CAUSES OF STUNTING OF CRAPPIE (Pomoxis nigro-maculatus and Pomoxis annularis) IN OKLAHOMA LAKES

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INTRODUCTION

This thesis contains the results of a study undertaken with the view of analyzing the growth rates of the black and the white crappie, Pomoxis nigro-maculatus (Le Sueur) and Pomoxis annularis Rafinesque, in association with their respective feeding habits, in representative Oklahoma lakes, to learn if food acquired is the dominant factor influencing growth rates. There has been much controversy regarding the cause or causes of poor growth exhibited by fish in many impoundments. Little factual information is available to substantiate such discussion.

Most impounded waters experience a rapid growing population of fish immediately following impoundment. The population builds to a peak, then gradually declines with resultant small returns to the fisherman and poor growth exhibited by fish in the lake. This condition has been noted by Bennett (1947), Irwin (1945), Ellis (1937) and others.

The rise and decline in fishing success has been attributed to many factors. Some fishery personnel contend that it is due to a space factor, that there is insufficient room for the fish to attain a large and more desirable size. Some say that it is due to "overpopulation". Overpopulation is such an indefinite term that its supporters may switch back and forth between any one of several explanations. Bennett (1947) has placed the basic responsibility for such conditions on the relative abundance of certain species of fish. Ellis (1937) and Irwin (1945) placed the decline in suitable fishing success to a decline or loss of necessary materials of organic origin but have not attempted to delineate what these materials might be. Rounsefell (Undated) suggests food as the limiting factor, as does Aldrich (1946b) but neither present data to substantiate the supposition.

Practices to rejuvenate impoundments are by draining the lake or by otherwise destroying the fish population present and restocking. Higher productivity of suitable fish has been obtained by both practices. The former method has been advocated by Swingle and Smith (1942), Langlois (1946), Aldrich (1946b) and others. Aldrich (1946a) and Thompson (1937) attribute the beneficial effects of drainage to soil aeration. Irwin (1945) and Irwin and Stephenson (1951) have added vegetation to small impoundments with subsequent improvement in productivity. Irwin (verbal (statement) has drained lakes, planted crops on the exposed bottom and reflooded with resultant satisfactory fishing increases. Swingle and Smith (1942), by the use of commercial fertilizers have obtained similar results. Under some conditions partial poisoning of lakes, whereby only the arms are treated, has given beneficial results. Poisoning the fish and later restocking has become common practice with the Oklahoma Game and Fish Department.

The present study was undertaken to determine if fish grew slowly because they were receiving insufficient food due to a larger population present than the available food could successfully support. Three lakes were chosen which, after examination of samples of fish, showed that the respective populations comprised three categories from the fisherman's viewpoint: (1), those making satisfactory growth, (2), those making poor growth, and (3), those intermediate in which only an occasional large crappie was taken. Fish sampling was conducted for one year (April 1952 to April 1953). Collections from each lake were made every day except Saturdays and Sundays from April to October and thereafter on alternate days. The fish were taken to the laboratory, measured, aged, their stomach contents analyzed and the resulting data examined for correla-

tions between food acquired and rate of growth.

The author wishes to express appreciation to the following persons who were instrumental in a successful completion of the work: Dr. W. H. Irwin, Department of Zoology, Oklahoma Agricultural and Mechanical College, without whose helpful advise and leadership the problem could not have been completed; Dr. D. E. Howell, Department of Entomology, for assistance in indentification of insects; Dr. Roy W. Jones, Dr. Eugene I. Wallen, Department of Zoology; Dr. Adolph M. Stebler, leader, Oklahoma Cooperative Wildlife Research Unit Oklahoma Agricultural and Mechanical College, with whom the writer discussed different phases of the problem and who influenced his thinking on particular points; Mr. R. O. Fox of Fox Lumber Company, Stillwater, Oklahoma, for permission to use the Country Club Lake for study; Mr. Harry Ransom, Superintendent of Parks for City of Stillwater, for permission to use Boomer Lake for study; Mr. Fred Mott, Superintendent at Boomer Lake, for assistance with boats and nets; members of the Sanborn Chapter of the Izaak Walton League of America, Inc., who gave permission to use their lake for study; Mr. Ernest E. Vincent, who loaned his boat during the initial phase of the study; Mr. Clarence McCurry, undergraduate student, Oklahoma Agricultural and Mechanical College, who gratuitously assisted in compiling parts of the data; Mr. W. M. McMurtry of the Payne County Soil Conservation District, for the use of aerial photographs; and appreciation to the writer's wife for continual encouragement during all graduate studies. The equipment used was furnished jointly by the Wildlife Unit, Department of Zoology and the Research Foundation, Oklahoma Agricultural and Mechanical College. Financial assistance was furnished by the Oklahoma Cooperative Wildlife Research Unit.

METHODS

Sampling Fish Populations

Fish collections were made by the use of wire traps, hoop nets, gill nets, hook and line, and seines.

Wire traps, as described by Buck and Cross (1951), were used most extensively. The traps were generally set on the lake bottom adjacent to the shore. However, one trap was tied to an empty oil drum and allowed to float free or anchored in a location, thus the trap could be held at the desired depth. It is believed this method might prove of advantage for capturing fish not closely associated with the bottom. The method was developed too late to receive a thorough test but future experiments might prove it profitable.

Hoop nets were of the O type, $3\frac{1}{2}$ feet in diameter with one inch square mesh. These nets were used both with 10 foot wings and without wings. Occasionally a 50-foot lead of two inch mesh was employed. One end of the lead was tied to the center of the first hoop and the other stretched at 45 degrees to the wings which were placed in the form of a V in relation to the trap. The hoop nets were often set by using poles on each end of a wing and one tied to the pot. The net was set in the form of a V. Anchors were sometimes employed instead of poles in deeper water. To run the net the wings were lifted into the boat and the fish worked into the pot. The pot could be opened and the fish easily removed.

Gill nets were used on two occasions only.

Hook and line fishing was done using wet flies and casting plugs. No attempt was made using live bait.

Seining was done in Country Club Lake using a 50-foot bag seine of 1½-inch mesh.

Gear sets were made throughout most of the lakes except for Boomer Lake where fishing was confined to the shallower areas adjacent to the shore. Fishing was consistently better in the waters close to the shore except in the hottest summer weather in Country Club Lake where crappie could be taken only toward the middle of the lake.

Fishing gear was run every day except Saturday and Sunday from April until October. Afterward, sets were run every other day. Due to the use of the lakes by the general public, sets were not run on the week-end, as it was thought advisable that trap locations not be made known.

Collecting and Recording Data

All crappie captured were used in the study. There was no selection other than the normal selection due to trapping methods or to the traps used. The specimens were weighted, measured and the stomachs removed while the fish were in a fresh condition. The longest period that any fish was held after removal from the traps was approximately 1½ hours and then they were placed in a pail of water. The lake visited first was alternated each week to prevent any undue favoritism toward the fish from a particular lake. As the traps were run, all fish were placed in the boat until each trap in that lake had been lifted and reset. The fish were then recorded as to species and numbers present and all but the crappie were returned to the lake, usually sufficiently active to swim away. The crappie were placed in a wet sack until the laboratory was reached, where they were immediately place in water and measurements begun.

Total lengths in inches and tenths and weights in pounds and

hundreths were recorded on scale envelopes. A sample of crappie scales from below the lateral line under the antenior end of the dorsal fin were taken and placed in the scale envelope. The number, date, species, sex and lake were recorded. The stomach was removed and placed with a number similar to that on the envelope, on a piece of cloth about 4 inches square.

The cloth was then rolled diagonally and the ends tied. The tools were inspected after each fish had been examined to prevent mixing of scales from one fish with those of another.

Preservation of Stomachs

After all fish stomachs for one days catch had been removed and tied in cloth they were placed in a half gallon fruit jar in 10 per cent formalin solution. The stomachs were fixed in this solution until the jar was full, then the formalin was emptied and replaced with fresh water. The water was replaced three or four times over a period of two days and finally replaced with a 50 per cent solution of isopropyl alcohol. The stomachs were in this solution until analyzed.

Stomach Analysis

The cloth containing a stomach was removed from a jar and the enclosed stomach and number removed and the number recorded. This number was the only identifying mark and prevented unconscious bias in analyzing the stomach contents. The stomachs were numbered consecutively, regardless of lake, hence, it was impossible to identify which lake a particular stomach was from without referring to the scale envelope. The stomach and lake from which it came were not matched until all stomachs had been analyzed.

The contents were removed from the stomach and placed in a graduated centrifuge tube which had been calibrated by the use of a graduated burette, in tenths of cubic centimeters. The tenths on the centrifuge tube were estimated to the nearest half. Water was titrated from the burette into the centrifuge tube until the stomach contents were covered and the number of cubic centimeters used recorded. The volume of the stomach content was computed from the total reading on the centrifuge tube and the known volume of water.

The stomach contents were then thoroughly mixed with the water in the centrifuge tube and 1 cubic centimeter withdrawn by use of a graduated pipette with a suction bulb attached. The sample was then placed in a Sedgewich-Rafter Counting Chamber and the chamber placed on a piece of plexiglass which had been grided with lines having 1/16 inch intervals. The cell of the counting chamber covered 394 squares of the grid. Three rows of 12 squares each (one-eleventh of the grid) were marked and except those mentioned below, each organism with at least half of the body inside a square was counted as one and recorded. Multiplying the number of organisms counted by 11 gave the number of organisms per cubic centimeter which when multiplied by the number of cubic centimeters to which the stomach contents had been diluted gave the number of organisms for that fish stomach. All large Insecta, Pisces, Decapoda and Isopoda were counted without the use of the counting cell. All small insects, algae and nematodes were enumerated by counting all contained in the counting chamber and the number for that stomach calculated. The calculated number of organisms and the proper identification number for that particular stomach were recorded on a sheet under appropriate headings.

The fish number on the sheet was matched with that on the scale

envelope to determine the lake from which the fish had come, after all stomachs had been analyzed. The data for each crappie was then placed on a 3 x 5 inch index card to facilitate filing and arranging the data for further analysis.

Calculation of Age and Growth

The age and yearly growth of crappie can be determined by the fish's scale (Van Oosten, 1929). Layers of hyalodentine are laid down on the outer margin of the scale forming ridges or circuli as the fish grow. When growth is retarded, as is the case during winter, these circuli are not always completed on the lateral margins of the scale. When the rate of growth is accelerated, as is the case in spring, the circuli parallel the entire margin of the scale, hence enclosing the uncompleted circuli forming a condition known as "cutting over".

Crappie scales in this study were aged by counting as year marks or annuli the number of those "cut over" areas in which the cut over portion of the scale was identifiable on the lateral sides and the succeeding circuli could be followed all the way around the scale. The age of a particular crappie then was equivalent to the number of annuli appearing on the scale. All scales aged were examined on a scale projection apparatus.

The method used to calculate the length of a fish at a particular age was by direct proportion in which it is assumed that the length of the scale and of the fish grow in direct proportion. That is: the total length of the fish at capture is to the total length of the scale (focus to anterior margin of the median radius) as the length of the fish at a particular age is to the length of the scale at that annulus.

A nomograph was constructed as described by Lowery (1951) and used to solve the above proportion for the fish length at each annulus. A piece of plexiglass 1/16 inch thick was ruled in tenth inch intervals with each tenth graduation inked and numbered consecutively. A second piece of 1/16 inch plexiglass one half inch wide was used as a swinging arm or marker. The arm was attached by one end to the ruled nomograph in such a manner that one edge coincided with zero on the nomograph. Zero of the nomograph was placed over the focus of a scale and the nomograph rotated until the number corresponding to the length of the fish at capture intercepted the most posterior margin of the scale image at its central radius. The arm was then rotated to this point and the length of the fish was read directly from the nomograph at each annulus intercepted.

All fish captured were not aged. A sample of the recorded crappie was taken by the following method. The recorded lengths of crappie were organized into groups limited to 1/10 inch intervals. All the fish in those groups containing five or less fish were aged. In groups containing 6-20 fish, one half of the fish were aged. In groups containing over 20 fish, one fourth of the fish were aged. The sample taken from a group included representatives from each season in nearly equal numbers. If all the fish in a sample were of the same age no additional fish in that group were aged. If however, a fish was found to vary in age from the remainder of the sample, an additional 25 per cent of the group were aged. If no variation in age occurred in the second sample all fish in that group, exclusive of the aberrant fish, were then assumed to be of the same age. All fish at both extremes of a normal length-frequency graph were aged, therefore, a population with more than one predominant

age group had a greater percentage of the fish aged. It seemed that a good representation of the fish was procured by this procedure.

Computation of Data

All data was computed and checked by means of a Monroe Calculator. The method of computing data for analyzing individual phases of the problem is explained at the beginning of each particular section.

DESCRIPTION OF THE THREE LAKES STUDIED

The lakes studied are in Fair Plains Township, Payne County, Oklahoma and subject to similar climatic influences. They are in the same general soil region so that a description of climate and soils will apply to each lake.

Soils: The soil is of the Reddish Prairie group which lie south of the true Prairie soils region. These soils occupy a broken belt of rolling prairie country extending from central Kansas through Oklahoma into north-central Texas. The soil has developed from the Permian "Red Beds" formation in which the parent material is of red calcareous clay or sandy clay. Surface soils, on the smoother areas, are rather deep and have a red or brown color largely composed of silt loam or very fine sandy loam texture, over subsoils of red and brown crumbly clay or sandy clay loam. The soils are thin and red on some of the sloping areas (Anonymous, 1938).

The soils on the watershed of the lakes studied belong in the Soil Conservation Service classification to Units 5 and 6. These soils are characterized by medium texture and vary from slow to very slow permeability.

