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THE SELECTIVE FEEDING OF IMMATURE BLUEGILLS
(LEPOMIS MACHROCHIRUS) AND BROOK SILVERSIDES
(LABIDESTHES SICCULUS) ON THE ZOOPLANKTON
OF GULL LAKE, MICHIGAN

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Roger William Ovink

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THE SELECTIVE FEEDING OF IMMATURE BLUEGILLS (LEPOMIS MACHROCHIRUS) AND BROOK SILVERSIDES (LABIDESTHES SICCULUS) ON THE ZOOPLANKTON OF GULL LAKE, MICHIGAN

By

Roger William Ovink

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ABSTRACT

THE SELECTIVE FEEDING OF IMMATURE BLUEGILLS (*LEPOMIS MACHROCHIRUS*) AND BROOK SILVERSIDES (*LABIDESTHES SICCULUS*) ON THE ZOOPLANKTON OF GULL LAKE, MICHIGAN

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Immature bluegills (*Lepomis machrochirus*) and brook silversides (*Labidesthes sicculus*) migrate to the limnetic epilimnion from the littoral zone of Gull Lake, Michigan, in the summer. They remain for approximately seven weeks and then return to the littoral zone. The apparent spatial overlap between the fish, both in the littoral and limnetic zones suggests that a feeding overlap may exist. In an effort to determine whether a feeding overlap occurred while they coinhabited the limnetic epilimnion of Gull Lake, immature bluegills and brook silversides, as well as zooplankton, were sampled on a weekly, diel basis from August 8 through September 19, 1974. The results indicate that no major feeding overlap occurred. Bluegills consumed prey mainly from the 0.5-1.0 mm (*Cyclops spp.* and *Diaptomus spp.*) and 1.0-2.0 mm (*Daphnia spp.*) size classes while brook silversides consumed prey mainly from the greater than 2.0 mm size class (*Chaoborus spp.*, *Leptodora kindtii* and adult Diptera).

To Jennifer, with much love.

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INTRODUCTION

Competition for food between animal species is common in most ecosystems. Fish fry are especially vulnerable to both interspecific and intraspecific competition for food (Werner, 1977). Survival rates of larval fishes are extremely low. Competition for food could be a major contributing factor in the high mortality rates of immature fish. Reducing this competition occurs in a variety of ways. Size selective predation (Werner, 1977; Werner, 1969), habitat selection (Werner and Hall, 1976; Werner, et al., 1977) and niche flexibility (Werner and Hall, 1974) have been presented as possible factors minimizing competition for food in freshwater sunfish. The migration of fish from the littoral zone to the limnetic zone in lakes (Hubbs, 1921; Werner, 1969) may also serve to reduce competition for food among immature fish species. A variety of fish fry, including sculpins (Heard, 1965), sockeye salmon (McCart, 1967), yellow perch, black crappie (Faber, 1965), bluegill (Faber, 1965; Werner, 1969) and brook silversides (Hubbs, 1921) have been shown to migrate from the littoral zone to the limnetic zone of lakes following yolk sac absorption. Pennak (1966) noted that much higher concentrations of zooplankton occurred in the limnetic zone than in the littoral zone of some Colorado lakes. In that zooplankton serve as a main food item for many immature fish species, the greater abundance of zooplankton in the limnetic zone may help to reduce interspecific and intraspecific competition for this food source.

Immature bluegills have been found to migrate from the littoral zone to the limnetic zone in the summer, where they remain for several weeks and then return to the littoral zone (Werner, 1969). Bluegills have also been noted to: feed almost exclusively on zooplankton (Baumann and Kitchell, 1974); feed almost continually throughout the day and night, consuming whatever is most active (Keast and Welsh, 1968); feed size selectively (Werner and Hall, 1974) and feed mainly on insects when they reach maturity (Gerking, 1962).

Immature brook silversides migrate to the limnetic zone from the littoral zone in the summer, remain for several weeks and return to the littoral zone (Hubbs, 1921; Keast and Webb, 1966); feed on whatever zooplankton are most abundant (Mullen, Applegate and Rainwater, 1968) and feed almost exclusively on insects when mature (Hubbs, 1921; Mullen, Applegate and Rainwater, 1968).

Considering the above information, it is evident that a major feeding overlap could exist both in the littoral and limnetic zones of lakes where these species coexist, and that the growth and development of one or both species could be impaired. The feeding dynamics of the two fish species were studied during their coexistence in the limnetic epilimnion of Gull Lake, Michigan, to determine whether a major feeding overlap occurred between them and if an overlap did occur, how it affected the immature bluegills and brook silversides.

METHODS AND MATERIALS

The limnetic epilimnion of Gull Lake was sampled for zooplankton and immature fish from August 8 through September 19, 1974, on a weekly, diel basis. Gull Lake is located in Barry (T.1N., R.9-10 W., Sections 31, 36) and Kalamazoo (T.1S., R.9-10 W., Sections 6, 7, 8, 17, 18, 20, 1, 2, 12) counties in southwestern Michigan. It is a hardwater lake, glacial in origin, with a surface area of 820 hectares and a maximum depth of 33 meters.

Immature fish were sampled at three stations (Figure 1) with a lift net, 3.0 meters square, constructed from conduit pipe and 3.0 mm nylon netting. The net was lowered into the lake to a depth of three meters. Gas lanterns were then directed over the net until numerous fish were attracted. The net was then lifted capturing them. The fish were removed and preserved in a five percent formalin solution. All fish were captured between 10:00 p.m. and 1:00 a.m.; no fish were captured during daylight hours.

Zooplankton samples were taken at 0, 5, and 10 meter depths at three stations by one of two methods. The first method was to tow a Clark-Bumpus plankton sampler equipped with a 0.018 mm mesh plankton net for two minutes at each depth (thus, filtering between 700 and 1000 liters of water). The second method involved taking triplicate, eight-liter samples with a modified Van Dorn water bottle from each depth and filtering the zooplankton out with a 0.018 mm mesh sieve. The second method was employed only when the Clark-Bumpus plankton sampler was not functional (August 8, 15). The zooplankton samples were

