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FEEDING INTERACTIONS OF STICKLEBACKS AND RAINBOW TROUT OF HASSE LAKE, ALBERTA.

by

© TERRY WILLIAM SMITH

A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **FEEDING INTERACTIONS OF STICKLEBACKS AND RAINBOW TROUT OF HASSE LAKE, ALBERTA,** submitted by **Terry William Smith** in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE.

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Abstract

Hasse Lake, Alberta, which has been regularly stocked with rainbow trout (Oncorhynchus mykiss (Salmo gairdneri)), was examined to determine if either competition between the trout and other species of fish or cannibalism was acting to produce a perceived decline in trout production. Diet analyses were used to determine what the major food organisms were for the four fish groups: adult trout, fingerling trout, brook stickleback, (Culaea inconstans), and threespine stickleback, (Gasterosteus aculeatus). Mean percent dry weight was the main indicator used; however, number, percent number, and percent occurrence were also measured. The types of analyses that were used to examine the extent of overlap included Schoener's index and two forms of multivariate analysis: canonical variate analysis and discriminant function analysis.

Little overlap occurred between the four main fish groups. Adult trout and fingerling trout fed on the main fish species, threespine stickleback, but at different periods of the summer. The main invertebrate food of the two different size classes of trout was also different. While fingerling trout ate terrestrial drift, adults consumed snails, dragonfly nymphs, and other large invertebrates. Cannibalism was rarely observed. There was little overlap between the threespine sticklebacks and fingerling trout. Brook and threespine sticklebacks had very similar diets, but they ate the most

numerically abundant food groups (chironomid larvae, cladocerans, and copepods). Based on these data, competition for food could not be inferred during the period of the study.

Fingerling trout showed rapid growth in both 1984 and 1985; this also supports the previous findings of little competition. A bimodality in length of fingerling trout occurred shortly after stocking and disappeared before winter. The reason for this was unclear.

Factors such as density of trout in the lake, stress due to stocking, or avian predation may be more important than competition for food in determining the number of trout available for sport fishermen in stocked lakes.

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Table of Contents

List of Tables

List of Figures

1. INTRODUCTION

Many water bodies in the western provinces are stocked with rainbow trout (Oncorhynchus mykiss (Salmo gairdneri)). While some are stocked for commercial aquaculture operations or to replenish natural populations, most are stocked in lakes, with no reproduction of trout, for the enjoyment of anglers (put and take fisheries). Stocking began on a significant scale in Alberta in the 1950's and is still carried out. A large proportion of the fish are put into shallow, productive kettle lakes called "pothole" lakes. The lakes vary in size from 1 ha to 100 ha and usually lack inlets or an outlet. Most of the lakes had northern pike and yellow perch before being poisoned with rotenone to remove the native fish. In the lakes stocked with trout, an attempt is usually made to maintain a monoculture.

Lakes traditionally go through a reduction in production after the first two or three years of stocking (Galbraith 1975, Miller and Thomas 1956, Paetz and Nelson 1970, Stringer *et al.* 1980). The reduction occurs in both winterkill and non-winterkill lakes. The decline in production is due to reduced growth rates and reduced survival in the first summer. The decline is usually attributed to a reduction in food availability (Donald and Anderson 1982, Galbraith 1975, Millar and Thomas 1956, Mottley 1941, Stringer *et al.* 1980).

In winterkill lakes it is believed that the ability of the lake to support a given population of fish is affected by the stocking density of the previous years and the total population size. If the lake is over-stocked in one year, the following year the fish may undergo a lower than normal growth rate or reduced survival owing to food depletion (Carl 1985, Stringer *et al.* 1980). In non-winterkill lakes food competition between resident populations of fish has been identified as the cause of the reduction (Crossman and Larkin 1959, Johannes and Larkin 1961). The competition may involve almost any other fish species or adult trout from previous stockings. In some situations stocked trout have been considered to be inferior competitors (Cordone and Nicola 1970, Smith 1957). Any other fish species that occurs in the lake, such as suckers, minnows, sticklebacks, or percids, is considered to be a potential competitor, and therefore detrimental to the trout fingerlings. The effects of competition for food are varied, but in non-winterkill lakes there are three identifiable results: an increased death rate, a decreased average growth rate, or a decreased area of habitation in the lake, termed ecological displacement (Fraser and Cerri 1982, Helfman 1978, Johannes and Larkin 1961, Werner *et al.* 1977, Wootton 1984).

Studying and measuring competition in the field is difficult (Krebs 1978, Ricklefs 1976). Therefore, examination of the diets of different species and age classes is used to determine food habits. Stomach content analysis is generally used to determine diet. Using these food habits, the degree of diet overlap is evaluated and from both the degree of overlap and prey abundance, the existence of competition is either supported or dismissed. If competition for food is occurring, the young trout fingerlings must be using the same resources as some other fish group in the lake. However, diet overlap does not necessarily mean competition, for if the food resource is abundant, overlap in diets can occur without detrimental effects. If food resources are being utilized near the carrying capacity of the lake, competition theory suggests that little diet overlap should occur. If overlap does occur it should be detrimental to the weaker competitors. Trout fingerlings should be affected to a greater extent than other species as they are in a foreign environment and therefore, must learn to feed on live food, deal with predators, and adapt to a new physical environment (Ayles *et al.* 1976).

Hasse Lake, a non-winterkill lake, has experienced declines in trout production since the late 1950's (K. Zelt, pers. comm.). The most recent decline occurred in the early

80's, as suggested from creel census information for the lake (Berry 1986).

Another factor thought to reduce survivorship in non-winterkill lakes is cannibalism of fingerlings by trout of previous age classes. Cannibalism is "intraspecific predation", and is able to drastically affect populations of freshwater organisms (Barber 1981, Fox 1975, Grimm 1983, Larkin 1956, Rinne 1980, Symons and Heland 1978).

The objectives of this study were the following: 1) to determine the food habits of the trout and sticklebacks of Hasse Lake; 2) to examine the degree of diet overlap of the four fish groups (threespine stickleback (Gasterosteus aculeatus), brook stickleback (Culaea inconstans), adult trout, and fingerling trout) using Schoener's index and multivariate analysis; 3) to determine relative abundance of benthic prey types for use in evaluating diet overlap; 4) to determine the level of cannibalism of adult trout on young trout; 5) to evaluate average growth of fingerling trout over their first summer in the lake.

2. STUDY SITE

Hasse Lake is 52 km southwest of Edmonton (Fig. 1). This small shallow lake has an area of 81 hectares and has a maximum depth of 9 m (Fig. 2). It has no inlets or outlets; productivity is moderate with a summer chlorophyll *a* level of 3.3 mg/m^3 and a high total nitrogen to total phosphorous ratio and total dissolved solids (Prepas 1983, Prepas and Trew 1983).

Hasse lake is typical of the lakes in the area in that it is bordered by a mixture of poplar groves and open farm land. The lake has a mixed shoreline composed of willow groves, reed beds, and sand beaches. The shallows has a ring of Chara and small open areas extending from shore to a depth of 1-2 m. The zone of Chara moves during the year from near shore in spring to a depth of 2 m by early summer. At the edge of the Chara is a narrow band of Potamogeton spp. Out to a depth of 5 m, the bottom is a mosaic of Ceratophyllum (coontail) and organic ooze.

Hasse Lake supported a self-sustaining population of northern pike, Esox lucius, and yellow perch, Perca flavescens, until 1953 (Nelson & Harris, 1987). The lake experienced a complete winterkill that year. The next year it was stocked with rainbow trout. Since then, the lake has been stocked regularly with rainbow trout; however, the lake has also received brook trout, Salvelinus fontinalis, northern pike, yellow perch, and walleye, Stizostedium *vitreum*. The northern pike and yellow perch were eradicated with rotenone in 1968. The only fish currently with self-sustaining populations in the lake are brook stickleback, threespine stickleback, and fathead minnow, *Pimephales promelas* (brook stickleback and fathead minnows either survived the rotenone in 1968 or were re-introduced). The threespine stickleback was probably introduced to the lake in the mid-1970's; the exact time is unknown as is the mode of introduction and location of parental stock (Nelson and Harris 1987). The threespine sticklebacks have become numerically the dominant fish.