Climate: The climate in Payne County is in general relatively mild. The mean temperature (Fahrenheit) over a 40 year period was 36.6 degrees for January and 80.7 degrees for July. The maximum temperature for the 40 year period was 115 degrees and the minimum was minus 18 degrees.

There is a long growing season of 213 days, with the latest killing frost in spring occurring about March 31, and the earliest killing frost in the fall occurring about October 30.

The section of the state in which the lakes are located is fairly well watered with an annual average precipitation of 33.31 inches. Rainfall is spread rather evenly throughout the year with May usually getting the greatest amount, and January the least. However, the rainfalls are frequently torrential in form, consequently much runoff occurs (Wahlgren, 1941).

Sanborn Lake

Sanborn Lake lies in section 3, T. 19 N., R. 2 E., Payne County, Oklahoma. It has a surface area of 9 acres and watershed of 150 acres. The average depth is about 7 feet. The lake was constructed prior to 1930 and used originally as a source of water for cattle.

The dam was cut allowing almost complete drainage of the lake in 1944. The fish population was drugged with rotenone in the spring of 1947, the dam repaired and in the fall Fathead Minnows, Pimephales promelas Rafinesque; Redfin Shiners, Notropis lutrensis (Baird and Girard); and Golden Shiners, Notemigonus crysoleucas (Mitchill), were stocked in the lake. An additional stocking, in 1948, took place by introducing Black Crappie, Pomoxis nigro-maculatus (Le Sueur); Largemouth Black Bass, Micropterus salmoides (Lacepede); Redear Sunfish, Lepomis microlophus (Gunther); Bluegill, Lepomis macrochirus Rafinesque; and Channel Catfish, Ictalurus lacustris (Walbaum). Fishing was allowed from the beginning and unauthorized stockings have undoubtedly occurred, but no particular management has been done on the lake since that time.

There are willow trees, Salix spp, of considerable size, as well as cottonwood trees, Populus spp, growing on the dam. A few elm trees, Ulmus americanus, are on the west bank of the lake. The northern portion

of the lake inundated much brush and small trees and has a few trees adjacent the waters edge. Numerous beds of pond weed, Potomogeton spp, are present in shallower areas along the shore and practically occupy about 1/2 acre of the northern portion of the lake. Coontail, Ceratophyllum demersum, is represented in the water. Cattail, Typha spp, and Jussiaea diffusa are common in portions of the shallow water.

The lake tends to become muddy in the spring, but clears after a week or more. The water is clear most of the year.

The large watershed and small lake combination causes periodic overflowing which replaces the more fertile water with less productive and frequently muddy water.

Boomer Lake

Boomer Lake is located two miles north of the courthouse, Stillwater, Oklahoma. It was built in 1923-24 as a source of water for the City of Stillwater. It began to fill in 1925 and served as a water supply for the city until 1951.

Including a small portion of the original creek, Boomer Lake has 215 surface acres, at spillway level, and an average depth of about nine feet. The watershed covers approximately 8,960 acres.

The shores tend to be wave swept and barren. Only a few scattered trees have grown above the shore line except at the upper or northern portion which includes the creek. Aquatic vegetation is sparse, with only a few scattered areas of cattail, Typha spp.

Boomer Lake has a much larger watershed for the size of the basin and like Sanborn Lake is subjected to periodic overflowing which prevents increase in fertility.

Copper sulfate has been repeatedly applied in an attempt to clear the water, with little success. It has been continually muddy for many years.

Country Club Lake

Country Club Lake is a pond of two surface acres, located in Section 19, T. 19 N., R. 2 E., Payne County, Oklahoma. The watershed covers 69 acres and similar to the other lakes it is subject to periodic overflow.

The lake was built prior to 1927 and used for recreation by the members of a group who leased the land but for several years it has served principally as a source of stock water.

Records are not available of the management practices employed but indescriminate stocking has undoubtedly occurred throughout its existence.

Post oak, Quercus stellata, and Blackjack oak, Quercus marilandica, trees border about 50 per cent of the shore while willow, Salix spp, are present on the dam and at intervals along the shore. American Lotus, Nelumbo lutea, covers an area of approximately 1/4 acre in the west part of the lake. Coontail, Ceratophyllum demersum, is present in the water.

The water in Country Club Lake is clear except following a hard rain and reclears within a few days after muddying. Periodic overflowing causes a loss of fertility.

LIST AND NUMBER OF EACH SPECIES CAPTURED

The species and the number of each that were collected from the respective lakes are listed in Table 1.

TABLE 1

NUMBER OF INDIVIDUALS OF EACH SPECIES CAPTURED FROM EACH LAKE

	Sanborn Lake	Boomer Lake	Country Club Lake
Pomoxis			
1. *annularis* Rafinesque	8	530	
2. *nigro-maculatus* (Le Sueur)	909	--	656
Lepomis			
1. *macrochirus* Rafinesque	956	32	32
2. *microlophus* (Gunter)	474	--	--
3. *megalotis* (Rafinesque)	61	--	--
4. *cyanellus* Rafinesque	47	1	69
Micropterus			
1. *salmoides* (Lacepede)	16	5	--
Ictalurus			
1. *lacustris* (Walbaum)	51	18	1
Pilodictus			
1. *olivaris* (Rafinesque)	--	3	--
Notemigonus			
1. *crysoleucas* (Mitchell)	131	--	6
Carpiodes			
1. *carpio* (Rafinesque)	--	41	--
Cyprinus			
1. *carpio* Linnaeus	--	2	--
Ameiurus			
1. *melas* (Rafinesque)	--	--	196

One can not imply that the species and their numbers (Table 1) represent population-compositions for all but the crappie were returned to the lake water and, hence, may have reappeared in the gear.

It soon became evident that traps set in certain areas captured fewer crappie than an equal number of traps in other areas. Conversely some areas were located which yielded good crappie numbers but few of other species. Crappie appeared to be more commonly found near submerged brush than elsewhere in the lakes and were scarce near submerged aquatic plants even though submerged brush was present.

AGE, GROWTH AND FOOD HABITS OF CRAPPIE FOR ALL THREE LAKES STUDIED

A total of 2103 crappie were taken during the study. Sanborn Lake contributed the major portion of the fish with 909 black crappie and 8 white crappie, weight, length and stomach contents of the latter were similar to the black crappie and are included in the data from that lake. The two other lakes yielded only the crappie species listed. Country Club Lake provided 656 black crappie and Boomer Lake 530 white crappie (Table 3).

Mean Length and Weight of Crappie

A total of 206.18 pounds of crappie was taken from the three lakes. The mean weight of the crappie taken (Table 2) was 0.10 pound and mean length was 5.8 inches.

Sanborn Lake yielded the major part of the fish both in numbers and weight. The total weight of crappie from Sanborn Lake was 117.85 pounds, with an average of 0.11 pounds and a mean length of 6.1 inches.

The black crappie from Country Club Lake weighed 45.83 pounds, had an average weight of 0.07 pound and a mean length of 5.4 inches.

White crappie from Boomer Lake weighed 56.74 pounds, averaged 0.11 pounds and 5.7 inches in length. The relatively high mean weight of the crappie from Boomer Lake was increased greatly by 39 large crappie which comprised the fifth, sixth and seventh age groups (Table 26).

Age Groups of Crappie

Sanborn Lake had two major age groups (Table 3). The fish in age group II comprised 53.6 per cent of all crappie from that lake. Age

group III comprised 32.0 per cent of all fish taken from Sanborn Lake. Age group I contained 12.3 per cent of the total crappie followed in order by age group IV with 1.9 per cent and V with 0.2 per cent.

The major portion of crappie from Boomer Lake, 68.9 per cent, were in age group II while age group III comprised 17.9 per cent (Table 3). The remainder of the fish in order of percentage by age groups were; IV, 4.0 per cent; V, 4.0 per cent; VI, 3.2 per cent; I, 1.8 per cent and VII, 0.2 per cent.

Country Club Lake had 88.4 per cent of the black crappie in age group IV (Table 3). Age group II was second numerically with 6.1 per followed by groups III with 2.6 per cent; I, with 1.8 per cent; V, with 0.9 per cent and VI, with 0.2 per cent.

Table 2

Mean Length and Weight and Total Number and Weight of Crappie Captured From the Lakes

Lake	Number of Crappie	Mean Length (Inches)	Mean Weight (Pounds)	Total Weight (Pounds)
Sanborn	917	6.1	0.11	117.85
Boomer	530	5.7	0.11	56.74
Country Club	656	5.4	0.07	45.83
Total and Mean	2103	5.8	0.10	206.18

Mean Length of Crappie for Specific Age Groups in the Lakes

The mean length of crappie (Table 4) was compiled by totaling all measurements within each age group and dividing the sum by the number of

fish actually aged in that age group. The total for each lake was made in a similar manner rather than calculating the average of the sum of the means. The latter method would introduce errors because the sample sizes were different for each age group.

Table 3

Age Groups of Crappie, the Number and Percentage of the Crappie Population for Each Lake

Age Group	Sanborn		Boomer		Country Club	
	No.	Per cent of Population	No.	Per Cent of Population	No.	Per Cent of Population
I	66	12.3	10	1.8	12	1.8
II	492	53.6	365	68.9	40	6.1
III	294	32.0	95	17.9	17	2.6
IV	18	1.9	21	4.0	580	88.4
V	1	0.2	21	4.0	6	0.9
VI			17	3.2	1	0.2
			1	0.2		
Total	917		530		656	

White crappie during their first year in Boomer Lake made slightly greater growth, 0.1 inch, than black crappie in Country Club and 0.6 inches more growth than the black crappie in Sanborn Lake.

The second year, crappie in Sanborn Lake made 0.8 inches more growth than those in Boomer Lake and 0.9 inches more than the crappie in Country Club Lake.

The third year, crappie from Sanborn Lake again grew more by 1.2

inches than the crappie from Boomer Lake and by 2.1 inches than the crappie from Country Club Lake.

When the fourth annulus was completed, which was at the beginning of the fifth year of life, black crappie from Sanborn Lake were 0.4 inches and 3.2 inches longer than those from Boomer and Country Club Lakes respectively.

One crappie only, of age group five, was taken from Sanborn Lake. The fish was 0.01 inches shorter than the average for Boomer Lake but was 3.7 inches longer than the average for Country Club Lake at the same age.

Only one crappie was taken from Country Club Lake in the sixth age group. The fish was 4.4 inches shorter than the fish of the same age from Boomer Lake.

The oldest crappie taken, age group seven, of which there was but one, was a 15.4 inch white crappie from Boomer Lake.

Table 4

Mean Length of Crappie for Specific Age Groups from the Lakes Studied

Lake	Age Groups						
	I	II	III	IV	V	VI	VII
Sanborn	1.8	4.9	6.8	8.0	10.0		
Boomer	2.4	4.1	5.6	7.6	10.1	10.8	15.4
Country Club	2.3	4.0	4.7	4.8	6.3	6.4	
Total Mean	2.0	4.5	5.7	5.8	9.7	10.1	15.4

Monthly Mean Weights, Lengths and Volumes of Stomach Contents

The recorded mean weight and length of crappie given in Table 5 was computed by adding all weights and lengths of individual fish collected during the month and dividing the sum by the total number of crappie taken for that month. The mean volume of stomach contents for each month was determined by adding the cubic centimeters of food from all fish which were collected that month and contained food and the sum divided by the number of fish involved.

Table 5

Number of Crappie Collected, Crappie Weights, Lengths, Number of Stomachs Containing Food and Volumes of Stomach Contents Recorded for the Month of Capture From the Lakes Studied

Captured	Number of Crappie Collected	Mean Weight (Pounds)	Mean Length (Inches)	Number of Stomachs Containing Food	Mean Volume of Stomach Content (Cubic Centimeters)
January	16	0.09	5.9	6	0.10
February	19	0.10	6.0	18	0.13
March	32	0.17	10.1	26	0.32
April	158	0.11	6.0	77	0.22
May	223	0.07	5.5	144	0.23
June	446	0.08	5.7	222	0.16
July	381	0.07	5.4	197	0.09
August	337	0.08	5.6	251	0.11
September	164	0.09	4.7	126	0.12
October	85	0.09	5.9	54	0.10
November	115	0.08	5.7	80	0.08
December	27	0.08	5.6	18	0.05

It was impossible to determine the monthly mean weight, length and volume of stomach content for all individual age groups because some age groups were absent from certain monthly collections.

Mean Weight by Months

The highest mean weight, 0.17 pound, was recorded in March (Table 5). There was a rapid decline in weight from March until May when the lowest average weight of 0.07 pound was recorded. Slight fluctuations occurred, never more than 0.01 pound between successive months, during the remainder of the year.

Mean Length by Months

The highest mean length recorded was 10.1 inches in March (Table 5). There was close correlation between mean length and mean weight for individual months except in September when the mean length decreased nearly one inch and the mean weight increased by 0.01 pound.

Crappie Capture by Months

Fishing gear was run five days per week from April until October and three days per week thereafter. The total number of crappie collected during the months that the traps were run on alternate days was small, except for November and April, but if the total capture had been doubled by running the traps each day the number collected would still be small (Table 5).

January provided the lowest number of fish taken in a month with only 16 crappie caught from all lakes. February and December were next lowest with 19 and 27 crappie captured for the respective months.

The best months for numbers of crappie captured were May, June, July and August. April, September and November were intermediate and

provided nearly equal numbers of crappie.

