# SEASONAL FOOD HABITS OF BLUEGILLS IN RICHMOND LAKE, SOUTH DAKOTA

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ABSTRACT

Although the bluegill *Lepomis macrochirus* is a popular panfish species in South Dakota, little information has been collected on seasonal trends in food habits in this geographic location. Richmond Lake, a 336-ha impoundment located in northeastern South Dakota, contained a moderate density bluegill population. We collected bluegills using trap nets in April, early June, late July, and October of 1998. Stomachs were removed from up to 20 bluegills in each of three length groups (80-149, 150-199, and >200 mm) on each date. Throughout the study, and across length groups, *Daphnia*, chironomids, and corixids made up the majority of bluegill diets. Based on percent by number and weight, bluegills in the smallest length group primarily fed on zooplankton. *Daphnia* continued to dominate by number in the larger length groups, but their importance by weight decreased, especially in later months. Bluegills in the two larger length groups principally consumed *Daphnia* in April, and switched to a diet dominated by corixids and chironomids in both June and July. No larger bluegills were collected in October.

Keywords

bluegill, *Lepomis macrochirus*, food habits, South Dakota

## INTRODUCTION

The bluegill *Lepomis macrochirus* is a popular panfish often sought by anglers, and can also serve as a prey source for predatory fishes. While extensive work on food habits of other panfishes such as crappies *Pomoxis* spp. and yellow perch *Perca flavescens* has recently been completed in South Dakota (Guy and Willis 1993; Lott et al. 1996; Fisher and Willis 1997; Pope and Willis 1998), no recent work has been completed on bluegill food habits. Seaburg and Moyle (1964) found that the majority of bluegill diets in Maple and Grove lakes, Minnesota, were aquatic insects, followed by aquatic plant material. The objective of this project was to determine the seasonal food habits of bluegills in a South Dakota impoundment.

## STUDY SITE

Richmond Lake is a 336-ha impoundment located in Brown County near Aberdeen, SD. The lake has a maximum depth of 8.8 m, a mean depth of 4.6 m, and is considered eutrophic to hypereutrophic based on the trophic state index (Stueven and Stewart 1996). The panfish community in Richmond Lake includes black crappie *Pomoxis nigromaculatus*, bluegill, and a low density of green sunfish *Lepomis cyanellus*. Other common fish community members include walleye *Stizostedion vitreum*, saugeye [i.e., purposeful walleye X sauger *Stizostedion canadense* hybrids (Pope et al. 1996)], channel catfish *Ictalurus punctatus*, black bullhead *Ameiurus melas*, common carp *Cyprinus carpio*, and white sucker *Catostomus commersoni*.

## METHODS

Bluegills were collected from April 27–May 2, June 2–8, July 28–August 3, and October 5–9 of 1998 to determine seasonal patterns in food habits. Trap (modified fyke) nets with 13-mm bar mesh were used to capture the bluegills. Short-term sets of approximately 4-hr duration were used to reduce the extent of digestion while fish were in the nets; however, when catch per unit effort was low, nets were set overnight. Collected bluegills were measured (nearest millimeter), weighed (nearest gram) and immediately placed in an ice bath to prevent regurgitation and further digestion of stomach contents. Stomachs were removed from up to 20 bluegills per length group (80-149 mm, 150-199 mm, and >200 mm) and stored in 10% formalin until analysis in the laboratory. Lengths were taken from first 20 organisms of each prey taxon, when possible, and total wet weights were recorded to the nearest 0.01 g for the different prey taxa in each stomach.

Stomach contents were quantified using frequency of occurrence (number of fish where specific taxon was present in stomach divided by total number of fish), percentage by number (number of specific taxon divided by total number of food items present in each stomach), and percentage by weight (weight of specific taxon divided by total weight of stomach contents in each stomach). However, percent by weight is probably the most important due to its indication of caloric value of consumed food items.

Electivity of bluegills for zooplankton was determined using the linear electivity index (Strauss 1979), which is calculated as:

$$L = r_i - p_i ,$$

where $r_i$ is the relative abundance of prey type "I" in the diet, and $p_i$ is the relative abundance of prey type "I" in the environment. Values range from +1 to –1, with +1 indicating complete selection of a prey item, and –1 indicating complete avoidance.

