoz aged only group I and II for *I. melas* but groups I-IV for *I. natalis*. He listed *I. natalis* as being 0.6 centimeters longer for year I but 11.4 centimeters for both species at year II.

The average total lengths and weights of Tables IX and X were then plotted graphically to show the calculated growth in length (Fig. 6) and weight (Fig. 7) for the study species. *I. natalis* weighed less then *I. melas* at years I and II but was heavier at years III and IV.

## Length-weight Relationships

Tables XI and XII show the numbers of fish and average weights used to calculate the length-weight relationships of *I. melas* and *I. natalis*.

Logarithmic equations were calculated to express the relationships between length and weight for the study species.

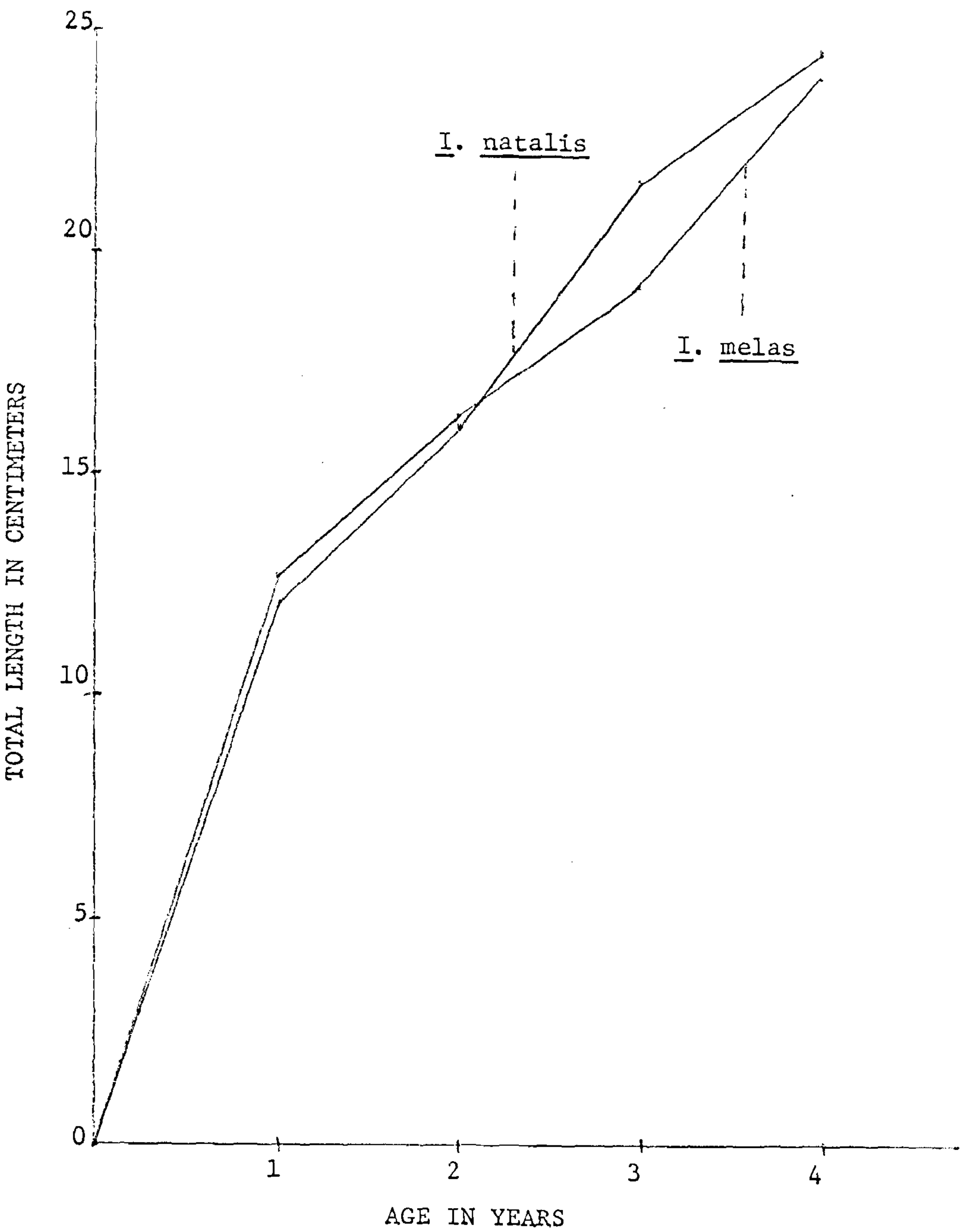



Figure 6. Calculated growth in length of 79 *I. melas* and 84 *I. natalis* captured from Clear Creek collecting stations between 10 August 1971 and 26 November 1971.

