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# THE FEEDING ECOLOGY OF THE BLACK AND WHITE CRAPPIES IN BEAVER RESERVOIR, ARKANSAS, AND ITS EFFECT ON THE RELATIVE ABUNDANCE OF THE CRAPPIE SPECIES

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## ABSTRACT

Stomachs of black and white crappies (*Pomoxis nigromaculatus* and *P. annularis*) collected during the early impoundment (1964-1967) and the late impoundment (1969-70) periods from Beaver Reservoir were analyzed. Black crappie were dominant in the early impoundment period, whereas white crappie was the dominant crappie species in the late impoundment period. During the early impoundment period, large numbers of earthworms (January to April) and shad (during the remainder of the year) were consumed by both species, although white crappie appeared to concentrate on shad even when earthworms were available. During the late impoundment period 0-age fishes, zooplankton, and aquatic insects comprised the diet of both species. However, white crappie adults concentrated on fishes all year round, whereas black crappie adults concentrated on benthic insects in the spring and fishes in other seasons. The availability of earthworms and benthic insects in the early impoundment period and their lack of availability in the late impoundment period, along with the deterioration of much of the submerged terrestrial vegetation, appear to have been the major factors in determining the dominance of the two crappies.

## INTRODUCTION

The black crappie and the white crappie display an interesting pattern of relative abundance in Beaver Reservoir. The early impoundment period (1964-1967) was marked by a large black crappie population and a relatively small population of white crappie; by 1969, the relative abundance of the two species had been reversed (South Central Reservoir Investigations (SCRI) unpublished creel data).

This paper describes the food habits of the black and white crappies in the early (1964-1967) and late impoundment (1969-1970) periods of Beaver Reservoir. Food habits were evaluated in relation to habitats and their influence on the relative abundance of the crappie species with the age of the reservoir.

## DESCRIPTION OF LAKE

Beaver Reservoir (36°05′ to 36°27′N93°47′ to 94°06′W), a steep-sided 11,420-hectare impoundment, is the uppermost main stem reservoir on the White River, northwest Arkansas. It was impounded in December 1963 and reached power pool level in 1968. At the power pool level, the reservoir stretches 118 kilometers upstream. Mean and maximum depth are 17.7 and 65.9 meters, respectively.

## METHODS AND MATERIALS

During the early impoundment period, 377 black and 9 white crappies were collected by midwater trawling, electrofishing, angling, and trap netting. In the late impoundment period, 148 black and 847 white crappies were collected by similar methods. The majority of fishes collected in both periods of this study were obtained with a modified version of the British Columbia midwater trawl (Houser and Dunn, 1967; Houser and Netsch, 1971). Electrofishing samples were collected with a boat-mounted 230-volt AC generator. Trap netting, which was restricted to the months of November to March, was conducted with Great Lakes Ederer type nets. Angling was conducted with artificial lures. Nine specimens were collected by gill nets (2.5 to 7.5 cm bar mesh), and the stage of digestion of the stomach contents of these was comparable to that of fishes taken by active methods of capture.

Collections were made throughout the length of the reservoir during both impoundment periods. However, during the late impoundment period, collections by all methods except midwater trawl were concentrated in the upper half of the reservoir because of the greater populations present there.

Crappies were either preserved immediately after capture in 10% formalin, or placed on ice and the stomachs removed before being preserved. In order to reduce the frequency of regurgitation, most fishes captured in the latter half of the late impoundment period were placed on ice prior to being preserved in formalin (Doxtater, 1963). Regurgitation by specimens captured in the first half was not considered to be of great importance as it was usually limited to small proportions of the stomach contents. Empty stomachs were rare throughout the study.

During July and August 1969, crappies were grouped and analyzed according to species, size group, and place and date of capture. Subsequent samples were analyzed individually to facilitate statistical analysis. Only yearling and older crappies were included in this study.

