# FOOD HABITS OF LARVAL LEPOMIS SPP. IN OLD HICKORY RESERVOIR, TENNESSEE

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*Abstract*: In the Dixon Springs area of the Cumberland River, Tennessee, larval *Lepomis* spp. began feeding upon crustacean zooplankton, especially *Bosmina longirostris*, when the fish attained lengths of 6.7 mm in 1975 and 8.8 mm in 1974. Cladocerans remained the dominant food item throughout the larval stage. The fish food selection diversified [to include other taxa.] larva reached approximately 11.5 mm. At greater lengths, *Lepomis* spp larvae and postlarvae begin to rely more on chironomid larvae.

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Knowledge of the food habits of fish is important in understanding the trophic relationships which exist in aquatic environments. The suitability of a given aquatic environment for the maintenance of a population of fish is dependent upon a complex of conditions which may exist throughout the life cycle of that species. The composition, abundance, and availability of food organisms for larval fish and the utilization of these food organisms are important components of the ecology of fish species. Larval fish food habits are relatively unknown. Few studies of food habits of larval fish have provided a complete representation of aquatic organisms utilized by larval fish once feeding is initiated or a determination of how much selectivity is involved in the foraging process.

The main objectives of this study were: (1) to determine which taxa of organisms were fed upon by larval *Lepomis* spp. collected from the Cumberland River in the spring and summer months of 1974 and 1975; (2) to relate the food habits of these larval fish to existing data on the plankton community of the Cumberland River; and (3) to determine whether there was selectivity involved in the feeding habits of these larval fish.

This is part of an investigation conducted during 1974 and 1975 as part of a contract between Tennesseee Technological University and the Division of Forestry, Fisheries, and Wildlife Development, Tennessee Valley Authority.

## METHODS AND MATERIALS

### *Study Area*

The study site was characteristically riverine and located in the headwaters area of Old Hickory Reservoir near the mouth of Dixon Creek at Cumberland River Mile 284.5 (longitude 86° 05' 09.8" W; latitude 36° 21' 15.2". N). The area was located in north central Tennessee in Trousdale and Smith Counties approximately 64 km northeast of Nashville and 8 km northwest of Hartsville, the nearest community (Fig. 1).

Old Hickory Reservoir is a Corps of Engineers impoundment completed in 1954. Water elevation varies from a winter pool of 135 m to a summer level of 136 m. At full pool, Old Hickory impounds a volume of $5.4 \times 10^7$ $m^3$ and a surface area of 9,105 ha. Reservoir width in the vicinity of the study area averages 305 m. Downstream widths increase to 1,200 m near the dam.

Mainstream impoundments upstream include Cordell Hull and Lake Cumberland. Center Hill and Dale Hollow Reservoirs are upstream tributary impoundments. Mean daily flow at the study area, based on 50 recorded years, was 480 $m^3/s$.

### *Procedures*

The fish used in this study were collected by tow nets. In 1974, a 0.8 mm mesh net with a 1 m diameter circular opening was used. In 1975, 0.5 m diameter nets were used. The nets were 3 m long with a detachable 1.5 1 plastic bucket fitted with a section of 0.5 mm mesh screening.

Sampling was carried out weekly during the evening hours from April to August at CRM 285.5, at the mouth of Dixon Creek, and at 2 locations within the creek backwater area. In 1975, 1 additional river station at CRM 284.5 was sampled. At each station, 2 replicate tows were taken at depths of 0.5 and 2.0 in near the left bank, right bank, and midchannel for a total of 12 samples per station for each sampling date. Vertical tows