Mean Volume of Stomach Contents by Months

There was, on a monthly basis, a remarkable similarity in the volume of food taken (Table 5). The maximum volume recorded was for March when the average volume per stomach reached 0.32 cubic centimeters. The maximum volume seemed to be due to the fact that the March sample contained large fish. There were three months when the average monthly volume of stomach contents were below 0.10 cubic centimeters, November, December and July. March, April and May had mean volumes above 0.21 cubic centimeters while the volumes for the remainder of the months were intermediate. The data indicate that crappie fed more during the months of March, April and May than during any other three months, otherwise seasonal changes and food consumed show little correlation.

Food Habits

Food habits of the black and the white crappie were studied by obtaining stomachs from fresh fish, preserving and later analyzing them as described under Methods. Crappie stomachs were collected throughout one year to determine the volume of food contained, the changes in volume for different seasons, the numbers and kinds of food items present, and the changes in food taken with age or size of fish. Comparisons are made between Sanborn Lake where black crappie were making satisfactory growth, Boomer Lake where white crappie were of an undesirable size, and Country Club Lake in which the black crappie were severely stunted.

Food Volume

From the total of 2103 crappie captured, 61.7 per cent or 1299 had

food in their stomachs (Table 10). Sanborn lake provided 610 crappie stomachs containing food which comprised 47.0 per cent of all stomachs with food. Boomer Lake yielded 259 crappie stomachs with food which comprised 20.0 per cent of all crappie having food. Country Club Lake specimens had 428 food containing stomachs which was 33.0 per cent of all stomachs with food.

A total of 275.65 cubic centimeters of food was measured from the crappie stomachs collected (Table 6). The average amount of food contained per crappie from all lakes was 0.13 cubic centimeters. The average volume was greatly increased by the stomachs of 39 large crappie from Boomer Lake.

Table 6

Cubic Centimeters of Food and the Mean Volume Contained in Crappie for the Three Lakes

Lake	Cubic Centimeters of Food Present	Average Cubic Centimeters Present
Sanborn	117.85	0.19
Boomer	119.85	0.46
Country Club	37.95	0.09
Total	275.65	0.13

Stomach Contents

No attempt was made to record the stage of maturity of the insects present in the crappie stomachs (Table 7). Larval, or immature, forms comprised practically all insects present. Due to the relatively rapid

rate of digestion in fish stomachs, particularly in the summer months, there were frequently only the chitinous portion of the insects remaining. Each insect head was recorded as an insect, and after analyzing several stomachs, the insects could usually be classified to order on this basis. Chitinous portions of insects which obviously did not belong with the insect heads present were recorded as unidentified Insecta. The insects were identified to order.

Ephemerida--A total of 3362 Ephemerida were recorded from all crappie, resulting in an average content of 2.6 per stomach. Black crappie in Sanborn Lake had 80.7 per cent of all Ephemerida recorded. White crappie in Boomer Lake contained 11.6 per cent and black crappie in Country Club lake 7.7 per cent of all these insects recorded.

Diptera--A total of 38697 Dipterous insects were present in the stomachs analyzed. The average number recorded per stomach was three insects. Crappie from Sanborn Lake had 80.2 per cent, Boomer Lake 2.3 per cent, and Country Club Lake 17.5 per cent of the total Diptera recorded.

Coleoptera--There were 138 Coleoptera recorded resulting in an average of 0.1 contained by all crappie. Crappie from Country Club Lake had 49.0 per cent of the total Coleoptera. Sanborn Lake was secondnwith 47.0 per cent followed by Boomer Lake with 4.0 per cent of the total Coleoptera found in crappie stomachs.

Insecta--As previously mentioned, the insects which were too broken or digested to be identified to order were placed under the heading of Insecta. A total of 1745 insects were thus recorded giving an average of 1.3 for each stomach containing food. Crappie from Sanborn Lake con-

tained 43.7 per cent of the unidentified insects recorded; Country Club Lake, 31.3 per cent; and Boomer Lake, 25.0 per cent.

Table 7

Insects Eaten by Crappie and Percentage of Total from the Three Lakes Studied

Lake	Ephmerida	Per cent	Diptera	Per cent	Coleoptera	Per cent	Unid.	Per cent
Sanborn	2713	80.7	31054	80.2	65	47.0	763	43.7
Boomer	390	11.6	881	2.3	6	4.0	437	25.0
Country Club	259	7.7	6762	17.5	67	49.0	545	31.3
Total number	3362		38697		138		1745	
Average per fish	2.6		3.0		0.1		1.3	

Invertebrate Eggs--Invertebrate eggs were by far the most numerous food items in crappie stomachs (Table 8). Most of the eggs were from Cladocera but insect eggs were common during the summer and some eggs were not identified even to phylum. A total of 1,071,401 invertebrate eggs were recorded.

Crappie stomachs for the lakes studied contained an average of 824.8 invertebrate eggs each. The crappie from Sanborn Lake contained 59.8 per cent of the total; crappie from Country Club Lake, 27.2 per cent; and Boomer Lake, 13.0 per cent.

Cladocera--Numerically Cladocerans were second in rank of food present. The total number for all lakes was 202,846 Cladocerans resulting in an average number per stomach of 156.2. Crappie from Sanborn Lake accounted

for 54.0 per cent of the total eaten; Country Club Lake, 24.3 per cent; and Boomer Lake, 21.7 per cent.

Ostracods -Ostracods were numerically fourth in rank for the food recorded. Practically all of the Ostracods recorded were from crappie taken in Sanborn Lake. These comprised 96.4 per cent of the total Ostracods counted. Crappie from Country Club Lake contained 2.7 per cent and those from Boomer Lake 0.9 per cent of all Ostracods found.

Spermocarp--The oogonium of Ulotrichales, a filamentous algae, with its enclosing sheath of cells is termed a spermocarp. The present identification is not positive due to the lack of fresh specimens but it is believed for the purposes of this study it is more satisfactory than placing these items under the general heading of algae.

There were 19,904 spermocarps recorded resulting in an average consumption of 15.3 for each stomach containing food. Crappie from Sanborn Lake had 76.7 per cent; Country Club Lake, 23.1 per cent; and Boomer Lake, 0.2 per cent of all spermocarps recorded.

Algae-- No attempt was made to classify the Algae into lower groups. Algal plants were counted as one whether a plant consisted of a single cell or a filament. There were 650 algal plants recorded from all crappie stomachs resulting in an average of 0.5 for each stomach that contained food. Crappie from Sanborn Lake had 43.1 per cent of all algae; Boomer Lake, 31.1 per cent; and Country Club Lake, 25.8 per cent.

Pisces--Only 48 of the crappie taken had fed on fish. Two of the prey were identified as crappie but the remainder were unidentifiable. Of these 48 crappie containing fish in their stomachs 72.9 per cent were from Boomer Lake, 22.9 per cent were from Sanborn Lake and 4.2 per cent from Country Club Lake.

Table 8

Material (Exclusive of Insects) in Crappie Stomachs and the Percentage for each Lake

Lake	Invertebrate Eggs	Copepoda	Cladocera	Ostracoda	Nematoda	Algae	Spermocarp	Pisces
Sanborn	641,015	91,506	138,733	21,575	2,228	280	15,257	11
Boomer	138,106	36,758	53,804	180	352	202	4	35
Country Club	292,280	41,155	10,309	608	803	168	4,643	2
Total	1,071,401	169,419	202,846	22,363	3,383	650	19,904	48
			Per Cent of Total					
Sanborn	59.8	54.0	68.4	96.4	65.9	43.1	76.7	22.9
Boomer	13.0	21.7	26.5	0.9	10.4	31.1	0.2	72.9
Country Club	27.2	24.3	5.1	2.7	23.7	25.8	23.1	4.2

Miscellaneous-- The items present in the crappie stomachs which were in very small numbers or of infrequent occurrance were recorded as Miscellaneous. Acarina, Odonata, Homoptera, Orthoptera, Hymenoptera, Isopoda, Amphipoda, Decapoda, unidentified crustaceans and plant debris were present. A more complete record is given under Food Present in Crappie in Individual Lakes.

Monthly Variations of Volume and of Per Cent of Stomachs Containing Food

Specimens collected varied from month to month in mean volume of stomach contents and in the number of stomachs that contained food. The amount of increase or decrease from the preceeding months mean average and the variation in the per cent of specimens which had food in their stomachs are listed in Table 9. The purpose of the calculations was to learn if a correlation existed between the mean volume of stomach contents and the percentage of stomachs containing food.

There was small, if any, correlation between the monthly fluctuations in volume of stomach contents and the per cent of the stomachs containing food. The maximum increase in volume of food present occurred in March but during the same month there was a decrease of 22.0 per cent in number of stomachs containing food. The sharpest decrease in volume occurred in April with 0.10 cubic centimeters which was accompanied by a drop of 24.0 per cent in number of stomachs containing food. In May there was an increase of 0.01 cubic centimeters in stomach contents and an increase of 16.0 per cent in stomachs having food.

Stomachs Containing Food by Months

The lowest monthly percentage, 37.5, of stomachs containing food occurred in January and the highest was in February, 95.0 per cent. (Table

11). Two months only, January and April, were below 50 per cent in numbers of stomachs containing food. The yearly average for all stomachs containing food was 61.7 per cent. The data shows that for a given period during the year slightly over one half of the crappie had recently fed.

Empty Stomachs

The stomachs were empty in 804 crappie which comprised 38.3 per cent of all fish taken (Table 10). Sanborn Lake had 307 or 38.2 per cent of the crappie with empty stomachs. White crappie from Boomer Lake had 271 or 33.5 per cent of the crappie with empty stomachs. The black crappie from Country Club Lake had 228 or 28.3 per cent of all crappie which had not recently fed.

Empty Stomachs by Months

The percentage of empty stomachs varied considerably from month to month (Table 11). Variation in sample sizes could account for some of the fluctuations but not for all those found.

January provided the highest percentage with 62.5 per cent of the stomachs empty and February the lowest with 5.0. During the spring and summer months of April, June and July approximately one half of the specimens did not have food in their stomachs. February, March, August and September were the better months with a range of 5 to 27 per cent of the stomachs empty. Empty stomachs comprised 38.3 per cent of all stomachs examined.

Table 9

Monthly Variations From the Previous Month in the Mean Volume of Stomach Content and in Per Cent of Stomachs Containing Food

Month	Mean Volume Variation in Cubic Centimeters	Variation in Per Cent of Stomachs Containing Food
May*	0.23	64.6
June	-0.07	-15.0
July	-0.07	+ 2.0
August	+0.02	+22.0
September	+0.01	+ 3.0
October	-0.02	-13.0
November	-0.02	+ 6.0
December	-0.03	- 3.0
January	+0.05	-29.5
February	+0.03	+58.5
March	+0.29	-22.0
April	-0.10	-24.0

*Recorded Volume and Per Cent. + Increase, - Decrease.

Table 10

The Number of Empty Stomachs and Stomachs with Food, Their Totals, Their Percentages for Each Lake, and the Percentage for Each Group Of All Specimens Collected

Lake	All Specimens Collected	Empty Stomachs		Stomachs With Food	
		Number	Per Cent of Total	Number	Per Cent of Total
Sanborn	917	307	38.2	610	47.0
Boomer	530	271	33.5	259	20.0
Country Club	656	228	28.3	428	33.0
Total	2103	804	38.3	1299	61.7

Sex Ratio

There were 1054 females, 50.2 per cent, and 882 males, 41.9 per cent, in the total of 2103 crappie captured. Sex could not be determined for 167 specimens which represented 7.9 per cent of all crappie caught (Table 12).

Sanborn lake provided, (1), 490 females or 46.5 per cent of all females taken, (2), 360 males or 40.8 per cent of all males collected, and (3), 67 specimens of undeterminable sex or 40.1 per cent of the total unsexable specimens.

Boomer lake yielded, (1), 184 females or 17.5 per cent of all females taken, (2), 262 males or 29.7 per cent of all males collected, and (3), 84 specimens of undeterminable sex or 50.3 per cent of the total unsexable specimens.

Country Club Lake provided, (1), 380 females or 36.1 per cent of

all females taken, (2), 260 males or 29.5 per cent of all males collected and (3), 16 specimens of undeterminable sex or 9.6 per cent of the total unsexable specimens.

Table 11

Monthly Percentage of Stomachs Empty and Those Containing Food From the Three Lakes Studied

	Per cent of Empty Stomachs	Per cent of Stomach Containing Food
January	62.5	37.5
February	5.0	95.0
March	27.0	73.0
April	51.0	49.0
May	35.0	65.0
June	50.0	50.0
July	48.0	52.0
August	26.0	74.0
September	23.0	77.0
October	36.0	64.0
November	30.0	70.0
December	33.0	67.0
Average	38.3	61.7

Table 12

Sex Numbers and Sex Per Cent of Total Crappie Captured From the Three Lakes

Lake	Number of Females	Per Cent of Total Females	Number of Males	Per Cent of Total Males	Number Unidentifiable	Per Cent
Sanborn	490	46.5	360	40.8	67	40.1
Boomer	184	17.5	262	29.7	84	50.3
Country Club	380	36.1	260	29.5	16	9.6
Total	1054	50.2	882	41.9	167	7.9

AGE, GROWTH AND FOOD HABITS OF CRAPPIE BY INDIVIDUAL LAKES

The method used to determine the calculated length of fish at a particular age is explained under Methods. The mean calculated length reported for crappie at different ages was determined by adding all lengths recorded for fish in a particular age group and dividing the sum by the total number of fish aged in that group. The number aged as given in Tables 13, 14, and 15 designates the number of fish aged at completion of each particular annuli.

Age Groups and Mean Lengths of Black Crappie from Sanborn Lake

Age group I comprised 12.3 per cent of all fish taken from Sanborn Lake. The fish had an average length of 1.8 inches at completion of the first annulus (Table 13).