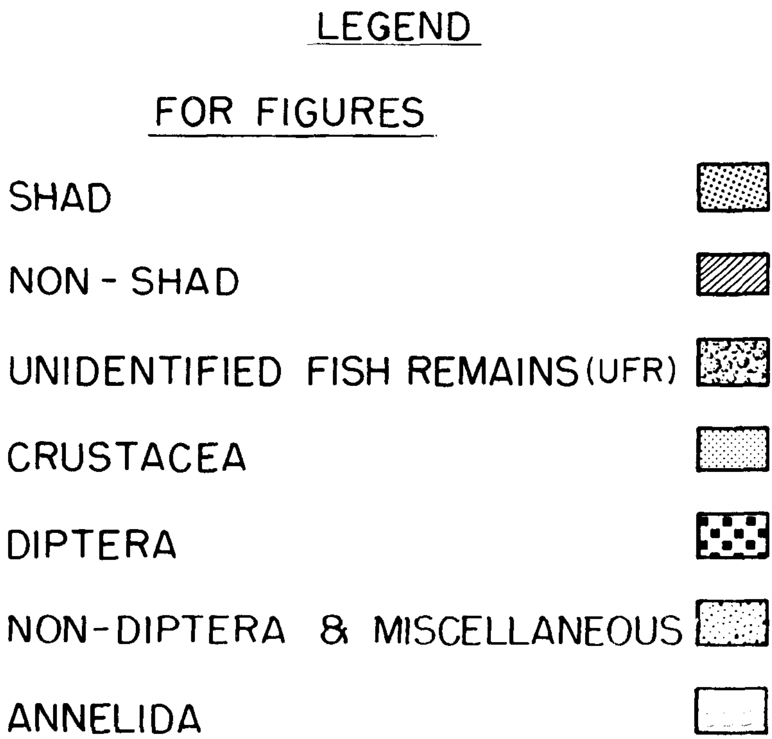
Large food organisms were identified, counted, blotted, and measured volumetrically (early impoundment period) or gravimentrically (late impoundment period). Small organisms were subsampled using either a Sedgewick-Rafter counting cell or by counting the organisms in approximately half of the contents by weight from each fish. Average weights or volumes of small organisms were computed every three months.

To compare the proportions of general categories constituting the diets of the crappies of the two impoundment periods, the seasonal percent compositions were determined from volumes (early impoundment period) and weights (late impoundment period). Volume to weight conversion factor of 1.03 was obtained for the forage fishes in the diet of the late impoundment crappies, but the conversion factor for the early impoundment period was not available. Conversion factors for other food items could be different, but the error resulting from direct proportional conversion was not felt to be significant. The sample size of each month was weighted to make it equal to that of each of the other months of a season.

## RESULTS

### *Seasonal Comparisons between Crappies of the Early and Late Impoundment Periods*

During all four years of the early impoundment period annelids (earthworms) dominated the black crappie diet in both winter and spring seasons (Figure 1). Crustaceans and immature dipterans were of some importance in the winter months of 1964 and 1965. In the winter months of 1966 and 1967, shad and unidentified fishes were second to earthworms in importance. In the summers of the early impoundment period, shad made up 88 to 90% of the diets of the black crappie. Non-shad fishes and unidentified fishes were second in importance. The greatest divergence of the food habits of the 1966 and 1967 years from those of 1964 and 1965 was in the fall months. In this season in the first two years, immature dipterans made up 81% of the diet, followed by crustaceans. In 1966 and 1967, the fall diet was composed primarily of shad.



