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Food and feeding relationships of young fish in the first weeks after the beginning of exogenous feeding in Lake Opinicon, Ontario*

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Synopsis

Young fish of six species in an open water community all began their exogenous feeding by taking nauplii and small cyclopoids of body length (less tail) of 0.1–0.3 mm. Appearance of larvae of the different species in the system was, however, sequential, the resource being utilized by the different species in turn. The sequence was: *Perca flavescens, Percina caprodes, Pomoxis nigromaculatus, Ambloplites rupestris, Lepomis gibbosus* and *L. macrochirus*.

The larvae and juveniles changes their diet rapidly as they grew. Fish 10–14 days after hatching and 8–10 mm in length i.e. close to the beginning of the juvenile period, consumed larger-bodied prey items (including several genera of Cladocera) and had more diversified diets than the 4.5–6.0 mm first-feeding larvae. These differences, and progressive dispersal of the larger young from the area, served to minimize the chances of food competition between batches of young of different ages.

The composition of the fish community of larvae changed from week to week as new species entered it, increased in size and departed. Patterns of food utilization changed accordingly.

Numbers of cyclopoids, their nauplii, and *Bosmina longirostris*, fell rapidly in May – early June, and did not increase again until August. These changes coincided with the rise and fall in numbers of the young fish in the habitat.

Introduction

Few comparative ecological studies have been made of the beginning of exogenous feeding in young fish. However, diet in the first weeks of external feeding, and possible starvation as a result of excessive numbers of young entering the system, have not received the attention they merit.The present study is directed at the analysis of the feeding of a seasonally changing open water community of young fishes in Lake Opinicon, Ontario. It expands the study of Amundrud et al. (1974), and deals with the larval and early juvenile stages as per the definitions of Balon (1975).

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Materials and methods

The study lake

Lake Opinicon is a small eutrophic lake of 3.7 x 0.6 km and maximum depth of 10 m in the Rideau Canal System. Its physiography and temperature regime is typical of many small lakes in eastern Ontario. It is ice-covered from December to mid-April and the spawning of the dominant perciform fishes extends from early May to late July.

Netting and processing procedures

Netting of the young fish was by twin conical nets of mesh size 0.5 mm with a mouth diameter of 61 cm mounted at the ends of a 3 m long wooden frame placed across the bow of the boat (see Amundred et al. 1974). The nets were 2.5 m long and tapered to a diameter of 10 cm, terminating in a 2 liter plankton bucket. The tows were made in water 1.4–2.3 m deep, parallel to the shore with the boat moving at the speed of 38.5 m per minute. Sampling was carried out at 5–7 day intervals from May 8 to August 19, 1970. Five stations along a 750 m section of shoreline were used, four paired samples being taken at each. The netting was done at night (2200–0130 h) since previous workers (Faber 1967, Noble 1970) found that the larvae aggregate less during darkness. The young fish were preserved in 5% formalin.

Zooplankton were collected by means of an 0.2 m diameter plankton net (no. 25 mesh-200 meshes per inch) towed behind the boat immediately after collection of the fish. The series of collections at each site involved the filtering of 36 m^3 of water on each occasion. In making counts the subsampling method of Allanson & Kerrich (1961) was followed, with the numbers of subsamples being increased as needed to achieve proper counts of the different species.

The fish counts are expressed as numbers per 100 m^3 of water filtered, zooplankters as numbers per m^3 of water.

The young fish

The larvae and early juveniles were identified according to keys listed in Amundred et al. (1974) and with the help of keys provided by Dr. D. J. Faber. After each collection was sorted, the numbers of each species were counted and their lengths measured. At the time of first appearance in the open water community, young centrarchids measured 4.5–5.5 mm in length and those of the longer-bodied *Perca* and *Percina* 5–6 mm. The appearance of these could be correlated with the maturing of successive batches of eggs in the female ovaries (unpublished data). *Percina, Pomoxis*, and *Lepomis* were multiple spawners.

Stomach analyses were made on 40–50 individuals of each species and size group (Tables 1–3). This proved to be easy since individual young commonly contained only 3–10 items per stomach. Length measurements of the various prey organisms were made in order to relate prey and predator size. Those given for adult cyclopoids represent the trunk length which is a little more than half the total length of the animal.