Zooplankton samples were collected with a 2-m long, 75-mm diameter tube sampler. Offshore and near shore samples were taken from each of four different sites, with three samples taken from each location. Samples were filtered through a 70-*u*m plankton net and preserved in 4% sucrose-formalin. In the lab, samples were diluted to 60 mL, and three 2-mL subsamples were drawn with a Henson-Stempel pipet and all organisms in the subsamples were enumerated. Total numbers were then extrapolated from the subsample data. Zooplankton densities were enumerated as number/L of filtered water, and percent composition by number was determined for electivity analysis.

Benthos samples were collected with a Ponar grab in the same manner as zooplankton samples. Samples were sifted through a mesh screen and preserved in 4% sucrose-formalin solution. Benthic organisms were identified and enumerated in the laboratory. However, this gear did not sample the entire macroinvertebrate community, so we could not determine electivity of bluegills for this food type.

## RESULTS

### Diet overview

A total of 116 stomachs were collected from bluegills in Richmond Lake. No bluegills from the two larger length groups (150-199 mm, and >200 mm) were sampled in October. During all sampling periods, zooplankton and macroinvertebrates were the only prey items observed in bluegill stomachs (Table 1). No fish were ever observed in bluegill stomachs. During April, macroinvertebrates and zooplankton were nearly equal in diet composition by weight for 150- to 199-mm bluegills, while zooplankton made up the majority of diet by weight for the larger (>200 mm) bluegills. Macroinvertebrates were the prevalent prey item for all three length groups in June. During July and October, macroinvertebrates were the principal diet item for bluegills >150 mm while zooplankton was the primary food item consumed by 80- to 149-mm bluegills.

### Diet of 80- to 149-mm bluegills

Only four prey groups were consumed by this length group of bluegills during all sampling dates at Richmond Lake (Table 1). In April, only one bluegill was sampled and its stomach contained only macroinvertebrates (chironomids and corixids). June sampling yielded only one bluegill as well; however, its stomach showed a more equal distribution of food items. Chironomids made up the highest percentage of its diet by weight, followed by nearly equal proportions of corixids, calanoid copepods, and *Daphnia*. *Daphnia* constituted nearly 90% of the diet by weight for bluegills collected during July and October. Zooplankton commonly dominate the diet of small (e.g., <150 mm) panfish, including yellow perch (Lott et al. 1996) and white crappies (Guy and Willis 1993). In general, zooplankton tend to constitute a higher proportion of adult panfish diets in "stunted" populations compared with lower density populations (e.g., Mills and Schiavone 1982; Mills et al. 1987; Lott et al. 1996).

Table 1. Food habits by length group and date for bluegills collected from Richmond Lake, South Dakota, during 1998. Specific sampling dates can be found in the Methods. FOO = frequency of occurrence; PBN = percent by number; PBW = percent by weight; macroinvert. = macroinvertebrates.