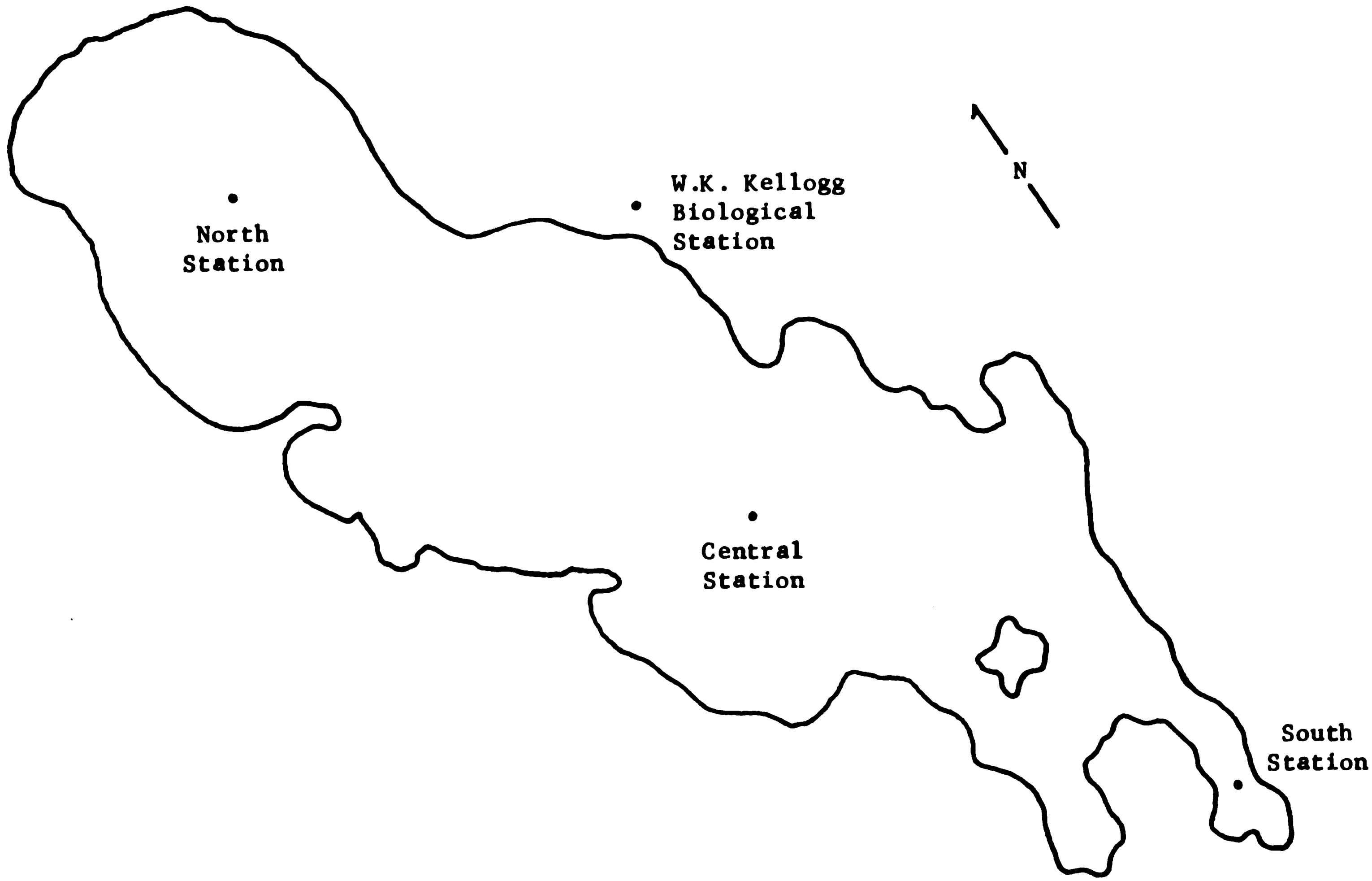

Figure 1. Sample sites on Gull Lake

preserved in a four percent sucrose-formalin solution (Haney and Hall, 1973). All zooplankton samples were taken between 10:00 a.m. and 1:00 p.m., and 10:00 p.m. and 1:00 a.m.

The fish were identified to species, weighed to the nearest .01 gram and measured to the nearest 1.0 mm (for total and standard lengths). The length and weight measurements were corrected for the effects of formalin preservation (Parker, 1963).

Gut analyses involved cutting the fish ventrally from the lower jaw to the anus and removing the entire viscera with a spatula. The stomach and foregut were then isolated and their contents were usually identified to genus and enumerated using a Wild dissecting microscope at 250X magnification. The prey were measured with an ocular micrometer to the nearest .01 mm and were separated into five size classes (Table 1).

Duplicate, 0.3 ml sub-samples were taken from the zooplankton samples. The zooplankton were usually identified to genus and enumerated using a Wild dissecting microscope at 250X magnification (except Chaoborus spp. and Leptodora kindtii which were counted in total). Zooplankton densities per cubic meter were then calculated for each station-depth and date.

Data analyses included the calculation of electivity indices (Ivlev, 1961), single classification analysis of variance (Sokal and Rohlf, 1969) and product-moment correlation coefficients (Sokal and Rohlf, 1969).

The electivity indices were calculated using mean prey size class densities in the water column and in the gut contents of the fish for each sample date to determine whether the immature bluegills and brook silversides actively selected any of the prey size classes. Since fish samples were taken at night (between 10:00 p.m. and 1:00 a.m.), the prey

Table 1. Prey size classes

Size class	Prey name
<0.2 mm	Copepod nauplii
0.2-0.5 mm	*Bosmina* *spp.*
0.5-1.0 mm	*Cyclops* *spp.*; *Diaptomus* *spp.*
1.0-2.0 mm	*Daphnia* *spp.*
>2.0 mm	*Chaoborus* *spp.*; adult Diptera; *Leptodora* *kindtii*

size class densities used from the water column were mean values for each size class from the night sampling periods.

Single classification analysis of variance was used to determine whether significant* differences existed in the mean prey size class densities in the water column among sample stations or among sample dates. The size class densities in the fish gut contents were also analyzed to determine whether significant variance existed among size class densities on the same sample date, among densities of each size class on different sample dates, between densities of size class pairs on the same sample date, or between the gut content of each fish species on the same sample date. Mean densities for the size classes in the gut contents were used in these analyses.

Product-moment correlation coefficients were calculated with respect to the mean prey size class densities in the water column and in the gut contents of each fish species. The size class densities used in the calculations were mean values for each prey size class from the night sampling periods.

Planktivoirous fish are known to follow the vertical migrations of zooplankton in lakes (Narver, 1970; Johnson, personal communication). Brook silversides and bluegills feed continuously through the day and night and undoubtedly follow their zooplankton prey deeper in the water column during the day and then return with them to the surface at night. The data discussed herein were collected at night but the general behavioral and forage patterns of planktivoirous fish suggest that the predator-prey relationship probably would remain the same over a twenty-four hour period.

*Unless otherwise indicated, all significance referred to will be at the 0.05 confidence level or above.

RESULTS AND DISCUSSION

Prey size class densities in the water column

The mean densities for each size class were not significantly different among sample stations for any sample date (Table 2). Thus, there were no concentrated prey communities at any of the sample stations during any of the sample dates, and the limnetic epilimnion of Gull Lake was essentially homogeneous, in terms of the prey size class densities.

The mean densities for several of the size classes varied significantly among sample dates (Table 3). Significant density variations occurred in the <0.2 mm, 0.5-1.0 mm and the 1.0-2.0 mm size classes. This variation among sample dates may be attributed to the periodic "pulsing" of different zooplankton genera in lakes in response to certain parameters (light, temperature, oxygen concentration, food availability, etc.) causing the rapid development of their immature stages thereby initiating a sudden population increase (for more prey density information see Figures 2 and 3).

Bluegill predation

There was significant variation in the frequencies of predation upon several of the prey size classes among sample dates (Table 4). Significant differences occurred in predation on the <0.2 mm, 0.2-0.5 mm, 0.5-1.0 mm and 1.0-2.0 mm size classes. Frequencies of occurrence in the gut content of the various prey size classes also varied significantly on several sample dates (Table 5). The 0.5-1.0 mm size class was consumed significantly more often than any other on August 8, August 29 and September 19. The 1.0-2.0 mm size class was consumed

Table 2. Results of single classification analysis of variance for mean prey size class densities among sample stations on the same sample date.

Source of variation	8 August	15 August	22 August	29 August	5 Sept.	10 Sept.	19 Sept.
<0.2 mm X station	ns	ns	ns	ns	ns	ns	ns
0.2-0.5 mm X station	ns	ns	ns	ns	ns	ns	ns
0.5-1.0 mm X station	ns	ns	ns	ns	ns	ns	ns
1.0-2.0 mm X station	ns	ns	ns	ns	ns	ns	ns
>2.0 mm X station	ns	ns	ns	ns	ns	ns	ns

Critical F = 2.27
* = significant at 0.05 or above
ns = not significant at 0.05 or above

Table 3. Results of single classification analysis of variance for mean prey size class densities among sample dates.

