The Comparative Ecology of Pearl Dace (*Semotilus margarita*) and Fathead Minnow (*Pimephales promelas*) in Lake 114, the Experimental Lakes Area, Northwestern Ontario, with an Appended Key to the Cyprinids of the Experimental Lakes Area

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May 1984

Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1756

Government of Canada Fisheries and Oceans
Gouvernement du Canada Pêches et Océans

Canadian Manuscript Report of Fisheries and Aquatic Sciences

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Canadian Manuscript Report of

Fisheries and Aquatic Sciences 1756

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by

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This is the 46th Manuscript Report

from the Western Region, Winnipeg

Cat. no. Fs 97-4/1756 ISSN 0706-6473

Correct citation for this publication:

Tallman, R.F., K.H. Mills, and R.G. Rotter. 1984. The comparative ecology of pearl dace (*Semotilus margarita*) and fathead minnow (*Pimephales promelas*) in Lake 114, the Experimental Lakes Area, northwestern Ontario, with an appended key to the cyprinids of the Experimental Lakes Area. Can. M~~anuscr~~. Rep. Fish. Aquat. Sci. 1756: iv + 27 p.
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ABSTRACT

Tallman, R.F., K. H. Mills, and R. G. Rotter. 1984. The comparative ecology of pearl dace (Semotilus margarita) and fathead minnow (Pimephales promelas) in Lake 114, the Experimental Lakes Area, northwestern Ontario, with an appended key to the cyprinids of the Experimental Lakes Area. Can. Manuscr. Rep. Fish. Aquat. Sci. 1756: iv + 27 p.

The growth, length-weight relationship, condition and diet are described for pearl dace (Semotilus margarita) and fathead minnow (Pimephales promelas) from Lake 114 in the Experimental Lakes Area (ELA), northwestern Ontario. At least three age groups of fathead minnow and four of pearl dace were present. Pearl dace grew faster than fathead minnow and diets of the two species overlapped to a great extent. A key to the cyprinid species of ELA is included which gives external morphological characteristics to distinguish between species and sexes of each species.

Key words: pearl dace; fathead minnow; growth; condition; diet.

RESUME

Tallman, R.F.. K. H. Mills, and R. G. Rotter. 1984. The comparative ecology of pearl dace (Semotilus margarita) and fathead minnow (Pimephales promelas) in Lake 114, the Experimental Lakes Area, northwestern Ontario, with an appended key to the cyprinids of the Experimental Lakes Area. Can. Manuscr. Rep. Fish. Aquat. Sci. 1756: iv + 27 p.

Ce rapport renferme des données sur la croissance, le rapport longueur-poids, l'état physique et le régime alimentaire du mulet perlé (Semotilus margarita) et du tête-de-boule (Pimephales promelas) provenant du lac 114 dans la Région des Lacs Expérimentaux du Nord-Ouest ontarien. On a compté au moins trois groupes d'âge chez le tête-de-boule et quatre chez le mulet perlé. Ce dernier croît plus rapidement que le tête-de-boule, même si les régimes alimentaires des deux espèces se ressemblent énormément. Le rapport comprend une légende des caractéristiques morphologiques propres aux mâles et aux femelles des différentes espèces de cyprinidés de la Région des Lacs Expérimentaux.

Mots-clés: mulet perlé; tête-de-boule; croissance; état physique; régime alimentaire.

INTRODUCTION

The tourist industry is one of the most important economic groups in northwestern Ontario. Within this region angling is usually conducted with live bait, usually minnows. An extensive baitfish fishery has developed in this region to support the tourist industry. The wholesale value of this fishery in northwestern Ontario has grown from ≈$400 000 in 1972 (Beamish et al. 1976) to over $800 000 in 1983 (N. Ward, Ontario Ministry of Natural Resources, Kenora, Ontario, personal communication). In the past two years, the wholesale value of the fishery has increased ≈40%. When the wholesale value of the fishery was scaled to total value, the value of the fishery in 1982 was $2 361 000. The total value of the fishery in all Ontario regions was $5 693 402 in 1982. These totals are probably substantial underestimates of the true value; it is unlikely that every minnow sold in Ontario is reported.

In spite of the importance of this fishery to the economic base in Ontario and other provinces, very little is known about the biology of the prime baitfishes (Scott and Crossman 1973): fathead minnow (Pimephales promelas), pearl dace (Semotilus margarita), finescale dace (Chrosomus neogaeus), redbelly dace (Chrosomus eos), emerald shiner (Notropis atherinoides) and spottail shiner (Notropis hudsonius). The life histories of many of these species -- age, growth, mortality, diet, production, etc. -- are poorly known for Canadian populations, especially for lake populations where most commercial exploitation occurs. Most data are for more southerly populations in the central United States where climatic conditions and fish community structure are quite different from central Canada. Little is known about the impact of commercial fisheries on baitfish populations. Because life history data are very incomplete, predicting optimum yields on a quantitative basis is impossible. The impact of various exploitation rates on baitfish and their competitors is unknown. Management of baitfish populations is based more on the intuition of individual fishermen than on stock-recruitment or other relationships developed for commercial species. In addition, baitfish are usually one of the first fishes impacted by pollution (Mills 1984; Mount 1973). The purpose of this report is to present background data for two minnow species, pearl dace (Semotilus margarita) and fathead minnow (Pimephales promelas), from Lake 114, the Experimental Lakes Area (ELA) for 1979: length frequency distributions, growth, condition, diet and activity. While Scott and Crossman (1973) provide reviews of the life histories of both species, a significant number of additional studies have occurred in recent years. These will be summarized in a short review. As an aide for further cyprinid studies in the Experimental Lakes Area, brief species descriptions emphasizing differences between species are included as an appendix. These are necessary because cyprinids hybridize readily in many geographic areas, and it is difficult to distinguish between species, even with the help of general taxonomic keys.

A SHORT REVIEW OF PERTINENT LIFE HISTORY INFORMATION

The two ubiquitous cyprinid species in the ELA are the pearl dace (Semotilus margarita) and the fathead minnow (Pimephales promelas). They co-occur in many ELA lakes of varying sizes. Therefore, this review is organized so the similarities and differences in the two species' life histories are highlighted.

DISTRIBUTION AND SUBSPECIES

Semotilus margarita (Cope 1869) is widely distributed in Canada. It occurs from the maritime provinces west to the Peace River system of British Columbia, and from the arctic tundra south to Montana in the west and to Pennsylvania and Virginia in the east (Hubbs and Lagler 1958; McPhail and Lindsey 1970; Scott and Crossman 1973). Four subspecies, S. m. margarita (Cope 1869), S. m. nachtriebi (Cox 1869), S. m. koelzi (Hubbs and Lagler 1949), and S. m. athabascae (Bajkov 1927) are recognized (Scott and Crossman 1973). Pearl dace are not abundant in waters of the southern portion of its range, the United States and southern Ontario (Fava and Tsai 1974; Loch 1969), but are very abundant in many northern streams (Tallman 1980; Tallman and Gee 1982) and lakes (Beamish et al. 1976; Lalancette 1977).

Pimephales promelas (Rafinesque 1820) occurs from New Brunswick west to Alberta, and from Great Slave Lake south to Chihuahua, Mexico in the west and to Louisiana in the east (McPhail and Lindsey 1970). No distinct subspecies are recognized by Scott and Crossman (1973) but physical characteristics vary extensively along clinal axes.

HABITAT AND DIET

A detailed literature review of habitat and diet of lake and stream populations of pearl dace is located in Tallman (1980). Tallman and Gee (1982) found that pearl dace partitioned habitat and food both intra- and interspecifically in headwater streams to avoid overlap of resource utilization. They concluded that pearl dace had an unusually broad feeding niche for a temperate climate species. Breadth of diet in both variety and size was remarkable: terrestrial insects, winged insects, small benthic invertebrates, benthic macro-invertebrates, detritus, aquatic plants, terrestrial plant seeds and berries. While Lalancette (1977) found that fish were a dietary component in a Quebec lake, this did not occur in a stream population (Tallman and Gee 1982). Pearl dace occur in winterkill lakes and streams. Their oxygen requirements were studied by Gee et al. (1978) and other authors (Doudoroff and Shumway 1970). In deep lakes (>5m), pearl dace move to deeper, cooler hypolimnetic waters when epilimnetic temperatures are >20°C (J. Schulz and D. Beaushene, Sioux Narrows, personal communication).