Diet diversity and niche overlaps were calculated by the formula of Levins (1968, pp. 43 and 51), as follows:

$$\beta_i \text{ (niche breadth)} = \frac{1}{\sum_{h=1}^{s} (p_{ih}^2)},$$

$$\alpha_{ji} \text{ (niche overlap)} = \frac{\sum_{h=1}^{s} p_{ih}p_{jh}}{\sum_{h=1}^{s} p_{ih}^2},$$

Table 1. Prey of newly feeding larvae, inshore open water, Lake Opinicon. Numbers of organisms per 10 fish. Based on batches of 50 stomachs.

May 1970							
Food organisms length, mm		nauplius 0.1–0.2	*Cyclops* 0.1–0.2	*Cyclops* 0.2–0.3	*Cyclops* 0.3–0.7	*Bosmina* 0.1–0.2	*Bosmina* 0.2–0.4
May 8							
Fish length mm							
Perca	6–7	12		7	14		
May 14–15							
Perca	6–8	9		10	7		
	8–10	10		11	9		1
Percina	4–5	27	14	4			
May 21–23							
Perca	7–9	10	11	89	4		1
	9–12	20		107	10		3
Percina	5–7	10	13	6	1	3	
	8–9		35	40	1	10	3
Pomoxis	4–5	65		3	1		

Table 2. Prey of newly feeding larvae, inshore open water, Lake Opinicon. Numbers of organisms per 10 fish. Based on batches of 40 stomachs on each date.

Food organisms		nauplius	*Cyclops*			*Bosmina*		*Sida*	*Poly-phemus*	*Diapha-nosoma*	*Cerio-daphnia*	
length mm		0.1–0.2	0.1–0.2	0.2–0.3	0.3–0.7	0.1–0.2	0.2–0.4	0.1–0.4	0.3–0.5	0.3–0.4	0.3–0.7	Other
June 5, 1970												
Fish length mm												
Perca	17–19	3			58		33		8			
Percina	6–7	15	15	10		1	2	1				
	8–10	6	25	40		1	2	1		3		
	12–16		35	90	50	4	3	2	2	27		2
	17–20				230		4			96	12	2
Pomoxis												
	5–7	35		22	6		1			3	1	
	7–9	11		25	40		6			4	3	
	10–12			2	44				2	10	5	
June 15–17, 1970												
Perca	18–23				48		6	5	18		28	35
Percina	5–6	36		14						2	2	
	6–8	140		24						6	6	
	8–11			40	38					82		
Pomoxis												
	4–5	26	18	18	4					1	3	
	5–7	9	46	25	16			2		8	2	2
	12–14		9	35	8		6	20	7	7		2
Micropterus												
	8–10		25	22		75	49	16	12			103
Ambloplites												
	7–9				88							
Lepomis												
	5–6	10	5	3	2							
	6–8		3		9	1	1			4	4	1
	8–9		4	8	10	2	2			9	7	
Alosa	9–12			10	20							
July 17–19, 1970												
Lepomis												
	4.5–5.5	4	17									
	6–7	2	13	10	1			4		6		
	8–10	6	4	12	3	2	1			14		
	10–13			10	9	5	8	15		14		
	15–20			1	15	23	29	30		16		
Alosa	9–12			40	8							
	13–16			5	9					60		

Table 3. Prey of young *Lepomis* in inshore open waters, Lake Opinicon. Numbers of organisms per 10 fish. Based on batches of 50 stomachs.

	August 4–5, 1970							
Food organisms	*Cyclops*		*Bosmina*		*Sida*	*Chydorus*	*Diaphanosoma*	*Ceriodaphnia*
length mm	0.2–0.3	0.3–0.7	0.1–0.2	0.2–0.4	0.1–0.4	0.1–0.3	0.3–0.4	0.3–0.7
Fish length mm								
6–8	9	2					5	2
9–11	2	3	27	36			21	4
12–14	8	7	11	36	31		50	
15–20	5	24		165	40	10	20	

where α_{ji} is the overlap of species j on species i relative to the niche breadth of species i for all h sample of resource s; p_{ih} is the proportion of a particular item h in the diet of species i; p_{jh} is the proportion of a particular item h in the diet of species j; and p_i is the breadth of utilization of a particular resource by species i, in this case food. May (1975) showed that of all the niche calculations available, the Levins formulae seem to be the most appropriate.

Using these formulae, calculated overlap values range downward from a figure slightly in excess of 1. A value of 1 or greater indicates total overlap. The overlaps are expressed as reciprocal pairs, i.e. one size group on another and the reverse.