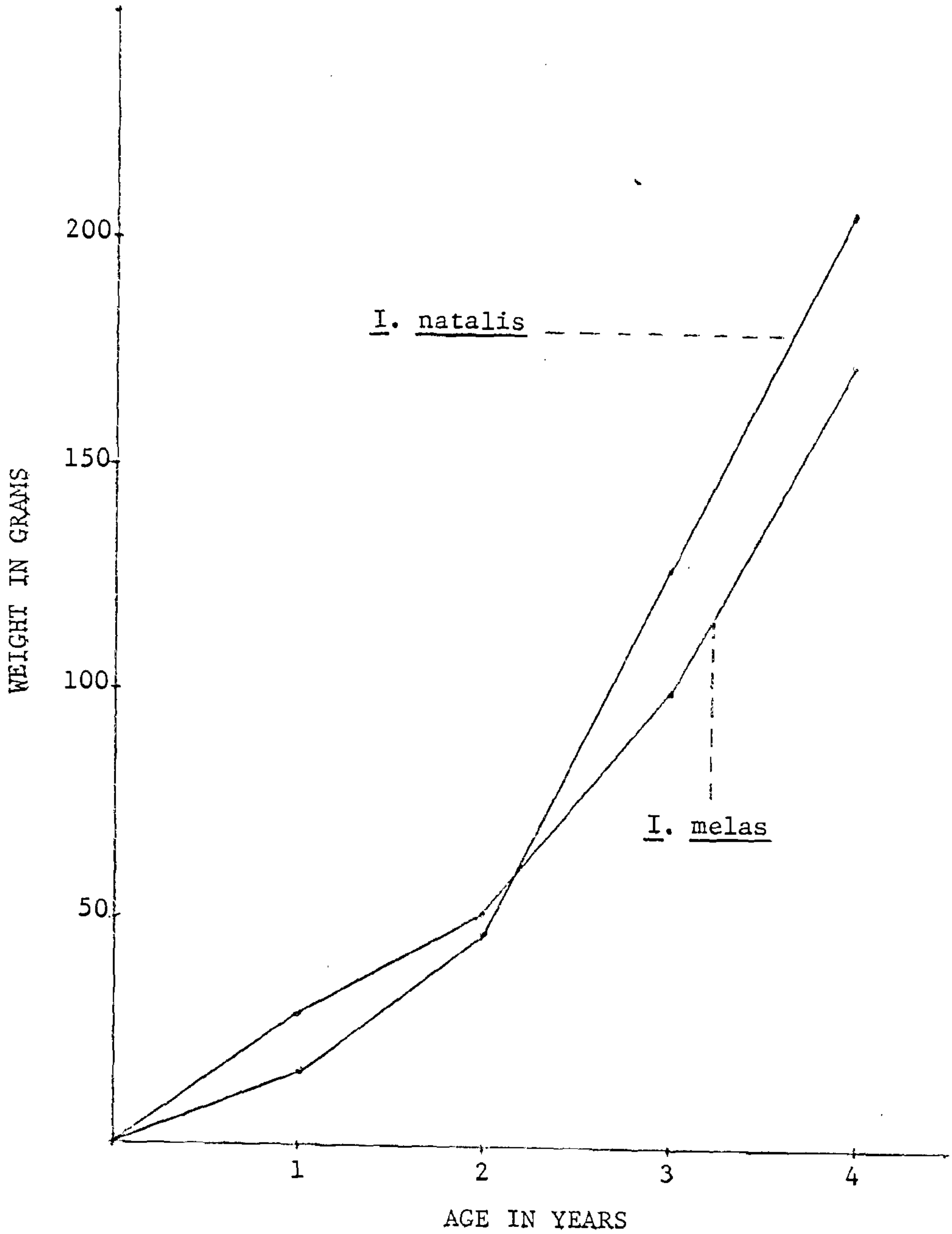



Figure 7. Calculated growth in weight of 79 *I. melas* and 84 *I. natalis* captured from Clear Creek collecting stations between 10 August 1971 and 26 November 1971.

TABLE XI. Number of fish and average weights used to calculate the length-weight relationship of *I. melas*.

| Total Length cm | Number of Fish | Average Weight Grams | Total Length cm | Number of Fish | Average Weight Grams |
|---|---|---|---|---|---|
| 10.2 | 1 | 13.0 | 14.1 | 1 | 45.0 |
| 11.0 | 2 | 14.5 | 14.4 | 1 | 33.0 |
| 11.4 | 1 | 17.0 | 14.5 | 1 | 38.0 |
| 11.5 | 1 | 5.0 | 14.6 | 1 | 29.0 |
| 11.7 | 2 | 24.5 | 14.9 | 1 | 45.0 |
| 11.8 | 1 | 33.0 | 15.1 | 2 | 37.5 |
| 12.1 | 1 | 34.0 | 15.3 | 2 | 39.5 |
| 12.3 | 1 | 27.0 | 15.0 | 1 | 45.0 |
| 12.4 | 1 | 27.0 | 15.7 | 2 | 39.0 |
| 12.5 | 4 | 24.5 | 15.8 | 1 | 32.0 |
| 12.6 | 3 | 32.7 | 16.0 | 1 | 40.0 |
| 12.9 | 1 | 33.0 | 16.1 | 2 | 53.0 |
| 13.0 | 1 | 30.0 | 16.2 | 1 | 58.0 |
| 13.1 | 2 | 35.0 | 16.3 | 2 | 59.0 |
| 13.4 | 2 | 23.5 | 16.4 | 1 | 60.0 |
| 13.5 | 2 | 36.0 | 16.5 | 2 | 52.0 |
| 13.6 | 1 | 41.0 | 16.7 | 2 | 45.5 |
| 13.7 | 1 | 45.0 | 16.9 | 1 | 60.0 |
| 13.8 | 1 | 43.0 | 17.0 | 1 | 70.0 |