The crappie in age group II were the most numerous yielding 53.6 per cent of all crappie taken from the lake and the calculated mean length was 4.9 inches.

The second largest group of crappie were in age group III which comprised 32.0 per cent of the total. All crappie in the age group averaged 6.8 inches in length at completion of the third annulus.

Age group IV comprised 1.9 per cent of all crappie from Sanborn Lake and the fish had a calculated mean length of 8.0 inches.

One crappie taken from Sanborn Lake was in age group V. The fish comprised 0.2 per cent of all crappie from the lake and measured 10.0 inches at completion of the fifth annulus.

Age Groups and Mean Lengths for White Crappie from Boomer Lake

White crappie in age group I from Boomer Lake comprised 1.8 per cent

of all crappie taken from the lake (Table 14) and averaged 2.4 inches in length at annulus completion.

Table 13

Mean Length and Composition Per Cent by Age Groups of Black Crappie Collected from Sanborn Lake

Age Group	Average Calculated Length in Inches at Annulus Completion					Per Cent of Composition
	1	2	3	4	5	
I	2.1					12.3
II	1.6	4.7				53.6
III	1.9	5.2	6.8			32.0
IV	1.8	3.7	6.6	7.9		1.9
V	2.8	4.4	5.4	9.2	10.0	0.2
Mean Length	1.8	4.9	6.8	8.0	10.0	
Number Aged	650	529	139	15	1	

Most white crappie from Boomer Lake had completed the second annulus and were in their third growing season. Age group II comprised 68.9 per cent of all white crappie taken and the calculated mean length was 4.1 inches.

The crappie in age group III comprised 17.9 per cent of the total white crappie taken and had a calculated mean length of 5.6 inches.

There was a rapid decline in number of crappie after age group III. Age group IV comprised only 4.0 per cent of the white crappie taken and had a calculated mean length of 7.6 inches.

Table 14

Mean Length and Composition Per Cent by Age Groups of White Crappie Collected from Boomer Lake

Age Group	Average Calculated Length in Inches at Annulus Completion							Per Cent of Composition
	1	2	3	4	5	6	7	
I	2.3							1.8
II	2.4	4.1						68.9
III	2.5	4.2	5.4					17.9
IV	2.3	4.0	5.6	7.2				4.0
V	2.5	4.5	6.0	7.8	10.6			4.0
VI	2.5	4.3	5.9	7.4	9.6	10.1		3.2
VII	2.2	4.4	6.0	8.0	10.8	13.8	15.4	0.2
Mean	2.4	4.1	5.6	7.6	10.1	10.8	15.4	
Number Aged	330	315	123	51	32	5	1	

There were the same number of white crappie in the fifth age group as in the fourth. The five year old fish comprised 4.0 per cent of the crappie catch from Boomer Lake and had a calculated mean length of 10.1 inches.

There were slightly fewer fish in the sixth age group than in the fifth. The six year old fish comprised 3.2 per cent of the total catch and the calculated mean length was 10.8 inches.

The oldest crappie taken was one seven year old specimen which comprised 0.2 per cent of all fish taken from Boomer Lake and it meas-

ured 15.4 inches when the seventh annulus was complete.

Age Groups and Mean Length of Black Crappie from Country Club Lake

Age group I comprised 1.8 per cent of the crappie from Country Club Lake (Table 15) and the calculated mean length was 2.3 inches.

Age group II comprised 6.1 per cent of the crappie from Country Club Lake and the mean length was calculated to be 4.0 inches.

There was 2.6 per cent of the crappie from Country Club Lake that had completed the third annulus and their average calculated length was 4.7 inches.

There was only one major age group of black crappie from Country Club Lake. The fish in age group IV comprised 88.4 per cent of all crappie taken and had a mean length at that annulus of 4.8 inches.

Four fish were taken which had completed their fifth annulus. These comprised 0.9 per cent of the total crappie taken from Country Club Lake and had a mean length calculated to be 6.3 inches.

Only one crappie taken from Country Club Lake had completed the sixth annulus and it measured 6.4 inches at completion of the last annulus. The fish comprised 0.2 per cent of the total crappie captured from the lake.

Mean Length and Length Range at Capture of Black Crappie from Sanborn Lake

The mean length at capture of all black crappie from Sanborn Lake was 6.1 inches with a range from 3.7 to 11.2 inches (Table 16).

The mean length of crappie in age group I was 4.6 inches with a range of 3.7 to 5.7 inches. In this age group 77.7 per cent of the crappie were 4.0 to 5.0 inches long.

The crappie in age group II had an average length at capture of

5.8 inches with a range of 4.5 to 7.3 inches. There were 78.3 per cent of the crappie 5.3 to 6.3 inches long.

Age group III had an average length at capture of 7.1 inches and a range of 5.8 to 10.2 inches. There were 75.9 per cent of the crappie 6.7 to 7.7 inches long.

Table 15

Mean Length and Composition Per Cent by Age Groups of Black Crappie Collected from Country Club Lake

Age Group	Average Calculated Length in Inches at Annulus Completion						Per Cent of Composition
	1	2	3	4	5	6	
I	3.0						1.8
II	2.2	5.2					6.1
III	1.9	3.4	4.5				2.6
IV	2.2	3.7	4.7	4.8			88.4
V	2.4	3.6	4.4	5.4	6.6		0.9
VI	2.3	3.6	4.4	5.5	5.7	6.4	0.2
Mean	2.3	4.0	4.7	4.8	6.3	6.4	
Number Aged	211	197	152	123	4	1	

Age group IV averaged 8.4 inches long with a range of 6.6 to 11.2 inches. There was 83.3 per cent of the crappie in the age group 7.5 to 9.3 inches long.

The variation in range of crappie lengths at capture from Sanborn Lake formed a uniform progression for all ages. The variation in length

within each age group was as follows: I, 2.0 inches; II, 2.8 inches; III, 4.4 inches; and IV, 4.6 inches. The greatest variation increase occurred during the third growing season which was between the completion of the second and third annulus.

Table 16

Mean Length at Capture, Length Range and Major Length Range Distribution by Per Cent of Black Crappie from Sanborn Lake

Age Group	Mean Length (inches)	Length Range (inches)	Major Length Range Distribution	
			Per Cent	Range (inches)
I	4.6	3.7-5.7	77.7	4.0-5.0
II	5.8	4.5-7.3	78.3	5.3-6.3
III	7.1	5.8-10.2	75.9	6.7-7.7
IV	8.4	6.6-11.2	83.3	7.5-9.3
V	10.7		One Specimen	
Mean of Total	6.1			
Number of Specimens	917			

Mean Length and Length Range at Capture of White Crappie from Boomer Lake

The mean length at capture of white crappie from Boomer Lake was 5.7 inches and varied from 4.1 to 15.5 inches (Table 17).

Age group I averaged 4.6 inches long with a range of 4.1 to 4.9 inches and 70.0 per cent of the crappie were 4.2 to 4.7 inches.

The crappie in age group II averaged 5.1 inches in length with a range of 4.3 to 6.4 inches and 98.9 per cent of the group were 4.4 to 5.9 inches long.

The crappie in age group III averaged 5.8 inches long with a range of 4.9 to 7.1 inches while 74.7 per cent were 5.2 to 6.2 inches.

Age group IV had a mean length of 7.3 inches. The range for the group was 5.1 to 10.9 inches and 81.0 per cent of the crappie were 5.7 to 8.1 inches long.

Age group V crappie averaged 10.3 inches long with a range of 7.0 to 14.9 inches while 76.2 per cent fell within 8.2 to 11.6 inches.

The crappie in age group VI averaged 11.5 inches in length at capture with a range of 7.1 to 14.0 inches and 70.6 per cent were 7.1 to 12.8 inches.

The variation in range of crappie lengths at capture from Boomer Lake increased similar to that of weight through the fourth growing season or until the time when the average length reached approximately six inches. The variation in length within each age group was as follows: I, 0.8 inches; II, 2.1 inches; III, 2.2 inches; IV, 5.8 inches; V, 7.9 inches; and VI, 6.9 inches.

Mean Length and Length Range at Capture of Black Crappie from Country Club Lake

The mean length at capture of 656 black crappie from Country Club Lake was 5.4 inches. The size range varied from 4.0 to 13.9 inches (Table 18).

Crappie in age group I had an average length of 4.4 inches and a range of 4.0 to 4.9 inches while 58.3 per cent of the crappie were 4.2

to 4.7 inches.

Age group II crappie averaged 5.7 inches long with a range of 4.3 to 6.9 inches and 67.5 per cent were 5.7 to 6.4 inches long.

The crappie in age group III averaged 5.2 inches long which is less than the previous age group. The range for age group III was 4.2 to 8.5 inches with 70.6 per cent within 4.3 to 5.0 inches long.

Table 17

Mean Length at Capture, Length Range and Major Length Range Distribution by Per Cent of White Crappie from Boomer Lake

Age Group	Mean Length (inches)	Length Range (inches)	Major Length Range Distribution	
			Per Cent	Range (inches)
I	4.6	4.1-4.9	70.0	4.2-4.7
II	5.1	4.3-6.4	98.9	4.4-5.9
III	5.8	4.9-7.1	74.7	5.2-6.2
IV	7.3	5.1-10.9	81.0	5.7-8.1
V	10.3	7.0-14.9	76.2	8.2-11.6
VI	11.5	7.1-14.0	70.6	7.1-12.8
VII	15.5		One specimen	
Mean of Total	5.7			
Number of Specimens	530			

Age group IV crappie averaged 5.4 inches long. The range was 5.0 to 13.9 inches with 95.5 per cent of the fish 5.1 to 5.7 inches long.

Crappie in age group V averaged 7.1 inches long. They had a maximum range of 5.6 to 7.7 inches and 66.7 per cent were 7.1 to 7.4 inches long.

The variation in range of crappie lengths at capture from Country Club Lake was greatest in the fourth age group. This coincides with the age in which the weight showed the maximum variation. The maximum variation in length in the crappie occurred one year before they began an accelerated growth. The variation in length within each age group was as follows: I, 0.09 inches; II, 2.6 inches; III, 4.3 inches; IV, 8.9 inches; and V, 2.1 inches.

Mean Weight and Weight Range of Black Crappie from Sanborn Lake

The mean weight of 917 black crappie from Sanborn Lake was 0.11 pounds. The minimum weight was 0.03 and the maximum weight was 0.66 pounds (Table 19).

Crappie in age group I had 69.9 per cent that weighed from 0.04 to 0.05 pounds while the mean weight for the group was 0.05 pounds.

Age group II had a relatively narrow range with 93.5 per cent of the crappie weighing 0.06 to 0.13 pounds. The maximum range was 0.04 to 0.17 pounds with an average weight of 0.09 pounds.

Age group III covered its range rather uniformly with less than one half of the crappie weighing 0.13 to 0.21 pounds. The maximum range was 0.08 to 0.56 pounds and the mean was 0.17 pounds.

The range within age group IV was 0.13 to 0.66 pounds while 77.8 per cent of the crappie were 0.20 to 0.40 pounds. The mean weight of the group was 0.27 pounds.

There was only one crappie taken in Sanborn Lake in age group V and its weight was 0.65 pounds.

Table 18

Mean Length at Capture, Length Range and Major Length Range Distribution by Per Cent of Black Crappie From Country Club Lake

Age Group	Mean Length (inches)	Length Range (inches)	Major Length Range Distribution	
			Per Cent	Range (Inches)
I	4.4	4.0-4.9	58.3	4.2-4.7
II	5.7	4.3-6.9	67.5	5.7-6.4
III	5.2	4.2-8.5	70.6	4.3-5.0
IV	5.4	5.0-13.9	95.5	5.1-5.7
V	7.1	5.6-7.7	66.7	7.1-7.4
VI	6.5		One Specimen	
Mean of Total	5.4			
Number of Specimens 656				

The variation in range of crappie weights in the various age groups was: I, 0.03 pounds; II, 0.13 pounds; III, 0.48 pounds and IV, 0.53 pounds. The maximum variation in range of weights occurred in the third growing season during the time that accelerated growth occurred for crappie in Sanborn Lake.

Mean Weight and Weight Range of White Crappie from Boomer Lake

The average weight of 528 white crappie from Boomer Lake was identical with that of black crappie in Sanborn Lake, 0.11 pounds. The minimum weight was 0.03 pounds and the maximum weight was 2.64 pounds (Table 20).

Table 19

Mean Weight, Weight Range and Major Weight Range Distribution by Per Cent, of Black Crappie From Sanborn Lake

Age Group	Mean Weight (pounds)	Weight Range (pounds)	Major Weight Range Distribution		
			Per Cent		Weight (pounds)
I	0.05	0.03-0.06	69.9	were	0.04-0.05
II	0.09	0.04-0.17	93.5	were	0.06-0.13
III	0.17	0.08-0.56	43.9	were	0.13-0.21
IV	0.27	0.13-0.66	77.8	were	0.20-0.40
V	0.65		One specimen		
Mean of Total	0.11				
Number of specimens 917					

The narrow range of 0.03 to 0.04 pounds included 90.0 per cent of the fish in age group I. The mean for the group was 0.04 pounds.

Age group II which averaged 0.05 pounds had a range of 0.03 to 0.11 pounds and the crappie had 92.9 per cent from 0.04 to 0.07 pounds.

Age group III averaged 0.08 pounds per fish. The range was 0.04 to 0.13 pounds while 94.7 per cent weighed 0.05 to 0.10 pounds.

Specimens in age group IV averaged 0.16 pounds each and the range was 0.05 to 0.56 pounds with 81.0 per cent of the crappie weighing 0.06 to 0.18 pounds.