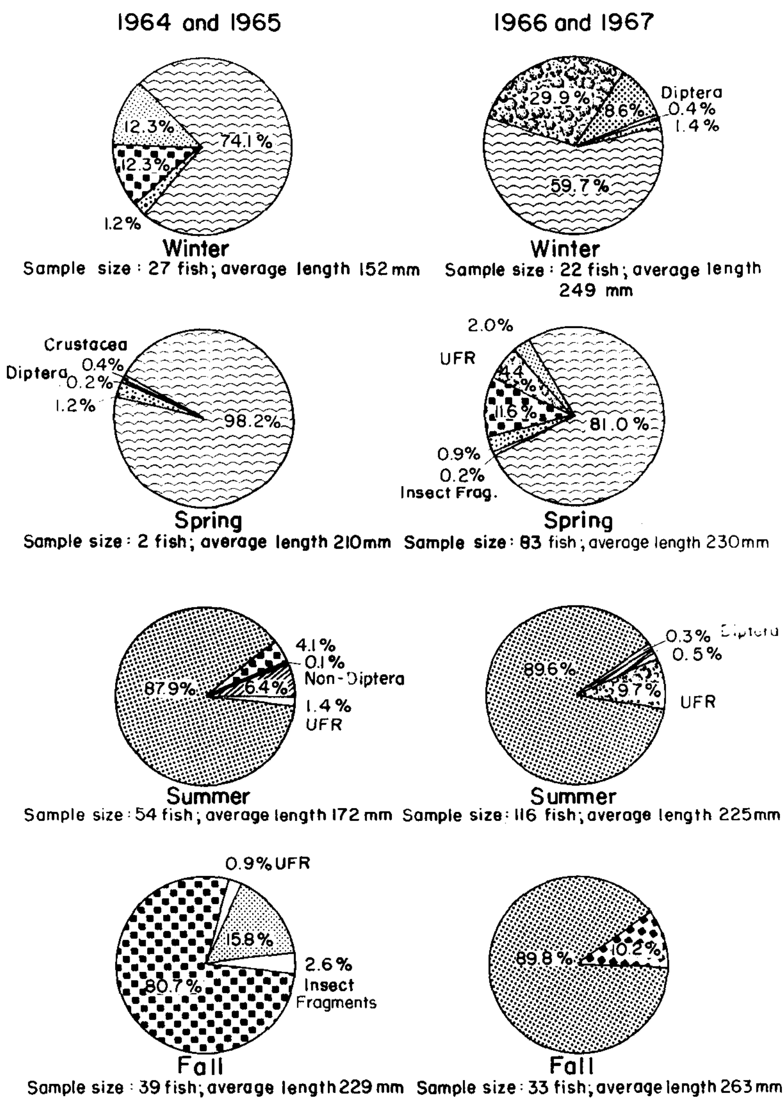



Figure 1. Seasonal Food Habits of the Black Crappie in Beaver Reservoir during the Early Impoundment Period, 1964-67.