TABLE XI. (Continued)

| Total Length cm | Number of Fish | Average Weight Grams | Total Length cm | Number of Fish | Average Weight Grams |
|---|---|---|---|---|---|
| 17.3 | 1 | 62.0 | 18.8 | 1 | 82.0 |
| 17.4 | 1 | 62.0 | 19.1 | 1 | 107.0 |
| 17.8 | 1 | 60.0 | 19.5 | 2 | 105.0 |
| 18.0 | 2 | 67.0 | 19.6 | 1 | 109.0 |
| 18.2 | 1 | 75.0 | 19.9 | 1 | 110.0 |
| 18.3 | 1 | 86.0 | 20.5 | 1 | 143.0 |
| 18.4 | 1 | 101.0 | 20.8 | 1 | 122.0 |
| 18.5 | 2 | 85.0 | 21.5 | 1 | 122.0 |
| 18.6 | 4 | 94.3 | 24.2 | 1 | 173.0 |

TABLE XII. Number of fish and average weights used to calculate the length-weight relationship of *I. natalis*.

| Total Length cm | Number of Fish | Average Weight Grams | Total Length cm | Number of Fish | Average Weight Grams |
|---|---|---|---|---|---|
| 10.4 | 1 | 16.0 | 15.4 | 2 | 37.5 |
| 10.5 | 1 | 3.0 | 15.5 | 1 | 34.0 |
| 11.1 | 1 | 9.0 | 15.8 | 2 | 43.0 |
| 11.5 | 2 | 23.5 | 16.0 | 1 | 38.0 |
| 11.7 | 1 | 4.0 | 16.1 | 1 | 56.0 |
| 11.8 | 2 | 19.0 | 16.2 | 3 | 50.3 |
| 12.5 | 2 | 17.0 | 16.3 | 3 | 48.3 |
| 12.6 | 1 | 19.0 | 16.6 | 1 | 45.0 |
| 13.0 | 3 | 19.0 | 16.7 | 1 | 55.0 |
| 13.3 | 1 | 17.0 | 16.8 | 1 | 72.0 |
| 13.9 | 2 | 21.5 | 16.9 | 1 | 57.0 |
| 14.2 | 3 | 29.3 | 17.0 | 2 | 54.0 |
| 14.5 | 3 | 34.0 | 17.2 | 1 | 56.0 |
| 14.7 | 3 | 30.3 | 17.3 | 1 | 71.0 |
| 14.8 | 1 | 29.0 | 17.4 | 1 | 47.0 |
| 14.9 | 1 | 25.0 | 17.5 | 2 | 64.0 |
| 15.0 | 3 | 39.3 | 17.6 | 1 | 72.0 |
| 15.1 | 3 | 47.0 | 17.8 | 1 | 70.0 |
| 15.2 | 2 | 29.0 | 17.9 | 1 | 50.0 |
| 15.3 | 2 | 31.0 | 18.0 | 1 | 85.0 |

TABLE XII. (Continued)

| Total Length cm | Number of Fish | Average Weight Grams | Total Length cm | Number of Fish | Average Weight Grams |
|---|---|---|---|---|---|
| 18.5 | 2 | 74.5 | 21.7 | 1 | 118.0 |
| 18.6 | 1 | 65.0 | 22.0 | 1 | 130.0 |
| 18.7 | 1 | 58.0 | 22.2 | 1 | 136.0 |
| 20.0 | 1 | 82.0 | 22.7 | 1 | 148.0 |
| 20.2 | 1 | 123.0 | 22.8 | 1 | 136.0 |
| 21.1 | 1 | 131.0 | 24.5 | 3 | 197.3 |
| 21.2 | 2 | 115.0 | 25.0 | 1 | 195.0 |

The equations were as follows:

*I. melas* $\log W = -2.9533 + 3.7974 \log L$

*I. natalis* $\log W = -1.9815 + 3.0743 \log L$

Where W = weight in grams and L = total length in centimeters (Tables XIII and XIV).

Figures 8 and 9 show the length-weight relationships for *I. melas* and *I. natalis* from Clear Creek. The dots represent empirical averages (Tables XIII and XIV) and the curves are graphs of the length-weight equation.

## Condition Factor

The condition factor or coefficient of condition expresses the condition (degree of plumpness) of a fish in numerical terms (Lagler, 1956). Tables XIII and XIV illustrate the average condition factor for each of the recorded capture lengths. The average condition factor for *I. melas* was 1.31. This was greater than the 1.09 found for *I. natalis* and would indicate that, on the average, *I. melas* were more robust or plump than *I. natalis*. Carlander (1969) reported similar condition factors for the two species. He gave a condition factor of 1.38 for 8,130 *I. melas* and 1.21 for 317 *I. natalis*.