Table 20

Mean Weight, Weight Range and Major Weight Range Distribution by Per Cent of White Crappie From Boomer Lake

Age Group	Mean Weight (pounds)	Weight Range (pounds)	Major Weight Range Distribution	
			Per Cent	Weight (pounds)
I	0.04	0.03-0.05	90.0	0.03-0.04
II	0.05	0.03-0.11	92.9	0.04-0.07
III	0.08	0.04-0.13	94.7	0.05-0.10
IV	0.16	0.05-0.56	81.0	0.06-0.18
V	0.61	0.11-2.64	81.0	0.20-0.68
VI	0.80	0.13-1.30	75.3	0.13-0.93
VII	2.38		One specimen	
Mean of Total	0.11			
Number of specimens	528			

The crappie in age group V had an average weight of 0.61 pounds, ranged from 0.11 to 2.64 and 81.0 per cent were within 0.20 to 0.68 pounds.

Age group VI had the highest average weight with 0.80 pounds, and a range of 0.13 to 1.30 pounds. Of all crappie in the group 73.3 per cent ranged from 0.13 to 0.93 pounds. It seems possible that the group contained crappie from an age group previously dominant in numbers which, after stunting, never made a compensatory growth. This could account for the low minimum range.

The variation in range of crappie weights in the various age groups from Boomer Lake was: I, 0.02 pounds; II, 0.08 pounds; III, 0.09 pounds; IV, 0.51 pounds; V, 2.53 pounds; and VI, 1.17 pounds. The maximum variation in range of weights occurred during the fourth growing season during the time that accelerated growth took place by white crappie from Boomer Lake.

Mean Weight and Weight Range of Black Crappie From Country Club Lake

The average weight of 656 black crappie from Country Club Lake was 0.07 pounds (Table 21). The range in weight varied from 0.03 to 1.07 pounds.

Age group I had an average weight per fish of 0.04 pounds and a range of 0.03 to 0.05 pounds while 50.0 per cent of the age group weighed 0.04 pounds each.

Age group II had an average weight per fish of 0.08 pounds. They ranged from 0.04 to 0.12 pounds and 67.5 per cent were 0.08 to 0.11 pounds each.

Age group III had an average weight per crappie of 0.07 pounds and a range of 0.03 to 0.28 pounds. Within the group 70.6 per cent were 0.04 to 0.07 pounds each.

Age group IV had an identical mean weight per fish as the previous group, 0.07 pounds. The range was large varying from 0.04 to 1.07 pounds each. Crappie from this lake did not increase in mean weight during their fourth growing season. The range was large but 97.6 per cent of the crappie averaged 0.05 to 0.07 pounds.

Age group V had an average weight per fish of 0.16 pounds. The

range was from 0.07 to 0.20 pounds with 66.7 per cent 0.14 to 0.19 pounds each.

Table 21

Mean Weight, Weight Range and Major Weight Range Distribution by Per Cent of Black Crappie from Country Club Lake

Age Group	Mean Weight (pounds)	Weight Range (pounds)	Major Weight Range Distribution Per Cent		Weight (pounds)
I	0.04	0.03-0.05	50.0	were	0.04
II	0.08	0.04-0.12	67.5		0.08-0.11
III	0.07	0.03-0.28	70.6		0.04-0.07
IV	0.07	0.04-1.07	97.6		0.05-0.07
V	0.16	0.07-0.20	66.7		0.14-0.19
VI	0.13		One speciman		
Total	0.07				
Number of Specimens 656					

The variation in range of crappie weights in the various age groups from Country Club Lake was: I, 0.02 pounds; II, 0.08 pounds; III, 0.25 pounds; IV, 1.03 pounds; and V, 0.13 pounds. The maximum variation in range of weights occurred in the fourth age group which was the beginning of the year accelerated growth took place.

Calculated Mean Increase in Length, Weight and Total Length at Capture by Age Groups for Crappie from the Lakes

The data presented in Tables 22, 23, and 24 shows comparisons be-

tween lengths and weights of crappie from the three lakes sampled.

The number of fish used in computing the lengths in the tables is only the number actually aged and is not the total number of fish taken from that lake. The number of crappie aged (Tables 13, 14 and 15) were 650 from Sanborn Lake, 211 from Country Club Lake and 330 from Boomer Lake. The mean total lengths at capture and the weight measurements were computed from all crappie captured in the respective lakes. The samples vary both between lakes and in the number of crappie aged for a particular age group but all samples exclusive of the last age groups in each lake are believed to be of sufficient size to justify direct comparisons.

No appreciable differences in weight at completion of the first year of life were found. Sanborn Lake, considered the most productive, yielded crappie 0.5 inch shorter than those from Country Club Lake and 0.6 inch shorter than those from Boomer Lake. The fish from Sanborn Lake were 0.01 pounds heavier than those from either of the other lakes.

Black crappie from Sanborn Lake averaged 0.8 inches longer and 0.04 pounds heavier than the white crappie from Boomer Lake at the completion of the second year, which is the beginning of the third growing season. Crappie of age group II were 0.9 inches longer and 0.01 pounds heavier from Sanborn Lake than from Country Club Lake.

Crappie in Sanborn Lake nearly doubled in average weight during the third growing season. The calculated length at completion of the third annulus was 6.8 inches from Sanborn Lake which was 1.2 inches longer than from Boomer Lake and 2.1 inches longer than from Country Club Lake.

Table 22

The Mean Length, Weight and Total Length at Capture with the Calculated Increase by Age Groups in Black Crappie from Sanborn Lake

Age Group	Mean Length (inches)	Calculated Increase (inches)	Mean Weight (pounds)	Calculated Increase (pounds)	Mean Total Length at Capture (inches)	Calculated Increase (inches)
I	1.8	1.8	0.05	0.05	4.6	
II	4.9	3.1	0.09	0.05	5.8	1.2
III	6.8	1.9	0.17	0.08	7.1	1.3
IV	8.0	1.2	0.27	0.10	8.4	1.3
V	10.0	2.0	0.65	0.38	10.7	2.3

Table 23

The Mean Length, Weight and Total Length at Capture with the Calculated Increase by Age Groups in White Crappie from Boomer Lake

Age Group	Mean Length (inches)	Calculated Increase (inches)	Mean Weight (pounds)	Calculated Increase (pounds)	Mean Total Length at Capture (inches)	Calculated Increase (inches)
I	2.4	2.4	0.04	0.04	4.6	
II	4.1	1.7	0.05	0.01	5.1	0.5
III	5.6	1.5	0.08	0.03	5.8	0.7
IV	7.6	2.0	0.16	0.08	7.3	1.5
V	10.1	2.5	0.61	0.45	10.3	3.0
VI	10.8	0.7	0.80	0.19	11.5	1.2
VII	15.4	4.6	2.38	1.58	15.5	4.0

Table 24

The Mean Length, Weight and Total Length at Capture with the Calculated Increase by Age Groups in Black Crappie from Country Club Lake

Age Group	Mean Length (inches)	Calculated Increase (inches)	Mean Weight (pounds)	Calculated Increase (pounds)	Mean Total Length at Capture (inches)	Calculated Increase (inches)
I	2.3	2.3	0.04	0.04	4.4	
II	4.0	1.7	0.08	0.04	5.7	1.3
III	4.7	0.7	0.07	-0.01*	5.2	-0.5
IV	4.8	0.1	0.07	0.00	5.4	0.2
V	6.3	1.5	0.16	0.09	7.1	1.7
VI	6.4	0.1	0.13	-0.03	6.5	-0.6

* - decrease

Crappie from Sanborn Lake continued accelerated growth both in weight and length in the fourth growing season. During this period crappie from Boomer Lake increased by doubling in average weight after reaching a length of six inches. The average calculated length for crappie from Boomer Lake increased from 5.6 to 7.6 inches by the end of that year. A slight increase in length of 0.1 inch with no increase in weight was made by crappie from Country Club Lake.

The crappie increased 0.38 pounds and 2.1 inches in Sanborn Lake during the fifth growing season, which was the oldest recorded fish for that lake. Increases of 0.45 pounds and 2.5 inches were made by crappie during the fifth growing season from Boomer Lake. Crappie from

Country Club Lake made an accelerated growth by more than doubling in weight and adding 1.5 inches after reaching an average of six inches in total length which was attained during the fifth growing season.

An increase in rate of growth by crappie occurred during the fourth growing season in Boomer Lake and the fifth growing season in Country Club Lake as shown by the increase in average weight, length and total length at capture. Crappie in Sanborn Lake failed to show this accelerated increase but maintained a more uniform rate of growth throughout their life.

Food Habits

The mean volume of stomach contents (Table 25, 26 and 27 was determined by adding the individual volumes for all crappie in an age group and dividing the sum by the number of stomachs in that group which contained food. The percentage of stomachs with food in each age group was determined by dividing the total number of stomachs collected into the number of stomachs containing food. The percentage of stomachs empty was determined by dividing the number of stomachs empty by the total number of stomachs in each age group. The total mean was computed by adding the volume of all stomachs and dividing the sum obtained by the total number of stomachs with food. The total percentages of stomachs with food was determined by dividing all stomachs with food by the total number of stomachs collected. The total percentage of empty stomachs was computed by dividing the number of stomachs empty by the total number of stomachs collected.

Volume of Food of Crappie from Sanborn Lake

The mean volume of food in crappie stomachs progressively increased

from age groups I through V for those fish from Sanborn Lake (Table 25). The maximum variation was 0.07 to 2.00 cubic centimeters with a mean number of 0.19 cubic centimeters for each fish from Sanborn Lake. Likewise there was a progressive increase in the percentage of stomachs containing food. The minimum percentage of stomachs containing food was 56.2 in age group I and the maximum was 100 in group V. The total average per cent of crappie stomachs with food present was 66.5.

Age group I had an average of 0.07 cubic centimeters of food in the stomachs and 56.2 per cent of the group had recently fed. Age group II had an average of 0.12 cubic centimeters of food and 61.8 per cent of all fish in the age group had food in the stomach. The crappie in age group III averaged 0.23 cubic centimeters of food with 77.2 per cent having food items present. Age group IV crappie stomachs averaged 1.45 cubic centimeters of food and 83.3 per cent had food present. The one crappie in age group V had 2.00 cubic centimeters of food in its stomach.

The percentage of stomachs empty varied inversely with the age. The total average of stomachs empty was 33.5 per cent. The percentage of empty stomachs varied with age groups as follows: I, 43.8; II, 38.2; III, 22.8; IV, 16.7 and V, represented by one fish, had no empty stomachs.

Volume of Food of Crappie from Boomer Lake

The average volume of stomach contents for white crappie from Boomer Lake varied from 0.05 to 7.00 cubic centimeters (Table 26). The average was 0.46 cubic centimeters for all fish containing food in the stomach from this lake. The per cent of stomachs with food by age group varied from 44.7 to 100 per cent with an average of 49.2 per cent for all stomachs from white crappie. There was a gradual increase in volume of

food from age group I through IV. The age groups after IV were composed of larger crappie and the volumes recorded were comprised almost entirely of fish taken as food.

Table 25

Mean Volume of Stomach Contents, Number of Stomachs Empty, and Percentage of Stomachs with Food and Empty, for Black Crappie from Sanborn Lake

Age Group	Stomachs with Food		Stomachs Empty	
	Mean Volume (cubic centimeters)	Per Cent of Total	Total Number	Per Cent of Total
I	0.07	56.2	49	43.8
II	0.12	61.8	188	38.2
III	0.23	77.2	67	22.8
IV	1.45	83.3	3	16.7
V	2.00	100.0	0	0
Total Mean	0.19	66.5	307	33.5

Age group I averaged 0.05 cubic centimeters of food and 70.0 per cent of the stomachs contained food. Age group II had an average of 0.08 cubic centimeters of food and 44.7 per cent of the stomachs contained food. Age group III averaged 0.31 cubic centimeters of food per fish and 52.6 per cent of the stomachs had food. The fish stomachs in age group IV averaged 0.40 cubic centimeters of food and 66.7 per cent of them contained food. In age group V 71.4 per cent of the stomachs had

food which averaged 3.56 cubic centimeters each. Age group V was the age at which the crappie of Boomer Lake began an accelerated growth and is also the age at which the crappie began most actively to feed on fish. Age group VI averaged 2.09 cubic centimeters of food per stomach with 64.7 per cent of the stomachs containing food. The one fish in age group VII had 7.00 cubic centimeters of food in its stomach.

Table 26

Mean Volume of Stomach Contents, Number of Stomachs Empty, and Percentage of Stomachs with Food and Empty for White Crappie from Boomer Lake

Age Group	Stomachs with Food		Stomachs Empty	
	Mean Volume (cubic centimeters)	Per Cent of Total	Total Number	Per Cent of Total
I	0.05	70.0	3	30.0
II	0.08	44.7	203	55.3
III	0.31	52.6	46	47.4
IV	0.40	66.7	7	33.3
V	3.56	71.4	6	28.6
VI	2.09	64.7	6	35.3
VII	7.00	100.0	0	0.0
Mean Total	0.46	49.2	271	50.8

The number of stomachs empty formed no apparent pattern. The percentage of empty stomachs by age groups was: I, 30.0; II, 55.3; III,

47.4; IV, 33.3; V, 28.6; VI, 35.3. An average of 50.8 per cent of the stomachs for all age groups from Boomer Lake were empty.

Volume of Food of Crappie from Country Club Lake

There were no apparent patterns formed in the feeding habits of the black crappie from Country Club Lake, other than average relatively small amount of food taken by all age groups (Table 27). The overall range for the fish was 0.05 to 0.27 cubic centimeters of food contained in the stomach which had a total mean of 0.09 cubic centimeters. The crappie from this lake had 65.2 per cent of the stomachs which contained food.