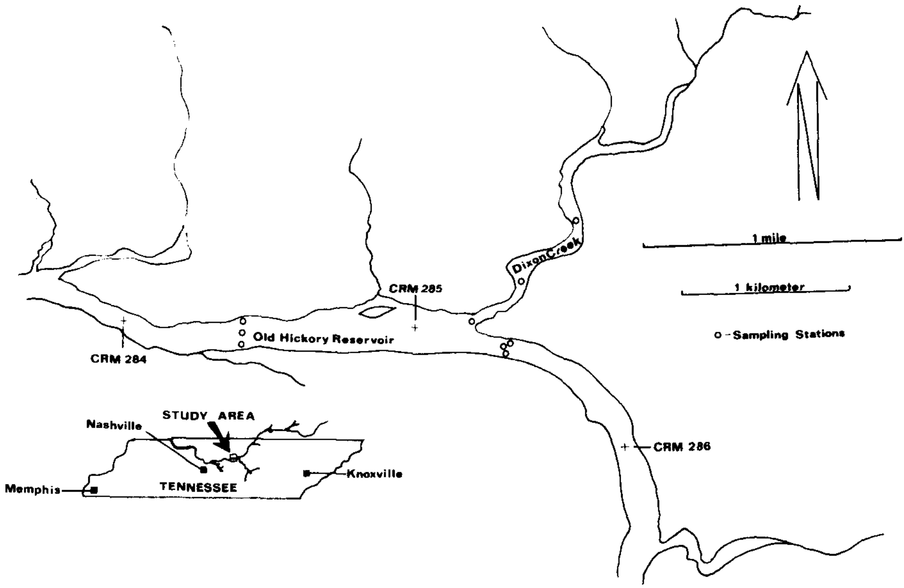


Fig. 1. The study area, Old Hickory Reservoir, Trousdale and Smith Counties, Tennessee.

were utilized at those stations in Dixon Creek, instead of the typical horizontal tows, because of low velocities and the abundance of floating debris. After collection, fish were placed in vials of 10 percent formalin and labeled to appropriate station, date, and depth.

Plankton were collected with an 8.2 l Van Dorn bottle. River samples were taken at 4 depths (surface, 1, 3, and 5 m) at CRM 292.4, 285.1, 284.5, and 278.6. The Dixon Creek samples were taken at DCM 0.3 at 3 depths (surface, 1, and 3 m).

In this investigation, each fish was measured to the nearest 0.1 mm, blotted dry, and weighed to the nearest milligram on a Mettler balance. Fish were then placed under a dissecting microscope where viscera and contents were teased out directly into a plankton settling chamber in approximately 2 ml of water and allowed to settle for 20 min. The entire alimentary tract was removed to ensure retention of all organisms consumed. After settling, the chamber was placed in position on a Wild M-40 inverted miscroscope and vertical and horizontal scans of the entire chamber were made to ensure that no organisms were overlooked. Each food organism encountered was identified to the lowest possible taxon and measured to the nearest 0.0073 mm using a calibrated ocular micrometer.

To fully assess the importance of the organisms found, a biomass estimate was deemed necessary. A volumetric method (Edmondson 1971) was used for this study. The volume of each food organism encountered was measured by application of actual dimensions to the organism's closest geometric shape. Edmondson stated that with small organisms it was easier to measure volume than mass, and assuming a specific gravity close to 1.0, biomass is directly proportional to volume. With the Edmondson approach, then, 1 $\mu^3$ of volume is equal to 1 $\mu$g of biomass.

To determine selectivity in the feeding habits of these fishes, an electivity index (Ivlev 1961) was calculated using the following formula.

$$E = \frac{(r-p)}{(r+p)}$$

Where r = proportion of food organism in diet and
p = proportion of food organism in the environment.

The index range is from −1 to +1. In those cases where there is a preference shown toward the organisms by the fish, the index value will have a positive sign. In those cases of avoidance, the index will provide a negative sign. Electivity values were calculated for each organism found in the stomachs, except in those cases when the food organism was not collected in the plankton samples.

## RESULTS

A total of 117 fish was examined in 1974 and 146 in 1975. Fifteen fish in both years were found to have no discernible stomach contents.

### Dominant Food Types

#### *Zooplankton*

Zoolankters comprised the majority of food organisms for larval *Lepomis* spp. in 1974 and 1975. Analyses of gut contents revealed that in both years cladocerans were the major zooplankters in the diet. *B. longirostris* dominated the cladocerans and represented the initial food item of larval *Lepomis* spp. in both years of the investigation. *Bosmina* had the highest frequency of occurrence in both years, 63.8 percent in 1974 and 90.9 percent in 1975. *Bosmina* also comprised a major portion of the biomass of all food ingested, 23.8 percent in 1974 and 30.4 percent in 1975. Another cladoceran, *Alona quadrangularis,* made up the larger portion, or 45.5 percent of the total mean diet, by weight, in 1975. *Alona* and *Bosmina* together comprised 75.9 percent of the total mean diet, by weight, in 1975 (Table 1).