The fathead minnow is abundant in many small streams and shallow lakes (McPhail and

Lindsey 1970). The feeding ecology of the fathead minnow in lakes and resource partitioning with other species are not well defined. Habitat preferences are reviewed by Scott and Crossman (1973). The most complete descriptions of fathead diet are those of Coyle (1930) and Held and Peterka (1974). Algae, detritus, insect larvae and zooplankton occurred in fathead stomachs. Because fatheads possess a long convoluted intestine, Scott and Crossman (1973) predicted a diet rich in plant material. Fatheads are generally viewed as a "temperate generalist" (Hyatt 1979). The fathead minnow occurs in many winterkill lakes and streams. Their oxygen requirements were studied by Gee et al. (1978) and many other authors (Doudoroff and Shumway 1970). In deep lakes (>5m) fathead minnows are distributed throughout the water column during hot summer months, but sometimes congregate in deeper waters (K.H. Mills, unpublished data). The under-ice distribution of fathead minnows in a winterkill lake was studied by Mills (1972).

AGE AND GROWTH

Pearl dace may live to age 4 (Lalancette 1977; Stasiak 1978) but few individuals survive beyond age 3 in northern waters (Tallman 1980; ELA staff, unpublished data). Females usually live longer, grow faster and reach greater maximum lengths than males. Age 0 fish (young of the year) have the greatest growth rate and over 75% of yearly growth takes place from May to November (Fava and Tsai 1974; Lalancette 1977). Sex ratios of adults (age 1 and older) vary from 2:1 (male:female, Fava and Tsai 1974) for the southern pearl dace (S. m. margarita) to 1:1 for the northern subspecies (S. m. nachtriebi) (Lalancette 1977; Tallman 1980).

The fathead minnow may live to age 3 (Scott and Crossman 1973) but few individuals survive beyond age 2. Little data are available for northern populations of fathead minnow. Growth is very rapid in warm, food rich waters and fish become sexually mature by ≈5-7 cm. Males generally grow more rapidly and attain a larger size than females.

In general, most studies of age and growth of either the pearl dace or fathead minnow are very descriptive with little quantitative data.

REPRODUCTION

Pearl dace spawn in early spring, about the time spring melt and ice-off occurs in many northern lakes. Spawning occurs in tributary streams or in the vegetation on the periphery of lakes (D. Beashene and J. Schulz, Sioux Narrows, personal communication; Scott and Crossman 1973). Sexual maturity is reached during the second summer of life (age 1). Langlois (1929) summarized the reproductive behavior of pearl dace in streams.

Fathead minnow reproduction has been studied extensively in both Canadian and American waters (Scott and Crossman 1973). Spawning usually occurs in June; the minimum temperature for onset of spawning is ≈15.8-17.8°C. Spawning sites are usually located along the lake. Richardson (1937) gives a thorough description of fathead minnow spawning in lakes.

MATERIALS AND METHODS

Lake 114 is a small (12.1 ha), shallow (5.0 m z_m) lake in the ELA. Details of the bathymetry, pre-acidification water chemistry and other limnological features in the lake can be found in Brunskill and Schindler (1971), Armstrong and Schindler (1971) and other articles in the Journal of the Fisheries Research Board of Canada, Volume 28, number 2, 1971. Small mesh (1.6 mm) trapnets (Beamish 1973) were used to collect cyprinids from May to August 1979 at approximately biweekly intervals. Patterns of daily activity were determined by emptying nets at 4 h intervals over 24 h sampling periods every one to two weeks from May 23 to July 31 except for one week when a 24 h set was used. The taxonomic guide in Appendix A was developed prior to this study from available keys (Scott and Crossman 1973; Hubbs and Lagler 1949) and was used to identify cyprinids to the species level. Four cyprinid species are present in Lake 114: pearl dace, fathead minnow, finescale dace and redbelly dace. The lake is periodically exploited by a local bait fisherman (J. Schulz, Sioux Narrows, personal communication).

After capture fish were transported live to an ELA laboratory where they were sorted and frozen. Later, standard length, and sex, when discernible,were recorded. When a particularly large catch was obtained, a random sample volume was taken for analysis. The remaining fish were counted by species and returned alive to L114.

Age classes of pearl dace and fathead minnow in L114 were determined by examination of length frequency histograms of collections made in 1979 and those from 1978 and 1980 (ELA staff, unpublished data). This method was validated by following modes between and within individual years 1978-80. Monthly collections were made during the ice-free seasons of 1978 and 1980 (ELA staff, unpublished data). The 1979 pearl dace and fathead minnow collections were converted from standard lengths to fork lengths by multiplying by 1.13 and 1.17 respectively after determining the relationship between the measurements for individual fish (Tallman, unpublished data). Few young of the year (age 0) dace or fathead minnow were captured.

Pearl dace and fathead minnow growth rates were calculated as the difference between the modal lengths for each age class from successive samples. The result was divided by the number of days in the interval to yield a daily growth increment. Length-weight ratio was described by regression analysis. Individuals of various lengths of each age and sex were weighed after damp-drying. A coefficient of condition was calculated for each fish using:

$$K = \frac{W \times 10^5}{L^b} \qquad \text{(Carlander 1969)}$$

where W = weight, L = fork length and b was the slope of the length-weight regression. Sex ratios of pearl dace were determined for each size frequency mode in each sample. Sex was determined by examination of secondary sexual characteristics and confirmed on occasion by dissection of gonads (see Appendix A for descriptions of species differences and sexual dimorphism).

Dietary patterns of fathead minnow and pearl dace were determined from the food items that were present in the anterior two-thirds of the gut of five fish of each sex and age group from each of the six daily sampling periods during 1979. Food items were identified at least to taxonomic order. The percent numbers and percent occurrence methods described by Hynes (1950) were used. Percent occurrence and percent numbers were added together for each food item and divided by two to obtain a percent "Importance value" ("I") (Tallman 1980). "I" values for items such as detritus and plant material were based on percent occurrence only (and therefore not divided by 2). Intra- and inter-specific dietary comparisons between age groups, sexes and times of day were made using Morisita's (1959) "Index of Overlap", C_τ. A C_τ value of greater than 0.50 indicated significant dietary overlap.

The use of percent numbers and percent occurrence was criticized by Wallace (1981) because these measures biased dietary estimates in favor of smaller items. This is true for percent numbers but in practice when several fish comprise the sample, the bias of percent occurrence is minimized.

RESULTS

AGE GROUPS, LENGTH-WEIGHT RELATIONSHIP, GROWTH RATE AND CONDITION INDEX

At least four age groups were distinguished for the pearl dace (Fig. 1) while three or more were observed for fathead minnow (Fig. 2). After sexual maturity, female dace attained greater length on average than males of similar age (Fig. 3). No length differences were discernable between the sexes of fathead minnow.

The growth increment for pearl dace from age 1 to age 2 was 14.7 mm or 30.1%. From age 2 to age 3^+ (age 3 and older fish) male dace increased in length by 24.8% or 15.8 mm on average. Female dace grew 21.1 mm or 32.4% in this same period. Fathead minnow grew from 37.5 mm to 48.8 mm on average, an increase of 11.3 mm or 30.1% from age 1 to age 2^+.

The length-weight relationships for pearl dace and fathead minnow were typical of other fishes (Bagenal and Tesch 1978; Ricker 1975). The length-weight relationship of pearl dace was described by the following equation: $\ln W = 2.90 \ln L - 10.98$, $r = 0.92$ (L = length, W = weight). Fathead minnow length-weight relationship was $\ln W = 3.65 \ln L - 13.52$, $r = 0.94$.

The mean coefficients of condition of pearl dace and fathead minnow over all four sampling periods were 2.987 and 3.646 respectively. Comparisons between sampling periods showed that dace were in highest condition during late July and lowest condition in late May after spawning had occurred. Fathead minnow were in highest condition during July and lowest during May.

SEASONAL CATCH TOTALS AND DAILY ACTIVITY

Catch totals of pearl dace were greatest in May and rapidly declined until July when a moderate increase occurred (Table 1). Fathead minnow catches were greatest at the beginning of June with dramatic fluctuations throughout the summer (Table 1). Pearl dace and fathead minnow were caught in relatively equal numbers. Age 2 pearl dace and age 1 fathead minnow were the most frequently caught of the age groups. The other species, red-belly dace and finescale dace were caught much less frequently than pearl dace and fathead minnow.