Source of variation	Sum of squares	Degrees of freedom	Mean sum of squares	F - Statistic
<0.2 mm X date	8.4×10^{8}	6	1.4×10^{8}	2.33*
0.2-0.5 mm X date	1.7×10^{7}	6	2.9×10^{6}	1.17^{ns}
0.5-1.0 mm X date	3.0×10^{10}	6	5.0×10^{9}	16.72*
1.0-2.0 mm X date	4.2×10^{9}	6	7.0×10^{8}	2.33*
>2.0 mm X date	8.0×10^{4}	6	3.0×10^{5}	0.27^{ns}

Critical F = 2.27
* = significant at 0.05 or above
ns = not significant at 0.05 or above

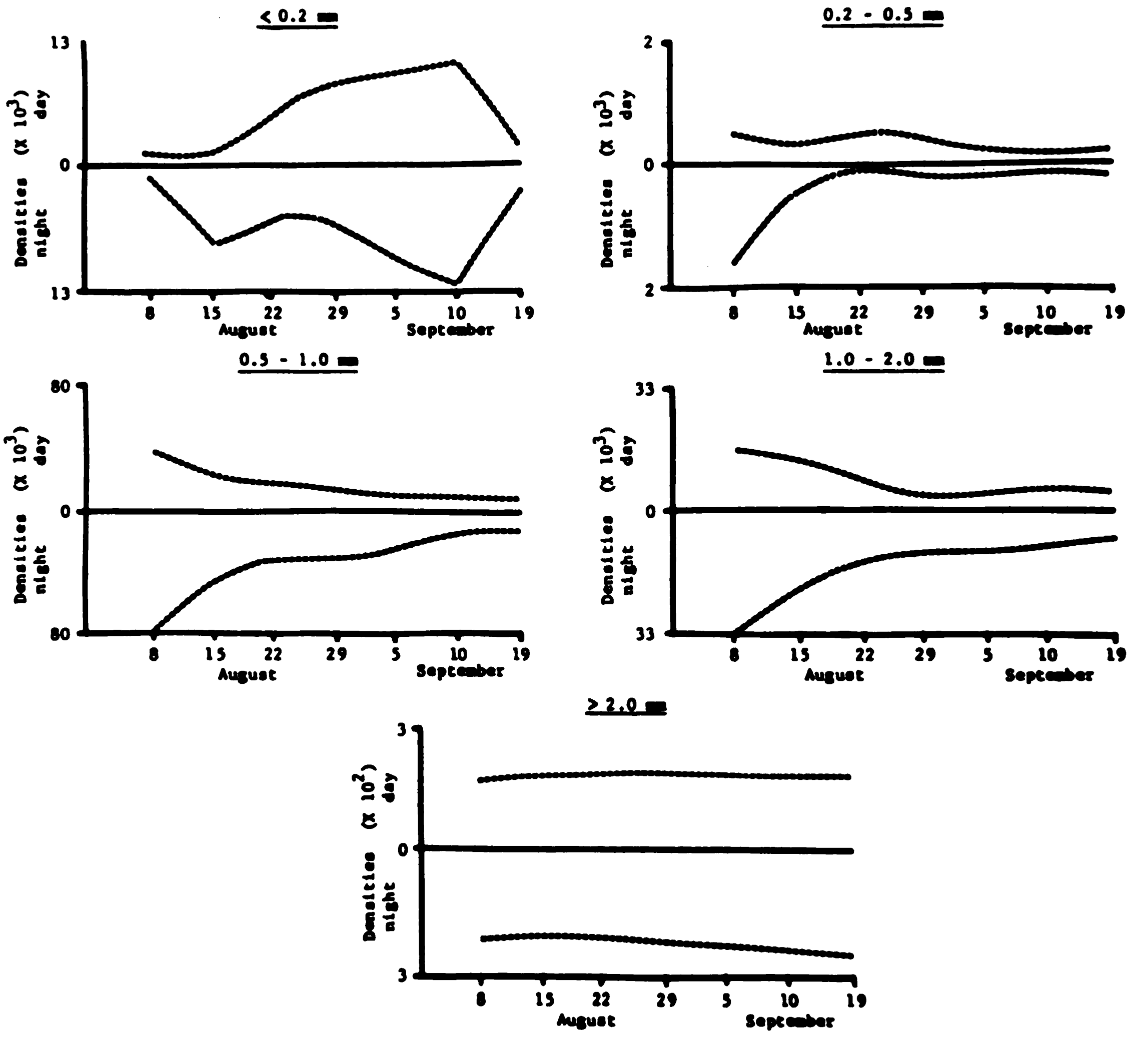

Figure 2. Mean prey size class densities/cubic meter in the epilimnion of Gull Lake during day and night sampling periods.