The Shannon-Weaver formula (Shannon & Weaver 1963) was used to calculate species diversity of the zooplankton community:

$$H' = -\sum_{i=1}^{s} p_i \log p_i.$$

Results

Successional occurence of the species in the community and its relationship to temperature

The seasonal occurrence of young fish (length 4.5–6.0 mm) of the various species in the study site is shown in Figure 1. The 1970 data are compared with equivalent data from 1969. Similar sequence of first appearance occurred in the two years, although the initial spawning of all species was accelerated in 1970 due to early warming of the water in the spring. A mean temperature of 10° C was reached on May 5 that year and not until May 16 in 1969. By May 31 in both years, however, mean daily temperatures were 16° C (Amundrud et al. 1974).

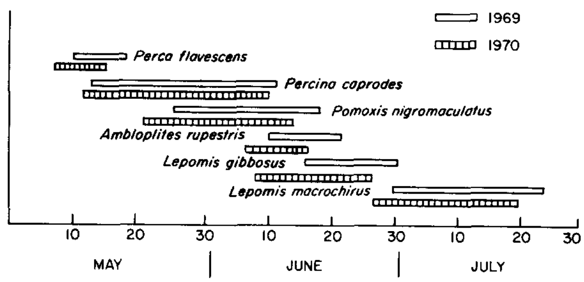

Fig. 1. Occurrence of larvae (length 4.5–6.0 mm) in the inshore open water community, Lake Opinicon, during the spring and summer of 1969 and 1970. With the exception of *Perca flavescens* most species are protracted spawners.

The seasonal occurrence of the various species in the community was as follows (Fig. 2–4):

Perca flavescens. Perch first appeared on May 8. Thereafter there was a numerical build-up to peak numbers of 650 per 100 m^3 on May 22. Most were then in the larger 8–10 mm length range and their relatively uniform size showed that (a) there had been only one rather massive spawning and, (b) the young perch continued to move up into the open waters from the spawning areas for some days after hatching. After May 28 there was a marked drop in perch numbers with a few large-sized (13–18 mm) individuals lingering in the community until June 17. Confirmatory evidence that perch are single spawners comes from the ovarian studies of Sheri & Power (1969).

Percina caprodes. Larvae (4–6 mm long) of this species were present from May 8 until June 17. Peak numbers occurred rather later than in the perch (May 28 to June 5). Spawning was more protracted and the numbers smaller than for perch.

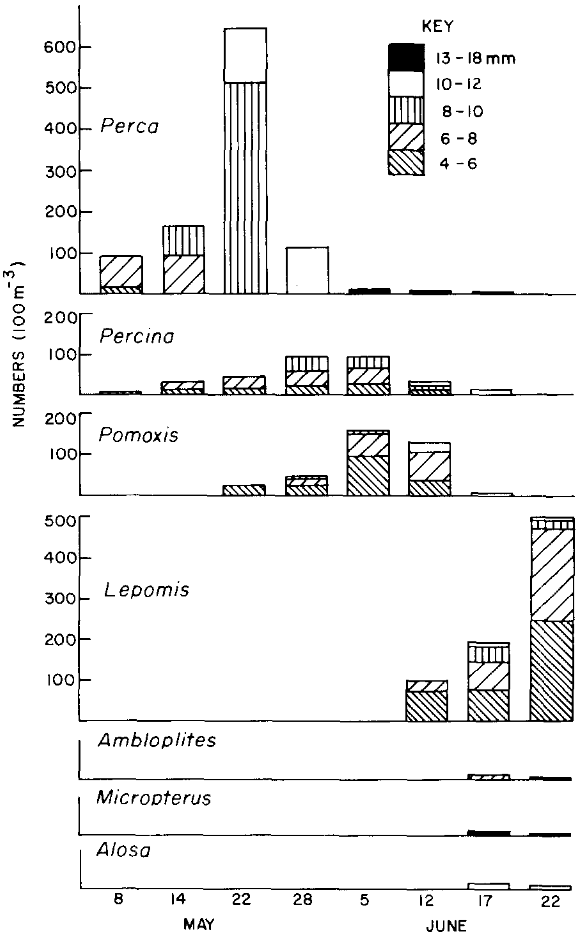

Fig. 2. Numbers of young fish of various species per 100 m^3 and their lengths in the inshore open waters of Lake Opinicon, May and June 1970.

Pomoxis nigromaculatus. Batches of 4–6 mm larvae were present from May 22 to June 12; crappie also had a protracted spawning season. Peak numbers occurred on June 5 and 17, with the total only being slightly greater than in *Percina.*

Ambloplites rupestris. This species, which nests solitarily along the shoreline, appeared briefly in the open water community only in very small numbers. A count of 8 per 100 m^3 of water was obtained on June 17. Young rock bass apparently keep mostly to the marginal shallows and bottom.