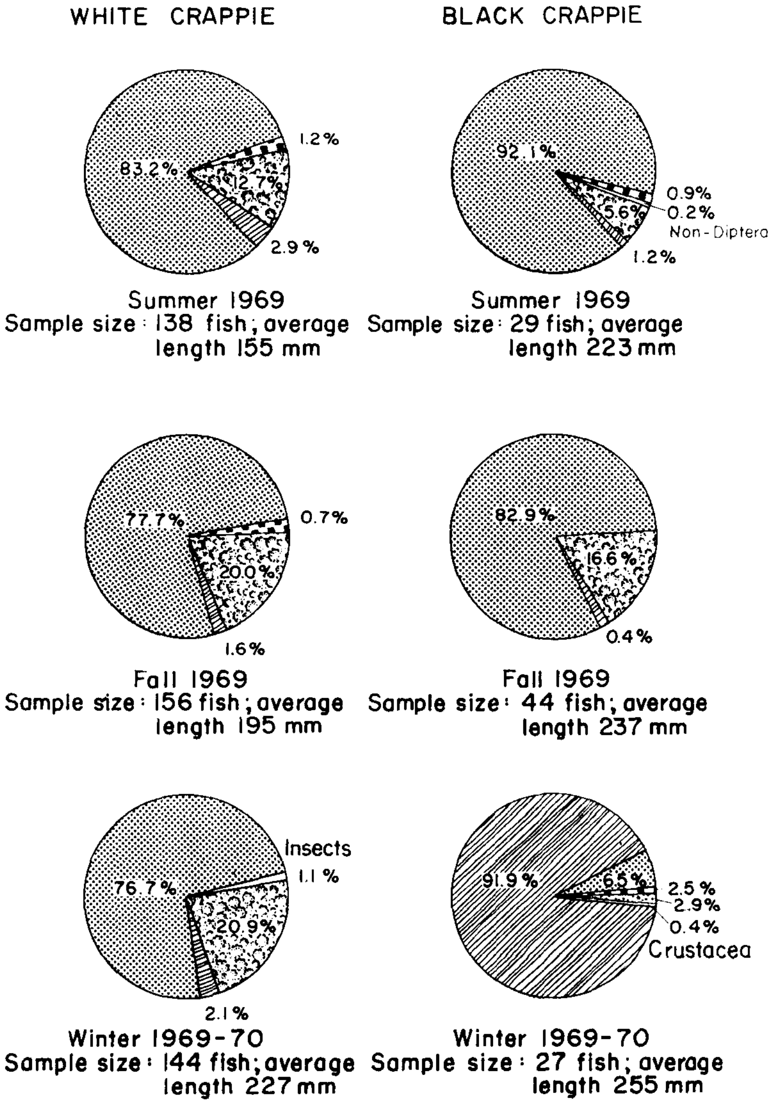



Figure 2. Seasonal Food Habits of Both the Crappie Species in Beaver during the Late Impoundment Period, 1969-1970.

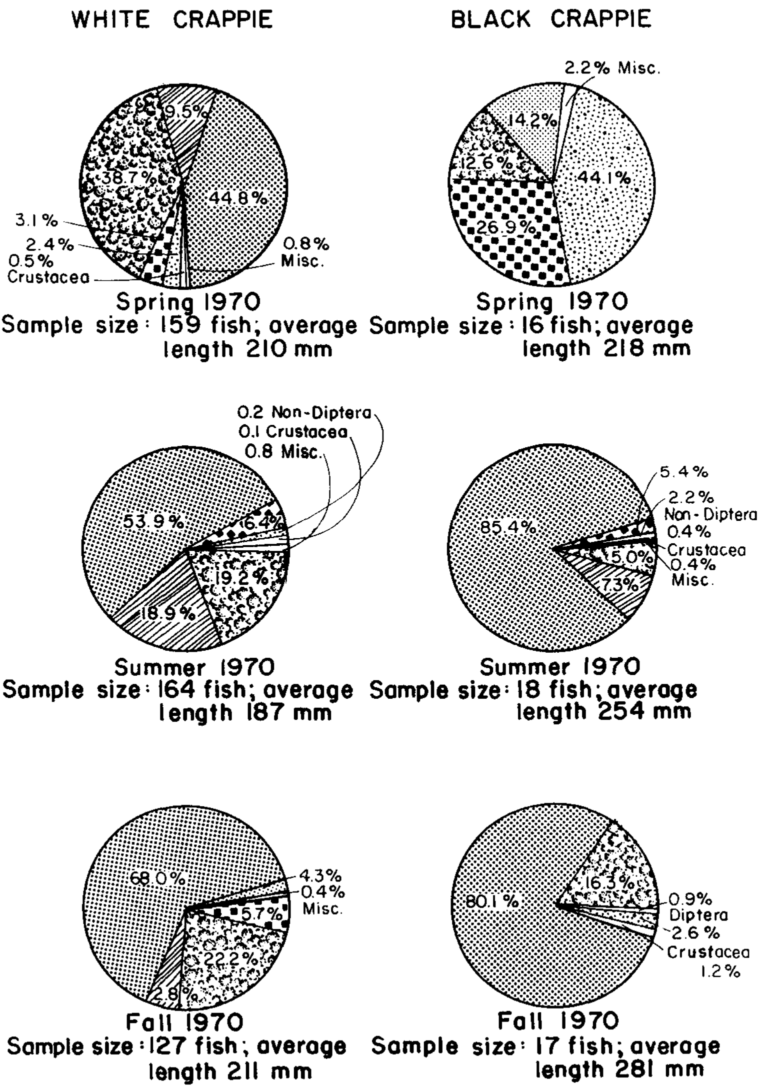



Figure 2. Seasonal Food Habits of Both the Crappie Species in Beaver during the Late Impoundment Period, 1969-1970.