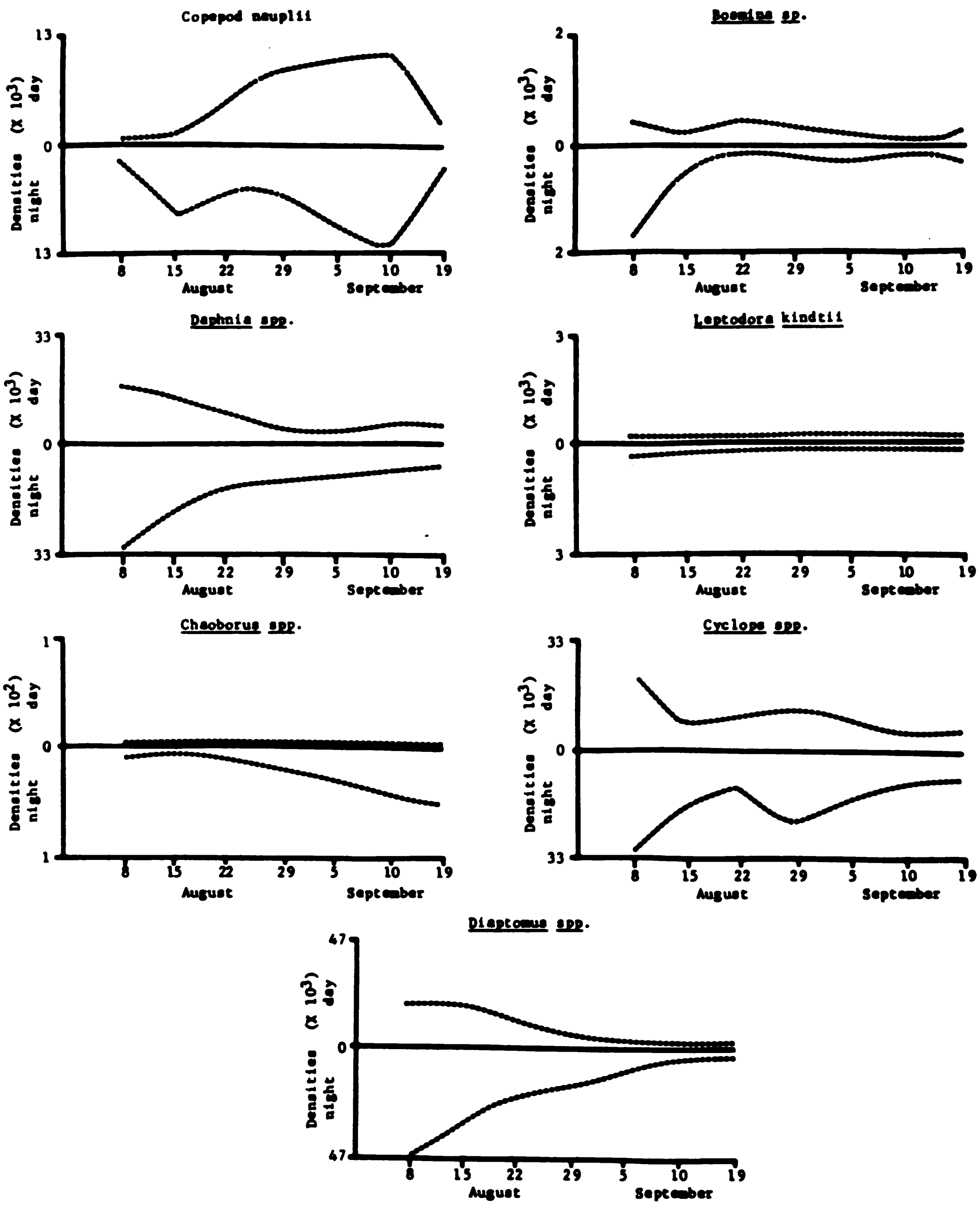

Figure 3. Mean zooplankton population densities/cubic meter in the epilimnion of Gull Lake during day and night sampling periods.

Table 4. Results of single classification analysis of variance for bluegill predation on different prey size classes among sample dates.

Source of variation	Sum of squares	Degrees of freedom	Mean sum of squares	F - Statistic
<0.2 mm X date	81.80	6	13.63	4.34*
0.2-0.5 mm X date	2180.35	6	363.39	16.09*
0.5-1.0 mm X date	27824.00	6	4637.33	11.61*
1.0-2.0 mm X date	1333.50	6	222.25	8.00*
>2.0 mm X date	0.09	6	0.01	0.50^{ns}

Critical F = 2.15
* = significant at 0.05 or above
ns = not significant at 0.05 or above

Table 5. Bluegill predation.* A summary of single classification analysis of variance results between the mean densities of pairs of prey size classes found in the gut content on each sample date.

Size class	8 August	15 August	22 August	29 August	5 Sept.	10 Sept.	19 Sept.
<0.2 mm	2	ns	ns	ns	ns	ns	ns
0.2-0.5 mm	ns	ns	ns	ns	ns	ns	2
0.5-1.0 mm	1	ns	2	1	ns	ns	1
1.0-2.0 mm	2	ns	2	2	1	ns	2
>2.0 mm	ns	ns	ns	ns	ns	ns	ns
Fish/Sample	48	3	68	49	6	1	11

*On a particular sample date, 1 indicates that a prey size class was consumed significantly more often than any other size class on that date; 2 indicates that a size class was consumed significantly more often than those size classes labeled ns but not as often as those size classes labeled 1 on that date; and ns indicates that a size class was not consumed significantly more often than any other size class on that date.

significantly more often than any other on September 5. Generally, the 0.5-1.0 mm size class was preyed upon significantly more often than the other size classes (Table 6).

The results indicate that the immature bluegills fed upon the 0.5-1.0 mm and 1.0-2.0 mm size classes with relation to their abundance while they selected against the <0.2 mm, 0.2-0.5 mm and >2.0 mm prey size classes. The product-moment correlation coefficients (Table 7) indicate that a significant relationship existed between the 1.0-2.0 mm prey size class densities found in their gut contents and those found in the water column. A strong (though not significant) relationship was also indicated between the gut content and water column prey size class densities for the 0.5-1.0 mm size class. The electivity indices and the correlation coefficients indicate, therefore, that the immature bluegills preyed mainly upon the most abundant prey size classes.

The bluegill predation results concur with the literature in that they were found to feed exclusively on zooplankton (Baumann and Kitchell, 1974) with the crustacean planktors being their most selected prey (Werner, 1969). Further, their predation was size selective (Werner and Hall, 1974; Werner, 1969). The variability in the electivity indices (Table 6) through the sampling period may be attributed, in part, to the behavioral flexibility of bluegills (Werner and Hall, 1974) which enables them to better utilize their available food resources.

<u>Brook silversides predation</u>

Significant variation among sample dates occurred concerning two of the prey size classes (Table 8). Brook silversides gut content counts varied significantly with respect to the 1.0-2.0 mm and the greater than 2.0 mm size classes. Frequencies of occurrence of the prey size classes

Table 6. Bluegill electivity indices (based on mean prey size class densities in the gut contents and in the water column for each sample date).

Size class	8 August	15 August	22 August	29 August	5 Sept.	10 Sept.	19 Sept.	Overall weighted mean
<0.2 mm	+0.64	-1.00	-1.00	-0.83	-1.00	-1.00	-1.00	-0.51
0.2-0.5 mm	-1.00	-1.00	0.00	-0.50	-1.00	+0.71	+0.71	-0.37
0.5-1.0 mm	+0.07	-1.00	-0.16	+0.01	-0.41	+0.27	+0.27	-0.06
1.0-2.0 mm	-0.47	+0.58	+0.32	+0.16	+0.54	+0.03	+0.03	+0.02
>2.0 mm	-1.00	-1.00	+0.33	-1.00	-1.00	-1.00	-1.00	-0.50

Table 7. Product-moment correlation coefficients for bluegills and brook silversides (correlating mean prey size class densities in the gut content with mean prey size class densities in the water column over sample dates).

Size class	Bluegill sunfish	Brook silversides
<0.2 mm	.56	.46
0.2-0.5 mm	.05	.35
0.5-1.0 mm	.63	.60
1.0-2.0 mm	.82	.51
>2.0 mm	.00	.13

Critical F = 0.75
Df = 5.00
P = 0.05

Table 8. Results of single classification analysis of variance for brook silverside predation on different prey size classes among sample dates.

Source of variation	Sum of squares	Degrees of freedom	Mean sum of squares	F - Statistic
<0.2 mm X date	101.20	6	16.86	0.25^{ns}
0.2-0.5 mm X date	11.19	6	1.86	0.81^{ns}
0.5-1.0 mm X date	4630.00	6	771.66	1.35^{ns}
1.0-2.0 mm X date	5364.34	6	894.05	3.21*
>2.0 mm X date	4805.00	6	800.83	684.47*

Critical F = 2.16
* = significant at 0.05 or above
ns = not significant at 0.05 or above

in the gut content varied significantly on several dates (Table 9). On September 19, the 0.5-1.0 mm size class was consumed significantly more often than all other size classes. On August 22 and August 29 the greater than 2.0 mm size class was consumed significantly more often than all other prey sizes. Generally, the greater than 2.0 mm size class was preyed upon significantly more often than the other prey size classes.

Immature brook silversides were size selective predators. Their prey were generally from the largest, least abundant size class (>2.0 mm). The electivity indices (Table 10) indicate that they selected most strongly for the greater than 2.0 mm size class. A further indication of their selective ability is presented in the product-moment correlation analyses (Table 7). No significant relationship was indicated between they prey size class densities found in their gut content and those found in the water column. A significant relationship between the two densities would suggest that they were consuming the most abundant prey. No significant relationships, therefore, suggest that the brook silversides were feeding selectively.

The brook silverside predation results both agreed and conflicted with the literature. They fed almost exclusively on zooplankton (Hubbs, 1921) but they were not found to feed on the most abundant zooplankton (Mullen, Applegate and Rainwater, 1968). On the contrary, the brook silversides preyed mainly upon the least abundant zooplankton and insects (>2.0 mm size class) throughout the sampling period.