Micropterus salmoides. From early June onwards, widely scattered schools of bass larvae occurred in the study area. A few only were caught in the net (5–9 per 100 m^3 of water) between June 17 and 22 by

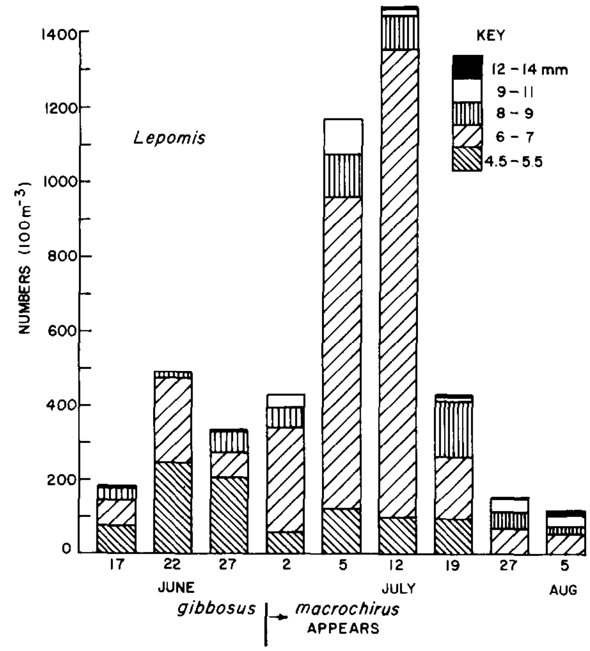

Fig. 3. Occurrence of young *Lepomis* spp. of different lengths, Lake Opinicon, late June to August, 1970.

which time they had reached lengths of 13–18 mm.

Lepomis gibbosus and *L. macrochirus.* Although Werner (1969) distinguished larvae of these two species, Amundrud et al. (1974) were unable to do so. Studies of nests, however, showed *L. gibbosus* to have eggs in its nests from June 4 to June 27, and *L. macrochirus* from June 15 to July 14, 1970. Accordingly, it can

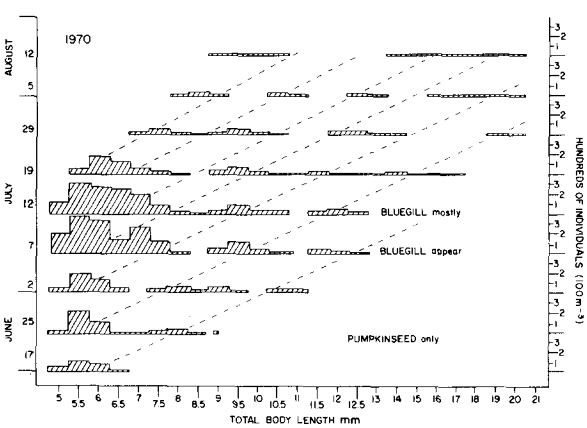

Fig. 4. Size distributions and abundances of young lepomids, inshore open waters of Lake Opinicon, June to August, 1970, and suggested growth rates (indicated by the dotted line) of successive clutches.

be assumed that nearly all the young sunfishes up to June 27 were *L. gibbosus*. Subsequently most, including the peak numbers of July 5 and 12 (counts of 1200 and 1450 per 100 m^3), were largely *L. macrochirus*.

Bluegills are by far the commonest fish species in Lake Opinicon, with a density of probably ten times that of other species (unpublished data). A detailed picture of the changing numbers and week to week size distribution of young *Lepomis* spp. between June 16 and August 12, is shown in Figure 4. Thus batches of new (4.5–5.5 mm) larvae occurred from June 12 (Fig. 2) to July 21. Five or six separate clutches are indicated, probably representing three of each species, with the last *L. gibbosus* and first *L. macrochirus* overlapping. Ovarian studies (unpublished) on both species prior to spawning showed three sets of egg sizes. At late spring and summer temperatures, it apparently takes about a week for a clutch of 5–6 mm young to reach 7–8 mm, or 2–3 weeks to grow to 10–12 mm (Fig. 4). Progressive decreases in numbers are presumably due to a combination of mortality and dispersal. Young *Lepomis* spp. leave the open waters to concentrate in the dense inshore weedbeds at an age of about four weeks. This habitat shift has also been documented for Crane Lake, Indiana (Werner 1967).