Table 1. Composition of larval *Lepomis* spp. gut contents by number and weight.

| | *Number of Organisms* | | | | *Weight (μg of Organisms)* | | | |
|---|---|---|---|---|---|---|---|---|
| | 1974 | | 1975 | | 1974 | | 1975 | |
| *Taxa* | $\bar{X}$ | % | $\bar{X}$ | % | $\bar{X}$ | % | $\bar{X}$ | % |
| *Alona quadrangularis* | 0.13 | (1.5) | 1.00 | (3.6) | 0.60 | (1.7) | 7.65 | (45.5) |
| *Bosmina longirostris* | 1.80 | (20.9) | 1.86 | (6.8) | 8.36 | (23.8) | 5.12 | (30.4) |
| *Cyclops sp.* | 0.64 | (7.5) | 0.31 | (1.1) | 4.18 | (11.9) | 1.04 | (6.2) |
| Calanoid copepod | 0.16 | (1.8) | 0.18 | (0.7) | 2.71 | (7.7) | 0.81 | (4.8) |
| *Daphnia* sp. | 0.22 | (2.6) | — | | 1.10 | (3.1) | — | |
| *Diaphanasoma* sp. | 0.13 | (1.5) | — | | 0.60 | (1.7) | — | |
| *Branchionys* sp. | 0.31 | (3.6) | — | | 0.19 | (0.5) | — | |
| *Euchlanis* sp. | 0.02 | (0.3) | — | | 0.27 | (0.8) | — | |
| *Keratella* sp. | 1.27 | (14.7) | — | | 0.33 | (1.0) | — | |
| *Trichocera* sp. | 0.04 | (0.5) | — | | 0.006 | (Tr) | — | |
| Ostracoda | 0.22 | (2.6) | — | | 0.05 | (0.1) | — | |
| *Dinobryon* sp. | 0.02 | (0.3) | — | | 0.001 | (Tr) | — | |
| *Eudorina* sp. | 0.09 | (1.0) | — | | 0.006 | (Tr) | — | |
| *Melosira* sp. | — | | 0.13 | (0.5) | — | | 0.01 | (Tr) |
| *Pandorina* sp. | 0.33 | (3.9) | 0.36 | (1.3) | 0.042 | (0.1) | 0.025 | (0.1) |
| *Phacus* sp. | — | | 9.95 | (36.1) | — | | 0.12 | (0.7) |
| *Spirogyra* sp. | 0.04 | (0.5) | — | | 0.001 | (Tr) | — | |
| *Trachelomonas* sp. | 0.09 | (1.0) | 11.68 | (42.4) | 0.002 | (Tr) | 0.11 | (0.7) |
| Unid. cladoceran | 0.09 | (0.3) | — | | 1.44 | (4.1) | — | |
| Unid. egg | 2.60 | (30.1) | 1.72 | (6.3) | 0.74 | (2.1) | 0.48 | (2.8) |
| Chironomidae larvae | 0.31 | (3.6) | 0.31 | (1.1) | 13.85 | (29.5) | 1.47 | (8.8) |
| Nematoda | 0.04 | (0.5) | — | | 0.056 | (0.2) | — | |
| Total | 8.62 | | 27.54 | | 35.08 | | 16.81 | |

The other zooplankters played a less significant role in the diet of larval *Lepomis* spp. *Daphnia* spp., *Cyclops* spp., and calanoid copepods together contributed almost 23 percent of the total mean diet, by weight, in 1974, and *Cyclops* and calanoid copepods combined to yield a total of almost 11 percent of the total mean diet, by weight, in 1975.

Rotifers seemed to be relatively insignificant in the diet of larval *Lepomis* sp. *Keratella* spp. had a moderately high frequency of occurrence (51.0%) for 1974. Electivity values indicated that the fish were not selecting for this rotifer. This hypothesis was substantiated in 1975 by the fact that no rotifers were found in those fish examined.

*Phytoplankton*

The role of phytoplankton in the diet of *Lepomis* sp. was minor. In 1975, the phytoplankters *Trachelomonas* spp. and *Phacus* spp. made up the greater portion of the diet, by number, with 11.7 and 10.0 items, respectively, out of a total mean diet of 27.5 items. By weight, however, these organisms comprised less than 1 percent each of the weight of the total mean diet. In 1974, phytoplankters were even less significant, both numerically and by weight (Table 1).