Table 27

Mean Volume of Stomach Contents, Number of Stomachs Empty, and Percentage of Stomachs with Food and Empty for Black Crappie from Country Club Lake

Age Group	Stomachs with Food		Stomachs Empty	
	Mean Volume (cubic centimeters)	Per Cent of Total	Total Number	Per Cent of Total
I	0.05	16.7	10	83.3
II	0.11	40.0	24	60.0
III	0.07	52.9	8	47.1
IV	0.07	68.6	182	31.4
V	0.27	50.0	3	50.0
VI			1	100.0
Mean Total	0.09	65.2	228	34.8

Crappie in age group I had an average of 0.05 cubic centimeters of food and only 16.7 per cent of the stomachs contained food. Age group II had 0.11 cubic centimeters of food in the stomach and only 40.0 per cent of the stomachs showed recent feeding. Age groups III and IV were identical with 0.07 cubic centimeters of food. These age groups had 52.9 and 68.6 per cent, respectively, of the stomachs containing food. Age group V had the highest mean volume recorded from the lake with 0.27 cubic centimeters and 50.0 per cent of the stomachs contained food.

The per cent of the stomachs empty, as with volume, formed no apparent pattern. The per cent of crappie with empty stomachs by age groups were: I, 83.3; II, 60.0; III, 47.1; IV, 31.4; V, 50.0 and VI, represented by only one fish, 100 per cent. The total mean of the empty stomachs was 34.8 per cent.

Stomach Contents of Crappie

Tables 28, 29 and 30 concern insects eaten by crappie from the individual lakes and all computations concern only those which contained food. The mean numbers were computed by adding the number of insects recorded by order for various age groups and dividing the sum by the total number of stomachs in that age group that contained food. The total mean was determined by adding for each order all the insects recorded and dividing the sum by the total number of stomachs containing food.

Insects Eaten by Crappie from Sanborn Lake

Diptera--Dipterous insects comprised the greatest number of insects recorded. Crappie from Sanborn Lake contained an average of 50.9 of these insects. Individuals of age group IV contained an average of 85.7 dipterous insects which was the highest number for any age group and was

followed by age groups III with 71.8; II with 40.6; and I with 17.6.

Ephemerida--Ephemerida larvae formed the second highest average number of insects found in the black crappie stomachs from Sanborn Lake. Crappie from the lake contained an average of 4.4 Ephemerida. Age group II contained the highest number with an average of 5.0 per stomach and was followed by age group III with an average of 4.8, age group I with 1.3 and age group IV with an average of 1.1 Ephemerida for each stomach.

Table 28

Mean Number of Insects Present in Black Crappie by Age Groups, from Sanborn Lake

Age Group	Ephmerida	Diptera	Coleoptera	Odonata	Orthroptera	Hymenoptera	Unid.*
I	1.3	17.6	0.03	0.2	0.09		1.0
II	5.0	40.6	0.08	0.12	0.008	0.04	1.2
III	4.8	71.8	0.16				1.2
IV	1.1	85.7					2.6
V							
Mean Total	4.4	50.9	0.11	0.15	0.01	0.01	1.3

*Unidentified

Odonata--Odonata were third largest in numbers of insects present. These insects were eaten in the amount of 0.15 per stomach and were present in only those stomachs from age groups I with 0.2 and II with 0.12.

Coleoptera--Coleoptera ranked fourth numerically in insects present with an average of 0.11 for each stomach. Age group III contained the greatest number of Coleoptera with an average of 0.16 and was followed by age group II with 0.08 and I with 0.03 for each stomach.

Orthroptera and Hymenoptera--Orthroptera and Hymenoptera were each represented by a few insects. The average found for both orders was 0.01 per stomach.

Unidentified Insecta--Insects which were too digested or too broken to be classified to order were listed as unidentified insects. They averaged 1.3 insects per stomach and crappie in age group IV contributed the greatest number with an average of 2.6. The numbers in age groups II and III were equal with an average of 1.2 and in age group I there was an average of 1.0 per stomach.

Insects Eaten by Crappie from Boomer Lake

Diptera--Dipterous insects were the highest in numbers of all insects recorded. White crappie had an average of 3.4 dipterous insects per stomach. Individual fish in age group III contained the greatest number of Diptera, averaging 4.9, followed by crappie in age group II with 3.7, age group IV with 1.2, and age group V with 0.8 per stomach.

Ephemerida--Numerically Ephemerida were second averaging 1.5 insects per stomach. Crappie in age group III ranked highest with an average of 4.2 per stomach followed by age group IV with 3.2, age group VI with 0.8, age group II with 0.7 and age group V with 0.3.

Hymenoptera--Hymenopterous insects averaged 0.7 for each stomach that had food. Crappie in age group III had an average of 1.3 Hymenoptera and were followed by age group I with 0.9 and age group II with 0.6.

Homoptera and Orthroptera--Homoptera and Orthroptera were represented by an average of 0.003 insects for each order. Stomachs from age group II only contained these insects and their average number present was 0.006.

Table 29

Mean Number of Insects Present in White Crappie by Age Groups from Boomer Lake

Age Group	Ephmerida	Diptera	Coleoptera	Homoptera	Hymenoptera	Orthroptera	Unid.*
I					0.9		0.9
II	0.7	3.7	0.01	0.006	0.6	0.006	1.8
III	4.2	4.9			1.3		2.5
IV	3.2	1.2					
V	0.3	0.8					
VI	0.8		0.4				0.09
VII							
Mean Total	1.5	3.4	0.02	0.003	0.7	0.003	1.7

*Unidentified

Unidentified Insecta--Unidentified insects averaged 1.7 per stomach. The bulk of these insects were present in the stomachs of crappie in age group III and averaged 2.5 insects per stomach. Crappie in age group II contained 1.8 unidentified insects followed by age group I with 0.9 and age group IV with 0.09 insects per stomach.

Insects Eaten by Crappie from Country Club Lake

Diptera--Numerically Diptera were the major insects taken by black crappie from Country Club Lake. The average of all stomachs that contained food was 15.8 per stomach. Age group II crappie contained the greatest number of Diptera with an average of 18.3 followed by age group IV with 16.1 per stomach. Age group V contained 7.7 insects and age group III contained 5.3 Dipterous insects per stomach while none were found in the stomachs of age group I.

Ephemerida--An average per stomach of 0.60 Ephemerida was found among all stomachs containing food. Age group IV with an average of 0.70 Ephemerida per stomach was the only group in which the insect was found.

Table 30

Mean Number of Insects Present in Black Crappie by Age Groups from Country Club Lake

Age Group	Ephmerida	Diptera	Coleptera	Odonata	Homoptera	Unidentified
I						
II		18.3				2.7
III		5.3	1.2			1.3
IV	0.70	16.1	0.14	0.01	0.003	1.2
V		7.7				
VI						
Mean Total	0.60	15.8	0.16	0.01	0.003	1.3

Coleoptera--Numerically Coleoptera were third with an average of 0.16 per stomach. Age groups III and IV with an average of 1.2 and 0.14 per stomach, respectively, comprised the only groups in which Coleoptera were found.

Odonata and Homoptera--Odonata and Homoptera were represented. respectively with an average of 0.01 and 0.001 for each stomach. Age group IV averaged 0.01 Odonata and 0.003 Homoptera per stomach and was the only group which had eaten the insects.

Unidentified Insecta--Unidentified insects averaged 1.3 per stomach. Age group II had eaten the greatest number of insects per stomach with an average of 2.7 and was followed by age group III with 1.3 and age group IV with 1.2.

Stomach Contents (Exclusive of Insects) of Black Crappie from Sanborn Lake

The seperate items in the stomach contents other than insects are ranked in order of numerical value. Due to the highly unequal proportion of the total amount of the stomach contents comprised by the insect and non-insect food items, it was thought preferable to group the data in separate tables. Stomach contents exclusive of insects, (Table 31, 32 and 33), were computed as described for "Insects Eaten by Crappie."

Invertebrate Eggs--The food items that appeared in greatest numbers in stomachs of black crappie from Sanborn Lake were invertebrate eggs. The average found in each stomach was 1051.8. Age group I contained the highest average number of invertebrate eggs per stomach with 1352.4 while age group IV contained the lowest with 497.5. There was a gradual decline in numbers eaten by crappie from age group I through IV.

Table 31

The Mean of Stomach Contents (Exclusive of Insects), In Black Crappie By Age Groups, From Sanborn Lake

Age Group	Invertebrate Eggs	Copepoda	Cladocera	Ostracoda	Nematoda	Algae	Spermocarp	Pisces	*
I	1352.4	167.9	292.5	82.3	2.2	0.06	15.3		
II	1241.6	179.9	184.7	34.0	3.2	0.09	25.1		
III	718.2	112.3	281.1	26.6	3.2	1.00	28.7	0.02	
IV	497.5	53.5	20.6		9.9	0.80	7.3	0.22	
V								1.00	
Mean of Total	1050.8	150.0	227.4	35.4	3.7	0.46	25.0	0.02	

*Miscellaneous Items Present:

Isopoda	Mean of Total	0.001
Amphipoda	Mean of Total	0.006
Crustacea	Mean of Total	0.004
Decapoda	Mean of Total	0.001
Acarina	Mean of Total	0.46

Cladocera--The cladocerans were numerically next to invertebrate eggs with an average of 227.4 contained in each stomach. They varied in number from 292.5 for crappie in age group I to 20.6 in age group IV.

Copepoda--Copepods ranked third numerically in the food items listed. Crappie from Sanborn Lake contained an average of 150.0 for each fish that had food present in the stomach. Crappie in age group II contained the greatest number with 179.9 and age group IV contained the least number with 53.5 copepods per stomach.

Ostracoda--Practically all ostracods recorded were found in the crappie stomach from Sanborn Lake and they ranked fourth in food items exclusive of insects. The average number present was 35.4 for all crappie from this lake. Age group I contained the most individuals with an average of 82.3 ostracods and age group III had the least with an average of 26.6. These crustaceans were present only in the first three age groups.

Spermocarp--Spermocarp was the fifth category numerically with an average of 25.0 for all crappie stomachs from Sanborn Lake. Age group III contained the greatest number with 28.7 and age group IV the lowest with 7.3 per stomach.

Nematoda--An average of 3.7 nematodes were found in each crappie stomach from Sanborn Lake. Age group IV had the highest average number of nematodes with 9.9 and the lowest number was 2.2 in age group I.

Algae--Algal forms averaged 0.46 per crappie stomach. The erratic occurrence of algae in the stomachs analyzed might suggest they were taken accidently while feeding for only a few individual fish contained them. Age group III averaged the highest with 1.00 per stomach and age group I the lowest with 0.06 algae.

Pisces--Fish were never common in the crappie stomachs analyzed. The average for all crappie stomachs from Sanborn Lake was 0.02 fish and age group V was highest in number with 1.00 per stomach and age group III the lowest with 0.02 fish.

Miscellaneous--The food items listed under Miscellaneous were of such infrequent occurrance that mention need be made only to note their presence. Acarina were represented by an average number of 0.46; Amphipoda 0.006; unidentified Crustacea 0.004; Isopoda 0.001; and Decapoda 0.001 in each crappie which had food present.

Stomach Contents (Exclusive of Insects) of White Crappie from Boomer Lake

Invertebrate Eggs--Eggs of invertebrates formed the greatest numerical proportion of the food of white crappie from Boomer Lake. The age groups averaged 529.1 invertebrate eggs for each stomach containing food. Age group III had the highest number with an average of 897.8 and age group V the lowest with an average of 0.5 invertebrate eggs per stomach.

Cladocera--The cladocerans were second numerically in white crappie stomachs from Boomer Lake. Cladocerans were present in the first four age groups of crappie and averaged 206.1 per stomach. Age group I had the largest number with 796.7 cladocerans per stomach and age group IV the smallest with 0.7 per fish stomach.

Algae--Algae ranked third in average number of items contained in crappie stomachs. Only crappie of age group II with an average of 0.4 and age group III with an average of 2.6 had algae in the stomach contents. The mean number present was 0.80 algae per stomach.

Ostracoda--Ostracods were numerically fourth in rank in white crappie

stomachs. The mean number of ostracods eaten was 0.69. Ostracods were represented only in crappie age group II with an average of 1.1 for each stomach.

Nematoda--Nematodes were present in all age groups found except age group VII. They average 0.13 per stomach and varied from 1.90 nematodes in age group III to 0.13 in age group V.

Pisces--Most of the crappie and a wider range of age groups, that had fed on fish were from Boomer Lake. The average fish eaten per specimen was 0.15 and varied from 0.02 in age group II to 2.0 in age group VII.

Miscellaneous--Miscellaneous items occurred rarely. The following were found in white crappie stomachs in the average numbers shown: Decapoda 0.03; Rotifera 0.02 and Acarina 0.003.

Stomach Contents (Exclusive of Insects) of Black Crappie from Country Club Lake

Invertebrate Eggs--Invertebrate eggs ranked highest in numbers of food items present in black crappie from Country Club Lake. The average for all stomachs was 682.8 eggs and ranged from 947.8 in age group II to 142.0 in age group I. Invertebrate eggs were present in all crappie age groups except age group VI.

Copepoda--Copepods were second in number of food items eaten by black crappie from this lake and were present in stomachs only from the first four age groups. The average number for each crappie was 96.2 and the variation was from 99.8 in age group IV to 33.0 copepods in age groups I and III.