Both pearl dace and fathead minnow catches were highest during the 1800-2200 h sampling period (Table 1). Both species were relatively active from 0200-0600 h, also.

Two way analysis of variance (AOV) using a randomized complete block design (RCB) of time of day versus age for pearl dace showed that activity of dace, as measured by catchability, varied by time of day (Table 2) and that the catch totals for each age were significantly different ($P < 0.05\%$). Statistical comparisons of the daily activity pattern for each age group of pearl dace (RCB design, time of day versus sample date) showed that ages 1, 3^+ males and 3^+ females (Table 3) have significant variations in their activity with time of day ($P < 0.05\%$). Significant seasonal variation in numbers was not found for any age group of dace. Multiple comparisons of means of the four hour periods using the LSD (Least Squared Difference) method for age 1 dace showed that activity was significantly higher ($P < 0.05$) during the 1800-2200 period compared to all other periods. No significant differences between any of the other periods were detected. For both age 3^+ male and female dace activity during the 1800-2200 period was significantly greater than during the daylight periods (0600-1000, 1000-1400, 1400-1800).

The ratio of male to female pearl dace increased from 0.81:1.00 in late May to a peak of 1.21:1.00 in the third week of June and then declined to 0.65:1.00 by the end of July (Table 4). The highest ratio of male to female occurred two weeks earlier for age 3^+ dace than for age 2 dace. Male age 3^+ dace were caught less frequently than females by late July.

Two way AOV using RCB of time of day versus age for fathead minnow (Table 5) indicated that there were no detectable differences due to time of day or age ($P > 0.05\%$).

INTRASPECIFIC AND INTERSPECIFIC DIETARY OVERLAP IN FEEDING DURING 24 HR PERIODS

Pearl dace fed on 13 different taxa (Table 6). No differences in diets between age groups were apparent. Important food items for age 1 dace were: larval Chironomidae (I value: 26.5), Cladocera (18.1), detritus (17.8) and adult Diptera (11.0). Larger prey such as Pelecypoda and fish were not consumed. Age 2 fish relied on larval Chironomidae (27.2), detritus (24.0), Cladocera (13.3) and the larger larval Ephemeroptera (10.6). Similarly, age 3^+ fish consumed mainly larval Chironomidae (28.1), detritus (23.2) and Cladocera (8.3). Both age 2 and 3^+ dace utilized Pelecypoda and fish. Dietary comparisons with $C\tau$ yielded a high degree of overlap between all ages and sexes of pearl dace (Table 7). The stomach contents of dace by 4 h sampling period are listed in Appendix B.

Fathead minnow diet was more restricted, comprising only seven taxa (Table 8). Age 1 fatheads consumed mainly Cladocera (I value: 53.0) and detritus (30.1) while age 2^+ utilized chiefly detritus (36.5), Cladocera (33.7) and larval Chironomidae (9.5).

Comparisons of dietary overlap using $C\tau$ between ages of fathead minnow gave a value of 0.77 (Table 7), indicating a fairly large overlap in diet.

Comparisons between age groups of the two species (Table 7) produced a low dietary overlap value of 0.50 (age 1 fathead with age 3+ pearl dace) and a high value of 0.78 (age 2^+ fathead and age 1 pearl dace).

DISCUSSION

Size and age class structure of Lake 114 pearl dace was similar to lake populations described by Loch (1969), Lalancette (1977) and Stasiak (1978). The size and age class structure of stream dwelling dace was dominated by younger, smaller fish. This suggests that survivorship is higher for lake dwelling pearl dace than for stream dwelling pearl dace. Many more lake dwelling dace live to age 4 than those inhabiting streams. Results of Carlson (1967) for stream fathead minnow populations contrast with our data from Lake 114. He found at least 2 age groups while we discerned at least three. These differences may be due to the greater fluctuating nature of the stream environment as opposed to lakes (Hynes 1970; Tramer 1977). Tallman and Gee (1982) noted that fishes in small streams often experience summer and winter kill. Hynes (1970) stated that the food base in running waters can undergo greater fluctuations than in lakes.

The capacity of female dace to live longer, grow faster and attain greater maximum lengths than males, as recorded in this study and others (Loch 1969; Stasiak 1978; Tallman 1980) probably is a mechanism to allow for greater egg production. Moshenko and Gee (1970) found a similar growth pattern and survival rates for sexes of creek chub, Semotilus atromaculatus. They noted that Semotilus fecundity rose roughly as a cubic function of female fish length. Thus, larger size, greater longevity and faster growth is favored in the female dace even though these characteristics may require greater energy resources.

The length-weight relationship of Lake 114 pearl dace is similar to that of southern pearl dace from streams in Maryland, U.S.A. (Fava and Tsai 1974). However, southern pearl dace grow at a faster rate than the northern subspecies. Three factors may contribute to the slower growth rate of northern pearl dace: genetic differences, climate or stream versus lake existence (Hynes 1970).

Our results for fathead minnow growth are similar to those of Held and Peterka (1974) for fathead minnow populations in Minnesota. The geographical proximity of our fish and those studied by Held and Peterka (1974) allows us to assume that genetic and climate factors affecting each population's growth pattern are similar.

Minimum condition coefficients for each species correspond to their respective post-spawning periods as recorded by Tallman (1980) and Scott and Crossman (1973). Improved food supply may have been responsible for the subsequent recovery of condition in each species. The temporal pattern of gonad maturation for Lake 114 pearl dace (Tallman, unpublished data) is similar to findings of Tallman (1980) for dace in southeastern Manitoba streams. Spawning probably occurs in early spring between March 1 and the first week of May depending on the length of winter.

The decline in the ratio of male to female dace over the summer agrees with results of other researchers. Tallman (1980) hypothesized that this decline was due to differential mortality of males relative to females. Increased male mortality may result from the abrasions received in courtship (Smith 1976).

Assuming that increased fish activity (as reflected in trapnet catches) is related to increased feeding intensity, pearl dace feed most actively at dusk. Two factors may make this the best time for this species to be active. First, aquatic invertebrates, especially adult Dipterans, are more active which makes them more susceptible to predation by dace. Second, light levels are sufficient for dace to see prey yet probably low enough to reduce attacks by piscivorous birds and mammals.

In contrast, fathead minnows do not have a marked period of highest daily activity. Fatheads incorporate more detritus and algal material in their diet than pearl dace. There is no advantage to fish feeding on a stationary food in restricting browsing to one specific time of day. As with grazing mammals, the fathead minnow may need to browse for long periods to fulfil its energy requirements.

The relatively restricted diet of Lake 114 pearl dace compared to that of stream dace (Tallman and Gee 1982) clearly demonstrates the difference between environments. In a stream there are many more niches available for invertebrates and fishes than in a lake (Hynes 1970). Our results show that lake pearl dace rely heavily on Cladocerans, a minor dietary item for stream populations. Cladocera are a major component of lacustrine fauna but are of little importance in stream ecosystems.

In contrast to Tallman and Gee (1982), our data show great dietary overlap between age groups of dace. The lack of intraspecific resource partitioning probably reflects the greater secondary production or abundance of certain primary consumers found in a lake as opposed to a stream (Hynes 1970). With abundant resources it is not necessary to partition food supply (Keast 1977).

The fathead minnow is less of a "generalist" (Hyatt 1979) than pearl dace. Dietary overlap between ages of fathead minnow probably is a result of abundant food supply. Unfortunately, no comparable data from stream populations are available. Our results for the overall fathead diet are similar to those of Held and Peterka (1974).

The lack of dietary separation between pearl dace and fathead minnow would have been surprising in a stream population. Tallman (1980) performed a brief study of interspecific resource partitioning between pearl dace and cohabiting cyprinids in a stream and found overlap values to be generally low (generally 0.3-0.4). Presumably, the abundant resources available account for the interspecific overlap in Lake 114. Our results show that fishes of different size (i.e. age 1 fathead, ≈20-40 mm, and age 3+ dace, $\geq$ 80 mm) have lower dietary overlap values than fishes of similar size (age 2+ fathead, ≈40-60 mm and age 1 pearl dace, ≈40-60 mm). One would expect that predator size and size of food eaten would be closely related in times of abundant food resources. Hence, overlaps will occur between similar sized fishes.