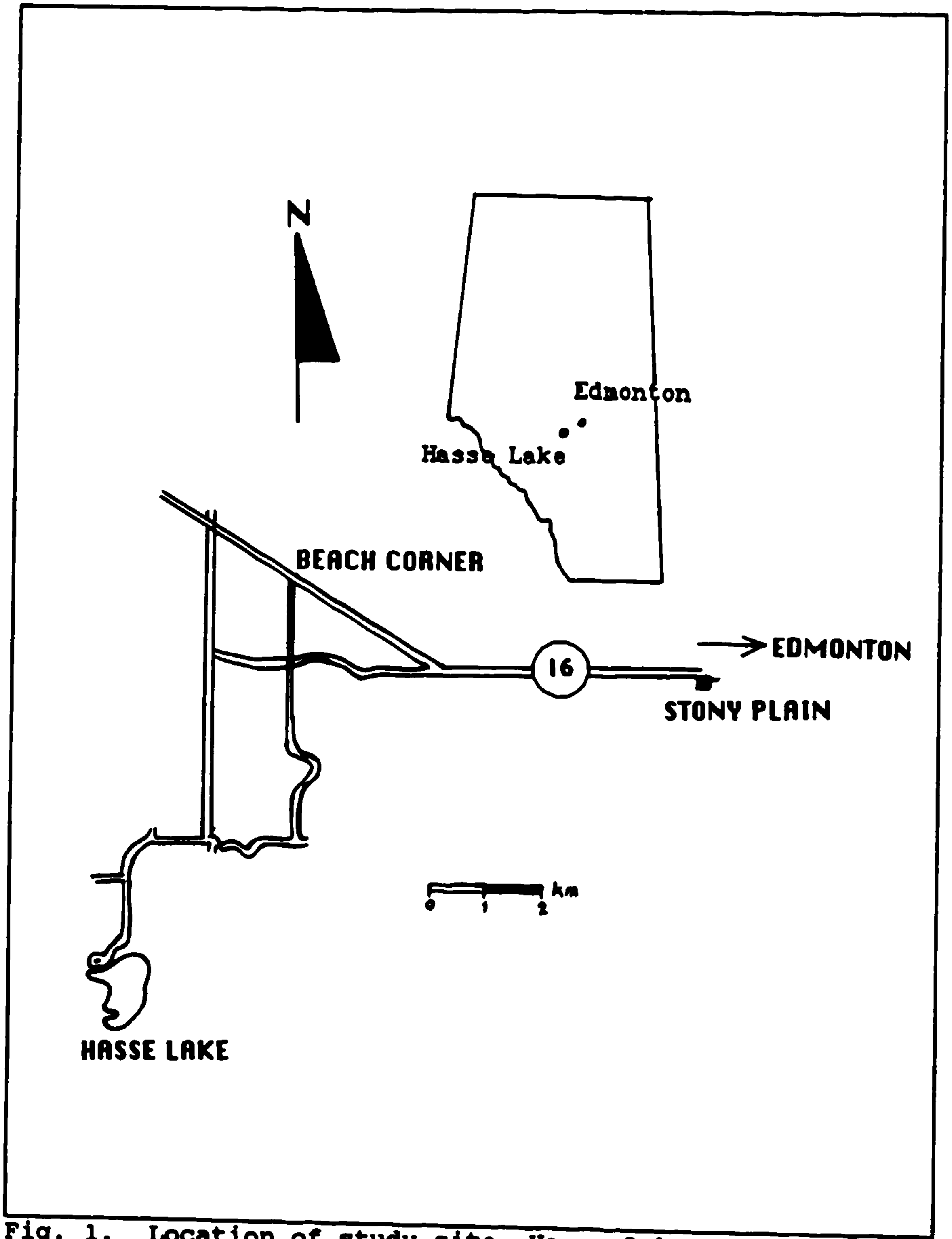


Fig. 1. Location of study site, Hasse Lake, Alberta (after Berry 1986).

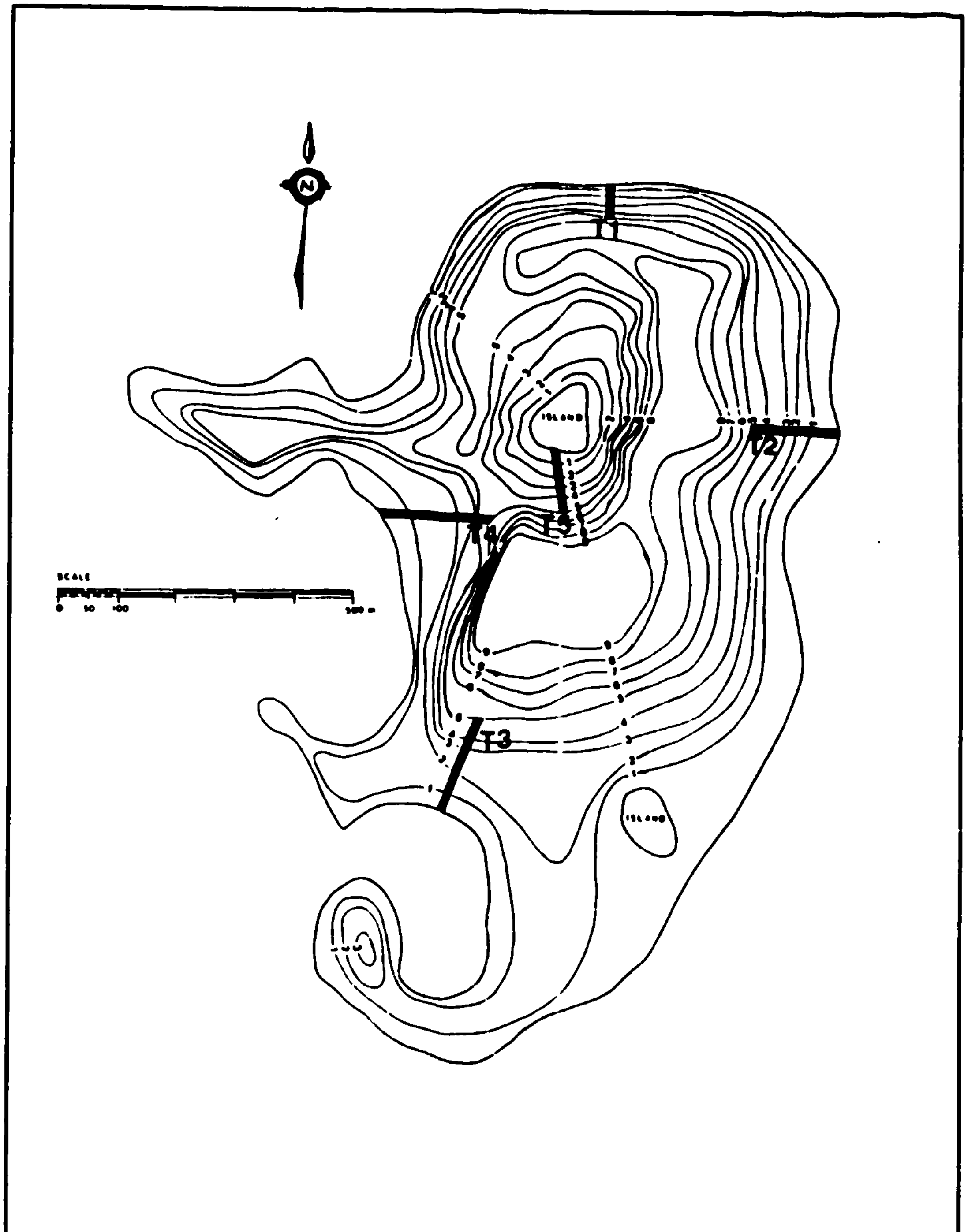


Fig. 2. Contour map of Hasse Lake showing the sampling transects (after Babin 1984). Contours in meters.

3. MATERIALS AND METHODS

All fish and dredge samples and temperature and oxygen measurements of the lake were obtained along five transect lines (Fig. 2). No attempt was made to study differences between sites on the lake. Temperature and oxygen were also measured at the deepest spot in the lake. During the summers of 1984 and 1985 all transects were used; however, during the winter only transects 3 and 5 were used due to the difficulty of sampling through the ice. Transects were set up to extend from shore to a depth of 5 m; preliminary work showed low dissolved oxygen below this depth.

DREDGING

Dredging was carried out in May and August of 1984 using a 500 cm^2 Ekman dredge. Samples were taken at 1 m depth intervals along all transect lines. Three samples were taken at each sampling depth as recommended by Downing 1979. No samples were obtained at 1 m for the month of August due to the large bed of *Chara*. Samples were passed through a 0.5 mm sieve at the lake. The samples taken in May were sorted live. The August samples were fixed in 10% buffered formalin. The samples were sorted and counted in the lab with the aid of a dissecting microscope. Numbers per dredge of various taxa were then converted to numbers/m^2 to provide an index of relative abundance of different prey categories.

TEMPERATURE AND OXYGEN

Temperature and oxygen were measured using a YSI oxygen meter (model # 57). The meter was calibrated before each trip to the lake by measuring the level of an oxygen saturated water sample and correcting for altitude and barometric pressure. The samples were taken at 1 m intervals from 9 m to 1 m. There was strong agreement between measurements at similar depths in the deepest hole and along the transect lines.

FOOD HABITS

Rainbow Trout

Rainbow trout, both adults (AD) and young-of-the-year (YOY), were caught using gill nets, traps, and angling gear. Fish caught in traps and gill nets were released after capture. The fish were measured and the stomachs of AD were sampled using a modified hand operated bilge pump; YOY were sampled using a 10 ml syringe fitted with a length of canula tubing. Both pumps were approximately 90% efficient in evacuating the contents of the stomach proper as determined by angler-caught fish whose stomachs were pumped and then removed and analyzed. Dead fish and angler-caught fish were measured, weighed, and dissected to remove their stomachs. All stomach samples were placed in 10% buffered formalin and then transferred to 70% ethanol after a minimum of 24 hours.

Adult trout were sampled extensively in May and June of both years; few AD were caught at any other time of the year. The YOY trout were sampled starting 2 weeks after stocking and at biweekly intervals until late August in both years; however, very few fish were caught in 1984. In 1984 there was difficulty in sampling because the stocking was spread over three weeks. Normally, stocking of the lake is done in one release.