The stomach contents of a sample of nine white crappie (not illustrated) taken in the winter of 1965 diverged from those of the black crappie of this season in that fishes (43.9% of the volume, 22.8% being shad) were the dominant category. Earthworms (28.5%) and insects (27.6%) were also present. The average length of white crappie in this sample was 236 mm, somewhat greater than that of the black crappie for the 1964 and 1965 springs.

In the late impoundment period (Figure 2), fishes increased in importance. Shad predominated in the diet of white crappie from the summer of 1969 through the fall of 1970. In the diet of the black crappie, shad were predominant in the summer and fall of 1969; but non-shad fishes predominated in the following winter and insects, led by non-dipterans, in the spring of 1970. Fishes (unidentified fish remains) declined to only 12.6% of the black crappie diet. In the summer and fall of 1970, shad were again predominant in the diet of the black crappie. In the summer and fall seasons of 1969 and 1970, shad and total fishes made up larger proportions of the black crappie food than it did of the white crappie food. The average lengths of the black crappie were greater than those of the white crappie, reflecting the scarcity in the samples of younger black crappie.

A comparison of the food habits of the crappies of the two impoundment periods shows that the diets of both species were consistently dominated by fishes (92% and more) in the summer, with shad the predominant subgroup. A similar pattern exists in the fall seasons except for those of 1964 and 1965, when insects predominated. Differences in food consumed were greater in the winter, with fishes being of greatest importance in the late impoundment period. In the winter months of 1964 and 1965, the black crappie did not consume any fishes; however, they were of small average length. Earthworms dominated the diet when they were available in the early impoundment period (winter and spring). In the spring season of the late impoundment period, the black crappie concentrated on insects, especially non-dipterans, while the largest white crappie continued to feed almost exclusively on fishes. However, benthic insects formed the major portion of the diet of 135-234 mm white crappie in April. Smaller crappie (90-134 mm) of both species utilized immature *Chaoborus* and chironomids throughout the year, but the predation by this size group appeared to be entirely on free-swimming forms.

*Feeding Selectivity of Crappies Collected by Midwater Trawl*

Determining the preferences of a species for various foods helps to define the niche of that species more precisely. Ivlev (1961) suggested the index E (electivity) expressed as $E = (r-p)/(r+p)$ where r is the relative proportion of any food category in the ration and p is the relative proportion of the same category in the environment. E ranges from +1 to -1, and 0 indicates no electivity registered.

Electivity of crappies for various species of fishes was determined by using 350 yearling and older crappies taken by midwater trawl in Beaver Reservoir during July through October of 1969 and 1970 in conjunction with all fishes collected by Houser (unpublished) from the same trawl runs (Table 1). Young-of-the-year of only two genera or species were encountered in trawl catches but not in crappie stomachs. These were *Morone chrysops* (white bass) and *Lepomis* sp. White bass were omitted from the calculations because of their rarity in midwater trawl samples and also because of their relatively larger size as compared to young-of-the-year shad. However, *Lepomis*, sp. were included in total non-shad fishes because they may have been among the occasional unidentified centrarchids found in the crappie stomachs.

The characteristic gizzard of the shad endures digestion better than characteristics of any other fish in this study. To reduce the bias that this produces in favor of shad, all shad in very advanced stages of digestion were eliminated from this analysis.

Table 1. A. Electivity Results for July to October of 1969.
Part 1. Shad and non-shad electivity.

| | Shad | Non-Shad |
|---|---|---|
| Number of fish in ration of white crappie | 277 | 4 |
| Number of fish in ration of black crappie | 99 | 4 |
| Number of fish in environment | 160808 | 1433 |
| E of white crappie | -0.003 | 0.235 |
| E of black crappie | -0.015 | 0.630 |

Part 2. Species and genus electivity.

| | Threadfin shad | Gizzard shad | Crappies | Brook silversides |
|---|---|---|---|---|
| Number of fish in ration of white crappie | 64 | 1 | 1 | 0 |
| Number of fish in ration of black crappie | 24 | 2 | 2 | 0 |
| Number of fish in environment | 151709 | 9099 | 454 | 979 |
| E of white crappie | 0.018 | -0.574 | 0.689 | -1.000 |
| E of black crappie | -0.043 | 0.120 | 0.925 | -1.000 |