The values of the condition factor for *I. melas* did not follow any apparent pattern when considered for the

TABLE XIII. Length-weight relationship and condition factor, K(TL), of *I. melas* from Clear Creek.

| Total Length cm | Weight Grams | Average K(TL) | Total Length cm | Weight Grams | Average K(TL) |
|---|---|---|---|---|---|
| 10.2 | 13 | 1.23 | 13.7 | 45 | 1.75 |
| 11.0 | 24.5 | 1.09 | 13.8 | 43 | 1.64 |
| 11.4 | 17 | 1.15 | 14.1 | 45 | 1.61 |
| 11.5 | 5 | 0.33 | 14.4 | 33 | 1.11 |
| 11.7 | 24.5 | 1.03 | 14.5 | 38 | 1.25 |
| 11.8 | 33 | 2.01 | 14.6 | 29 | 0.93 |
| 12.1 | 34 | 1.92 | 14.9 | 45 | 1.36 |
| 12.3 | 27 | 1.45 | 15.1 | 37.5 | 1.09 |
| 12.4 | 27 | 1.42 | 15.3 | 39.5 | 1.11 |
| 12.5 | 24.5 | 1.26 | 15.6 | 45 | 1.19 |
| 12.6 | 32.6 | 1.63 | 15.7 | 39 | 1.01 |
| 12.9 | 33 | 1.54 | 15.8 | 32 | 0.81 |
| 13.0 | 30 | 1.37 | 16.0 | 40 | 0.98 |
| 13.1 | 35 | 1.56 | 16.1 | 53 | 1.28 |
| 13.4 | 23.5 | 0.98 | 16.2 | 58 | 1.36 |
| 13.5 | 36 | 1.46 | 16.3 | 59 | 1.36 |
| 13.6 | 41 | 1.63 | 16.4 | 60 | 1.36 |

TABLE XIII. (Continued)

| Total Length cm | Weight Grams | Average K(TL) | Total Length cm | Weight Grams | Average K(TL) |
|---|---|---|---|---|---|
| 16.5 | 52 | 1.16 | 18.5 | 85 | 1.34 |
| 16.7 | 45.5 | 0.98 | 18.6 | 94.3 | 1.48 |
| 16.9 | 60 | 1.24 | 18.8 | 82 | 1.23 |
| 17.0 | 70 | 1.42 | 19.1 | 107 | 1.54 |
| 17.3 | 62 | 1.20 | 19.5 | 105 | 1.42 |
| 17.4 | 62 | 1.18 | 19.6 | 109 | 1.45 |
| 17.8 | 60 | 1.06 | 19.9 | 110 | 1.40 |
| 18.0 | 67 | 1.15 | 20.5 | 143 | 1.66 |
| 18.2 | 75 | 1.24 | 20.8 | 122 | 1.36 |
| 18.3 | 86 | 1.40 | 21.5 | 122 | 1.23 |
| 18.4 | 101 | 1.62 | 24.2 | 173 | 1.22 |

TABLE XIV. Length-weight relationship and condition factor, K(TL), of *I. natalis* from Clear Creek.

| Total Length cm | Weight Grams | Average K(TL) | Total Length cm | Weight Grams | Average K(TL) |
|---|---|---|---|---|---|
| 10.4 | 16 | 1.42 | 15.2 | 29 | 0.83 |
| 10.5 | 3 | 0.26 | 15.3 | 31 | 0.87 |
| 11.1 | 9 | 0.66 | 15.4 | 37.5 | 1.03 |
| 11.5 | 23.5 | 1.55 | 15.5 | 34 | 0.91 |
| 11.7 | 4 | 0.25 | 15.8 | 43 | 1.09 |
| 11.8 | 19 | 1.16 | 16.0 | 38 | 0.93 |
| 12.5 | 17 | 0.87 | 16.1 | 56 | 1.34 |
| 12.6 | 19 | 0.95 | 16.2 | 50.3 | 1.18 |
| 13.0 | 19 | 0.86 | 16.3 | 48.3 | 1.12 |
| 13.3 | 17 | 0.72 | 16.6 | 45 | 0.98 |
| 13.9 | 21.5 | 0.80 | 16.7 | 55 | 1.18 |
| 14.2 | 29.3 | 1.02 | 16.8 | 72 | 1.52 |
| 14.5 | 34 | 1.11 | 16.9 | 57 | 1.18 |
| 14.7 | 30.3 | 0.95 | 17.0 | 54 | 1.10 |
| 14.8 | 29 | 0.89 | 17.2 | 56 | 1.10 |
| 14.9 | 25 | 0.76 | 17.3 | 71 | 1.37 |
| 15.0 | 39.3 | 1.17 | 17.4 | 47 | 0.89 |
| 15.1 | 47 | 1.40 | 17.5 | 64 | 1.20 |