Alosa pseudoharengus. The surface waters of the mid-lake region is the main habitat of young alewives; hence they are only marginal in the inshore open waters. The species was first recorded there between June 17 and 22 at a length of 10–12 mm.

Seasonal changes in larval community structure

Differences in the breeding seasons of the species explains the changing structure of this open water larval community (Fig. 1). On May 8 and 14 only 5–6 mm long *Perca* and the first few *Percina* were present. By May 21–23 the community contained also *Pomoxis* but continued to be dominated by perch. By June 5, only a few 13–18 mm perch remained, *Pomoxis* was the most common species and total number of all larvae and juveniles was 320 per 100 m^3. The community achieved its greatest diversity on June 12–17 with the addition of *Lepomis gibbosus* and a few *Ambloplites*, *Micropterus*, and *Alosa.* Despite this, total numbers of young fish was only about 250–300 per 100 m^3 of water. From June 17 onwards sunfishes completely dominated the community, with numbers of young fish reaching an all time peak of 1400 per 100 m^3 on July 12 (Fig. 3). The absence of other species in the community at this time is presumably a factor permitting such high numbers to be maintained.

The feeding of the species and size sub-groups

The prey of the various fish species are compared for four dates as follows: May 8–23, June 15–17, July 17–19 and August 4–5 (Tables 1–3).

Several major points emerge. Larvae of all species 4–7 mm in length fed almost entirely on nauplii 0.1–0.2 mm long and adult cyclopoids 0.2–0.3 mm long, especially*Tropocyclops prasinus.* As the fish grew, the size of prey eaten increased and a correlation between fish size and prey size became apparent. Thus, on May 21–23, *Percina* larvae 5–7 mm in length, ate mostly nauplii and the smaller adult cyclopoids of length 0.1–0.2 mm. Fish of 8–9 mm contained also 0.2–0.3 mm, plus 0.1–02. mm *Bosmina longirostris.* Similar separations characterised *Pomoxis* of 4–5, 5–7 and 12–14 mm length on June 15–17, and the different sized *Lepomis* spp. on July 17–19. Again the youngest fish took only small numbers of organisms, e.g. 6–7 mm *Perca* on May 8 averaged only 3 organisms per individual. Perch of 9–12 mm on May 21–24 took 14 organisms per individual.

Just as the smallest size (4–6 mm) fish of different species, netted on different dates, had similar diets, so had fish of different species of equivalent sizes – note the similar diets of 8–10 mm *Perca, Percina*, and *Lepomis*. Some species differences are suggested, however. Thus 8–9 mm *Percina* on May 21–23 contained more *Bosmina longirostris* than did young *Perca*. Diets at any time also reflect abundance levels – note that heavy consumption of *Ceriodaphnia* spp. by fish on June 15–17 is linked to its higher standing crop at this time (Fig. 5).

An important feature of the diet of the growing fish larvae is increasing diversity of food organisms. Compare, for example, the organisms eaten by 6–8 mm *Perca* on May 8 and 14–15 with those taken by the 18–23 mm ones on June 15–17 (Table 2), and the diets of *Lepomis* of different lengths on July 17–19 (Table 2).

Diet breadth in young *Perca, Percina, Pomooxis*, and *Lepomis* of different ages is quantified by the Levins diversity index (Levins 1968). The progressive increase in diet diversity (Table 1–3) characterizes all

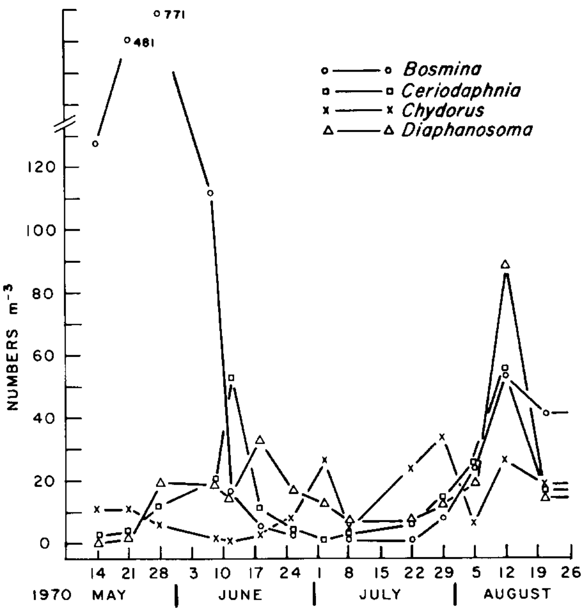

Fig. 5. Population fluctuations in four genera of cladocerans, *Bosmina longirostris, Ceriodaphnia quadrangular, C. lacustris* and *C. reticulata, Chydorus sphaericus* and *Diaphanosoma leuchtenbergianum* in inshore open waters of Lake Opinicon, May to August, 1970.