Both species, with the possible exception of age 1 fathead minnow, did not vary the content of their diet over the daily cycle. Unfortunately, it proved impossible to use a conventional measure of gut distention such as Hynes' (1950) points method, so daily activity and quantity of food consumed could not be directly compared.

Lake 114 has been acidified from 1979-1983 with sulfuric acid. Prior to acidification fathead minnow and pearl dace in Lake 114 were abundant fishes. The two species occupied slightly different niches but differences in activity and diet were minimized because resources were in abundant supply. Pearl dace had a broader feeding niche but also had more specialized activity patterns than fathead minnow. In contrast to stream populations, the species overlap heavily in diet both intraspecifically and interspecifically. This reflects the greater production but less complex biota found in lakes as opposed to streams.

ACKNOWLEDGMENTS

We thank Mr. Shawn Prychitko for assistance with field sampling. Comments on earlier drafts of this manuscript by Drs. R.A. Bodaly and W.G. Franzin were very helpful.

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Table 1. Catch by date and time of day totals in Lake 114 sampled in 1979 by trapnet. PD = pearl dace; FHM = fathead minnow; FS = finescale dace; RB = redbelly dace.

			Time of day (time interval collected)						
Sample Date	Lake	Species	1000-1400	1400-1800	1800-2200	2200-0200	0200-0500	0600-1000	24 h total
May 23,24,28,29	114	PD	37	22	1369	157	852	51	2521
		FHM	64	550	534	78	195	122	1543
		FS	34	8	123	98	175	8	446
		RB	13	8	258	93	604	9	985
		Total	148	588	2284	426	1926	196	5468
Jun 4- 5	114	PD	10	2	1010	292	358	0	1671
		FHM	62	6	1351	153	548	0	2120
		FS	9	0	6	23	95	0	133
		RB	30	0	0	244	257	0	531
		Total	111	8	2367	712	1257	0	4455
Jun 20-21	114	PD							432
		FHM	24 h sample						667
		Other							176
		Total							1275
Jul 3- 4	114	PD	29	116	204	87	1	35	472
		FHM	440	492	306	63	34	299	1634
		Other	36	80	105	140	35	15	411
		Total	505	688	615	290	70	349	2517
Jul 30-31	114	PD	28	0	389	12	154	135	718
		FHM	16	0	149	3	184	15	367
		Other	15	0	186	10	194	7	412
		Total	59	0	724	25	532	157	1497

Table 2. Total catch by age and time of day for pearl dace and fathead minnow in Lake 114, 1979 (n = 5).

	Time of Day					
Age	1000-1400	1400-1800	1800-2200	2200-0200	0200-0600	0600-1000
			Fathead minnow			
1	1186	822	1724	143	390	406
2+	345	429	677	262	572	241
Total	1531	1251	2401	405	962	647
			Pearl dace			
1	34	43	120	7	17	13
2+	355	688	2481	409	1134	207
3+	33	30	447	150	144	12
Total	422	761	3048	566	1295	232

Table 3. Total catch by age, sex and time of day for pearl dace in Lake 114, ELA.

Sample date	1000-1400	1400-1800	1800-2200	2200-0200	0200-0600	0600-1000
			Age 1 (Immature)			
May 24, 25-29	2	5	20	3	17	5
Jun 4- 5	7	0	51	2	0	0
Jul 3- 4	3	13	11	1	0	4
Jul 16-17	21	25	4	1	0	2
Jul 30-31	1	0	34	0	0	2
			Age 2 (Males)			
May 24, 28-29	18	9	563	32	323	14
Jun 4- 5	0	2	437	99	95	0
Jul 3- 4	6	47	73	39	0	10
Jul 16-17	91	245	46	0	10	6
Jul 30-31	9	0	41	0	39	90
			Age 2 (Females)			
May 24, 28-29	14	7	537	77	413	32
Jun 4- 5	2	0	431	108	176	0
Jul 3- 4	14	49	84	32	1	13
Jul 16-17	183	329	40	13		3
Jul 30-31	18	0	229	9	77	39
			Age 3 (Males)			
May 24, 28-29	1	0	134	10	29	0
Jun 4- 5	0	0	77	55	29	0
Jul 3- 4	5	5	22	10	0	4
Jul 16-17	6	7	5	1	10	0
Jul 30-31	0	0	0	1	5	0
			Age 3 (Females)			
May 24, 28-29	1	0	117	36	41	0
Jun 4- 5	0	0	13	30	11	0
Jul 3- 4	1	6	16	5	0	3
Jul 15-17	19	12	8	0	0	1
Jul 30-31	0	0	85	2	29	4

Table 4. Sex ratios for adult pearl dace caught in Lake 114, in 1979.

Sample Date	Age 2+			Ratio (M-F)	Age 3+			Ratio (M-F)	Combined			Ratio (M-F)
	Male	Female	Total		Male	Female	Total		Male	Female	Total	
May 23, 24 28, 29	377	456	833	0.83:1.00	67	91	158	0.73:1.00	444	547	991	0.81:1.00
June 4-5	155	194	349	0.80:1.00	49	20	69	2.45:1.00	204	214	418	0.95:1.00
June 20-21	45	35	80	1.29:1.00	6	7	13	0.86:1.00	51	42	93	1.21:1.00
July 3-4	175	193	368	0.91:1.00	46	31	77	1.48:1.00	221	224	445	0.99:1.00
July 16-17	264	369	633	0.72:1.00	14	26	40	0.54:1.00	278	295	673	0.70:1.00
July 30-31	119	149	268	0.80:1.00	2	37	39	0.05:1.00	121	186	307	0.65:1.00
Total	1135	1396	2531	0.81:1.00	184	212	396	0.87:1.00	1319	1608	2927	0.82:1.00

Table 5. Total catch by time of day for fathead minnow in Lake 114, 1979. Sample dates vs time of day by age group.

Sample date	1000-1400	1400-1800	1800-2200	2200-0200	0200-0600	0600-1000
			Age 1			
May 24, 25-29	28	346	350	28	79	81
Jun 4- 5	37	5	1100	32	239	0
Jul 3- 4	408	378	198	70	9	171
Jul 16-17	703	93	28	12	0	36
Jul 30-31	10	0	48	1	63	12
			Age 2			
May 24, 28-29	9	204	184	50	116	41
Jun 4- 5	25	1	251	122	309	0
Jul 3- 4	32	114	114	58	25	128
Jul 16-17	277	110	53	30	1	6
Jul 30-31	2	0	75	2	121	3

Table 6. Importance values of food items for Ages 1, 2 and 3+ (fish age 3 and older) pearl dace for 24 h samples (N = 180) May-August 1979.

Food item	Age 1	Age 2	Age 3+
Chironomidae larvae	26.5	27.2	28.1
Ephemeroptera larvae	2.5	10.6	2.9
Diptera adults	11.0	3.3	3.3
Hymenoptera adults	2.0	0.0	0.0
Cladocera	18.1	13.3	8.3
Copepoda	1.5	1.9	2.9
Ostracoda	2.5	1.2	0.7
Hydracarina	5.3	2.9	5.0
Pelecypoda	0.0	4.2	2.1
Fish	0.0	1.2	4.6
Invert. Parts	10.8	8.0	14.0
Plant matter	1.8	2.4	5.0
Detritus	17.8	24.0	23.2
TOTAL	99.9	100.2	100.1

Table 7. Morisita's (1959) index of dietary overlap between pearl dace and fathead minnow.

	Pearl dace			Fathead minnow	
Species - age	Age 1	Age 2	Age 3+	Age 1	Age 2+
Pearl dace - age 1		0.93	0.93	0.64	0.78
Pearl dace - age 2	0.93		0.96	0.60	0.76
Pearl dace - age 3+	0.93	0.96		0.50	0.73
Fathead minnow - age 1	0.64	0.60	0.50		0.77
Fathead minnow - age 2+	0.78	0.76	0.73	0.77	

Table 8. Importance values of food items for Age 1 and 2+ (fish age 2 and older) fathead minnows for 24 h samples (n = 90), May-August 1979.