TABLE XIV. (Continued)

| Total Length cm | Weight Grams | Average K(TL) | Total Length cm | Weight Grams | Average K(TL) |
|---|---|---|---|---|---|
| 17.6 | 72 | 1.32 | 21.1 | 131 | 1.39 |
| 17.8 | 70 | 1.24 | 21.2 | 115 | 1.21 |
| 17.9 | 50 | 0.87 | 21.7 | 118 | 1.15 |
| 18.0 | 85 | 1.46 | 22.0 | 130 | 1.22 |
| 18.5 | 74.5 | 1.18 | 22.2 | 136 | 1.24 |
| 18.6 | 65 | 1.01 | 22.7 | 148 | 1.27 |
| 18.7 | 58 | 0.89 | 22.8 | 136 | 1.15 |
| 20.0 | 82 | 1.03 | 24.5 | 197.3 | 1.34 |
| 20.2 | 123 | 1.49 | 25.0 | 195 | 1.25 |

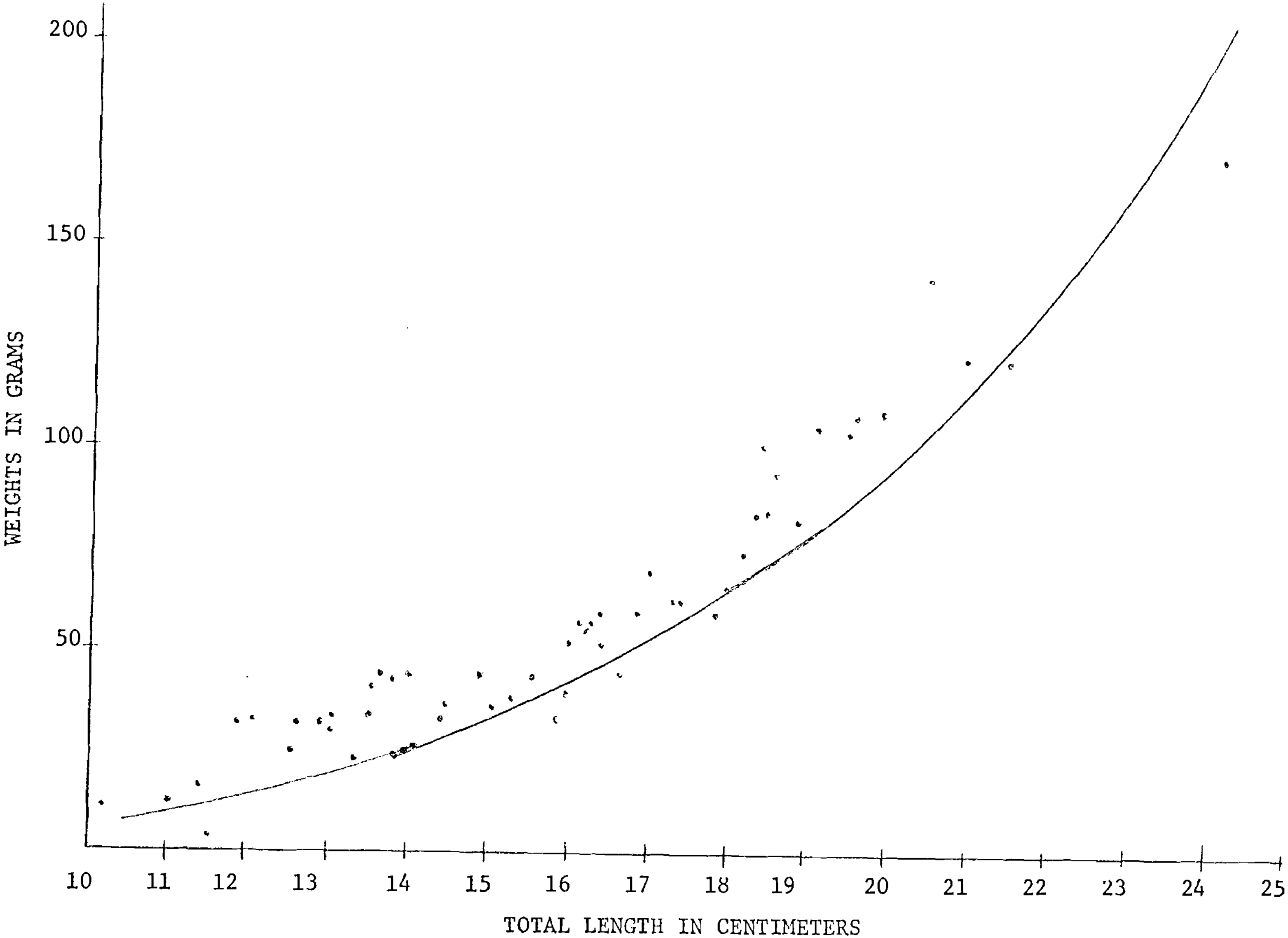



Figure 8. Length-weight relationship of 79 I. melas captured from Clear Creek collecting stations between 10 August 1971 and 26 November 1971.