Many different methods of assessing the importance of food organisms in a diet exist, Hynes (1956) and Hislop (1980) reviewed these methods and their uses. Three methods, occurrence, numerical, and gravimetric(weight), were used to provide a varied assessment of the diet, and to facilitate comparison between this and previous studies. Occurrence is the simplest method of recording data on stomach contents; it involves recording the number of stomachs containing one or more of a particular organism. The number of stomachs containing the organism was expressed as a percentage of the total number of stomachs containing food. The numerical method involves counting the number of individuals in a particular prey category and expressing this as a percentage of the total number of food organisms consumed by all fish in the sampling period. Both the numerical and occurrence methods give valid information on the numbers of individuals consumed but are of little use in determining the bulk of each prey item in the diet. Obtaining the weights or each category found in the stomach gives a better measure of amount. The dried weight was obtained for each category and expressed as a percent of the total content of each stomach.

Stomach contents, of both YOY and AD, were sorted into 23 prey categories (Appendix 1 and 2.) and counted. Individual prey categories for each fish were dried at 60 ^{o}C until a constant weight was obtained (approximately 24 hours). For very small items, such as zooplankton, samples from many stomachs were combined and an average dry weight was obtained for each prey type. These values were then multiplied by the number of items found in a stomach to obtain dry weights for the individual samples. For each sample period a mean percent dry weight, percent occurrence, and percent of numbers was calculated.

Sticklebacks

Both threespine (TS) and brook (BR) sticklebacks were sampled monthly using minnow traps; each transect was sampled using 5 stations and each station consisted of minnow traps suspended at 1 m intervals from the bottom to within 1 m of the surface. The traps were set at different times of the day, without bait, for 3 hours. The contents of each trap were sorted by species and counted. From each trap a sample of up to 5 TS and 5 BR was saved. These fish were anaesthetized with 2-phenoxyethanol and then fixed in 10% buffered formalin. After 1 week the fish were transferred to 70% ethanol and stored until sorting. All fish were measured and the stomachs were removed and sorted into 18 prey categories (Appendix 3 and 4.). As with the rainbow trout data, percent occurrence, percent number, and mean percent dry weight was calculated for each sample period.

Calculating dry weights was made difficult by the small size of individual prey items. Therefore, for each prey category, samples were pooled for the sample period. The pooled sample was then dried and weighed. Using the total number of individuals and total weight an average dry weight was calculated. The average weight was used in calculating the total dry weight of each prey category found in individual stomachs. The samples for each species were kept separate, and so different average weights were obtained for each species.

DIET OVERLAP

Diet overlap can be measured using many different indices. The four most commonly used are: Spearman's rank correlation coefficient, Horn's index (Horn 1966), Levin's index (Levin 1968), and Schoener's index (Schoener 1970). All of these indices have been used by different authors to determine the amount or significance of overlap between different fish species or age classes within a single fish species (Fritz 1974, Galat and Vucinich 1983, George and Hadley 1979, Keast 1978, Knight *et al.* 1984, Mathur 1977, Wallace 1981, Werner and Hall 1977, Zaret and Rand 1971). These indices are rather subjective in determining the level of significance, except for the Spearman rank correlation coefficient which can be tested using a t-test (Hulbert 1978, Wallace 1981). The other indices are considered to show a significant overlap if the index value ( ) exceeds 0.60 (Zaret and Rand 1971, Mathur 1977). The least biased of these indices and the preferred for diet overlap analysis is the Schoener's index (1) using mean percent volume(weight) as the diet measure (Wallace 1981).

$$\alpha = 1-(0.5(\Sigma a_i/100)) \quad \text{where } a_i = (|p_{xi}-p_{yi}|) \qquad (1)$$

Where p_{xi} is the proportion of food category i in the diet of species x, and p_{yi} equals the proportion of food category i in species y.

The index was used to calculate overlap in diet between YOY and TS and YOY and AD in the summer months June, July, and August. Diet overlap was also measured for the two stickleback species for May through August.

Multivariate analysis was also used to examine the diet overlap for each month during the summer. For the multivariate analysis only mean percent dry weight was used.

Mean percent dry weight was used for describing the diet of the fish due to its reliability and ready conversion to biologically important factors such as calories and protein content. All prey categories that accounted for less than 1% of the diet in all four species were removed from the analysis. Discriminant function analysis was used to examine the diet overlap; this method was used because it maximizes discrimination and minimizes within group variance (Pimentel 1979). Attempts were made to standardize the data, however, no transformation was able to normalize the variance, due to the large number of zeros in the matrix. Therefore, raw data were used.

Discriminant analysis has been commonly used in hybridization studies to evaluate the similarity of different parental stocks and their intermediates (Clarkson and Minckly 1988, Das and Nelson 1989, Whitmore 1983). The parental stocks were characterized by different morphological structures and characters. In this study the amount and types of prey consumed by the different groups were used for characterization.

Two multivariate analyses were used. The first, canonical variate analysis (CVA), involved using two *a priori* groups, to generate a discriminate function. This function was then used to calculate canonical scores for the individuals being examined (Pimentel 1979, Clarkson and Minckley 1988). The other method, discriminant function analysis (DFA), used all four groups as known groups to generate two discriminant functions. The four groups were then plotted in relation to the two functions (Clarkson and Minckley 1988, Matthews and Robison 1988, Reimchen *et al.* 1985, Whitmore 1983).

TS and AD were used as the two *a priori* groups. These groups were chosen because they were most likely to provide an indication of diet overlap. From the discriminant function, canonical scores were calculated for each individual in each group. The scores were then graphed as frequency distributions.

In the second analysis (DFA) the samples for each month were divided in half randomly (an option available with the BMDP program used). One half was used to generate the discriminant function and the other half to check the accuracy and validity of the functions. Canonical scores were generated and then plotted against the canonical axes.

The BMDP7M computer program (Dixon 1983) was used to generate the discriminant functions and calculate canonical scores for the June, July, and August data.

4. RESULTS

TEMPERATURE AND OXYGEN

Typical surface and bottom temperatures for the lake varied from 12°C to 21°C during the summer months (Table 1). The lake warmed rapidly from top to bottom; even by June the lower waters exceeded 10°C. No distinct t ocline developed in the summer. Surface water temperatures in the shallows reached a high of 27°C. Throughout the summer the water temperature was well within the tolerance of the fish species under study.

Oxygen levels were moderate during the summer (Table 1). Levels were high only during May and the fall, before ice-on, when the lake approached saturation levels from top to bottom (Babin 1984). Dissolved oxygen declined during the summer from the depths below 5 m; however, bouts of re-oxygenation occurred occasionally throughout the summer in association with extreme wind action. Some oxygen stress may have occurred but no evidence of this was noted.

BENTHIC INVERTEBRATES

Systematic dredging of the lake was carried out in May and August of 1984. Dredging during May showed that dipteran larvae and pupae were very abundant at all depths but were most abundant in the 3 and 4 m samples (Table 2). The next most abundant organisms were small gastropods, <u>Gyraulus</u>, which were more abundant in the 1 and 2 m samples (361.33/m^2

Table 1. Temperature and oxygen values for the summer months and October; values are means of weekly samples taken at the deepest spot in Hasse Lake.

	June	July		August		October	
Depth m	Temp °C	Temp °C	Ox mg/l	Temp °C	Ox mg/l	Temp °C	Ox mg/l
0	19.4	21.0	9.4	19.2	8.6	10.5	11.2
1	17.8	20.8	9.3	19.2	8.6	10.2	11.2
2	17.4	20.4	9.3	19.2	8.4	10.0	11.0
3	17.1	20.0	9.0	18.2	6.4	10.0	10.4
4	16.8	18.5	7.0	18.0	5.3	9.8	9.8
5	14.5	17.2	5.0	18.0	4.9	9.6	9.4
6	13.7	16.0	2.1	17.6	0.6	9.0	6.7
7	13.1	14.4	0.0	14.2	0.0		
8	12.8	12.8	0.0	13.0	0.0		
9	12.5	12.0	0.0	12.0	0.0		

Table. 2. Benthic invertebrate abundance and distribution for May 1984. Values are means of 15 dredges, converted to numbers/m^2 (standard deviation). + represents a sample where that taxa was present, if that taxa was found in less than four samples no standard deviation was calculated.

MAY 84

Organisms	Depth 1m	2m	3m	4m	5m
Chironomidae	467.78 (502.19)	726.67 (372.15)	1090.67 (533.45)	1166.67 (778.74)	784.00 (726.05)
Chaoborus			18.67 (22.00)	48.00 (52.26)	54.67 (63.90)
Odonata	68.89 (57.89)	28.00 (73.21)	6.67 (12.34)		9.33 (+)
Small Gastropoda	361.33 (469.19)	62.67 (138.54)		14.67 (26.69)	17.33 (+++)
Large Gastropoda	41.33 (61.16)				
Pelecypoda		2.67 (+)		5.33 (++)	5.33 (+)
Trichoptera	4.44 (+)	1.33 (+)	1.33 (+)		1.33 (+)
Hirudinea	13.33 (20.58)	4.00 (+++)		2.67 (+)	2.67 (++)
Amphipoda	18.89 (38.48)				
Ephemeroptera	3.33 (++)				1.33 (+)

May and 62.67/m^2 August), but were found even in the 4 and 5 m samples. Gastropods had a patchy distribution and were usually found in association with vegetation in the dredge. This association may explain the lack of gastropods in the 3 m sample in May; where few macrophytes were found in the dredge at that depth. In August, large clumps of coontail were found in depths greater than 2 m. Both large and small gastropods were present in the dredges; small snails were more abundant at every depth than large snails.