Table 1. B. Electivity Results for July to October 1970.
Part 1. Shad and non-shad electivity.

| | Shad | Non-Shad |
|---|---|---|
| Number of fish in ration of white crappie | 63 | 46 |
| Number of fish in ration of black crappie | 24 | 4 |
| Number of fish in environment | 136919 | 8000 |
| E of white crappie | -0.241 | 0.769 |
| E of black crappie | -0.049 | 0.443 |

Part 2. Species and genus electivity.

| | Threadfin shad | Gizzard shad | Crappies | Brook silversides | Lepomis |
|---|---|---|---|---|---|
| Number of fish in ration of white crappie | 2 | 27 | 27 | 2 | 0 |
| Number of fish in ration of black crappie | 0 | 16 | 2 | 0 | 0 |
| Number of fish in environment | 4155 | 132764 | 5291 | 1295 | 1414 |
| E of white crappie | 0.202 | -0.326 | 0.855 | 0.590 | -1.000 |
| E of black crappie | -1.000 | -0.015 | 0.505 | -1.000 | -1.000 |

Table 2. Densities and Average Lengths of Young-of-the-Year of Prey Species in Beaver Reservoir, 1970*.

| | June 18 | | July 31 | | September 25 | |
|---|---|---|---|---|---|---|
| | avg. length (mm) | den-sity** | avg. length (mm) | den-sity** | avg. length (mm) | den-sity** |
| Gizzard Shad | 30 | 23.4 | 56 | 43.6 | 92 | 4.1 |
| Threadfin Shad | -- | -- | -- | -- | 56 | 18.1 |
| White Crappie | 21 | 82.0 | 44 | 0.5 | 77 | 0.6 |
| Brook Silversides | 14 | 4.9 | 48 | 6.2 | 68 | 2.7 |

*All data from Alfred Houser (unpublished) except for gizzard shad (from Houser and Netsch, 1971).
**Number per $1000m^3$.

The data for both years and both species consistently showed a strong preference for non-shad (Table 1). Although in 1969 the numbers of non-shad in the rations were low, they were more plentiful in 1970 in the white crappie diet. In the species-generic data, the E-values for young-of-the-year crappies were consistently high in both years for both species.

Threadfin shad electivity values were variable especially in 1970 when it was present in very low numbers in the ration. Threadfin young-of-the-year did not appear in numbers in the lake until September 1970 (Houser and Netsch, 1971). This contributed to its rareness in the rations and probably accounted for the -1.0 value for the black crappie. If this -1.0 is omitted, the threadfin displays a much higher average electivity value than the gizzard shad. The white crappie with its larger sample size displayed a slightly positive electivity in both years. The white crappie showed strong selectivity against the gizzard shad both years, while the black crappie showed positive electivity in 1970.

The brook silversides electivity values are more difficult to interpret. Neither crappie species contained this fish in 1969; but in 1970 when the brook silversides formed a larger percent of the small-fish population, two were found in the stomachs of white crappie. Thus, it attained one highly positive value and three -1.00 values for electivity. The trawl catches indicated that there was an increase in the portion of the fish population represented by brook silversides from 1969 to 1970. If the sample of white crappie for 1970 had been larger, the positive electivity, judging from its large positive value, would probably have remained.

## DISCUSSION

*Utilization of Fishes*

Throughout the study, fishes were a major food for both species. This was especially true during the summer when much of the growth occurred. As suggested by Molnar and Tolg (1962), the much more rapid rate of digestion in fishes in summer as a result of high temperatures permits much faster assimilation of food. Consequently, the foods consumed during the summer are apparently of much greater importance on a yearly basis than the seasonal percentage composition would indicate. In addition, feeding intensity (weight of stomach contents divided by weight of fish) tended to be highest in July, September, and October in larger black and white crappies in Beaver Reservoir (Ball, 1972).

The predominance of threadfin shad in the diet of both crappies in 1969 is explained by this species' shorter average length (57 mm in October) as compared to gizzard shad (81 mm) and also to the much greater abundance of threadfin shad in that year (Houser and Netsch, 1971).