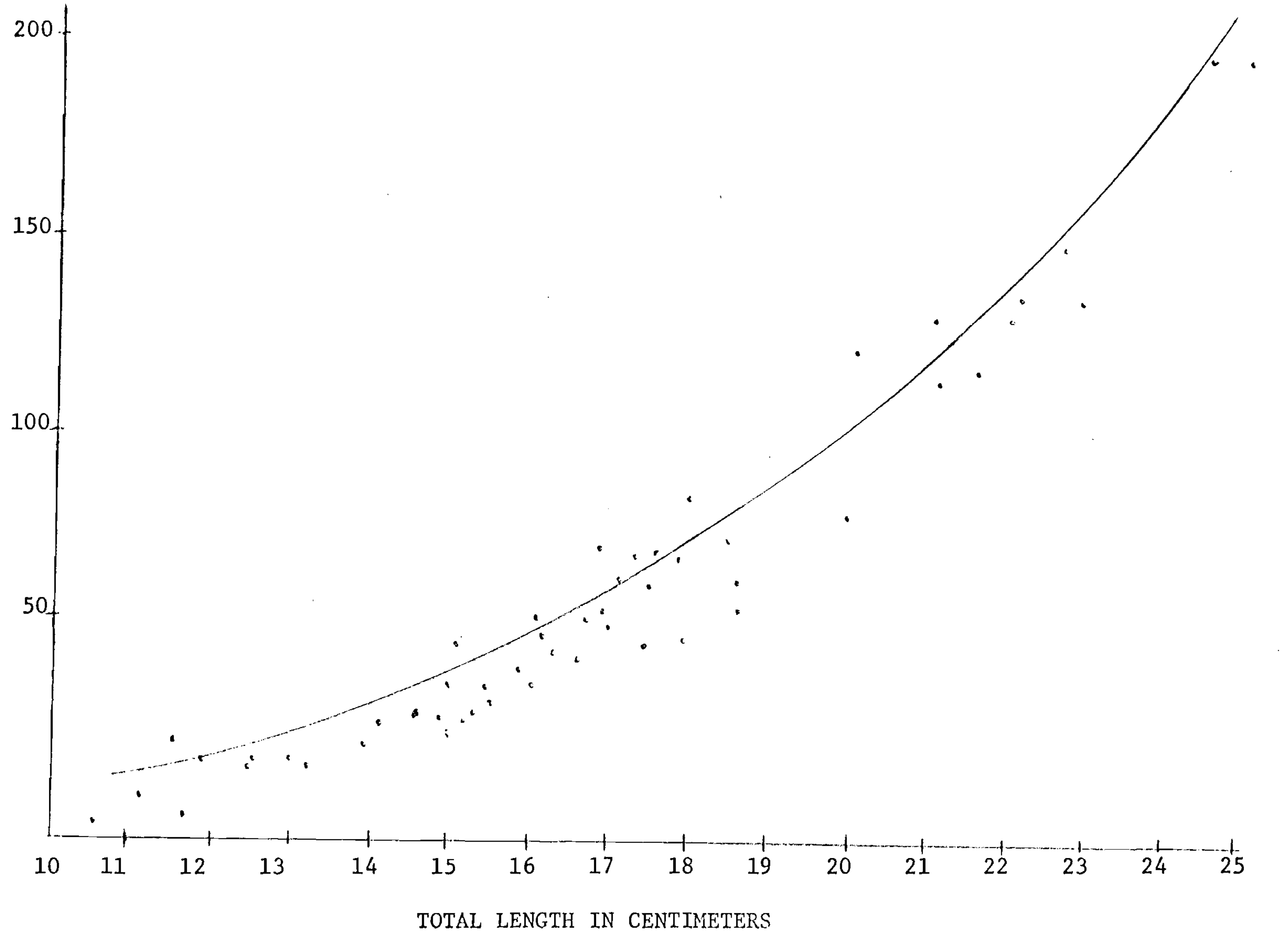



Figure 9. Length-weight relationship of 84 I. melas captured from Clear Creek collecting stations between 10 August 1971 and 26 November 1971.

different age groups (Table XV). The condition factors for *I. natalis*, however, became progressively greater through the age groups (Table XVI).

TABLE XV. The values of the condition factor, K(TL), for each age group of *I. melas* captured from Clear Creek between 10 August 1971 and 26 November 1971.

| Age in Years | Number of Fish | K(TL) |
|---|---|---|
| 1 | 34 | 1.38 |
| 2 | 26 | 1.15 |
| 3 | 18 | 1.42 |
| 4 | 1 | 1.22 |

TABLE XVI. The values of the condition factor, K(TL), for each age group of *I. natalis* captured from Clear Creek between 10 August 1971 and 26 November 1971.

| Age in Years | Number of Fish | K(TL) |
|---|---|---|
| 1 | 17 | 0.92 |
| 2 | 54 | 1.10 |
| 3 | 9 | 1.26 |
| 4 | 4 | 1.32 |

# CHAPTER IV

## SUMMARY

1. A study of two sympatric species of bullheads, *Ictalurus melas* (Rafinesque) and *Ictalurus natalis* (Le Sueur), was conducted from October, 1970, to November, 1971. A laboratory study was conducted on the Kansas State Teachers College campus for determining the species behavior, ecology, and interspecific relationships. A field study was conducted on Clear Creek, a small stream in west-central Lyon County, to determine distribution and growth data for the study species.