species, with the exception of *Percina* where in the 17–20 mm fish, diversity is reversed (Fig. 6). These fish were feeding heavily on a single food (mostly 0.3–0.7 mm *cyclopoid copepods*). This may reflect an abundance of this prey type at the time, however.

Increased body size made available a wider spectrum of prey types, including larger cladocerans such as *Diaphanosoma leuchtenbergianum, Polyphemus pediculus, Ceriodaphnia quadrangula, C. lacustris* and *C. reticulata*, and *Sida cyrstallina*, as well as ostracods and Hydracarina, a few of which appeared in the diets at ages of 3–4 weeks. The relatively large mouth of young *Micropterus salmoides* permitted this species to eat larger bodied organisms at an exceptionally early age. Fish only 7 mm long contained chironomids.

Diet separation in Lepomis spp. of different body sizes

Food size data for five length groups of *Lepomis* larvae, ranging from 4.5–5.5 to 15–20 mm (data for June 17 to July 21 grouped) is shown in Table 4. It is

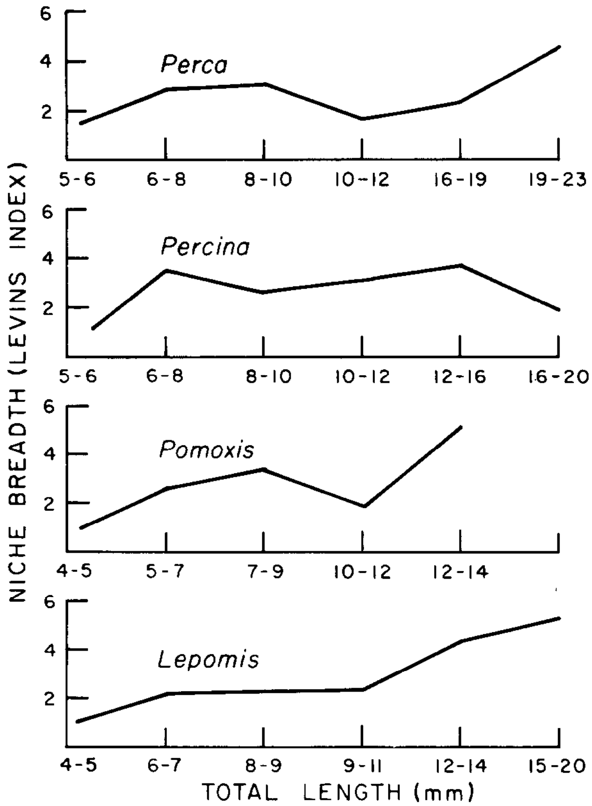

Fig. 6. Changing diet diversity with age in first 6–8 weeks of feeding for four members of the inshore open water community, Lake Opinicon.

based on the % volume of each prey size category eaten, rather than numbers. A striking degree of separation now emerges. Thus 91% by volume of the prey of the 4.5–5.5 mm fish is of organisms 0.08–0.14 mm, 80% of that of 6–7 mm fish 0.15–0.28, and 50% of the diet of 12–14 mm fish is in 0.28–0.42 mm range. The implications of this with respect to the avoidance of intraspecific competition should resources become limited is obvious.

Diet overlaps between the species and their size groups

Diet overlaps for nine species and their length groups, calculated by the Levins formula (Levins 1968, May 1975), are given in Table 5. To highlight trends, only smaller and larger fish of each species are contrasted. Whilst *Percina, Pomoxis* and *Lepomis* of the former

Table 4. Relationships between sizes of food organisms eaten and body length of young *Lepomis gibbosus* and *L. macrochirus*, Lake Opinicon, Ontario, June 17 to July 21, 1970. Fish of similar lengths from the various dates are combined. % volumes are based on entire series.