Odonates were abundant in the samples for May but had declined by August (Table 3). Odonates were most abundant in the 1 m sample for May. No 1 m samples were taken in August, therefore, odonates may be greatly underestimated for that month. Chaoborids were abundant below 2 m in May and below 3 m in August. These animals were a surprise encounter in the dredges, Chaoborus normally appear as representatives of planktonic communities rather than benthic communities.

Pelecypods were not very common in either May or August. However, large numbers of shells were found in all dredges below 2 m. The large number of clams found in the 3 m August sample may be an overestimate due to the difficulties of distinguishing live from dead organisms.

Differences in abundance between May and August were

Table. 3. Benthic invertebrate abundance and distribution for August 1984. Values are means from 15 dredges, converted to numbers/m^2 (standard deviation). + represents a sample where that taxa was present, if that taxa was found in less than four samples no standard deviation was calculated

AUGUST 84

Organisms	Depth 1m	2m	3m	4m	5m
Chironomidae		428.00 (552.26)	873.33 (1013.80)	382.00 (436.80)	85.71 (106.28)
Chaoborus				62.00 (80.80)	51.43 (56.40)
Odonata		16.00 (18.38)	3.33 (+)	2.00 (+)	
Small Gastropoda		152.00 (74.36)	110.00 (48.58)	26.00 (44.27)	3.14 (++)
Large Gastropoda		8.00 (++)	3.33 (+)		
Pelecypoda		4.00 (++)	183.33 (155.65)	52.00 (57.50)	65.71 (+++)
Trichoptera		16.00 (20.66)	6.67 (+)		
Hirudinea		4.00 (++)			
Amphipoda		26.00 (++)	16.67 (+)	6.00 (++)	5.71 (+)
Ephemeroptera		2.00 (+)		2.00 (+)	
Corixidae		2.00 (+)		2.00 (+)	

common. For example, gammorid amphipods were common in the 1 m dredges in May but were only rarely found in August dredges at any depth. Dredges of the lake suggest that many possible prey items were very abundant (chironomids, odonates, and gastropods); certain prey items, however, were found at low densities in both early and late summer (amphipods, trichopterans, and ephemeropterans).

Below is a partial list of invertebrates found through-out the summer in dredges:

Phylum Annelida
- Class Hirudinea
  - Order Rhynchobdellida
    - Family Glossiphoniidae
      - *Glossiphonia*, *Helobdella*
  - Order Gnathobdellida
    - Family Hirudidae
  - Order Pharyngobdellidae
    - Family Erpobdellidae

Phylum Mollusca
- Class Gastropoda
  - Subclass Pulmonata
    - Family Physidae
      - *Physa*
    - Family Lymnaeidae
      - *Lymnaea*
    - Family Planorbidae
      - *Helisoma*, *Gyraulus*
  - Subclass Prosobranchia
    - Family Valvatidae
      - *Valvata*
- Class Pelecypoda
  - Family Sphaeriidae
    - *Pisidium*

Phylum Arthropoda
- Class Crustacea
  - Subclass Branchiopoda
    - Order Cladocera
      - Suborder Eucladocera
        - Family Bosminidae
          - *Bosmina*

Subclass Ostracoda
Order Podocopa
Family Cypridae
Subclass Malcostraca
Order Amphipoda
Family Talitridae
Hyalella azteca
Family Gammaridae
Gammarus lacustris
Class Acarina
"Group" Hydracarina (Water mites)
Class Insecta
Order Hemiptera
Family Corixidae
Order Odonata
Suborder Anisoptera
Family Cordullidae
Epitheca, *Somatochlora*
Family Aeshnidae
Anax
Suborder Zygoptera
Family Coenagrionidae
Ischnura, *Enallagma*
Order Ephemeroptera
Family Heptageniidae
Family Leptophlebiidae
Family Baetidae
Family Caenidae
Order Trichoptera
Family Phryganeidae
Agrypnia
Family Leptoceridae
Family Limnephilidae
Nemataulius
Family Polycentropodidae
Order Diptera
Suborder Nematocera
Family Chironomidae
Family Chaoboridae

FISH SAMPLING

Most trout were caught in gill nets set along the bottom. Trout were caught along all transect lines; AD were more common along transects 1, 2, 3 and 4 (Fig. 2). YOY were caught at all depths and commonly along all transect lines.

The distributions of both threespine (TS) and brook (BR) sticklebacks were obtained using stratified minnow traps; no trout were caught in minnow traps (Fig. 3). Both species of sticklebacks were caught most frequently in the bottom traps and the traps 1 m from the bottom (+1 m). Throughout the year BR were never caught in traps above +1 m from the bottom. TS distribution changed through the year. During the winter TS were occasionally caught in surface traps as well as other traps closer to the bottom. During March and May, TS were caught at all depths. During the summer fewer fish were caught in the upper traps. August was the only exception when some fish were caught in the traps +2 m from the bottom. Just before ice-on both species of fish were only caught in the bottom traps.

FOOD HABITS

Almost 1600 fish from all four groups were sampled and in most months a low percentage of fish had empty stomachs (Table 4). The highest number of empty stomachs was found in January: 55% for BR and 19% for TS. The only other month with a high value of empty stomachs was July for AD (27%). All of the empty stomachs found during July were from angler caught fish; they may have been caught during or

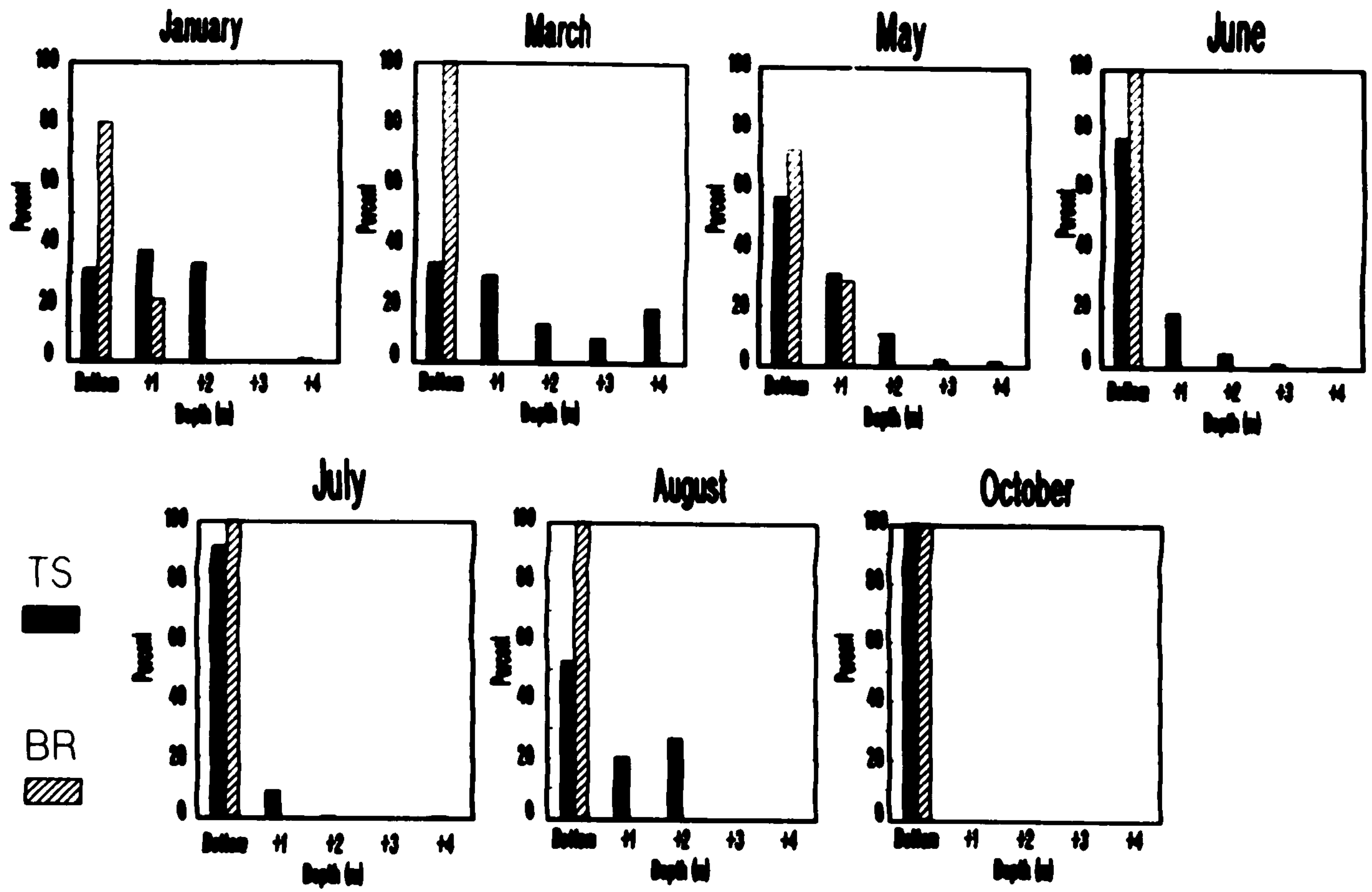


Fig. 3. Monthly vertical distribution of threespine and brook sticklebacks based on stratified minnow traps. Percents are combinations of *1984 and 1985 data.*

Table 4. Numbers of stomachs examined (n) and the numbers of empty stomachs (E) and the percent of empty stomachs (%E) for all months and all species sampled, with 1984 and 1985 data combined.