The threadfin shad did not appear again in significant numbers in Beaver Reservoir until the fall of 1970 due to a severe die off of this species in the winter of 1969-70. Consequently, in the summer of 1970, the gizzard shad and white crappie were the dominant species in the young-of-the-year population (Table 2). This difference accounts for much of the change in the fish portion of the diet in the summer compared to the previous year.

Since threadfin shad remained in the preferred size range of prey fishes for adult crappies (30 to 65 mm based on fishes found in stomachs) for a longer period than gizzard shad in 1969 and 1970, they were more vulnerable to predation. Selection for gizzard shad by black crappie in both years reflects a preference of larger predators for larger prey. Black crappie were larger in both years and selected gizzard shad over threadfin shad.

In July 1970, when the white crappie (235-348 mm) consumed more crappies than shad, the average length of white crappie young-of-the-year was 12 mm less than that of gizzard shad (Table 2). Silversides were also smaller than gizzard shad, and surpassed crappie in density during late June and July. *Lepomis*, the only young-of-the-year which were comparatively common in the trawl samples but not identified from stomach contents, were of smaller size than the white crappie (Houser, unpublished). This genus may have been among the occasional "unidentified centrarchids" in crappie stomachs.

The consistently high electivity values shown for young-of-the-year crappies in 1970 appears to be related to the slower crappie growth as compared to gizzard shad in that year. However, this does not explain the electivity value for crappies captured in 1969 because the dominant shad in that year, the threadfin, was of shorter average length (44 mm, July-August, as calculated from Houser and Netsch, 1971) than the young-of-the-year crappies caught concurrently by midwater trawl (47 mm).

Domanevskii (1968) stated that mobility rather than body height probably determines accessibility of fishes to pike (Esocidae) predation. Lewis and Helms (1964) found that differences in utilization of various fishes by largemouth bass (*Micropterus salmoides*) was as great between species of the same genus as it was between different genera. This was particularly true for the genus *Lepomis*. The relatively deep-bodied, gibbose crappies (Keast and Webb, 1966) would presumably be slower swimmers than the more nearly fusiform shad. This could account for the selectivity for crappies over threadfin shad.

One of the most distinct trends noted in the food habits of crappies was the tendency to feed on the largest potential prey available. The continuous concentration of white crappie (235-348 mm) on fishes shows a tendency to seek the most efficient size of prey. Also, the utilization of young-of-the-year fishes by all crappies during the summers emphasized this trend. Immature *Chaoborus*, although exceeded in abundance in plankton samples in August and September 1970 by the much smaller cyclopoid copepods (SCRI, unpublished), was seven times more abundant in smaller (50-134 mm) white crappie stomachs than copepods. Where crappie food habits have been investigated with the electivity index (Seifert, 1968; Unkenholz, 1971; this study), results consistently show that selection does take place. Size preferences appear to be one of the most important factors behind this selectivity.

*Utilization of Terrestrial and Benthic Organisms*

The preponderance of earthworms in the black crappie diet during early impoundment was paralleded by the results of an early impoundment study conducted on other centrarchids in Beaver Reservoir. Mullan and Applegate (1970) found terrestrial food, of which 78% of the volume were earthworms, was the predominant category in the stomachs of three *Lepomis* spp. and in 101-200 mm largemouth bass in the winter and spring. These two seasons encompassed most of the period of inundation of terrestrial habitat by the expanding reservoir.

April appeared to be the month of peak utilization of insects by larger individuals of both species. Iovino (1967) observed that numerically the populations of most benthic insects utilized by crappies were minimal in April. However, this occurred when many benthic insects had grown to their maximum size prior to emergence. Consequently, the availability of benthic insects increases.

Other authors have reported similar findings in the utilization of benthic insects by crappies. Reid (1949) observed that most of the non-dipteran insects consumed by black crappie were taken in the spring. Mitchell (1941), Finkelstein (1960), and Hansen (1951), in comparative studies of the crappies, also observed that larger black crappie had a greater preference for benthic insects, white crappie for fishes.