	June 17–July 21, 1970				
Fish, total length mm	4.5–5.5	6–7	8–11	12–14	15–20
Sample size	150	150	150	70	70
Lengths of food organisms mm	% vol.	% vol.	% vol.	% vol.	% vol.
0.08–0.14	91	5	.4		
0.15–0.28	9	80	52	26	2
0.28–0.42		15	38	50	36
0.42–0.66			9	24	21
1.3 –2.4					17

size, and *Percina, Pomoxis, Lepomis*, and *Alosa* of the latter, have high diet overlap levels, the diet overlaps are low between 5–6 mm and 8–12 mm pairs both within, and among species.

Seasonal changes in standing crop of the major food organisms and its relationship to fish feeding

Week to week changes in numbers of 0.1–0.2 mm, 0.2–0.3 mm, and 0.3–0.7 mm cyclopoids and of cyclopoid nauplii are shown in Figure 7. These size divisions are based on fish prey size selection patterns. Note the striking numerical dropoff of all three in May following appearance of the fish larvae. Numbers of prey remained low throughout June and July despite higher summer productivity. Prey numbers increased only in August when the fish numbers became very low. The larger 0.3–0.7 mm cyclopoid copepods were eaten by fish 8 mm and longer. They, however, continued to be utilized by the 15–20 mm long *Lepomis* in August and this helps explain their continued suppression through this month.

Seasonal variations in the standing crops of four cladocerans, three of importance to the young fish (*Bosmina longirostris, Ceriodaphnia* spp., *Diaphanosoma leuchtenbergianum*, and the other of little importance (*Chydorus sphaericus*) are shown in Figure 5. *Bosmina longirostris*, the most abundant species showed the same numerical dropoff in early spring as did the cyclopoids. Numbers again remained low all summer and there was a partial numerical recovery in August (to about 50 m^3). The less common *Diaphanosoma leuchtenbergianum*, most of which were in the 0.3–0.4 mm length range, showed a minor population peak in mid-June, followed by low numbers in late June and July, and a high peak in mid-August. It did not occur in the diet of any fish in

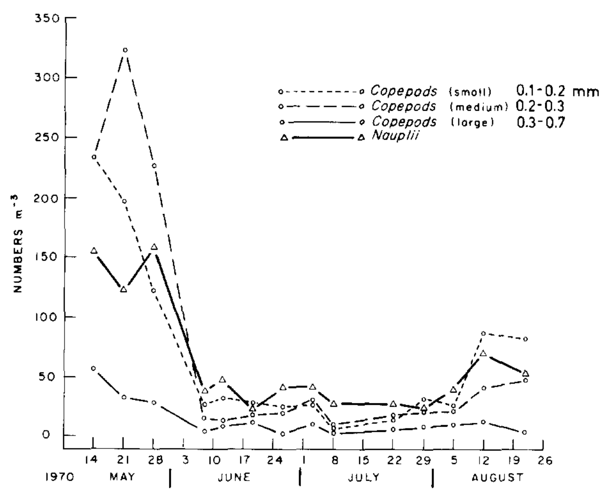

Fig. 7. Seasonal changes in numbers of three length categories of cyclopoid crustaceans, Lake Opinicon, May-August, 1970.

Table 5. Diet overlaps between species and size classes of young fish, inshore open water community of Lake Opinicon, June, 1970, expressed as pairs of reciprocals. The left hand figure of each pair represents α_{ij}, the right figure, α_{ji}.

Species and length (mm)	*Percina* 5–6	*Percina* 9–11	*Pomoxis* 4–6	*Pomoxis* 10–12	*Micropterus* 8–12	*Ambloplites* 7–9	*Lepomis* 5–6	*Lepomis* 8–9	*Alosa* 9–12
Perca 18–23	0.03, 0.01	0.36, 0.21	0.13, 0.10	0.20, 0.23	0.02, 0.02	1.5, 0.34	0.10, 0.15	0.22, 0.16	0.99, 0.58
Percina 5–6		0.16, 0.22	0.61, 1.15	0.19, 0.51	0.04, 0.10	0, 0	0.72, 1.08	0.61, 1.0	0.15, 0.20
9–11			0.22, 0.31	0.40, 0.79	0.05, 0.09	0.62, 0.24	0.16, 0.18	0.43, 0.52	0.49, 0.49
Pomoxis 4–6				0.46, 0.66	0.15, 0.21	0.21, 0.06	1.07, 0.85	0.89, 0.78	0.38, 0.28
10–12					0.27, 0.25	0.44, 0.09	0.46, 0.26	0.98, 0.60	0.72, 0.36
Micropterus 8–12						0, 0	0.17, 0.10	0.23, 0.15	0.10, 0.05
Ambloplites 7–9							0.10, 0.29	0.46, 0.15	0.51, 1.34
Lepomis 5–6								0.69, 0.77	0.26, 0.23
8–9									0.61, 0.50