	TSPINE			BROOKS			ADULT			YOY		
Month	n	E	%E	n	E	%E	n	E	%E	n	E	%E
Jan	22	4	18.18	11	6	54.55	8	0	0.00			
Mar	20	1	5.00	4	0	0.00						
May	202	5	2.48	81	5	6.17	18	0	0.00			
June	278	16	5.76	74	7	9.46	79	5	6.33	42	2	4.76
July	144	7	4.86	63	6	9.52	37	10	27.03	132	8	6.06
Aug	155	5	3.23	36	1	2.78	22	0	0.00	113	4	3.54
Oct	14	0	0.00	4	0	0.00	31	0	0.00			

just at the start of a feeding period.

Fish were sampled at different times of the day, ranging from early morning to late evening. Based on the low occurrence of empty stomachs it appears that all four groups feed throughout the day, during the summer months.

Adult Trout

The diet of AD was varied with the seasons (Fig. 4 and Appendix 1). The diet was narrow in winter, consisting mostly of TS (51%[1] or 49% by number, and four invertebrate prey that were dominated by odonates). As the season progressed fish remained important, but there was a shift from TS to BR between May and June with BR being the dominant food item in June (41%). During May, gastropods became the dominant invertebrate (37%). In June invertebrate dominance switched back to odonates which occurred in approximately 50% of the stomachs sampled until August.

In June the diet was much broader than in January and May (15 categories versus 8). Fathead minnows were found in stomachs along with eggs (mostly salmon eggs from anglers) and invertebrate eggs associated with floating vegetation. During June the least important food item in the diet was other rainbow trout: only one was ever found. In late

[1] All food compositions are to be considered as mean percent dry weight unless otherwise stated.

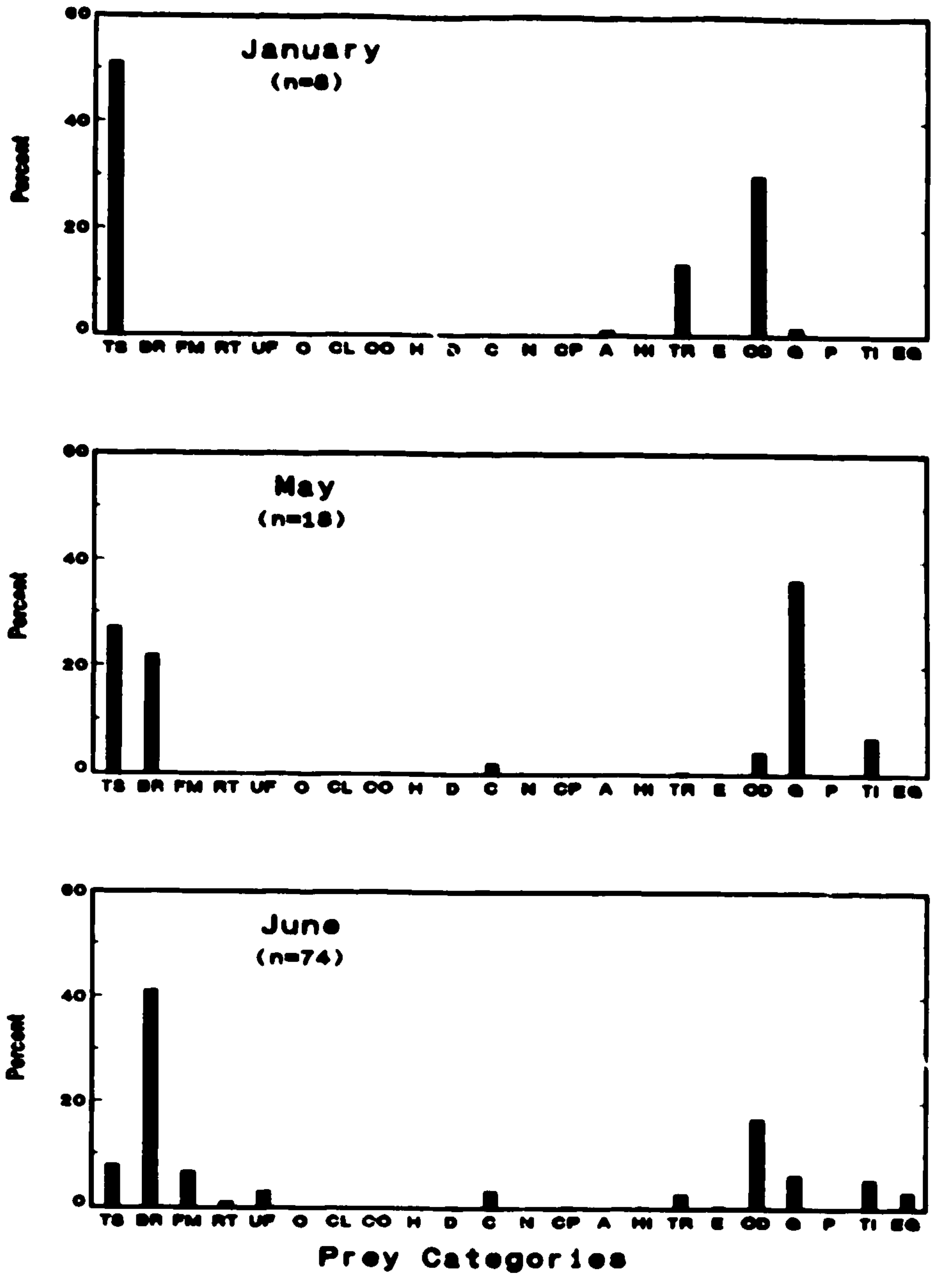


Fig. 4a & 4b. Monthly diet of adult trout expressed as mean percent dry weight. Data for 1983, 1984, and 1985 are combined for each month. Sample sizes (n) are indicated.

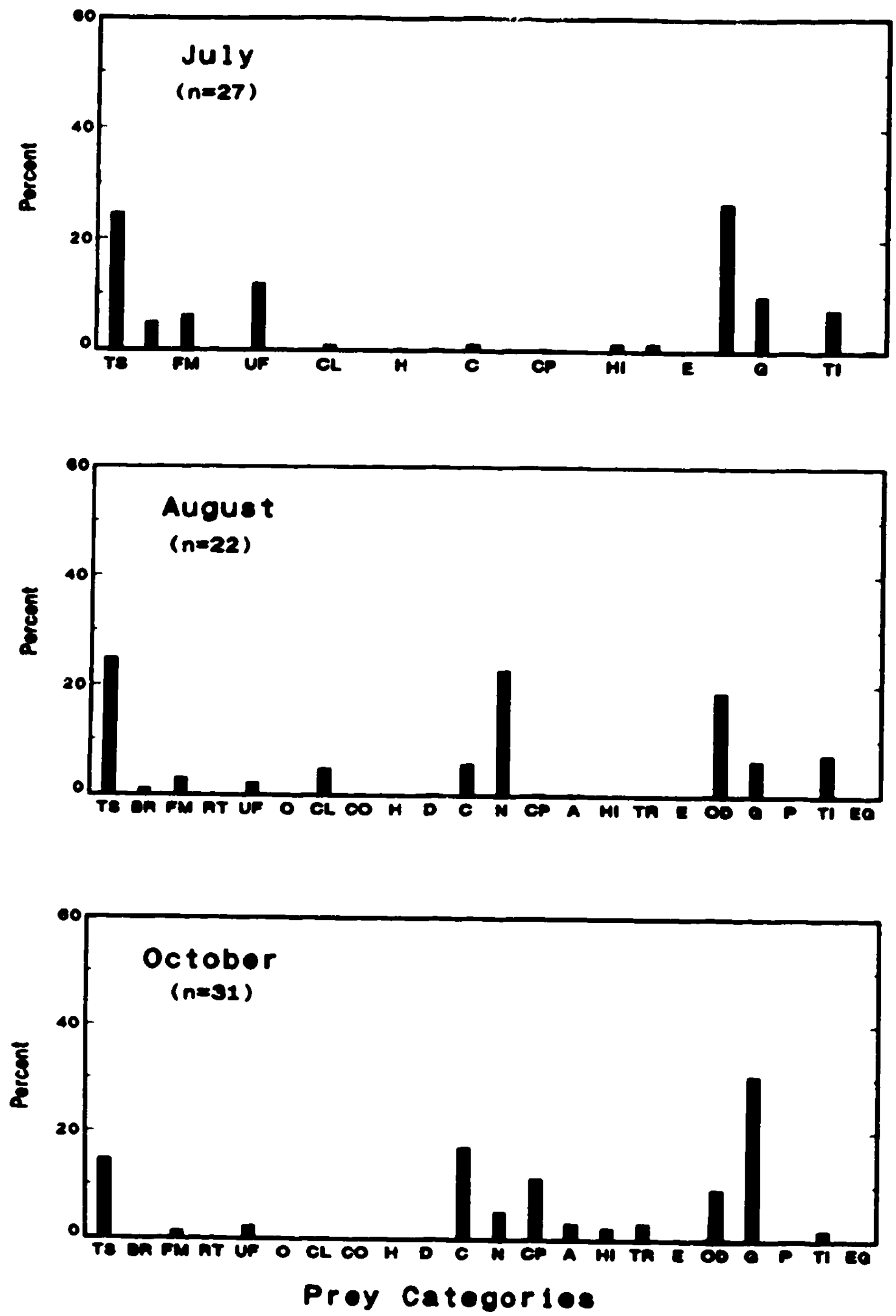

July
(n=27)
Percent
0
20
40
60
TS FM UF CL H C CP HI E G TI
August
(n=22)
Percent
0
20
40
60
TS BR FM RT UF O CL CO H D C N CP A HI TR E OD G P TI EG
October
(n=31)
Percent
0
20
40
60
TS BR FM RT UF O CL CO H D C N CP A HI TR E OD G P TI EG
Prey Categories