However, Hoopes (1960) found white crappie to feed predominantly on insects, particularly *Hexagenia* nymphs, in the Mississippi River. Unkenholz's (1971) pond study indicated a diet primarily of aquatic insects, entomostraca, and fishes, in that order, for white crappie.

*Changes in the Dominant Crappie Species*

No simple relationship between water clarity and the predominance of species of crappies appears to hold for Beaver Reservoir. Mean water clarity, as determined from Secchi disk readings taken at monthly intervals over twelve-month periods from six stations (located from Hickory Creek to the dam) was 1.8 meters in 1965, 2.1 meters in 1966, and 3.0 meters in 1967 (from unpublished SCRI data). However, large populations of both young-of-the-year and older black and white crappies during the late impoundment period, as indicated by midwater trawl catches, were at Hickory Creek and stations upreservoir from Hickory Creek. Transparency data collected from this portion of the reservoir (specifically, four stations from Blue Springs to and including Hickory Creek) from July 1970 through July 1971 showed an average transparency reading of only 1.2 meters (Department of Civil Engineering, University of Arkansas, unpublished). During the same period the average transparency value for six stations from Hickory Creek to the dam was 2.9 meters. Because the initial predominance of the black crappie has now been replaced by the white crappie in all regions of the reservoir, inspite of a trend toward the clearer water in the middle and lower regions of the reservoir, it is concluded that water quality is not the determining factor of crappie relative dominance in Beaver Reservoir. The preference of both species for the upper region (approximately Hickory Creek and above), where water clarity apparently has not greatly changed since impoundment, and the failure of the black crappie to maintain its predominance in the middle and lower regions, where water clarity has increased, lend support to this conclusion.

In Beaver Reservoir, the change from an early dominance of black crappie to the present dominance of white crappie appears to be associated with the deterioration of terrestrial vegetation which was flooded during impoundment. SCRI (unpublished) data from 1964 to 1966 show that black crappie were taken in large numbers by electrofishing in flooded fields, second-growth trees, and other vegetation. By 1969, terrestrial herbacious vegetation was gone and the dead trees although still standing in the reservoir, were in advanced stages of deterioration. Also, aquatic vegetation is scarce in the reservoir.

Ridenhour (1960) found a difference in the preferred habitats of the young-of-the-year crappies in an Iowa Lake. White crappie were found in large numbers in deep water, while black crappie preferred the aquatic vegetation near shore. In Beaver Reservoir prior to 1967, large numbers of young-of-the-year black crappie were caught near shore with 20- and 50-foot bag seines (SCRI, unpublished).

However, trawling also yielded large numbers of young-of-the-year black crappie (SCRI, unpublished). During the late impoundment period, young-of-the-year black crappie were scarce in trawl samples. An attempt at seining in August 1970 with a 20-foot seine netted eight young-of-the-year, all of which were black. It is possible that the deterioration of terrestrial vegetation had a more decisive effect on young-of-the-year black crappie than on adults. The young-of-the-year probably used the vegetation for cover as well as food.

Trautman (1957) indicated aquatic vegetation in streams and old impoundments was more important for black crappie than for white crappie. Goodson (1966) reported that black crappie sometimes predominated in reservoirs with clear water and little vegetation, but in such lakes it is seldom numerous enough to provide a good fishery. Since the adult black crappie seems more able to utilize benthic insects than the shite crappie, this situation would be expected in reservoirs with small young-of-the-year fish populations but with moderately large numbers of benthic insects.

In summary, the most important factor in bringing about the change in species dominance in Beaver Reservoir was the attainment of powerpool level in 1967, after which no additional large areas of terrestrial vegetation with associated invertebrate organisms were flooded by the reservoir, and that which was already flooded rapidly began to deteriorate. Whether the loss of vegetation was more important to the young-of-the-year or to the older black crappie is not known, but it presumably affected both the groups to a great extent. Water clarity showed no relationship to crappie dominance. The increasing numbers of white crappie probably brought about some interspecific competition, and may have accelerated the decline of the black crappie.

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