| Length (mm) | Month | N | Food item | FOO | n | PBN | Total weight (g) | PBW |
|---|---|---|---|---|---|---|---|---|
| 80-149 | April | 1 | Chironomidae | 100.0 | 45 | 95.7 | 0.82 | 98.6 |
| | | | Corixidae | 100.0 | 2 | 4.3 | 0.01 | 1.4 |
| | June | 1 | *Daphnia* spp. | 100.0 | 26 | 36.6 | 0.01 | 20.0 |
| | | | Calanoid copepods | 100.0 | 34 | 47.9 | 0.01 | 20.0 |
| | | | Chironomidae | 100.0 | 9 | 12.7 | 0.02 | 40.0 |
| | | | Corixidae | 100.0 | 2 | 2.8 | 0.01 | 20.0 |
| | August | 37 | *Daphnia* spp. | 100.0 | 8225 | 99.7 | 2.40 | 92.3 |
| | | | Calanoid copepods | 5.6 | 2 | -- | -- | -- |
| | | | Corixidae | 38.9 | 21 | 0.3 | 0.20 | 7.7 |
| | | | Culicidae | 5.6 | 1 | -- | -- | -- |
| | | | Trichoptera | 5.6 | 1 | -- | -- | -- |
| | October | 8 | *Daphnia* spp. | 100.0 | 494 | 97.4 | 0.24 | 88.9 |
| | | | Chironomidae | 12.5 | 4 | 0.8 | 0.01 | 3.7 |
| | | | Corixidae | 37.5 | 9 | 1.8 | 0.02 | 7.4 |
| 150-199 | April | 11 | *Daphnia* spp. | 100.0 | 5567 | 93.1 | 4.67 | 45.0 |
| | | | Trichoptera | 9.1 | 2 | -- | 0.01 | 0.1 |
| | | | Plecoptera | 9.1 | 1 | -- | 0.01 | 0.1 |
| | | | Ephemeroptera | 18.2 | 3 | -- | 0.14 | 1.3 |
| | | | Chironomidae | 81.8 | 312 | 5.2 | 4.90 | 47.2 |
| | | | Corixidae | 81.8 | 83 | 1.4 | 0.60 | 5.8 |
| | | | Culicidae | 27.3 | 7 | 0.1 | 0.05 | 0.5 |
| | | | Other macroinvert. | 18.2 | 2 | -- | -- | -- |
| | June | 17 | *Daphnia* spp. | 58.8 | 4746 | 91.6 | 2.31 | 26.3 |
| | | | Trichoptera | 11.8 | 2 | -- | 0.01 | 0.1 |
| | | | Ephemeroptera | 17.6 | 7 | 0.1 | 1.10 | 12.5 |
| | | | Chironomidae | 52.9 | 63 | 1.2 | 1.60 | 18.2 |
| | | | Corixidae | 100.0 | 333 | 6.4 | 3.50 | 39.8 |
| | | | Other macroinvert. | 11.8 | 31 | 0.6 | 0.28 | 3.2 |
| | August | 12 | *Daphnia* spp. | 83.3 | 2666 | 90.0 | 0.94 | 26.6 |
| | | | Trichoptera | 41.7 | 14 | 0.5 | 0.30 | 8.5 |
| | | | Plecoptera | 8.3 | 1 | -- | -- | -- |
| | | | Chironomidae | 16.7 | 20 | 0.7 | 0.10 | 2.8 |
| | | | Corixidae | 100.0 | 260 | 8.8 | 2.20 | 62.1 |
| | | | Culicidae | 16.7 | 2 | 0.1 | -- | |
| ≥200 | April | 3 | *Daphnia* spp. | 67.0 | 2750 | 97.0 | 2.60 | 79.0 |
| | | | Ephemeroptera | 33.0 | 1 | -- | 0.01 | 0.3 |
| | | | Chironomidae | 67.0 | 3 | 0.1 | 0.02 | 0.6 |
| | | | Corixidae | 67.0 | 76 | 2.7 | 0.60 | 18.2 |
| | | | Culicidae | 33.0 | 4 | 0.1 | 0.02 | 0.6 |
| | | | Other macroinvert. | 33.0 | 1 | -- | 0.04 | 1.2 |
| | June | 8 | *Daphnia* spp. | 75.0 | 2573 | 91.1 | 1.45 | 24.5 |
| | | | Trichoptera | 12.5 | 1 | -- | -- | -- |
| | | | Ephemeroptera | 12.5 | 2 | -- | 0.19 | 3.2 |
| | | | Chironomidae | 25.0 | 10 | -- | 0.10 | 1.7 |
| | | | Corixidae | 87.5 | 238 | 8.4 | 3.80 | 64.1 |
| | | | Other macroinvert. | 12.5 | 1 | -- | 0.39 | 6.6 |
| | August | 18 | *Daphnia* spp. | 66.7 | 1553 | 70.7 | 0.55 | 7.5 |
| | | | Trichoptera | 16.7 | 13 | 0.6 | 0.20 | 2.7 |
| | | | Plecoptera | 11.1 | 2 | 0.1 | 0.20 | 2.7 |
| | | | Chironomidae | 5.6 | 1 | -- | 0.10 | 1.4 |
| | | | Corixidae | 88.9 | 615 | 28.0 | 5.40 | 73.5 |
| | | | Culicidae | 11.1 | 5 | 0.2 | 0.10 | 1.4 |
| | | | Other macroinvert. | 33.3 | 9 | 0.4 | 0.8 | 10.9 |

### Diet of 150- to 199-mm bluegills

The 150- to 199-mm bluegills had greater variety in their diet than did the smaller bluegills (Table 1). In April, *Daphnia* and chironomids dominated the diet in nearly equal proportions by weight. In June and July, corixids made up the most biomass of the diet. *Daphnia* were always a substantial part of the diet for this length group during all three sampling periods. However, the percent by weight for *Daphnia* declined from 45% in April to 26% in both June and July. *Daphnia* consumption may be a supplement to the bluegill diet in the presence of an insufficient macroinvertebrate population. We wonder if the lack of submergent aquatic macrophytes in Richmond Lake results in less diversity of aquatic insects, perhaps resulting in more reliance on *Daphnia* as a food source.