Fig 4b.

summer TS became more important than the other fish species (averaging about 30%). The TS were young-of-the-year and yearling fish; where as the fish eaten earlier were mature adults. Although fish were a major part of the diet, invertebrates were also abundant in the diet with back swimmers (notonectids) being most important (26%). The diet just before ice-on was dominated by invertebrates with gastropods, mostly physids, being the most frequent (31%). Water beetles also occurred in the stomachs for the first time in October. Identification of prey items was relatively consistent: "unidentified" fish and "other" consisted of parts of organisms that could not be identified. Except for July the two categories tended to account for less than 10% of the total diet. The ranking was also low in the other methods of evaluating stomach contents. Unidentified fish was very high in July 1983 (Appendix 1.); this was the first group of samples examined and there was difficulty distinguishing between minnows and stickleback remains. With practice this was overcome and fewer remains were classified in this group.

To summarize through most of the year AD were highly piscivorous but shifted in late summer to an invertebrate diet, eating mostly chitinous food items.

Young Trout

Diet data for YOY was only available for the mid-summer months due to difficulties in obtaining samples in the other months. Samples from June show that fish had already become an important part (11%) of the YOY diet (Fig. 5). The piscivorous fish tended to be longer than 120 mm. The stomach contents of the fish caught during June were diverse, consisting of fish and many different invertebrates (Appendix 2.). As the summer progressed the breadth of the diet increased as different fish and invertebrates were added.

During June the second and third dominant items in the stomachs were small instars of corixids (27% and 19% by number) and terrestrial drift (22% and 20% by number). The rest of the diet was composed of small gastropods, caddis flies, water mites and chironomid larvae. During July all invertebrates except terrestrial drift became reduced, especially corixids, which dropped to 4.8% and were only found in 25% of the stomachs sampled (Appendix 2.). The diet, although consisting of many different prey species, was skewed towards BR (36%) and terrestrial drift (31% and 65% by number). In August the diet became more of a mixture, and 19 different categories of prey were found with both sticklebacks (11% TS and 18% BR, respectively), corixids (instar larvae and

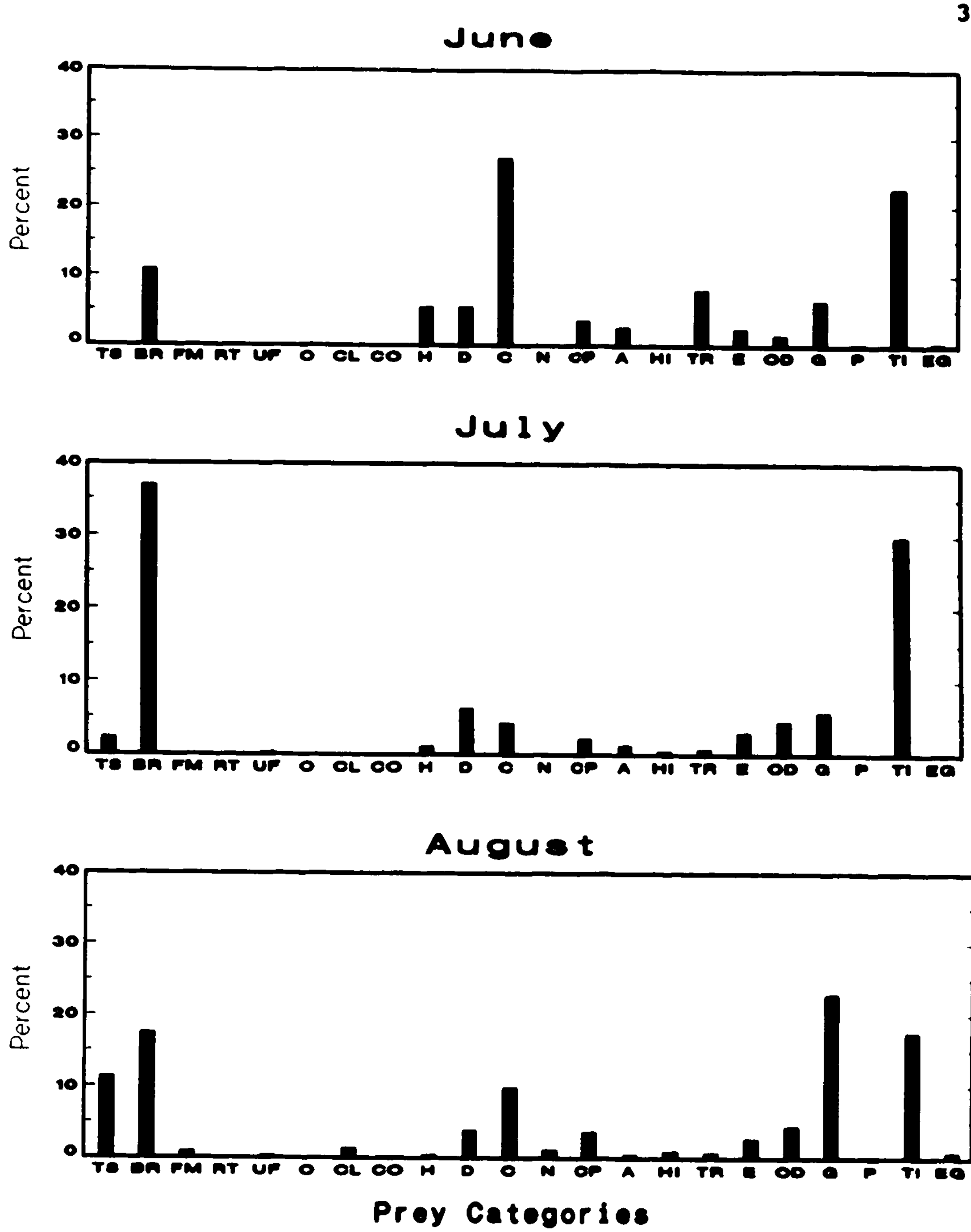


Fig. 5. Monthly diet of young trout expressed as mean percent dry weight. Data for 1984 and 1985 are combined for each month.

adults 10%), terrestrial drift (18%), and gastropods (23%) being important. Terrestrial drift was the most prominent based on numbers consumed and was present in 50% of the stomachs sampled. All other prey categories accounted for only 17% of the diet.

Brook Stickleback

Diet composition was available for the whole year for both threespine (TS) and brook (BR) sticklebacks. During the ice-on period the diet of BR tended to be restricted to only three or four items (Appendix 3.). During late winter cladocerans (mostly Bosmina) were the most dominant species, 60% and 89% by number, with amphipods and eggs also being found at approximately 20% each (Fig. 6 and Appendix 3.). The eggs were unidentified but were not fish eggs and were not similar to eggs found in the summer; similar eggs were found in March. In March, dipteran larvae (25%) were found in the stomachs of BR. Then dominance shifted from cladocerans (10%) to ostracods (40%), and copepods were also an important part of the diet. For the rest of the year chironomids became the most dominant organism in the diet, never dropping below 40% or occurring in less than 60% of the stomachs. In May, fish eggs were first found in stomachs. Fish eggs were a major prey item in June (16%), the height of the breeding season. During June both gastropods (snails)