2. *I. melas* fed more readily in the aquarium. *I. natalis* left their shelters much less than *I. melas*. *I. melas* often aggregated and rested with body contact; *I. natalis* aggregated only when frightened and would otherwise allow no physical contact. The large *I. natalis* were much more dominant over their populations and much biting was observed. Only one case of biting was observed for *I. melas*. Sexual and care-giving behavior were observed only with *I. melas*. *I. natalis* were observed trying to escape from the aquaria; but no *I. melas* made the attempt.

3. Individual *I. natalis* were the dominant fish in the mixed populations. Subordinate fish (of either species) were physically damaged or chased away from the dominant specimen's shelter. Two *I. melas* were killed by a *I.*

natalis of nearly equal size. This same individual, when introduced into an already established population of I. melas, became the dominant fish, even though four of the I. melas were longer and heavier.

4. The ecological conditions affected both species the same. The amount of light influenced activity. The fish were much more active when the overhead lights were off. The lights did not influence the bullheads when they were hungry. Changes in barometric pressure had no noticeable effect upon the laboratory specimens. Increased activity was noticed when the water was turbid. External stimuli, such as movement or vibrations, always frightened the study fish.

5. Eighty-four I. natalis and 79 I. melas were captured at 30 of the 37 collecting stations between 18 August 1971 and 26 November 1971. I. natalis were captured at 26 stations and I. melas at 21.

6. 1.2 meters was the average depth of the four pools where only I. melas were captured. The average depth for the nine pools where only I. natalis were captured was 0.7 meters.

7. An almost equal number of specimen were captured from pools with mud bottoms. I. natalis, however, were found in 19 of the 29 pools and I. melas in only 15. Thirty-five I. natalis were found in seven of the eight pools with large rocks. Only ten I. melas were captured from five of

the eight pools. No evidence was found to indicate a preference, by either species, for the remaining bottom types of Clear Creek.

8. *I. natalis* were more numerous than *I. melas* at four of the five recorded water velocities. The one velocity with more *I. natalis* was the second slowest. Both species were most numerous at the same two velocities. The two velocities were the second and third slowest and indicated a preference for a slow current.

9. The type of bank did not noticeably influence the number of bullheads in the pools. Both species were represented almost equally with the different bank types.

10. Both species showed a preference for the pools with more then just a trace of aquatic flora. *I. melas* were more numerous in all of the pools with coontail (*Ceratophyllum* sp.) but only *I. natalis* were captured from the three pools with a heavy growth of this plant species.

11. Both of the study species were captured when the daytime high was above 15.6°C. *I. melas* was captured more frequently then *I. natalis* above this temperature but the reverse was true when it went below 15.6°C. The same results were recorded when the low temperature was below 4.4°C.

12. Both species were captured on 57 per cent of the days that the barometric pressure was falling and 39 per

cent of the days that it was steady. _I. melas_, however, were captured on more days when the barometric pressure was rising. More _I. melas_ were captured per day when the reading was in the thirties. The reverse was true for the days with the barometric pressure in the twenties.

13. There was no discernible pattern for the number of either species captured at the different humidities.

14. More _I. melas_ than _I. natalis_ were captured on the days with only a trace or no precipitation. _I. natalis_, however, outnumbered _I. melas_ for the days with more than a trace of precipitation.

15. Leeches were found on four specimens of _I. natalis_. No leeches or scars were observed on any specimens of _I. melas_.

16. Four age groups were obtained for each of the two species. _I. melas_ attains a slightly greater length at group I, but _I. natalis_ is longer at age groups II and III. Age group IV was the same length for both species.

17. _I. melas_ had a normal frequency distribution (number decreasing each year), but _I. natalis_ had a high age group II.

18. Nineteen of the 79 _I. melas_ and 12 of the 84 _I. natalis_ were recaptured. Populations were estimated at 328 _I. melas_ and 588 _I. natalis_.

19. _I. natalis_ weighed less then _I. melas_ at years

I and II but was heavier at years III and IV.

20. *I. melas* had a higher condition factor than *I. natalis*. The average for *I. melas* was 1.31 and for *I.* natalis 1.09. The condition factors for the age groups of *I. melas* did not follow any apparent pattern. *I. natalis,* however, had condition factors that progressively increased from group I through groups IV.

# LITERATURE CITED

## LITERATURE CITED


Bailey, R.M. 1956. A revised list of the fishes of Iowa, with keys for identification, p. 327-377. In Iowa fish and fishing. Iowa Conserv. Comm., Des Moines, Iowa.

Bardach, John and Trudy Villars. 1970. Three fleeing bullheads. Natur. Hist. 79: 36-41.

Bowen, Edith S. 1931. The role of the sense organs in aggregations of *Ameiurus melas*. Ecol. Monogr. 1: 1-35.