A comparison of bluegill and brook silverside predation

A major feeding overlap did not occur despite the apparent spatial overlap of the two fish species. Bluegills consumed significantly more of the 1.0-2.0 mm and 0.5-1.0 mm size classes than did brook silversides

Table 9. Brook silverside predation.* A summary of single classification analysis of variance results between the mean densities of pairs of prey size classes found in the gut content on each sample date.

Size class	8 August	15 August	22 August	29 August	5 Sept.	10 Sept.	19 Sept.
<0.2 mm	ns	ns	ns	ns	ns	ns	ns
0.2-0.5 mm	ns	ns	ns	ns	ns	ns	ns
0.5-1.0 mm	ns	ns	ns	3	ns	ns	1
1.0-2.0 mm	ns	ns	2	2	ns	ns	3
>2.0 mm	ns	ns	1	1	ns	ns	2
Fish/Sample	3	5	9	25	85	23	14

*On a particular sample date, 1 indicates that a size class was consumed significantly more often than any other size class; 2 indicates that a size class was consumed significantly more often than those size classes labeled 3 and ns but not as often as those labeled 1; 3 indicates that a size class was consumed significantly more often than those size classes labeled ns but not as often as those labeled 1 or 2; ns indicates that a prey size class was not consumed significantly more often than any other size class.

Table 10. Brook silverside electivity indices (based on mean prey size class densities found in the gut contents and in the water column for each sample date).

Size class	8 August	15 August	22 August	29 August	5 Sept.	10 Sept.	19 Sept.	Overall weighted mean
<0.2 mm	-1.00	-1.00	-1.00	-1.00	-0.41	-1.00	-0.97	-0.67
0.2-0.5 mm	-1.00	-1.00	-0.72	-0.50	-0.50	-1.00	-0.52	-0.60
0.5-1.0 mm	-0.61	-1.00	-0.15	-0.35	+0.20	-0.98	-0.02	-0.13
1.0-2.0 mm	+0.35	+0.43	+0.03	+0.48	-0.53	+0.59	+0.18	-0.10
>2.0 mm	+0.98	+0.99	+0.98	+0.93	+0.92	+0.96	+0.83	+0.92

(Table 11). Brook silversides preyed upon significantly more of the >2.0 mm size class than the bluegills (Table 11).

It appears that a major feeding overlap between the fish species was prevented due to their different feeding habits. A recent study (Werner, et al., 1977) concerning the Centrarchidae indicated that habitat divisions aid in segregating fish species. This information may help explain the segregation of the immature bluegills and brook silversides. Brook silversides are generally found in the top twenty centimeters of the water column (Hubbs, 1921) while bluegills are generally located deeper in the water column (Werner, et al., 1977). Werner (1977) indicates that bluegills, with their compressed, short body shape and large pectoral fins are able to stop, turn and alter their vertical position in the water column readily but lack straightaway speed. They also have a small, highly protrusible mouth. This combination of abilities and structural features renders the bluegill very adept at capturing smaller, less mobile prey. The structural morphology of the brook silverside includes a narrow tubular body and dorso-terminal mouth with three rows of long, sharp, slightly retrocurved teeth. These features render the brook silverside highly mobile, enabling it to range widely over lakes and very adept at capturing surface insects (Keast and Webb, 1965).

The growth rates of the two fish species differed greatly during the sampling period. The immature bluegills grew at a rate of 0.09 mmSL/day (0.001 g/day) while the brook silversides grew at a rate of 0.59 mmSL/day (0.017 g/day). These growth rate differences suggest probable metabolic rate differences between the fish species. The metabolic rate of the immature brook silversides would probably be

Table 11. Bluegill (BG) - Brook silverside (BS) predation.* A summary of single classification analysis of variance results between the mean densities of prey size classes found in the gut content of the two fish species for each sample date.

Size class	8 August	15 August	22 August	29 August	5 Sept.	10 Sept.	19 Sept.
<0.2 mm	ns	ns	ns	ns	ns	ns	ns
0.2-0.5 mm	ns	ns	BS	ns	ns	ns	BG
0.5-1.0 mm	BS	ns	ns	ns	ns	BG	BG
1.0-2.0 mm	ns	ns	BG	BS	BG	ns	ns
>2.0 mm	BS	ns	BS	BS	ns	ns	BS

*On a particular sample date, BG indicates that bluegills consumed the size class indicated significantly more often than did brook silversides; BS indicates that brook silversides consumed significantly more of the size class indicated than did bluegills; and ns indicates that neither fish species consumed significantly more of the size class indicated than the other fish species.

greater than the bluegills, requiring the brook silversides to consume more food to provide energy necessary for their elevated growth rate. It would therefore be advantageous for the brook silversides to consume larger prey, acquiring more energy per food item. The different growth rates of the fish species (and probable metabolic rate differences) provide a partial explanation for their feeding differences.

It is evident that the different feeding preferences of the two fish species was probably not the only factor preventing a major feeding overlap. Other contributing factors include possible segregation by habitat, the different structural morphologies of the two fish species and their different growth (and probable metabolic) rates.

SUMMARY AND CONCLUSIONS

Immature bluegills and brook silversides both occupy the limnetic epilimnion of Gull Lake for several weeks during the summer. The feeding dynamics of the two fish species were studied during their coexistence in the limnetic epilimnion to determine whether a feeding overlap resulted from an apparent spatial overlap. The fish and their potential prey were sampled at three stations from August 8 through September 19, 1974. Prey density counts and fish gut analyses were calculated to compare the feeding behavior of the two species. The following conclusions can be drawn from this study.

1. Mean prey size class densities did not differ significantly among the sample stations on the same sample date.
2. The mean densities of several of the prey size classes differed significantly among sample dates.
3. Bluegill predation was size selective, with prey from the 0.5-1.0 mm and 1.0-2.0 mm size classes being consumed significantly more frequently than the other prey size classes.
4. Brook silverside predation was size selective, with prey from the >2.0 mm size class being consumed significantly more often than the other prey size classes.
5. The apparent spatial overlap of the two fish species did not result in a major feeding overlap due to differences in prey selectivity, possible habitat segregation, and possible differences in the structural morphology of the two fish species.

APPENDIX

Table 12. Capture, length, weight and gut content data for bluegills.

Specimen number	Capture date	Sample sites - (North, South and Central)	T.L. (mm)	S.L. (mm)	Wt. (g)	GUT CONTENTS							
						Copepod nauplii	*Bosmina* spp.	*Daphnia* spp.	*Leptodora kindtii*	*Chaoborus* spp.	*Cyclops* spp.	*Diaptomus* spp.	adult Diptera
1	8 Aug.	N	16	14	.04	2							
2	8 Aug.	N	17	15	.05	7					1		
3	8 Aug.	N	19	16	.06	4		1					
4	8 Aug.	N	17	15	.05	2					1		
5	8 Aug.	N	16	13	.04	1							
6	8 Aug.	N	17	14	.05								
7	8 Aug.	N	21	17	.09	5		2				1	
8	8 Aug.	N	19	16	.07	2		1					
9	8 Aug.	N	18	15	.06	7		1					
10	8 Aug.	N	16	14	.05	2							
11	8 Aug.	N	18	15	.05	4		2					
12	8 Aug.	N	16	14	.04	1							
13	8 Aug.	S	16	14	.05			1					
14	8 Aug.	S	16	12	.05			2			1		
15	8 Aug.	S	13	10	.02			1					
16	8 Aug.	S	17	15	.05			1					
17	8 Aug.	S	18	14	.05			1					
18	8 Aug.	C	17	15	.06			1					
19	8 Aug.	C	13	10	.02								
20	8 Aug.	C	18	15	.06			1					
21	8 Aug.	C	15	14	.04			1					
22	8 Aug.	C	18	15	.06			2					
23	8 Aug.	C	18	15	.06								
24	8 Aug.	C	18	15	.07			2			40		
25	8 Aug.	C	18	15	.06			5			39		
26	8 Aug.	C	18	15	.06			1			2		
27	8 Aug.	C	20	16	.08								
28	8 Aug.	C	21	18	.09	2					79		
29	8 Aug.	C	18	16	.06			2			1		
30	8 Aug.	C	18	16	.06			3					
31	8 Aug.	C	18	16	.06			1					
32	8 Aug.	C	28	24	.27	1					22		
33	8 Aug.	C	20	17	.09	1		3			71		
34	8 Aug.	C	19	16	.07			2			1		
35	8 Aug.	C	15	13	.04	1					187		
36	8 Aug.	C	17	14	.05			1			28		
37	8 Aug.	C	17	15	.05			4					

Table 12. (cont'd.)