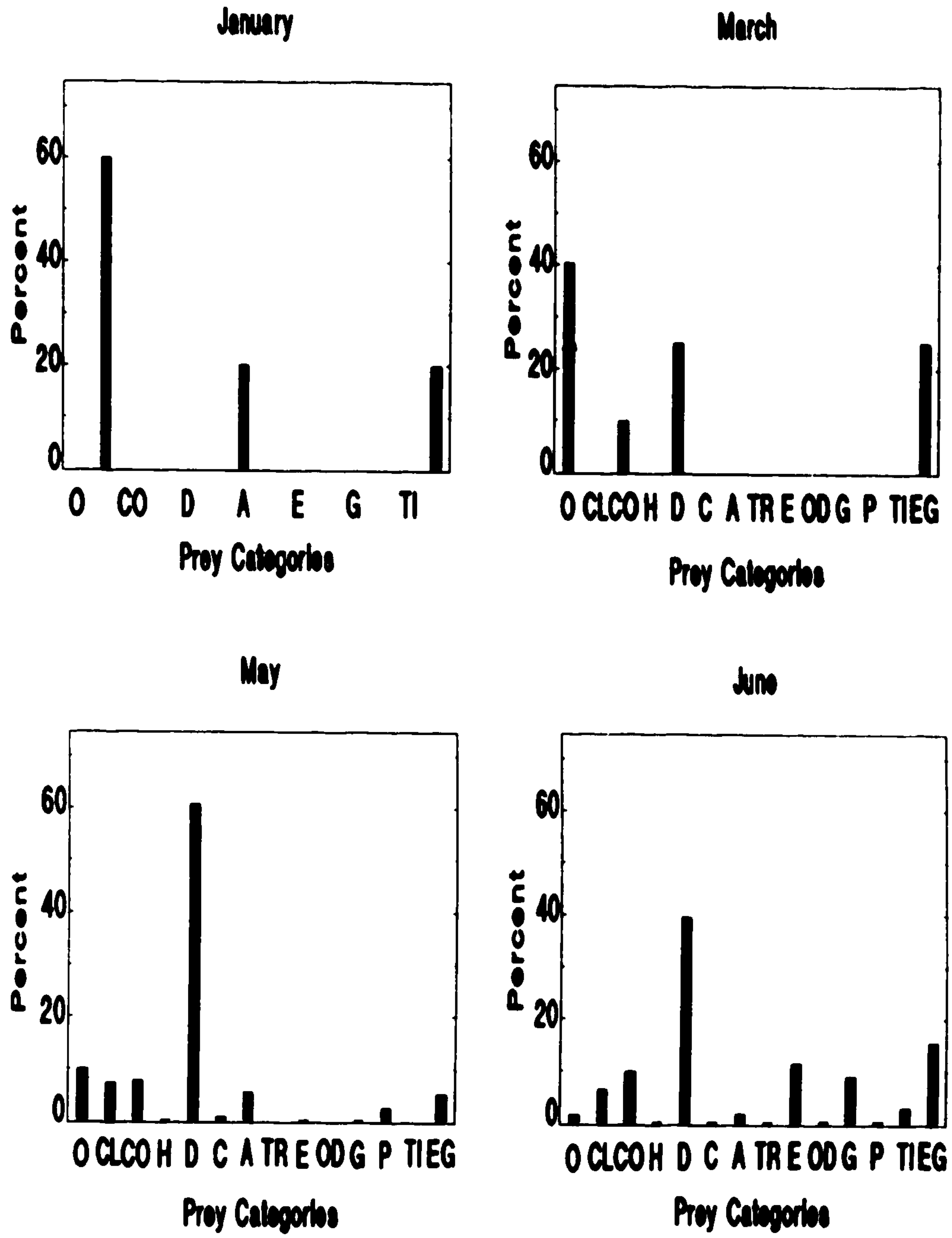


Fig. 6a & 6b. Monthly diet of brook stickleback expressed as mean percent dry weight. Data for 1984 and 1985 are combined for each month, sample sizes are presented in Appendix 3.

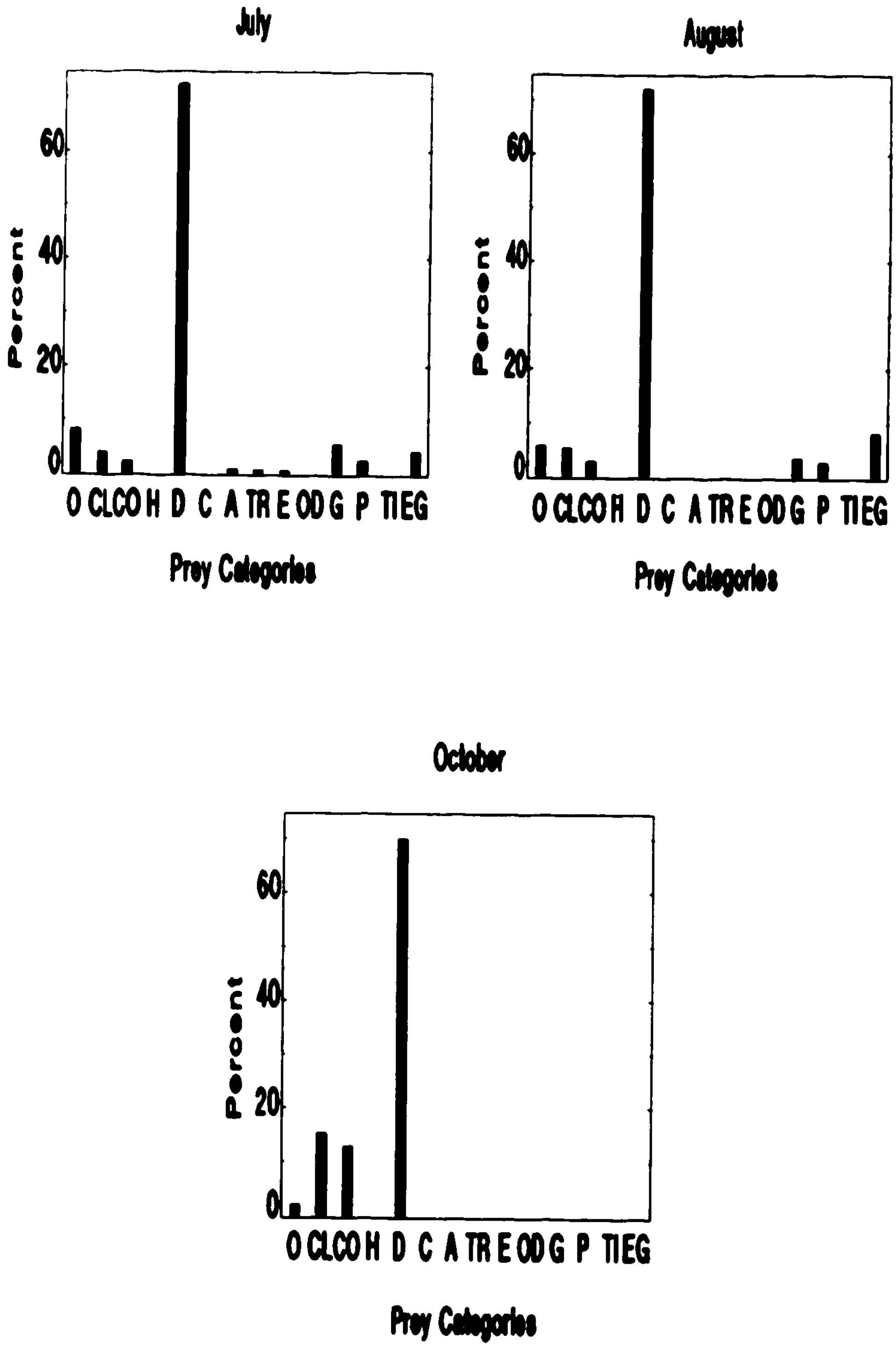

July
August
October
Percent
0
20
40
60
O CL CO H D C A TR E OD G P TI EG
Prey Categories

Fig. 6b.

and mayflies peaked in abundance in stomachs, accounting for 21% of the total, but declined to low amounts in the late summer. Through July and August all prey items except dipterns declined in importance. During the year, except for late winter, the dominant food organisms were diptern larvae and pupae with other benthic and planktonic prey fluctuating in importance.

Threespine Stickleback

From Fig. 7 it is apparent that dipteran larvae (mostly chironomids) were found in large numbers (Appendix 4.) and composed a large part of the diet of TS throughout the year. Unlike in BR, chironomid larvae were consumed even in the winter (20%). The stomachs analyzed in January had more cladocerans (33%) and copepods (22%) than other prey. Trichopteran larvae were only found in great abundance during the ice-on period, and they declined in the summer. January was also a period when the "other" prey categories, mainly algae, were found. This was the only month when algae was important. March appeared to be a transition month with the diet breadth increasing and more benthic forms becoming important. In March the second major item was "other", consisting of pieces of macrophytes, sand, and parts of unidentified prey items. "Other" was equal to dipterns, accounting for approximately 40%.