Food Item	Age	
	1	2+
Dipteran adults	4.8	0.0
Chironomidae larvae	6.1	9.5
Copepoda	3.0	0.3
Cladocera	53.0	33.7
Detritus	30.1	36.5
Filamentous Algae	0.7	3.1
Invert Parts	2.3	17.0
Total	100.0	100.0

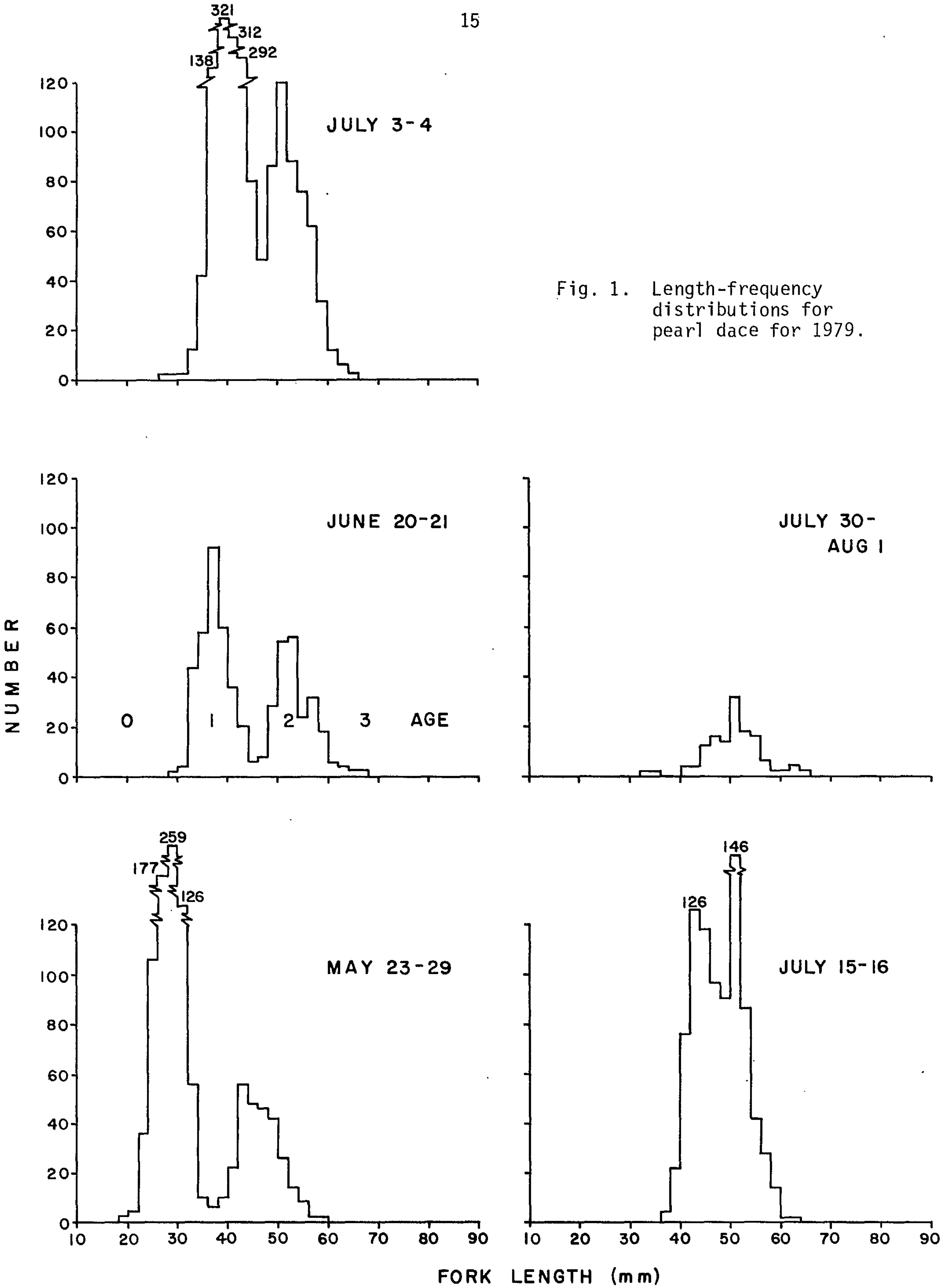

Fig. 1. Length-frequency distributions for pearl dace for 1979.

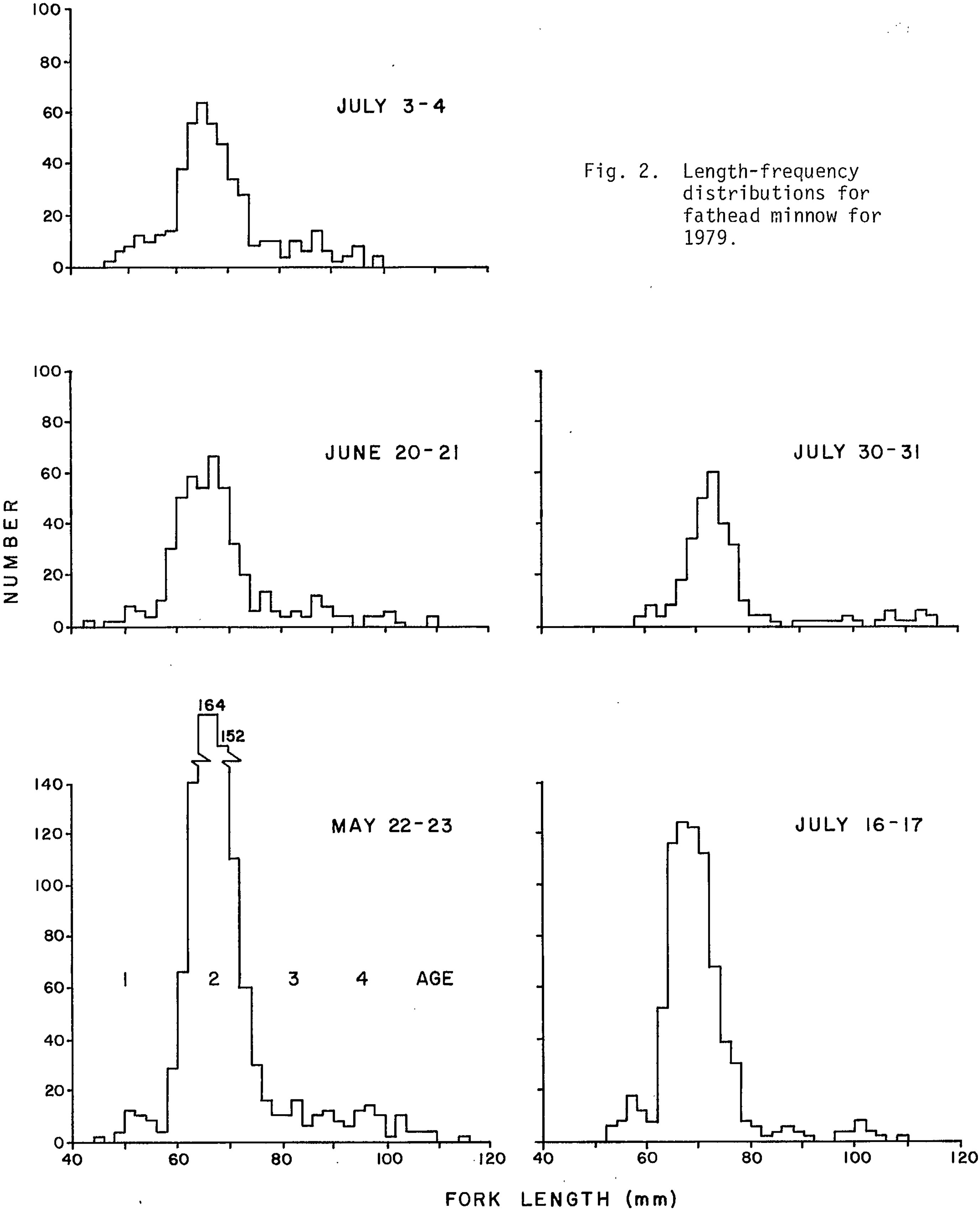

Fig. 2. Length-frequency distributions for fathead minnow for 1979.