Specimen number	Capture date	Sample sites - (North, South and Central)	T.L. (mm)	S.L. (mm)	Wt. (g)	GUT CONTENTS							
						Copepod nauplii	*Bosmina* spp.	*Daphnia* spp.	*Leptodora kindtii*	*Chaoborus* spp.	*Cyclops* spp.	*Diaptomus* spp.	adult Diptera
38	8 Aug.	C	19	16	.07			1					
39	8 Aug.	C	20	17	.08			4			67	1	
40	8 Aug.	C	15	13	.05								
41	8 Aug.	C	17	15	.08			3					
42	8 Aug.	C	18	16	.06								
43	8 Aug.	C	20	17	.09			1			78		
44	8 Aug.	C	22	18	.12			18				2	
45	8 Aug.	C	20	17	.07	17		3			1		
46	8 Aug.	C	18	16	.07	14		5			2		
47	8 Aug.	C	17	15	.06	4							
48	8 Aug.	C	17	15	.05								
49	15 Aug.	S	17	14	.05			1					
50	15 Aug.	S	17	15	.06								
51	15 Aug.	S	19	16	.06			4					
52	22 Aug.	S	17	15	.05			1					
53	22 Aug.	S	19	16	.07			4					
54	22 Aug.	S	20	17	.08			7					
55	22 Aug.	S	19	16	.07			3	1			2	
56	22 Aug.	S	19	15	.06			3				3	
57	22 Aug.	S	18	15	.05			4					
58	22 Aug.	S	20	17	.09			5			1		
59	22 Aug.	S	15	13	.05			9			8	8	
60	22 Aug.	S	19	16	.07			8			2	4	
61	22 Aug.	S	18	16	.05			5			1	3	
62	22 Aug.	S	23	18	.12			1			21	6	
63	22 Aug.	S	20	17	.07			7					
64	22 Aug.	S	20	16	.08			9			6	3	
65	22 Aug.	S	22	20	.11			1	2				
66	22 Aug.	S	19	16	.05			3			9	4	
67	22 Aug.	S	20	16	.07			7					
68	22 Aug.	S	19	16	.07			8					
69	22 Aug.	S	17	14	.04			3			1		
70	22 Aug.	S	22	18	.10		1	11			15	15	
71	22 Aug.	S	19	16	.06			5					
72	22 Aug.	S	19	16	.07			8			7	13	
73	22 Aug.	S	22	18	.11			14				8	
74	22 Aug.	S	23	19	.13			10			6	27	

Table 12. (cont'd.)

Specimen number	Capture date	Sample sites - (North, South and Central)	T.L. (mm)	S.L. (mm)	Wt. (g)	GUT CONTENTS							
						Copepod nauplii	Bosmina spp.	Daphnia spp.	Leptodora kindtii	Chaoborus spp.	Cyclops spp.	Diaptomus spp.	adult Diptera
75	22 Aug.	N	32	26	.38			7					
76	22 Aug.	N	30	24	.28			2					
77	22 Aug.	N	37	30	.58			1					
78	22 Aug.	N	27	23	.23			4					
79	22 Aug.	C	22	18	.11			14			4	8	
80	22 Aug.	C	17	15	.06			2					
81	22 Aug.	C	22	18	.11			18			1	1	
82	22 Aug.	C	22	19	.10			8				1	
83	22 Aug.	C	21	18	.11			15					
84	22 Aug.	C	19	17	.07			6			1	2	
85	22 Aug.	C	22	19	.13			11					
86	22 Aug.	C	21	18	.09			5			1	1	
87	22 Aug.	C	18	16	.06			6			1	1	
88	22 Aug.	C	18	15	.06			7			1	2	
89	22 Aug.	C	21	17	.08			10				2	
90	22 Aug.	C	20	17	.08								
91	22 Aug.	C	20	18	.06			9				2	
92	22 Aug.	C	21	18	.08			15			1	14	
93	22 Aug.	C	30	25	.29			26			2	7	
94	22 Aug.	C	21	18	.09			9				1	
95	22 Aug.	C	19	17	.06			10			1	8	
96	22 Aug.	C	20	18	.07			10				3	
97	22 Aug.	C	22	18	.11			20					
98	22 Aug.	C	21	18	.10			16				1	
99	22 Aug.	C	20	18	.07			8			1	7	
100	22 Aug.	C	21	18	.09		1	1					
101	22 Aug.	C	21	18	.10			6					
102	22 Aug.	C	17	15	.05			10				7	
103	22 Aug.	C	16	15	.04			2			2	58	
104	22 Aug.	C	19	16	.05			5				3	
105	22 Aug.	C	17	14	.04			16				4	
106	22 Aug.	C	20	18	.09			5				3	
107	22 Aug.	C	21	19	.10			6					
108	22 Aug.	C	17	15	.05			2			3	7	
109	22 Aug.	C	18	16	.06			6					
110	22 Aug.	C	20	18	.08			6				1	
111	22 Aug.	C	18	15	.05			10				3	

Table 12. (cont'd.)

Specimen number	Capture date	Sample sites - (North, South and Central)	T.L. (mm)	S.L. (mm)	Wt. (g)	GUT CONTENTS							
						Copepod nauplii	Bosmina spp.	Daphnia spp.	Leptodora kindtii	Chaoborus spp.	Cyclops spp.	Diaptomus spp.	adult Diptera
112	22 Aug.	C	21	18	.09			11				2	
113	22 Aug.	C	18	16	.06			12					
114	22 Aug.	C	24	20	.16			19				6	
115	22 Aug.	C	18	15	.06			4					
116	22 Aug.	C	18	15	.06			7				1	
117	22 Aug.	C	21	19	.11			10			9	28	
118	22 Aug.	C	20	18	.06						8		
119	22 Aug.	C	15	13	.03			5				1	
120	29 Aug.	N	17	14	.05			2				2	
121	29 Aug.	N	19	16	.07	3		5			16	8	
122	29 Aug.	N	16	14	.05	6		3					
123	29 Aug.	N	16	14	.05	2		3			10		
124	29 Aug.	N	17	15	.06			2			1		
125	29 Aug.	S	20	17	.06	1		17				1	
126	29 Aug.	S	21	18	.10								
127	29 Aug.	S	22	19	.14			10			1	17	
128	29 Aug.	S	21	18	.10			14			9	46	
129	29 Aug.	S	20	16	.08			10				1	
130	29 Aug.	S	19	16	.07			4			5	16	
131	29 Aug.	S	20	16	.06			5			2	5	
132	29 Aug.	S	21	18	.01			7			6	24	
133	29 Aug.	S	20	17	.09			24			2	6	
134	29 Aug.	S	19	17	.07			8					
135	29 Aug.	S	19	17	.05			1			11	2	
136	29 Aug.	S	18	15	.05			2					
137	29 Aug.	S	19	17	.06						1	17	
138	29 Aug.	S	19	16	.06		1				1		
139	29 Aug.	S	18	15	.06		1						
140	29 Aug.	S	20	18	.09		1	1			5	3	
141	29 Aug.	S	23	20	.12			29			2	17	
142	29 Aug.	S	19	16	.06			17			2		
143	29 Aug.	S	19	16	.07			10			2	24	
144	29 Aug.	S	17	15	.05			1				2	
145	29 Aug.	C	18	16	.06			8				58	
146	29 Aug.	C	17	15	.05			8				2	
147	29 Aug.	C	19	17	.07			8				2	
148	29 Aug.	C	15	13	.04			1				13	
149	29 Aug.	C	20	17	.09			7				2	

Table 12. (cont'd.)