### Diet of 200-mm and longer bluegills

The diet for this length group was dominated by *Daphnia* in April, and corixids in June and July (Table 1). While a number of other macroinvertebrates, such as chironomids, ephemeropterans, culicids, trichopterans, and plecopterans were consumed by these larger bluegills, these macroinvertebrates made up a small portion of the total weight of food items consumed.

Many panfish species change diets from zooplankton to larger prey items as they grow. Crappies and yellow perch may also become more piscivorous as they grow; however, most growth of adult yellow perch (Lott et al. 1996) and white crappie (Guy and Willis 1993) in South Dakota resulted from a diet of zooplankton and macroinvertebrates. Although bluegills may occasionally consume fish, they are not typically considered piscivorous (Seaburg and Moyle 1964). Thus, bluegill selection of lower numbers of larger prey leads them to feed on macroinvertebrates, but zooplankton persists as a considerable portion of their diet. We did not find any fish in the stomachs of bluegills, including the largest length group, in Richmond Lake.

### Linear electivity index

Electivity of bluegills for various zooplankton taxa present in Richmond Lake was similar across length groups (Table 2). For all three length groups, during all sample dates when each was collected, *Daphnia* spp. were positively selected by bluegills. The only other positive linear electivity index value was for calanoid copepods, which were positively selected by 80- to 149-mm bluegills during June. Linear electivity index values were negative for all other zooplankton taxa collected in environmental samples in Lake Richmond. Electivity values for the 150- to 199-mm and >200-mm length groups were identical because *Daphnia* were the only zooplankton consumed by bluegills in these groups, making percent by number 100% for both length groups.

Most of the *Daphnia* consumed by bluegills in Richmond Lake exceeded 1.3 mm in diameter. The only other zooplankton group for which we collected specimens that exceeded 1.3 mm was the calanoid copepods, and individ-

Table 2. Linear electivity index values for zooplankton consumed by bluegills (BLG) by date in Lake Richmond, South Dakota, during 1998. Specific dates of sampling are included in the Methods.

| BLG length (mm) | Taxon | April | June | August | October |
|---|---|---|---|---|---|
| 80-149 | *Daphnia* | a | 0.19 | 0.55 | 0.75 |
| | *Bosmina* | a | -0.01 | b | -0.38 |
| | Other Cladocera | a | b | -0.02 | b |
| | Calanoid Copepoda | a | 0.28 | -0.08 | -0.15 |
| | Cyclopoid Copepoda | a | -0.03 | -0.16 | -0.03 |
| | Copepoda nauplii | a | -0.25 | -0.29 | -0.15 |
| | Rotifera | a | -0.19 | b | -0.04 |
| 150-199 | *Daphnia* | 0.90 | 0.69 | 0.55 | c |
| | *Bosmina* | -0.20 | -0.01 | b | c |
| | Other Cladocera | b | b | -0.02 | c |
| | Calanoid Copepoda | -0.15 | -0.22 | -0.08 | c |
| | Cyclopoid Copepoda | -0.11 | -0.03 | -0.16 | c |
| | Copepoda nauplii | -0.30 | -0.25 | -0.29 | c |
| | Rotifera | -0.14 | -0.19 | b | c |
| >200 | *Daphnia* | 0.90 | 0.69 | 0.55 | c |
| | *Bosmina* | -0.20 | -0.01 | b | c |
| | Other Cladocera | b | b | -0.02 | c |
| | Calanoid Copepoda | -0.15 | -0.22 | -0.08 | c |
| | Cyclopoid Copepoda | -0.11 | -0.03 | -0.16 | c |
| | Copepoda nauplii | -0.30 | -0.25 | -0.29 | c |
| | Rotifera | -0.14 | -0.19 | b | c |

a = no zooplankton consumed by this BLG length group on this date
b = this zooplankton group not collected in environmental samples on this date
c = no BLG within this length group were collected on this date

uals that exceeded this size were quite rare. Thus, bluegills in Lake Richmond were apparently selecting the largest available zooplankton. Lott et al. (1998) found that the percent of *Daphnia* that exceeded 1.3 mm in environmental samples were useful predictors of both yellow perch growth and size structure in eastern South Dakota lakes.

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