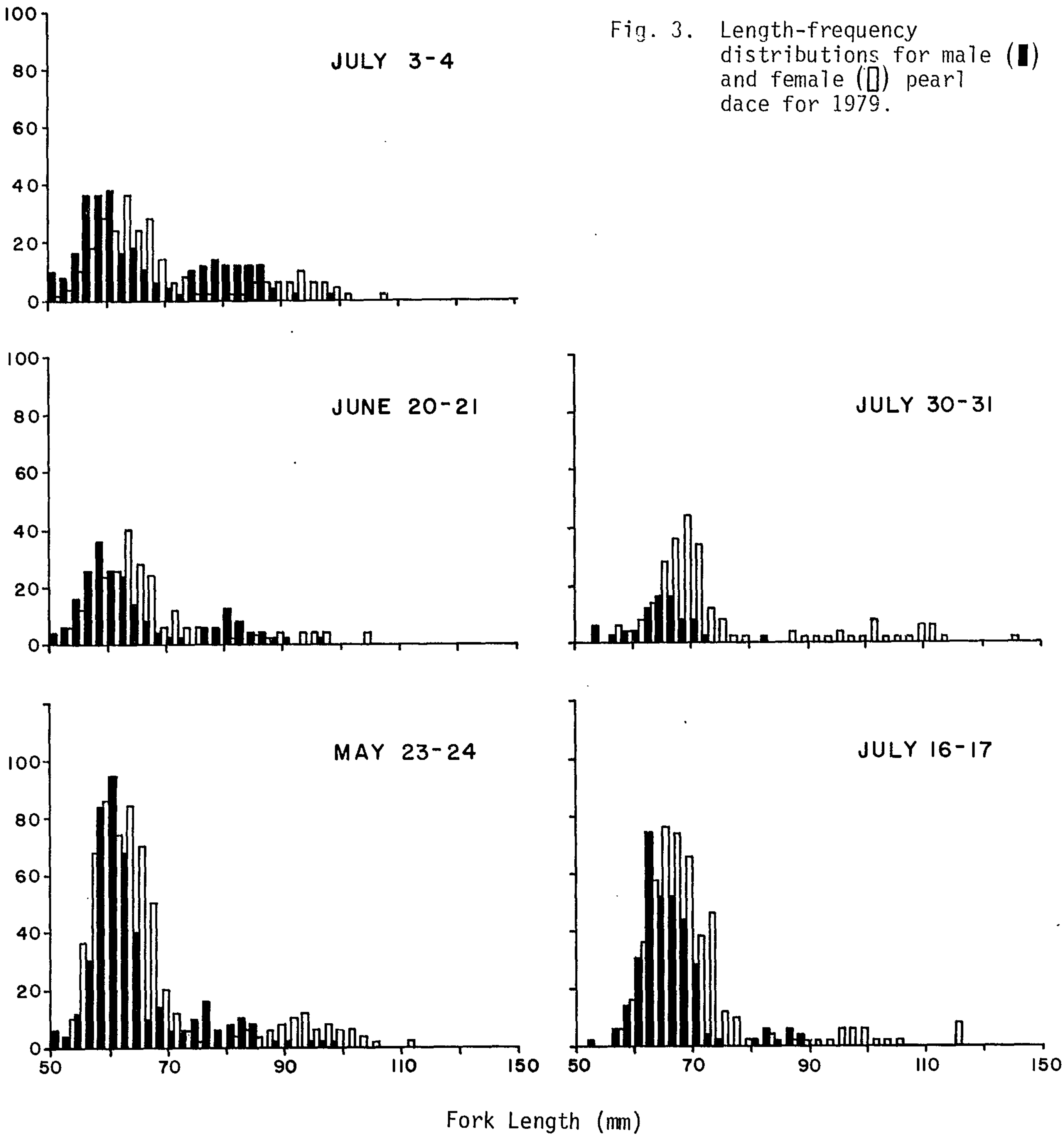

Fig. 3. Length-frequency distributions for male (▮) and female (▯) pearl dace for 1979.

APPENDIX A

IDENTIFICATION OF THE ELA CYPRINIDAE

Distinguishing between the small fishes of the minnow family is a task that has thwarted many a fisheries biologist. Fortunately, the ELA cyprinid species on record are, for the most part, easily recognized. However, use of this key should be qualified because almost certainly the list of species in the area is incomplete. One should always check with authorities such as Scott and Crossman (1973) if there is any doubt in species identification. As well, samples taken from new lakes should be sent to the Royal Ontario Museum (ROM) to have identification verified. As cyprinid species vary in external appearance along their distributions a photographic record of confirmed identifications of ELA species would be of great value.

CHARACTERISTICS OF ELA CYPRINIDS

Red-belly dace (<u>Chrosomus eos</u>)

Color: White-cream below lateral line. Pale gold darkening to olive-green above the lateral line.
Two horizontal black to brown bands along sides--lower band runs from snout through the eye to the center of the posterior most tip of the caudal peduncle. The narrower upper band runs from the dorsal edge of the body just posterior to the eye margin to the dorsal posterior tip of the caudal peduncle.
Spawning color: Belly of the females may turn canary yellow or lime green. Males usually have canary yellow bellies prior to and subsequent to spawning. During spawning the male belly is cardinal red. Fins of both sexes turn canary yellow. These colors may appear several times during the summer. Red-belly dace may spawn twice during the summer under favorable conditions.

Body shape: Very round bodied. Females generally more so than males. In northwestern Ontario body is much more rounded than is apparent from Scott and Crossman (1973). Compared to pearl dace and finescale dace, <u>Chrosomus neogaeus</u>, the body is much plumper and the dorsal aspect of the head curves much less sharply downward (Fig. A.1).

Mouth size: Mouth is small. It does not reach past the anterior margin of the eye (as opposed to the finescale dace mouth which extends to the middle of the eye or beyond). Best method of comparison is to examine the ventral surface of the head. In red-belly dace the intermandibular distance (Fig. A.2) divided by the snout length is less than one. In finescale dace this measure is greater than one.
Red-belly dace is distinguished from pearl dace by mouth position. The mouth is subterminal on pearl dace while red-belly dace have terminal mouths.

Internal characteristics: Peritoneum is uniformly black or occasionally dark brown. Gut is looped (Fig. A.3).
Variations in the gut pattern are thought to be indicative of hybrids.

Male-female differences: As well as the characters mentioned above the pectoral fin rays of the male are slightly thickened.

Lateral line: Usually terminates before pelvic fin origin. This pattern is similar to that of the finescale dace but contrasts with pearl dace whose lateral line extends to the caudal peduncle.

Finescale dace (<u>Chrosomus neogaeus</u>)

Color: White below lateral line. Broad pale gold darkening to olive green above the lateral line. Single black band extending from the eye and tapering to the posterior tip of the caudal peduncle. The band ends in an intense dark spot at the tip of the peduncle.
Spawning color: Belly of female turns a canary yellow. Males show an irregularly defined red slash on the flanks below the lateral band. This slash extends from the gill cover margin to the caudal peduncle tip. Splotches of red may appear on the gill covers and below the eyes. Fins of both sexes turn canary yellow. As with red-belly dace these colors may appear several times during the year. Finescale dace are thought to spawn only once just before ice break-up.

Body shape: Distinctive feature is the laterally compressed flanks. The fish appears slab-sided from the top of the gold band down. The body is fairly deep but rarely appears plump as does the red-belly dace (Fig. A.4). The picture in Scott and Crossman (1973) is a good rendition of the appearance of ELA fish. Caudal peduncle is relatively thicker than that of red-belly dace. Dorsal edge of the head curves sharply downward to the mouth. This combined with the slightly downward curve of the mouth give the fish a frowning appearance.

Mouth size: Mouth is large extending well past the anterior margin of the eye. The ratio of the intermandibular distance to snout length is greater than one.

Internal characteristics: Peritoneum is uniformly black (for gut shape see red-belly dace description, (Fig B.3).

Male-female differences: Males have a unique shape to the pectoral fins. Male pectoral fin rays are heavily thickened and bend sharply half way along their length (Fig. A.5). No other cyprinid shows this pattern.

Lateral line: See red-belly dace description.

Pearl Dace (<u>Semotilus margarita</u>)

Color: White or cream colored below lateral line. Pale gold darkening to olive green above lateral line. Specialized darkened scales along sides.
Spawning color: Both males and females have a cardinal red flush along flanks

commencing at the lower edge of the lateral band and spreading ventrally. This color is richer and spreads further in the male than in the female.

Body shape: The body is terete and torpedo-like. The picture in Scott and Crossman (1973) is a good example for ELA fish. The snout extends past the anterior of the mouth.