Specimen number	Capture date	Sample sites - (North, South and Central)	T.L. (mm)	S.L. (mm)	Wt. (g)	GUT CONTENTS							
						Copepod nauplii	Bosmina spp.	Daphnia spp.	Leptodora kindtii	Chaoborus spp.	Cyclops spp.	Diaptomus spp.	adult Diptera
150	29 Aug.	C	19	17	.07			2			3	24	
151	29 Aug.	C	25	21	.18			2			2	22	
152	29 Aug.	C	21	18	.12			15			2	13	
153	29 Aug.	C	18	16	.05			12				4	
154	29 Aug.	C	18	16	.06							37	
155	29 Aug.	C	25	21	.19			27			9	65	
156	29 Aug.	C	18	16	.07			4				29	
157	29 Aug.	C	19	16	.07			4			1	3	
158	29 Aug.	C	18	16	.06			1					
159	29 Aug.	C	23	20	.13			12				31	
160	29 Aug.	C	18	16	.06			3				23	
161	29 Aug.	C	17	16	.06			5			1	3	
162	29 Aug.	C	19	16	.06			6					
163	29 Aug.	C	22	19	.11			5				55	
164	29 Aug.	C	23	20	.12			14				16	
165	29 Aug.	C	16	14	.04							1	
166	29 Aug.	C	18	16	.05			1				1	
167	29 Aug.	C	22	17	.10			4				1	
168	29 Aug.	C	21	19	.09			6				37	
169	5 Sept.	S	15	13	.04			2					
170	5 Sept.	S	18	15	.06			19			5	1	
171	5 Sept.	S	19	15	.06			10					
172	5 Sept.	S	20	16	.06			5					
173	5 Sept.	S	19	15	.06			10			2	3	
174	5 Sept.	S	20	16	.07			1					
175	10 Sept.	C	22	18	.10		1	14			10	30	
176	19 Sept.	S	22	20	.14	1		1			20	4	
177	19 Sept.	S	22	20	.14		1	4			22	8	
178	19 Sept.	S	23	20	.17	1	9	3			131	13	
179	19 Sept.	S	23	20	.11		1	13			38	18	
180	19 Sept.	S	21	17	.10		6	9			71	40	
181	19 Sept.	S	21	18	.17			14			2	1	
182	19 Sept.	S	24	20	.17		55	3			63	39	
183	19 Sept.	S	23	20	.15		32	10			35	18	
184	19 Sept.	S	22	20	.13		9	12			20	5	
185	19 Sept.	S	22	18	.11		46	5			47	33	
186	19 Sept.	S	22	20	.19		1	9					

Table 13. Capture, length, weight and gut content data for brook silversides.

Specimen number	Capture date	Sample sites - (North, South and Central)	T.L. (mm)	S.L. (mm)	Wt. (g)	GUT CONTENTS							
						Copepod nauplii	*Bosmina* spp.	*Daphnia* spp.	*Leptodora kindtii*	*Chaoborus* spp.	*Cyclops* spp.	*Diaptomus* spp.	adult Diptera
1	8 Aug.	C	24	22	.06				2				5
2	8 Aug.	S	32	27	.15				1			2	
3	8 Aug.	S	35	30	.19			7					
4	15 Aug.	S	43	38	.33					8			2
5	15 Aug.	S	42	35	.29					6			3
6	15 Aug.	S	30	26	.12			5					1
7	15 Aug.	S	22	20	.04			2					
8	15 Aug.	S	35	31	.19			25	2				
9	22 Aug.	S	53	46	.58			2		7		1	2
10	22 Aug.	S	46	40	.37			1		3			
11	22 Aug.	S	56	48	.78					3	2		2
12	22 Aug.	S	50	44	.46			3					4
13	22 Aug.	S	25	22	.06		4	3				1	
14	22 Aug.	N	53	46	.61					1			18
15	22 Aug.	N	50	45	.48								7
16	22 Aug.	N	50	45	.47								8
17	22 Aug.	N	42	37	.32			1					10
18	29 Aug.	C	63	53	1.01			23	3				2
19	29 Aug.	C	58	31	.77								5
20	29 Aug.	C	53	46	.60			1	6				2
21	29 Aug.	C	40	36	.28			1			2		8
22	29 Aug.	C	47	41	.43						2		1
23	29 Aug.	N	25	21	.06			2			1	2	
24	29 Aug.	N	53	46	.63				5		7	4	4
25	29 Aug.	N	42	25	.28			39			4	5	2
26	29 Aug.	N	41	34	.28			5			3	10	7
27	29 Aug.	N	51	44	.57			17			1	5	4
28	29 Aug.	N	63	53	.95			33			3	12	7
29	29 Aug.	N	59	51	.75			81			5		4
30	29 Aug.	N	60	52	.88			12				3	1
31	29 Aug.	N	44	38	.33			33		2		1	3
32	29 Aug.	N	55	48	.71			20			4	13	5
33	29 Aug.	S	25	21	.06			1					
34	29 Aug.	S	55	48	.68								7
35	29 Aug.	S	37	31	.19			4					3
36	29 Aug.	S	25	22	.06		10	10			14	78	

Table 13. (cont'd.)

Specimen number	Capture date	Sample sites - (North, South and Central)	T.L. (mm)	S.L. (mm)	Wt. (g)	GUT CONTENTS							
						Copepod nauplii	*Bosmina* spp.	*Daphnia* spp.	*Leptodora kindtii*	*Chaoborus* spp.	*Cyclops* spp.	*Diaptomus* spp.	adult Diptera
37	29 Aug.	S	37	31	.20			5					3
38	29 Aug.	S	44	39	.35			13					6
39	29 Aug.	S	39	22	.33			17					
40	29 Aug.	S	27	24	.10			8					
41	29 Aug.	S	43	38	.31			4					2
42	29 Aug.	S	56	48	.70			26	1				
43	5 Sept.	S	60	52	.89		1				2	1	9
44	5 Sept.	S	32	27	.15	2	1	12			1		
45	5 Sept.	S	46	39	.36								3
46	5 Sept.	S	38	31	.23								2
47	5 Sept.	S	30	25	.09						8		4
48	5 Sept.	S	39	34	.21			1			1		1
49	5 Sept.	S	39	34	.27								
50	5 Sept.	S	42	36	.36								48
51	5 Sept.	S	41	26	.29				2		1		1
52	5 Sept.	S	61	54	.94								3
53	5 Sept.	S	22	20	.05	1					10		
54	5 Sept.	S	53	46	.69		1						9
55	5 Sept.	S	37	31	.24			8		1	7	4	
56	5 Sept.	S	63	52	.93			1					
57	5 Sept.	S	44	40	.34			8		1	2		3
58	5 Sept.	S	28	21	.10						6	1	2
59	5 Sept.	S	17	15	.02		3				2		
60	5 Sept.	S	28	25	.12								1
61	5 Sept.	S	51	44	.56								5
62	5 Sept.	S	52	45	.60			1					8
63	5 Sept.	S	48	42	.53				1				5
64	5 Sept.	S	32	28	.18			4		2	1	2	
65	5 Sept.	S	31	27	.16						2	4	2
66	5 Sept.	S	37	33	.24							1	4
67	5 Sept.	S	37	32	.24			4	1	1			
68	5 Sept.	S	31	27	.15	1					50		1
69	5 Sept.	S	34	29	.21			2					
70	5 Sept.	S	38	34	.31						2		2
71	5 Sept.	S	51	44	.62				4		1		19
72	5 Sept.	S	26	21	.07						85	5	
73	5 Sept.	S	32	21	.18				1		1	1	2