Breukelman, John. 1966. What have I caught? Forestry, Fish and Game Commission, Pratt, Ks. 36 p.

_______________, Thomas A. Eddy, and Emily L. Hartman. 1961. The F.B. and Rena G. Ross Natural History Reservation. Kansas School Naturalist. 7(4): 1-16.

Carlander, Kenneth D. 1969. Handbook of freshwater fishery biology. The Iowa State Univ. Press., Ames, Iowa. 752 p.

Clarke, Robert F., John Breukelman and Ted F. Andrews. 1958. An annotated check list of the vertebrates of Lyon County, Kansas. Trans. Kan. Acad. Sci. 61(2): 165-194.

Clay, William M. 1962. A field manual of Kentucky fishes. Kentucky Dept. of Fish and Wildlife Resources. vii + 147 p.

Cross, F.B. 1967. Handbook of Fishes of Kansas. University of Kansas. 357 p.

Darnell, Reznest M. and R.B. Meierotto. 1962. Determination of feeding chronology in fishes. Trans. Amer. Fish. Soc. 91(3): 313-320.

Dolan, Tom. 1960. Know your fish. Sports Afield, New York, N.Y.

Eddy, Samuel. 1957. How to know the freshwater fishes. Wm. C. Brown Co., Dubuque, Iowa. 253 p.

__________. 1947. Northern fishes (Ref. Ed.). Univ. Minn. Press. 276 p.

Elkin, Ronald E. 1954. The fish population of two cutoff pools in Salt Creek, Osage Country, Oklahoma. Proc. Okla. Acad. Sci. 35: 25-29.

Esterly, Calvin O. 1917. Specificity in behavior and the relation between habits in nature and reactions in the laboratory. Univ. of Calif. Zoo. 16(20): 381-392.

Forney, J.L. 1955. Life history of the black bullhead, Ameiurus melas (Rafinesque), of Clear Lake, Iowa. Iowa St. J. Sci. 30(1): 145-162.

Hall, Harry H. 1934. An ecological study of the fishes of Mineral Lake, Kansas. Trans. Kansas Acad. Sci. 37: 225-233.

Harms, Clarence E. 1960. Some parasites of catfish from Kansas. Jour. Parasit. 46(6): 695-701.

Hartman, Emily L. 1960. The F.B. and Rena G. Ross Natural History Reservation. The Emporia State Research Studies. 8(1): 40 p.

Houser, Alfred and C. Collins. 1962. Growth of black bullhead catfish in Oklahoma. Okla. Fish. Res. Lab. Rep. 79: 18 p.

Hubbs, Carl L. and A.I. Ortenburger. 1929. Fishes collected in Oklahoma and Arkansas in 1927. Univ. of Oklahoma Biological Survey. 1(3): 47-112.

__________ and K.F. Lagler. 1958. Fishes of the Great Lakes region (Second Ed.). Bull. Cranbrook Inst. Sci. 26: xiii + 213 p.

Lagler, Karl F. 1956. Freshwater Biology. Wm. C. Brown Co., Dubuque, Iowa. 421 p.

Langlois, T.H. 1936. Length-weight relationships in Ohio State fish ponds. Copeia. 1936(2): 120 p.

Larrabee, Austin P. 1926. An ecological study of the fishes of the Lake Okoboji region. Univ. of Iowa Studies. XI(12): 14-15.

Lewis, William M. 1949. The use of vertebrae as indicators of the age of the northern black bullhead, Ameiurus m. melas (Rafinesque). Is. St. J. Sci. 23(2): 209-218.

Metcalf, A.L. 1959. Fishes of Chautauqua, Cowley, and Elk counties, Kansas. Univ. Kansas Publ., Mus. Nat. Hist. 11(6): 345-400.

Minckley, W.L. 1959. Fishes of the Big Blue River basin, Kansas. University of Kansas Publications, Museum of Natural History. 11(7): 401-442.

Rounsefell, George A. and W.H. Everhart. 1953. Fishery science. Its methods and applications. John Wiley & Sons, Inc., New York. 444 p.

Sandoz, O. 1960. A pre-impoundment study of Arbuckle Reservoir, Rock Creek, Murray County, Oklahoma. Okla. Fish. Res. Lab. Rep. 77: 28 p.

Schoffman, Robert J. 1955. Age and rate of growth of the yellow bullhead in Reelfoot Lake, Tennessee. J. Tenn. Acad. Sci. 30(1): 4-7.

Scott, John P. 1958. Animal behavior. Univ. of Chicago Press. Chicago. 281 p.

Todd, John H. 1971. The chemical languages of fishes. Scientific American. 224: 98-106.

Toth, Andre. 1968. Ecto- and Endoparasites of the Black Bullhead (Ictalurus melas) in Lyon County. Unpub. masters thesis, KSTC, Emporia, Kansas.

Trautman, M.B. 1957. The fishes of Ohio. Ohio St. Univ. Press. 683 p.

Ulrey, L., C. Risk, and W. Scott. 1938. The number of eggs produced by some of our common freshwater fishes. Invest. Ind. Lakes and Streams. 1(6): 73-78.