May but was harvested by the 8–11 mm *Percina*, and to a lesser extent by 5–14 mm *Pomoxis* and 8–9 mm *Lepomis*, on June 15–17 (Table 2), by *Lepomis* and *Alosa* in mid July (Table 3) and to a marked extent by the small population of *Lepomis* (Fig. 3) remaining in August. Again there is correlation between intensity of fish predation and standing crop. *Chydorus sphaericus* (length 0.1–0.3 mm) is included on Figure 5 because it is a moderately abundant species. However, it proves to be of little significance in the diet of these young fish. This demonstrates the occurrence of a resource that is not being used. However, as shown elsewhere (Keast 1977) the larger *Lepomis macrochirus* utilize *Chydorus sphaericus* in July and August.

Sida and *Diaphanosoma*, by contrast are prominent in the diets. However, their numbers are quite low in the system and hence they are not included in Figure 5. Abundance per m^3 of water for the various study dates were as follows: *Sida* – May 14, 0; May 21, 0.5; May 28, 1.5; June 7, 0.4; June 11, 0.2; June 18, 0.2; June 25 0; July 2, 1.0; July 8, 0.5; July 22, 0; July 29, 4.0; August 5, 2.0; August 12, 0.7; August 21, 0.2. *Diaphanosoma* – May 14, 0.5; May 21, 2.0; May 28, 19.0; June 7, 19.0; June 11, 16.0; June 18, 33; June 25, 17.0; July 2, 13.0; July 8, 6.0; July 22, 7.0; July 29, 13.0; August 5, 19.0; August 12, 88.0; August 21, 15.0. Hence, there is selective predation on these larger organisms.

To investigate the possible link between the de-

Table 6. Species diversity in the zooplankton community, May 14–August 21, 1970. (Shannon-Weaver Index).

Date		Diversity
May	14	1.59
	21	1.46
	28	1.36
June	7	1.76
	11	1.90
	18	2.0
	25	1.90
July	2	1.94
	8	1.90
	22	2.06
	29	2.22
August	5	2.17
	12	2.16
	21	1.90

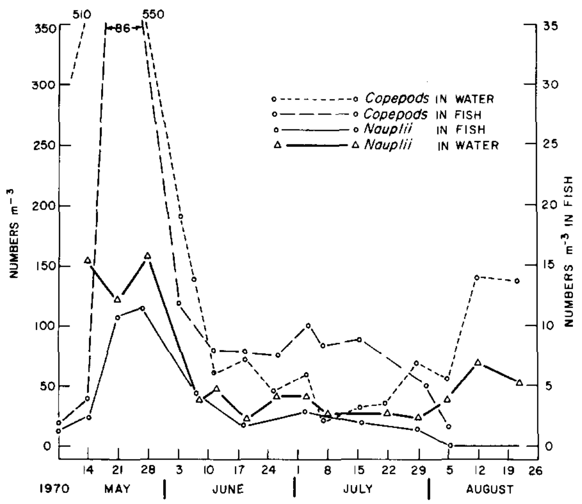

Fig. 8. Relative abundances of cyclopoid copepods and their nauplii in the water column compared to the numbers in the stomachs of fish in an equivalent volume of water, Lake Opinicon, May to August, 1970.

crease in cyclopoid numbers and increasing fish predation, data for total numbers of nauplii and adult cyclopoids in the water, expressed as numbers per m^3, and numbers in the stomach of the fish occurring in an equivalent volume of water are presented in Figure 8. A correspondence is apparent and this also extends into the increase in numbers of these organisms again in August by which time the young fish have left this habitat. This suggests but does not prove a cause and effect relationship.

Zooplankton densities are susceptible to suppression by planktivores (Brooks & Dodson 1965). This suppression doubtless characterizes situations where fish are concentrating on a single prey species. In Lake Opinicon, the youngest fish are limited to prey items 0.1–0.3 mm long. Larval and adult cyclopoids are the only organisms with a body size sufficiently small for them to eat.

The suggestion that (a) predation by young fish has an effect on the standing crop of copepods and (b) the different fish species avoid possible 'competition' by harvesting this resource at different times suggests that food could, on occasions, become limiting. This might happen in a spring when water temperatures warmed up unusually rapidly so that there was increased overlap in the spawning of species, and an unusually large number of larvae were present.

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