*Insect Larvae*

The only insect larvae found during visceral examination of larval *Lepomis* were larval chironomids. By weight, chironomids made up the greater portion of the mean diet in 1974. This was masked, however, by the fact that only 11 percent of those fish examined contained this food item. The greater weight per individual of chironomids made them an important food item.

*Unidentified Eggs*

During visceral examination, the appearance of eggs that ranged in size from 0.09 to 0.1 mm in diameter occurred frequently in the diet. It was thought that these were crustacean eggs, since they did not resemble eggs of gravid female insecs that occur in the Cumberland River and were too small to be fish eggs.

These eggs apparently contributed significantly to the diet of larval *Lepomis.* They had the second highest frequency of occurrence in both years (59.6% in 1974, and 50.0% in 1975). The eggs had the highest mean number of 1974 (2.60, out of a total mean diet of 8.62 items) comprising 30 percent, by number, of the total mean diet of larval *Lepomis* sp. for that year. For the same period, eggs had a mean weight of 0.7 $\mu$g in a total mean diet of 35.1 $\mu$g. In 1975, the eggs contributed a mean number of 1.7 out of a total mean diet of 27.5 items, which was 6.3 percent of the total mean diet. By weight, in 1975, the eggs were 0.5 $\mu$g out of a total mean diet of 16.8 $\mu$g. Expressed as a percentage this was 2.8 percent of the total mean weight of the diet.

ELECTIVITY VALUES

*Zooplankton*

Electivity values demonstrated that significant selectivity was involved in the foraging behavior of these fishes. Values for *Bosmina* ranged from +.72 to +1.0 in 1974 and from +.94 to +.99 in 1975. *Alona* consistently exhibited a value of +1.0 in 1974. *Alona* was not collected concurrently with *Lepomis* larvae during 1975, so electivity values could not be calculated.

The consumption of rotifers by *Lepomis* larvae proved to be a negatively selective feeding behavior in 1974. Even with the moderately high frequency of occurrence values for that year, electivity values were almost always negative.

*Phytoplankton*

*Lepomis* sp. larvae selected for some phytoplankters and against others. In 1974, electivity values for *Dinobryon, Trachelomonas,* and *Pandorina* were high enough to ascertain positive selectivity for these plankton. *Eudorina,* however, had consistently negative values, denoting avoidance of this phytoplankton. Electivity values could not be calculated for the "crustacean" eggs since the relative abundance of these food items in the environment could not be estimated.

## DISCUSSION

In this study, *Lepomis* larvae began feeding at lengths of 8.8 mm in 1974 and 6.9 mm in 1975. Smaller larvae examined had no discernible gut contents. Larval *Lepomis* began feeding on cladocerans and continued to do so throughout the larval period. Cladocerans made up the greatest portion of the diet from the length at which feeding was initiated to 11.5 mm when other food items began to appear in the diet. As previously mentioned, the *Lepomis* larvae in this study began their foraging behavior on *Bosmina. Bosmina* was one of the most abundant zooplankters and was positively selected by these larval fish throughout the summer months. *Bosmina* is also one of the more motile of the zooplankters and it has been noted that larval fish prey reactions are induced by movement (Braum 1967). Movement seems to have provided basis for the feeding of *Lepomis* sp. larvae in this study. Those organisms that were actively moving through the water column were preyed upon most readily.

Exceptions to the above assertion were the occurrence of eggs and phytoplankton. Eggs seem to be a preferred food item of larval *Lepomis*. The phytoplankton encountered in the gut contents were likely incidental feeding except in a few specimens where the gut contained such large numbers that the phytoplankters must have been taken intentionally as a prey of convenience.

Rotifers, as previously stated, apparently constituted an unimportant part of the ration of larval *Lepomis* sp. Even though highly abundant, the fish selected against *Keratella* in 1974 and rotifers were conspicuously absent from 1975 diets.

Utilization of chironomids was evidently a size dependent phenomenon and occurred only in the larger larvae ($>$ 12 mm) as an apparent ontogenetic change in the diet.

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