Table 13. (cont'd.)

Specimen number	Capture date	Sample sites - (North, South and Central)	T.L. (mm)	S.L. (mm)	Wt. (g)	GUT CONTENTS							
						Copepod nauplii	Bosmina spp.	Daphnia spp.	Leptodora kindtii	Chaoborus spp.	Cyclops spp.	Diaptomus spp.	adult Diptera
74	5 Sept.	S	31	27	.15		1	2			42	2	2
75	5 Sept.	S	30	27	.13			4			20		2
76	5 Sept.	S	25	21	.06								
77	5 Sept.	S	36	30	.19								
78	5 Sept.	S	31	27	.19								
79	5 Sept.	S	31	27	.16								7
80	5 Sept.	S	38	32	.26						7	1	2
81	5 Sept.	S	31	26	.13			2			179	7	1
82	5 Sept.	S	37	31	.24								1
83	5 Sept.	S	54	47	.70						11		
84	5 Sept.	S	32	28	.28								4
85	5 Sept.	S	25	23	.05								
86	5 Sept.	S	27	23	.08	1	1		1		32		4
87	5 Sept.	S	31	27	.16				2		2		2
88	5 Sept.	S	28	32	.23		1				1		3
89	5 Sept.	S	24	21	.06						46		
90	5 Sept.	S	32	29	.12	20	1			1	93		
91	5 Sept.	S	42	37	.31	4		6			145	4	
92	5 Sept.	S	21	19	.04		2	1			10	3	
93	5 Sept.	S	26	22	.07	101					3		
94	5 Sept.	S	46	40	.41		1				15		
95	5 Sept.	S	26	22	.06			1			17		
96	5 Sept.	S	19	16	.02						4		
97	5 Sept.	S	22	20	.03						1		2
98	5 Sept.	S	23	19	.06			5			9		
99	5 Sept.	S	32	27	.11	2					14	4	3
100	5 Sept.	S	44	39	.37		1	4			5	2	2
101	5 Sept.	S	25	21	.05		6	2			1	2	2
102	5 Sept.	S	25	21	.08		9	6			77	1	
103	5 Sept.	S	33	28	.16						2		8
104	5 Sept.	S	44	39	.32								3
105	5 Sept.	S	54	47	.67			4	2		1	2	
106	5 Sept.	S	32	27	.14						3	1	2
107	5 Sept.	S	26	23	.08			1			7	1	
108	5 Sept.	S	23	21	.05		1	3			1		
109	5 Sept.	S	32	28	.14		1				11	2	4
110	5 Sept.	S	31	26	.12		1			1	4	1	

Table 13. (cont'd.)

Specimen number	Capture date	Sample sites - (North, South and Central)	T.L. (mm)	S.L. (mm)	Wt. (g)	GUT CONTENTS							
						Copepod nauplii	Bosmina spp.	Daphnia spp.	Leptodora kindtii	Chaoborus spp.	Cyclops spp.	Diaptomus spp.	adult Diptera
111	5 Sept.	S	25	22	.08						10	2	1
112	5 Sept.	S	39	33	.38					1			1
113	5 Sept.	S	26	22	.06			1			10	6	
114	5 Sept.	S	32	29	.17					3			2
115	5 Sept.	S	43	38	.35								4
116	5 Sept.	S	28	25	.10					1	2	1	6
117	5 Sept.	N	64	55	1.04				1				
118	5 Sept.	N	61	53	.91				2				1
119	5 Sept.	N	63	55	.97			1				2	5
120	5 Sept.	N	64	55	1.07			14				1	
121	5 Sept.	N	63	55	.95								4
122	5 Sept.	C	71	62	1.45								8
123	5 Sept.	C	74	66	1.70								9
124	5 Sept.	C	74	64	1.69					2			20
125	5 Sept.	C	61	53	1.00				1	1			11
126	5 Sept.	C	61	53	.93								4
127	5 Sept.	C	53	47	.57					1			1
128	10 Sept.	N	69	62	1.23			1	1			1	1
129	10 Sept.	N	72	64	1.50				1				8
130	10 Sept.	N	73	64	1.46			2	2				12
131	10 Sept.	N	69	60	1.29				1				2
132	10 Sept.	N	64	56	.93								7
133	10 Sept.	N	73	63	1.44								23
134	10 Sept.	N	70	60	1.17								
135	10 Sept.	N	72	63	1.44				1				3
136	10 Sept.	N	71	63	1.39			2					9
137	10 Sept.	C	65	58	1.10			11					
138	10 Sept.	C	64	55	.97								5
139	10 Sept.	C	59	52	.76			6					
140	10 Sept.	C	72	63	1.39			5	2				1
141	10 Sept.	C	65	56	1.04						1		16
142	10 Sept.	C	69	63	1.38			15	3				6
143	10 Sept.	S	61	53	.84			4	1				
144	10 Sept.	S	70	61	1.31								
145	10 Sept.	S	41	63	1.47			46					3
146	10 Sept.	S	72	64	1.42			16					
147	10 Sept.	S	67	58	1.15			2					9

Table 13. (cont'd.)

Specimen number	Capture date	Sample sites - (North, South and Central)	T.L. (mm)	S.L. (mm)	Wt. (g)	GUT CONTENTS							
						Copepod nauplii	*Bosmina* spp.	*Daphnia* spp.	*Leptodora kindtii*	*Chaoborus* spp.	*Cyclops* spp.	*Diaptomus* spp.	adult Diptera
148	10 Sept.	S	73	64	1.49			145	2				1
149	10 Sept.	S	44	38	.31				1				
150	10 Sept.	S	63	55	.95				2				3
151	19 Sept.	N	52	44	.54					1			1
152	19 Sept.	N	63	54	.93				1				4
153	19 Sept.	N	67	59	1.12			1				1	
154	19 Sept.	N	69	60	1.20			9	2			2	5
155	19 Sept.	N	72	63	1.46								
156	19 Sept.	N	52	45	.51		11	2	2			72	
157	19 Sept.	C	73	63	1.44				2				4
158	19 Sept.	C	66	58	1.11			2					4
159	19 Sept.	C	60	52	.83			11					3
160	19 Sept.	S	53	46	.61			3		1	2	7	
161	19 Sept.	S	48	42	.44			22	1		2	5	1
162	19 Sept.	S	42	36	.26			18					
163	19 Sept.	S	42	36	.26	1	4	6			34	91	
164	19 Sept.	S	78	68	1.95			118				5	9

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