Cladocera--Numerically cladocerans ranked third for crappie stomachs from Country Club Lake. Crappie averaged 24.1 cladocerans per stomach with a range of 280.9 in age group II to 7.3 in age group V.

Table 32

The Mean of Stomach Contents (Exclusive of Insects), In White Crappie By Age Groups, From Boomer Lake

Age Group	Invertebrate Eggs	Copepoda	Cladocera	Ostracoda	Nematoda	Algae	Spermocarp	Pisces	*
I	351.7	136.7	796.7		0.14				
II	535.5	143.9	263.7	1.1	1.40	0.4		0.02	
III	897.8	213.3	104.4		1.90	2.6		0.10	
IV	246.5	118.9	0.7		1.20			0.50	
V	0.5				0.13		0.24	0.87	
VI					0.36			0.82	
VII								2.00	
Mean of Total	529.1	140.8	206.1	0.69	0.13	0.80	0.02	0.15	

*Miscellaneous Items: Mean of Total Decapoda 0.03

Acarina 0.003

Rotifera 0.02

Table 33

The Mean of Stomach Contents (Exclusive of Insects) In Black Crappie by Age Groups, From Country Club Lake

Age Group	Invertebrate Eggs	Copepoda	Cladocrea	Ostracoda	Nematoda	Algae	Spermocarp	Pisces	*
I	142.0	33.0	114.5		2.0	5.0			
II	947.8	64.6	280.9	2.8	3.1	1.0	4.1		
III	317.1	33.0	67.6		2.4		22.0		
IV	686.5	99.8	12.4	1.4	1.8	0.38	11.0		
V	240.0		7.3		2.0			0.33	
Mean of Total	682.8	96.2	24.1	1.4	1.9	0.4	10.8	0.002	

*Miscellaneous Items; Mean of Total Acarina 0.10

Crustacea 0.23

Spermocarp--Spermocarps ranked fourth in numbers of food items present in crappie from Country Club Lake. The mean number was 10.8 spermocarps per stomach and the range was 22.0 in age group III to 4.1 in age group II.

Nematoda--Nematodes ranked fifth in order of numbers present. There were an average of 1.9 nematodes in each crappie stomach and the range was from 3.1 in age group II to 1.8 in age group IV.

Algae--Algae ranked sixth in number of items present in the crappie stomachs from the lake. There was an average of 0.4 algae present for each stomach with a range of 5.0 to 0.38 in age group I and IV, respectively.

Pisces--Fish were found in the stomachs of crappie in the fifth age group only. The average number of fish eaten by crappie was 0.002 and the mean for age group V was 0.33 fish.

Miscellaneous--There were very few miscellaneous items in the crappie stomachs from Country Club Lake. There were on an average 0.10 Acarina and 0.23 unidentified crustaceans.

Monthly Mean Volume of Stomach Contents for Crappie by Individual Lakes

Sanborn Lake--The mean volume of the stomach contents of crappie from Sanborn Lake varied from a maximum of 0.63 cubic centimeters in May to a minimum of 0.05 cubic centimeters in December (Table 34). The monthly volumes during February, March, April, May and June were high while that for the remainder of the months varied around 0.10 cubic centimeters of food in the stomach contents.

Boomer Lake--The mean volume of stomach contents of the crappie from Boomer Lake varied from a maximum of 0.31 cubic centimeters in September to a minimum of 0.05 cubic centimeters in December (Table 34).

The stomachs taken during the months of March, April, May and September had the highest food content, averaging above 0.15 cubic centimeters while those for the remainder of the months varied around 0.09 cubic centimeters.

Country Club Lake--As previously mentioned, crappie were obtainable from Country Club Lake during six months only. The food content of all stomachs was low in comparison to that of the other lakes (Table 34). The maximum of 0.14 cubic centimeters of food per stomach occurred in April and the minimum was during September with 0.06 cubic centimeters while that for the remainder of the months varied around 0.08 cubic centimeters.

Table 34

Monthly Mean Volume in Cubic Centimeters of Stomach Contents for Crappie from the Individual Lakes

Month	Sanborn Lake Mean Volume	Boomer Lake Mean Volume	Country Club Lake Mean Volume
January	0.11	0.08	
February	0.15	0.10	
March	0.34	0.15	
April	0.28	0.29	0.14
May	0.63	0.18	0.09
June	0.20	0.09	0.11
July	0.11	0.12	0.07
August	0.13	0.10	0.07
September	0.13	0.31	0.06
October	0.10	0.11	
November	0.08	0.08	
December	0.05	0.05	

Food Contained Per Pound of Body Weight in Crappie from the Individual Lakes

The volume of food eaten per pound of body weight for each age group was computed by dividing the mean weight into the mean numbers of cubic centimeters of food eaten (Table 25). The total average through age group IV was computed from the sum of all measurements shown for those age groups.

The crappie in age group I from Sanborn Lake ate 1.40 cubic centimenters of food per pound of body weight while those from Boomer and Country Club Lakes each ate 1.25 cubic centimeters of food.

Crappie in age group II from Boomer Lake contained the greatest volume of food per pound of body weight with 1.60 while those from Country Club Lake contained 1.38 and Sanborn Lake 1.33 cubic centimeters of food.

Crappie from Boomer Lake in age group III ate 3.88 cubic centimeters of food per pound of body weight while crappie of the same age from Sanborn Lake contained 1.35 and those from Country Club Lake ate 1.00.

Crappie in age group IV from Sanborn Lake contained the greatest volume of food per pound of body weight with 5.37 cubic centimeters and those from Boomer Lake had 2.50, while crappie from Country Club Lake had 1.00.

Crappie in age groups I through IV from Boomer Lake ate the greatest volume of food per pound of body weight with 2.50, Sanborn Lake 1.73, and Country Club Lake 1.29 cubic centimeters.

Table 35

Comparison of the Volume in Cubic Centimeters of Food Eaten with Body Weight in Pounds For Crappie, By Age Groups, From the Individual Lakes

Age Group	Sanborn Lake			Boomer Lake			Country Club Lake		
	Body Weight in Pounds	Volume of Food in CC	CC of Food per Pound Body Weight	Body Weight in Pounds	Volume of Food in CC	CC of Food per Pound Body Weight	Body Weight in Pounds	Volume of Food in CC	CC of Food per Pound Body Weight
I	0.05	0.07	1.40	0.04	0.05	1.25	0.04	0.05	1.25
II	0.09	0.12	1.33	0.05	0.08	1.60	0.08	0.11	1.38
III	0.17	0.23	1.35	0.08	0.31	3.88	0.07	0.07	1.00
IV	0.27	1.45	5.37	0.16	0.40	2.50	0.07	0.07	1.00
V	0.65	2.00	3.08	0.61	3.56	5.84	0.16	0.27	1.69
VI				0.80	2.09	2.61	0.13	Empty	
VII				2.38	7.00	2.94			
Average for Age Group I--IV	0.11	0.19	1.73	0.06	0.15	2.50	0.07	0.09	1.29

Sex Ratio of Crappie by Individual Lakes

The sex of the crappie was recorded (Table 36) at the time the stomach was removed from the fish. The sex was usually determined easily by examination of the gonads. Some with sex questionable were found but with the possible exception of the crappie from Boomer Lake it is believed the number of questionable sexes are negligible.

The females comprised a higher percentage of all crappie taken from Sanborn Lake and Country Club Lake while males were more numerous from in Boomer Lake. However, it is believed that there were a sufficient number of males to insure fertilization of the eggs spawned by either black or white crappie.

Sex of Crappie from Sanborn Lake

There were 490 females from Sanborn Lake which comprised 53.4 per cent of the total number of crappie taken from the lake. The males numbered 360 crappie and comprised 39.3 per cent of the total. Those crappie in which it was impossible to determine the sex, numbered 67 or 7.3 per cent of all crappie collected from the lake. Most of the questionable sex were in age groups I and II. Little difficulty was experienced in sexing fish older than those in age group II.

Sex of Crappie From Boomer Lake

Boomer Lake was the only lake in which the males outnumbered the females. From a total of 530 white crappie collected there were 184 females, 262 males and 84 with the sex questionable. Percentage wise 34.7 were females, 49.5 were males and 15.8 were of questionable sex. The crappie of questionable sex were more common from Boomer Lake than elsewhere. The majority of these crappie were in age group II.

Difficulty was experienced in sexing some fish in age group II and III but the remainder were usually readily sexed throughout the year.

Table 36

The Numbers of Male and Female Crappie by Age Groups and the Percentage from the Individual Lakes Studied

Age Group	Sanborn Lake			Boomer Lake			Country Club Lake		
	Female	Unidentifiable	Male	Female	Unidentifiable	Male	Female	Unidentifiable	Male
I	55	32	25	4	3	3	4	3	5
II	250	30	212	130	64	171	16		24
III	178	5	111	26	14	55	8	3	6
IV	7		11	8	2	11	350	10	220
V			1	9	1	11	2		4
VI				6		11			1
VII				1					
Total	490	67	360	184	84	262	380	16	260
Per cent by Lake	53.4	7.3	39.3	34.7	15.8	49.5	57.9	2.4	39.7

Sex of Crappie from Country Club Lake

The number of females from Country Club Lake was slightly higher than males with 380 compared to 260 male crappie which was 57.9 per cent females and 39.7 per cent males. Those of questionable sex comprised 2.4 per cent of the crappie collected from the lake.

The highest numbers of fish of questionable sex from all lakes occurred in age group II followed in order by I and III. Since age groups II and IV were dominant in numbers for the samples collected the higher numbers of questionable sexes in these age groups could be due to the greater proportion of crappie taken.

EVALUATION OF THE DATA PRESENTED

The arithmetic mean was used to condense the data collected in order that the value of long lists of figures could be compared and evaluated. Since information from a single specimen from a population contributes little, it was felt that the arithmetical mean of numerous specimens would be more usuable in this paper and to other workers. The major range of measurements are also presented for broader comparisons.

Sanborn Lake yielded the most normal population of the three lakes studied for it was not dominated in numbers by a single age group as were the other two lakes (Tables 13, 14 and 15). Age group II comprised the greatest per cent composition of the crappie from both Boomer and Sanborn Lakes while age group IV strongly dominated the population from Country Club Lake.

There was overlapping in both total lengths and weights among some of the age groups from each of the three lakes studied (Tables 16-21), therefore, in aging the populations studied by the use of a sample of the specimens collected it was necessary to include the extreme lengths and weights of each size group rather than to select a sample based only upon a length or weight frequency graph.

May, June, July and August were the most successful months for the capture of crappie (Table 5). Good samples of stomach content volumes would undoubtedly have been obtained by collecting through March to September (Table 34) for during these months over one half of the stomachs collected contained food (Table 11). A satisfactory representa-

tion of food items eaten by crappie, with the exception of insects which were more abundant during the summer, could probably have been obtained at any time throughout the year.

The sex ratio from each lake, varied (Table 36) with black crappie having a higher percentage of females and white crappie a higher percentage of males. The sex ratio was not sufficiently askew to prevent a successful spawn in any of the lakes.

Trapping Methods

Wire traps were used most extensively to sample crappie for this study because they produced more consistant results than other devices. Traps were the only gear which was employed in all three lakes sampled, the other methods were used in only one or two lakes. The writer concurs with Buck and Cross (1952) on the advantages of wire traps over other gear. "(1), Traps could be used in a greater variety of habitats than hoop or gill nets. (2), They could be run and reset in a minimum of time. (3), Since traps are entire fixed units, sets by different persons should be comparable. (4), The traps were especially convenient for winter use because running them required minimal exposure. (5), They could be left several days if necessary without excessive damage to the equipment or injury to the sample. (6), Traps could be kept in continual operation, since they did not require periodic removal for drying. (7), They were more durable outlasting linen gill nets. (8), Most important, traps were highly effective...."

Traps had to be rewrapped with wire approximately every four months. It is believed that the use of some metal preservative, such as zinc chromate, on the wire after the traps were constructed might have re-

sulted in longer life of the wire.

The use of pig rings for securing the loose ends of the wire to the metal frame was satisfactory. Rings were superior to wire for this purpose for three reasons: (1) They were much faster to apply. (2), They do not rust as quickly as iron wire. (3), They are easy to remove from frames for rewrapping.

Hoop nets

Hoop nets were unsatisfactory for sampling crappie in the lakes under consideration. Hoop nets were used only in Boomer Lake and the fish catch was sometimes comparable to wire traps but the following factors became apparent which resulted in the discontinuance of their use. (1) It is difficult for one man to set or run hoop nets especially with a moderately strong wind. (2), Periodic drying was necessary which resulted in loss of sampling time while the nets were being dried and reset. (3), Use of the nets around submerged brush was impossible. (4), A longer period of time was necessary to run hoop nets.

Gill nets

Gill nets were used on two occassions in Country Club and Sanborn Lakes with little success. No crappie were taken in the sets at Country Club Lake and only three were taken at Sanborn Lake.

Hook and line

Hook and line fishing gave erratic results and the fish most consistently taken by this method was the green sunfish.

Seining

Seining was done in Country Club Lake using a 50 foot bag seine. Bullheads were the only fish taken. Boomer Lake was too large and had too

much shallow water near shore while Sanborn Lake was too completely filled with brush to seine.

Age, Growth, and Stomach Contents

One must consider the possibility of available food, crowding, heredity, or a combination of the factors as the reason for poor fish growth. There is no evidence that the total crappie populations of the lakes during the faster growing periods was less than the crappie populations during the years the crappie grew most slowly. From the general rate of growth and the abundance of each age group, one might assume that the total population was fairly constant during the lifetime of the specimens taken. Further, in the small Country Club Lake comparatively large numbers of crappie were removed during early sampling activities. The reduction of the number in the lake was not reflected in a more rapid growth directly afterward; however, the population was not sampled during the following growing season.