Mouth size: The intermandibular distance-snout length ratio is less than one. The mouth is slightly subterminal. Pearl dace are extremely similar in morphology to lake chub, Couesius plumbeus, but may be distinguished by the mouth barbels. In pearl dace the barbel is in front of the terminal margin of the jaw. It is often absent and has a flaplike appearance. Lake chub barbels are terminal and spike-like in appearance.

Internal characteristics: Peritoneum silvery, with speckling on the dorsal part. Intestine forms a single loop (Fig. A.3).

Male-female differences: Pectoral fins of male much larger and fin rays thickened. Female is plumper than the male.

Lateral line: Complete -- visible from the head to the tip of the caudal peduncle.

Fathead Minnow (Pimephales promelas) and Bluntnose Minnow (Pimephales notatus)

Pimephales is distinctive as a genus due to the short first ray of the dorsal fin separated by a membrane from the first well developed ray (Fig. A.6).

Lateral line: Fathead minnow -- lateral line complete. Bluntnose minnow -- lateral line incomplete.

At the ELA fathead minnows are more abundant.

Longnose Dace (Rhinichthys cataractae)

Readily distinguishable from other ELA cyprinids by the subterminal mouth, overhanging snout and the lack of protractile premaxillaries (i.e. no groove across snout). Pectoral fins are large. Body flattened ventrally -- profile like an airplane wing (Fig. A.7).

Lake Chub (Couesius plumbeus).

Color: Generally leaden silver but fish less than 60 mm are almost identical to pearl dace. Spawning adults may show splashes of brilliant red or orange on the flanks. The definitive test is the position and shape of the maxillary barbel. In pearl dace it is anterior to the end of the maxilla and flaplike. Lake chub barbel is terminal and spike-like in appearance.

Body shape and other morphological characters are similar to the pearl dace. Scott and Crossman (1973) give a good representative picture.

Shiners

Generally the most difficult animals of the North American fish fauna to distinguish between species. Fortunately, as the data stands now, the ELA is blessed with five species that are relatively simple to distinguish from one another.

Golden Shiner (Notemigonus crysoleucas)

Solid gold-yellow in color. Distinctive features are the relatively small scales (greater than 50 to lateral line), the strongly decurved lateral line that follows the ventral line of the body (Fig. A.8), the large number of anal fin rays (12 or 13) and the abdomen behind the pelvic fins with a fleshy keel lacking scales.

Blackchin Shiner (Notropis heterodon) and Blacknose Shiner (Notropis heterolepis)

Common characteristics: Large scales -- greater than 50 in lateral line

Slender delicate body, not compressed in any direction

Large eyes (greater than 1/4 length of head)

Lateral band dark and distinct

Mouth terminal and relatively large, reaching almost to below eye

Silver peritoneum

Distinguishing characteristics: N. heterolepis has a lateral on the chin and premaxillaries -- N. heterodon has lateral band on snout but not on the chin. The lateral line is complete in N. heterolepis and incomplete in N. heterodon.

Spottail Shiner (Notropis hudsonius)

Easily distinguished by the silvery sides (little pigment in lateral band, large scale -- 38-42 in lateral line, subterminal mouth and distinctive black spot at base of caudal fin.

Rosy-face Shiner (Notropis rubellus)

Snout comes to a sharp point (Fig. A.9). Silvery coloration. Body slender and terrete (streamlined).

Normally there are no markings on the body or fins.

When spawning adults develop a pinkish-orange coloration on the head above the mouth back to the eye. There may also be rosy streaks on the flanks.

Miscellaneous

Trout-perch (Percopsis omiscomaycus)

This species is not a cyprinid but attains maximum length at a small size (usually less than 100 mm) and so may be mistakenly classified as a minnow. The distinguishing characters are the presence of spines in the dorsal fin and the presence of an adipose fin (Fig. A.10).

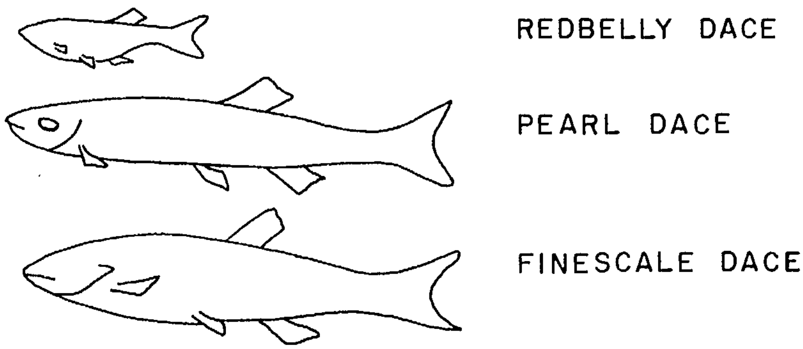

Fig. A.1. Body shapes of three species of dace.

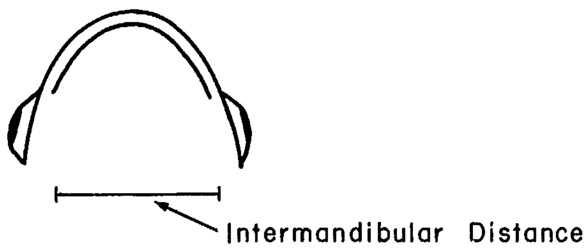

Fig. A.2. Ventral view of head of a redbelly dace.

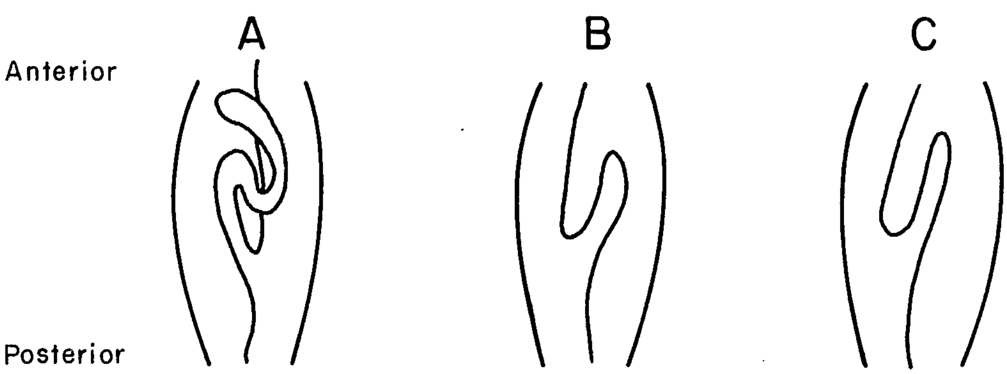

Fig. A.3. Lower digestive tracts of redbelly dace (A), finescale dace (B) and pearl dace (c).

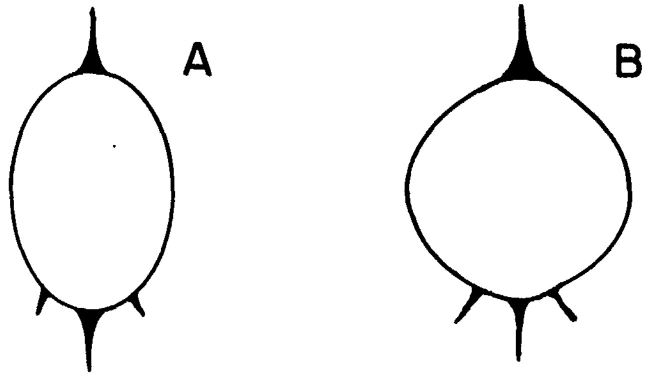

Fig. A.4. Transverse sections through the mid-bodies of finescale dace (A) and redbelly dace (B).

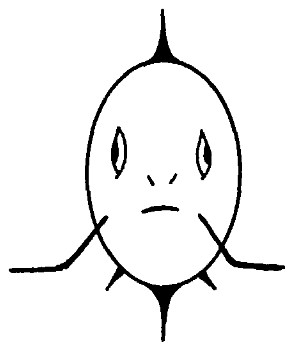

Fig. A.5. Anterior view of a male finescale dace showing angle in pectoral fins.