Crappie in age groups II and III, which comprised 85.6 per cent of the collection from Sanborn Lake made their greatest growth during their second year; moreover, the second year growth of these groups was more than that found for other age groups (Table 13). Similarly, crappie in age groups II and IV (Table 15), which comprised 94.5 per cent of the total crappie collection from Country Club Lake, made more growth their second year than did crappie in the other age groups from the same lake.

Johnson (1945) cites Allee in a brief resume of the harmful effects of crowding and also reports an instance in Greenwood Lake, Indiana, where "either accumulation of metabolic wastes or psychological effects would be possible causes of slow growth" which he substantiated by re-

ferring to a lake that had been drained to the creek channel thus concentrating an estimated crappie population at more than nine per square yard of water surface.

It is shown (Table 22, 23 and 24) that severe retardation of growth was not noticeable until after the first year of life and that renewed growth of importance was not resumed until the fish reached a total length of six inches and began to feed upon other fish. It seems likely that the greatest number of fish of similar size would exist during the first year of life for each age group. One might assume that the greatest competition for space should occur during the first year, but it was during this time that the fish made their best growth. Therefore, it seems necessary to explain the poor growth from some cause other than space.

It seems likely that the crappie population from each lake was derived from common ancestry used in stocking that body of water and that variations within the population would be normal variations likely to appear in any similar population where artificial selection had not been practiced. Therefore, it seems improbable that poor growth was the result of inheritance.

All crappie under six inches total length ate the same type of food which was composed of items of small size. Smaller fish require less volume of the same kind of food to satisfy their needs than larger fish do. If each fish ate the organisms one at a time, the smaller fish could obtain their fill with less effort and in less time than the larger fish could and when food organisms are scarce the small fish still might obtain a diet sufficiently satisfactory to permit growth while larger fish would obtain only a sustaining died. Since the fish of age group I were

smaller than individuals of the other age groups and their growth rate was greater, it would seem that they possessed the ability to acquire a nourishing meal of the same type of food more readily than did the members of the other age groups. The difference in rate of growth for the age groups would then appear to be the result of the availability of usuable food and its nutritive value and not the result of either crowding or heredity.

Growth made by the black and the white crappie, in the lakes studied, was not exceptional. However, the growth does compare favorably with that made in many other lakes. Table 37 and 38 contain the total lengths of crappie for various states, Carlander (1950), in which the direct proportion method was employed for determining the length of fish for each year of life.

Black crappie from Sanborn Lake, at completion of the first annulus, were smaller than those recorded from most of the other lakes, except for the "poorest lake" in Ohio. During the second growing season, however, crappie from Sanborn Lake made greater growth and were slightly longer than the crappie from the "average" lake in Ohio and about one half the length of crappie from Norris Reservoir, Tennessee. Throughout the remainder of their life they averaged slightly longer than crappie from the "average lake" in Ohio and one to four inches shorter than those from the "best lake" in Ohio, Norris Reservoir and Onized Lake, Illinois.

Table 37

Comparison of Lengths of Black Crappie At Completion of Each Annulus, From Sanborn Lake and Country Club Lake, With Those Lengths Shown For Black Crappie From Some Other Lakes

Lake	Average Calculated Total Length in Inches at Each Annulus						
	1	2	3	4	5	6	7
Sanborn Lake	1.8	4.9	6.8	8.0	10.0		
Country Club Lake	2.3	4.0	4.7	4.8	6.3	6.4	
Ohio, "poorest lake"*	1.4	3.5	5.0	6.6	8.3	9.0	
Ohio, "average lake"*	2.2	4.7	6.3	7.8	9.2	9.9	11.5
Ohio, "best lake"*	2.7	5.2	7.8	10.1	13.0		
Illinois, Onized lake*	3.4	8.0	11.4				
Tennessee, Norris Resv.*	3.2	9.5	11.8	12.7	13.7		

*From Carlander, 1950

Black crappie from Country Club Lake, at completion of the first annulus, were 0.1 inches longer than crappie from the "average lake" in Ohio and 0.4 inches shorter than crappie from the "best lake" in that state. Crappie from Country Club Lake, at completion of the second annulus were 0.5 inches longer than the "poorest lake" in Ohio and 0.7 inches shorter than the crappie in the "average lake" in that state. Poor growth was shown by the crappie from Country Club Lake although

during the fifth growing season they increased 1.5 inches over the previous year.

Records from Canton and Grand Lakes in Oklahoma give a greater first year growth but the white crappie from Boomer Lake surpassed those reported from other lakes. However, during the period from the first growing season until the completion of the fourth annulus the white crappie of all other lakes except the "poorest lake" in Ohio were consistently longer.

The data (Tables 22, 23 and 24) concerning the length weight relationship of crappie in the three lakes studied, show that both the black and the white crappie make essentially equal growths during their first year of life, white crappie being slightly longer. Retarded growth or stunting occurred following the first year of life. Growth continued to be retareded until the fish reached approximately six inches in total length when accelerated growth began.

Black crappie from Sanborn Lake reached approximately six inches in total length during their third year of life when a more rapid increase in weight occurred. Average increase in length was greatest during the second growing season and was rather uniform throughout their life.

White crappie from Boomer Lake reached approximately six inches in total length during their fourth year of life and the four year old fish showed a more rapid increase in both weight and total-length-at-capture.

A few crappie from Country Club Lake reached the advantageous length of six inches during the fifth growing season when a more rapid increase in weight and total-length-at-capture occurred.

Six inches in total length was the approximate length or critical

length when crappie began to feed on fish. Two specimens, 5.5 and 5.3 inches, were the only crappie less than six inches long which had fish in their stomach when captured.

Table 38

Comparison of Lengths of White Crappie, At Completion of Each Annulus, From Boomer Lake with Those Lengths Shown for White Crappie From Some Other Lakes

Lake	Average Calculated Total Length in Inches At Each Annulus						
	1	2	3	4	5	6	7
Boomer Lake	2.4	4.1	5.6	7.6	10.1	10.8	15.4
Ohio, "poorest lake"*	1.9	3.4	4.8	5.8	8.8		
Missouri, Lake of Ozarks*	2.2	4.8	6.4				
Iowa, East Lake*	2.1	5.3	6.7	7.7	8.4	9.1	10.7
Okla. Canton L. (Buck & Cross, 1951)	3.5	6.5	8.9	7.8	11.1	12.2	
Okla. Grand L. (Game & Fish Dept. Fish Mgt. Rept No. 18)	3.1	5.3	7.2	10.5	13.3	14.4	
Tenn. Cherokee Resv. (Stroud 1949)	1.5	8.7	11.6				

*From Carlander (1950)

Food and Body Weight

Food of crappie can only be considered herein as the food that was found in the stomach at the time of capture and cannot be considered as

the total food eaten. Also it must be remembered that the food sampling method offers no information concerning the rate of food digestion or the frequency of feeding. The data offers information on the food contained in a sample of the population and should be indicative of food values for the whole population.

The comparison of food eaten and body weight was made through age group IV because: (1), they included the major part of each sample for all lakes; (2), representation was small in the sample of the older age groups, and (3), the number of specimens from the older age groups was too small to justify comparisons of food eaten per pound of body weight.

Crappie from Boomer Lake contained 2.50 cubic centimeters of food, from Sanborn Lake 1.73 cubic centimeters of food and from Country Club Lake 1.29 cubic centimeters of food per pound of body weight (Table 35).

Crappie in Sanborn Lake made better growth than did those from Boomer or Country Club Lakes. It is interesting to note that the crappie from Sanborn Lake contained less food per pound of body weight than those from Boomer Lake, but crappie from both Boomer and Country Club Lakes were stunted. The crappie in Country Club Lake were so severely stunted that their general appearance showed malnutrition. They were extremely thin of body and the eyes were enlarged in proportion to the remainder of the body, as though the eyes had continued to grow while the body remained essentially the same size.

There seems to be no reason for stunting in crappie in the lakes studied on the basis of volume of food eaten. However, the data in Tables 7 and 8 shows there was considerable differences in the kinds of food eaten and hence probably differences in nutritive value. A cow fed

prairie hay can gain more weight by the use of cottonseed cake supplement than by feeding extra prairie hay and no supplement.

Crappie from Sanborn Lake contained greater numbers of most food items but as the average weight of the fish was greater the relation of food volume to body weight was smaller. The crappie from Sanborn Lake contained 80.7 per cent of all Ephemerida found in fish stomachs, 80.2 per cent of the Diptera, 47.0 per cent of the Coleoptera, and 43.7 per cent of the unidentified Insecta. The diet seems to show a higher protein ration.

The crappie in Boomer Lake possibly were unable to obtain the quality of food necessary for better growth but were able to partially offset the lack by greater volume intake. The food taken was principally smaller invertebrates.

Crappie in Country Club Lake lacked both food volume and quality of food necessary for satisfactory growth which resulted in severe undernourishment.

It is believed that crappie in Boomer and Country Club Lakes were eating a bare maintenance diet, nutritionally, and the crappie in the latter lake were unable to counteract the harmful effects by a greater intake of food. The fact that crappie in Country Club Lake averaged 0.01 pounds heavier than those from Boomer Lake is not surprising as they were predominately four year old fish and those in Boomer were predominatly two years old.

The data presented herein seem to show that the quality of the food eaten is more important than quantity in producing rapid growth in fish. It is believed that food studies based on volume of stomach contents,

number of organisms present or the frequency of their occurrences are inadequate for testing the nutritional effects of a diet.

The data also show that undernourished crappie, regardless of species or lake, grew faster when they reached the size at which they preyed on fish. It is believed that the more satisfactory growth was due to the relatively high nutritional value of fish as a food.

Investigations which determine the nutritional value as well as the items and volume of foods eaten should add valuable knowledge that could be used in fish management.

Since stunting of crappie is rather common and it seems probable that the stunted condition is due to undernourishment, two methods for controlling the situation in a lake present themselves. Additional food could be provided to properly feed the fish, or the crappie populations must be controlled at a number, sufficiently low, that the food produced will feed the remaining fish.

Fertilization to supply additional food would serve as a temporary measure without proper population control. Fertilization is too expensive to be practical in most lakes and information is too limited concerning the benefits to crappie.

The stocking of lakes with suitable forage fish, such as the gizzard shad, might provide supplemental food and thus permit a greater yield of crappie of more desirable size. Studies concerning both the values of forage fish and the effects of their added competition with crappie for similar food would be valuable.

Fish in impoundments react similarly to terrestrial animal crops. If a farm with 100 acres of land that is capable of supporting 25 cattle

finds 1000 head grazing the pasture, the farmer must remove a large portion of the herd and continue to harvest the increase in order to maintain a maximum sustained yield. Fecundity in fish is much greater than in cattle; therefore, an impoundment, in a short time, can gain a population too large for the available food and will require a heavy harvest.

Increased harvest can be attained in several ways. The encouragement of fishing, particularly selective fishing, would tend to control the population. The removal of restrictive laws which permit or limit the harvest of small crappie should increase the harvest and be conducive to the production of more rapidly growing fish. The establishment of markers or buoys at locations to which crappie concentrate, or the installation of a limited number of brush shelters to concentrate the fish usually permits a greater harvest. Fishing did not provide sufficient harvest from the three lakes studied, therefore additional harvesting methods are needed. The addition of predaceous species to the lakes such as channel catfish, flathead catfish, and white bass, where they do not already occur, should assist in a continued harvest.

When the fish population cannot be properly harvested through fishing and the action of predators, poisoning the fish in selected areas of the lake will decrease the population.

SUMMARY

1. The rate of food eaten in relation to rate of growth of both the black and the white crappie was studied in specimens collected from three Oklahoma Lakes, to learn if food acquired was the dominate factor influencing growth.

2. Wire traps gave better results than other devices for the collection of crappie in the lakes studied.

3. A total of 2103 crappie with a combined weight of 206.18 pounds were collected and the measurements analyzed.

4. Each lake was found to contain a numerically dominant age group but each varied in the degree to which the population was dominated. Crappie in age group II were more numerous in two lakes while those in age group IV comprised the majority of all the specimens collected from the third lake.

5. The mean length of crappie from Sanborn Lake was 6.1 inches, Boomer Lake 5.7 inches and Country Club Lake 5.4 inches.

6. The mean weight of crappie from Sanborn and Boomer Lakes was 0.11 pounds and 0.07 pounds from Country Club Lake.

7. The average cubic centimeters of food contained in crappie stomachs from the lakes was: Sanborn, 0.19; Boomer, 0.46; and Country Club, 0.09.

8. There was little correlation shown between volume of stomach content and the seasons of the year.

9. Crappie from Sanborn Lake contained the major percentage of all insects recorded.

10. Invertebrate eggs were numerically the most important item found in crappie stomachs. A total of 1,071, 401 invertebrate eggs were recorded.

11. A greater percentage of females than males in the black crappie was collected. Males were more numerous than females in the sample taken of white crappie.

12. Stunting of crappie, in the lakes studied, was not noticeable until after the first year of life. After stunting occurred, retarded growth continued until the crappie reached a length of approximately six inches. When the crappie reached a length of six inches a more rapid growth was shown.

13. Crappie, from the lakes studied, did not prey on fish until a length of six inches was attained.

14. Stunted crappie, from one of the lakes studied, contained a greater volume of food per pound of body weight than did crappie from other lakes in which growth was better.

15. A difference in diet was shown between stunted crappie and those in which growth was more satisfactory. Evidence seems to show that the quality of the diet rather than the quantity was responsible for growth made.

16. Some suggestions are given for the prevention and correction of stunted populations.

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