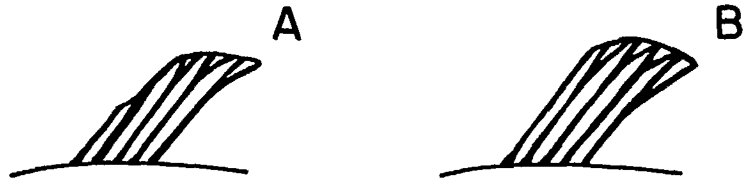

Fig. A.6. Schematic dorsal fins of Pimephales (A) showing a shortened first ray and of Notropis (B) showing full sized first ray.

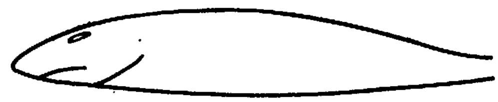

Fig. A.7. Lateral view of the body profile of a longnose dace.

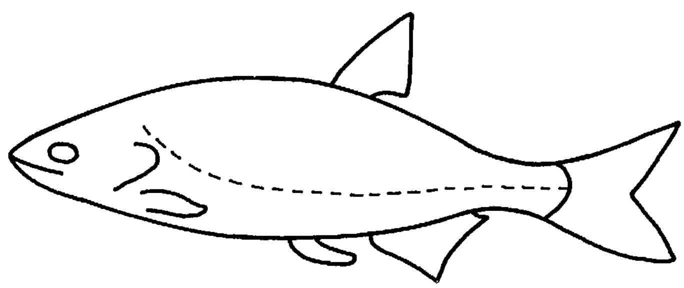

Fig. A.8. Lateral view of a golden shiner showing strongly decurved lateral line.

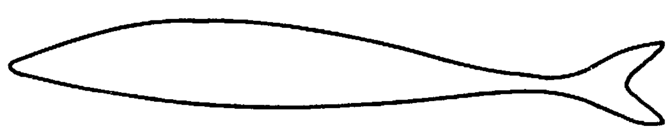

Fig. A.9. Lateral view of a rosy-faced shiner showing terrete shape and pointed snout.

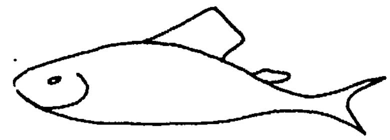

Fig. A.10. Lateral view of a trout-perch showing adipose fin between dorsal and caudal fins.

APPENDIX B

IMPORTANCE VALUES OF FOOD ITEMS FOR PEARL DACE

Table 1. Importance values of food items for age 1 (juvenile) pearl dace by four hour sampling periods. Data combined for all sampling periods.

Food item	Time period					
	1000-1400	1400-1800	1800-2200	2200-0200	0200-0600	0600-1000
Chironomid larvae	22.5	29.0	11.5	19.8	31.0	19.2
Ephemeroptera larvae	4.0	0.0	7.8	0.0	0.0	2.6
Dipteran adults	4.0	13.1	14.8	9.5	11.0	4.2
Hymenoptera adults	0.0	0.0	3.5	2.5	0.0	0.0
Cladocera	15.0	11.2	13.9	14.2	26.5	29.2
Copepoda	0.0	0.0	3.6	2.5	0.0	0.0
Ostracoda	0.0	0.0	6.2	3.5	0.0	4.6
Hydracarina	5.5	0.0	5.2	10.8	0.0	4.6
Misc. invertebrates	9.5	10.7	8.7	10.7	10.5	7.2
Fish	0.0	0.0	0.0	0.0	0.0	0.0
Misc. plants	0.0	6.0	4.0	0.0	0.0	0.0
Algae	18.0	4.5	6.0	5.0	0.0	9.4
Detritus	21.5	25.5	14.3	16.5	12.5	19.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table 2. Importance values of food items for age 2 pearl dace by four hour sampling periods. Data combined for all sampling periods. Values shown are for male pearl dace; values for female pearl dace are in parentheses.

	Time period					
Food item	1000-1400	1400-1800	1800-2200	2200-0200	0200-0600	0600-1000
Chironomid larvae	42.4(25.6)	31.5(25.8)	22.3(28.9)	22.3(21.1)	30.6(18.7)	27.5(26.3)
Ephemeroptera larvae	2.5 (6.6)	0.0 (0.0)	2.4 (0.0)	5.7 (4.4)	0.0 (0.0)	0.0 (1.5)
Dipteran adults	0.0 (0.0)	0.0 (4.9)	2.3 (4.2)	22.2(21.1)	0.0 (0.0)	5.0 (4.5)
Cladocera	4.6 (8.6)	15.6 (9.3)	20.7 (8.8)	8.2 (7.0)	16.6(15.6)	25.5(16.4)
Copepoda	4.8 (3.6)	0.0 (4.9)	0.0 (3.5)	0.0 (2.3)	5.6 (0.0)	1.5 (9.0)
Ostracoda	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (2.3)	0.0 (5.6)	0.0 (0.0)
Hydracarina	4.8 (0.0)	0.0 (4.9)	2.3 (5.8)	0.0 (0.0)	4.2 (0.0)	3.5 (1.5)
Pelecypoda	6.0 (8.6)	6.6 (6.7)	2.4 (8.8)	0.0 (0.0)	0.0 (0.0)	0.0 (6.4)
Misc. invertebrates	10.0(11.0)	12.0(10.5)	9.7 (7.2)	10.7 (3.8)	10.6 (5.0)	8.0 (5.4)
Fish	0.0 (0.0)	0.0 (0.0)	0.0 (2.0)	0.0 (0.0)	11.6 (0.0)	6.0 (5.5)
Misc. plants	0.0 (0.0)	0.0 (0.0)	2.7 (3.7)	5.1 (6.7)	0.0 (0.0)	0.0 (0.0)
Algae	3.0 (7.5)	4.5 (8.0)	10.7 (5.7)	0.0 (3.0)	0.0 (6.7)	3.0 (6.5)
Detritus	27.0(28.5)	30.0(25.0)	24.3(21.7)	25.8(28.5)	20.6(49.3)	20.0(17.0)

Table 3. Importance values of food items for age 3+ (fish age 3 and older) pearl dace by four hour sampling periods. Data combined for all sampling periods. Values shown are for male pearl dace; values for female pearl dace are in parentheses.

	Time period					
Food item	1000-1400	1400-1800	1800-2200	2200-0200	0200-0600	0600-1000
Chironomid larvae	17.2(13.0)	24.5(20.0)	16.5(19.0)	23.3(33.5)	17.0(17.9)	21.6(16.0)
Ephemeroptera larvae	9.1(12.0)	10.0 (4.0)	0.0 (0.0)	0.0 (1.0)	2.0 (6.1)	2.7 (4.3)
Dipteran adults	0.0 (0.0)	5.0 (0.9)	0.0 (6.0)	4.0 (9.0)	10.0 (5.2)	3.0 (0.0)
Cladocera	14.1(10.0)	18.1(11.0)	15.2(13.0)	7.7 (8.0)	10.4 (8.2)	11.2(18.0)
Copepoda	3.4 (7.5)	3.0 (0.0)	0.0 (3.5)	0.0 (0.0)	5.2 (5.2)	5.4 (8.7)
Ostracoda	0.0 (0.0)	0.0 (0.0)	6.3 (4.5)	10.0 (2.0)	0.0 (0.0)	0.0 (0.0)
Hydracarina	5.5 (8.5)	0.0 (0.0)	5.6 (4.0)	15.0 (2.5)	12.0 (4.4)	6.1 (4.2)
Pelecypoda	4.0 (6.0)	1.5 (9.0)	9.4 (0.0)	0.0 (0.0)	3.4 (6.0)	0.0 (0.0)
Misc. invertebrates	9.1 (7.0)	4.0 (8.0)	9.0(11.0)	8.0(11.6)	8.0(10.0)	9.3 (7.0)
Fish	0.0 (0.0)	3.0(18.0)	5.0 (0.0)	3.0 (9.0)	5.0 (7.0)	3.2 (7.0)
Misc. plants	10.2(11.0)	0.0 (0.0)	5.0 (7.0)	3.4 (2.4)	3.0 (7.0)	0.0 (0.0)
Algae	0.0 (0.0)	8.0 (6.0)	12.0 (7.0)	6.6 (3.7)	1.6 (0.0)	12.1(14.6)
Detritus	27.4(25.5)	23.0(24.0)	10.0(25.0)	19.0(17.3)	21.4(23.0)	25.3(20.2)

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Supply and Services Canada
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Freshwater Institute
Winnipeg, Manitoba
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