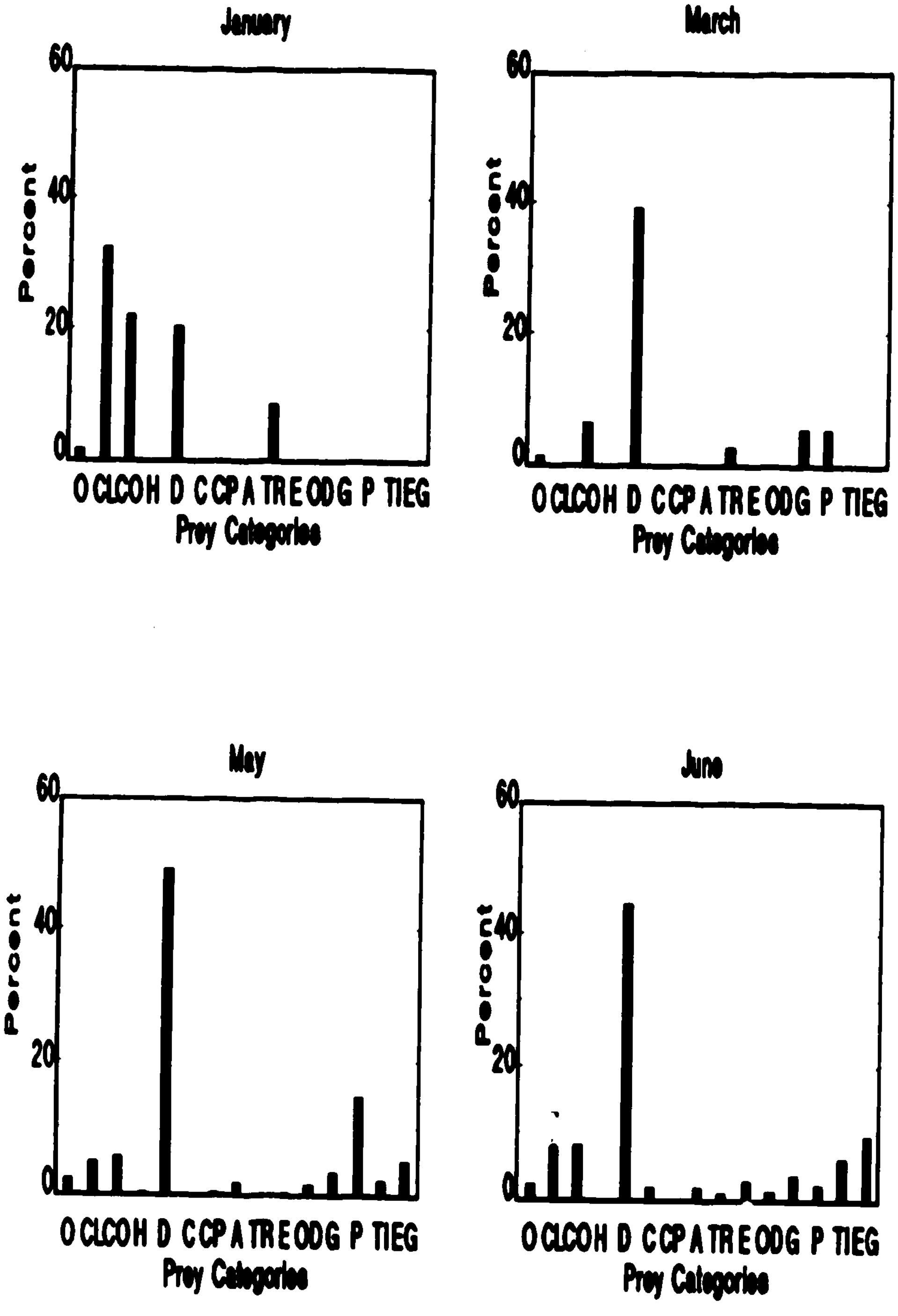


Fig. 7a & 7b. Monthly diet of threespine stickleback expressed as mean percent dry weight. Data for 1984 and 1985 combined for each month.

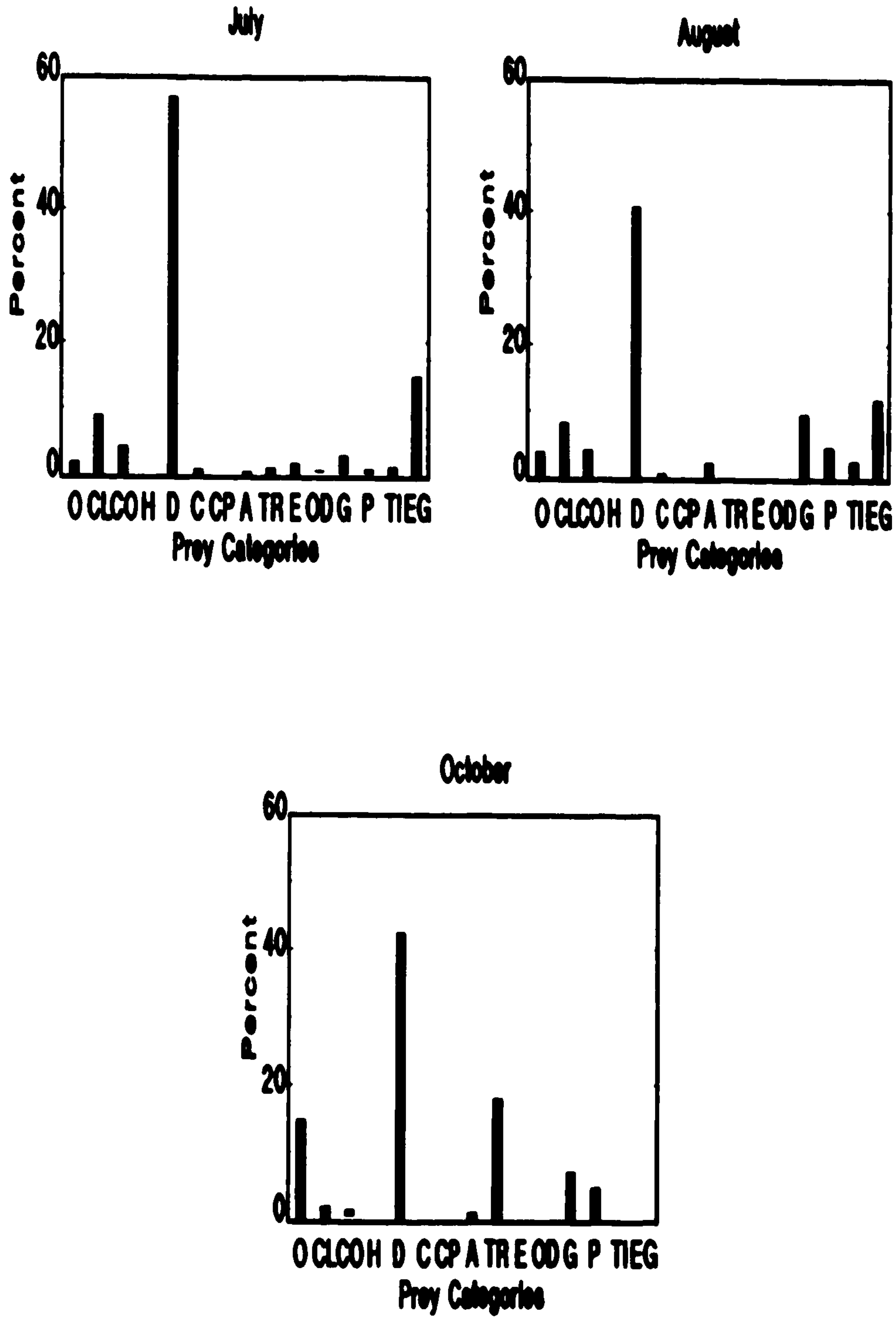

July
August
October
Percent
60
40
20
0
O CLCOH D CCPATREODG P TIEG
Prey Categories

Fig. 7b.

During the open water period, dipteran larvae never dropped below 39% of the diet, and were usually found in 56-78% of the fish checked. All other prey categories were at low levels during the summer. In May the first occurrence of fish eggs in stomach contents was noted. Eggs were of secondary importance throughout the summer, increasing to slightly greater than 10% in June through August. TS were very different from the other fish groups in that they preyed on fingernail clams. Pelecypods were consumed during the open water period, and in May they were the second most dominant item (15%). They were usually found in small numbers, but due to the weight of the shells, were highly ranked. The feeding of these fish on clams also resulted in an increased occurrence of "other" items in the diet.

Below is a partial list of prey types found in all species of fish examined.

- Phylum Annelida
  - Class Hirudinea
    - Order Rhynchobdellida
      - Family Glossiphoniidae
        - _Glossiphonia_, _Helobdella_
    - Order Gnathobdellida
      - Family Hirudidae
    - Order Pharyngobdellidae
      - Family Erpobdellidae
- Phylum Mollusca
  - Class Gastropoda
    - Subclass Pulmonata
      - Family Physidae
        - _Physa_
      - Family Lymnaeidae
        - _Lymnaea_
      - Family Planorbidae
        - _Helisoma_, _Gyraulus_

Subclass Prosobranchia
Family Valvatidae
Valvata
Class Pelecypoda
Family Sphaeriidae
Pisidium
Phylum Arthropoda
Class Crustacea
Subclass Branchiopoda
Order Cladocera
Suborder Haplopoda
Family Leptodoridae
Suborder Eucladocera
Family Bosminidae
Bosmina
Family Moinidae
Family Daphnidae
Daphnia
Subclass Copepoda
Order Cyclopoida
Subclass Ostracoda
Order Podocopa
Family Cypridae
Subclass Malcostraca
Order Amphipoda
Family Talitridae
Hyalella azteca
Family Gammaridae
Gammarus lacustris
Class Acarina
"Group" Hydracarina (Water mites)
Class Insecta
Order Hemiptera
Family Notonectidae
Notonecta
Family Corixidae
Order Odonata
Suborder Anisoptera
Family Cordullidae
Somatochlora
Family Aeshnidae
Anax
Suborder Zygoptera
Family Coenagrionidae
Ischnura, *Enallagma*
Order Ephemeroptera
Family Heptageniidae
Family Leptophlebiidae
Family Baetidae
Family Caenidae

Order Trichoptera
  Family Phryganeidae
    Agrypnia
  Family Leptoceridae
  Family Limnephilidae
    Nemataulius
  Family Polycentropodidae
Order Coleoptera
  Family Dytiscidae
  Family Hydrophilidae
    Hydrobius ametor
  Family Haliphilidae
    Haliplus
  Terrestrial Families
    Brentidae, Chrysomelidae,
    Anthribidae, Curculionidae
Order Diptera
  Suborder Nematocera
    Family Chironomidae
    Family Chaoboridae
    Family Heleidae
    Family Culicidae
  Suborder Brachycera (terrestrial)
    Family Tabanidae
Order Lepidotera(terrestrial)
Order Hymenoptera(terrestrial)
Order Homoptera(terrestrial)

DIET OVERLAP

Schoener's Index

A) Adult trout and young trout

Diet overlap values were calculated for AD and YOY for the three summer months (June to August) using Schoener's index. Mean percent dry weight was used and all prey types were included. Values were 0.352 for June, 0.362 for July, and 0.415 for August (Table 5). All values were below 0.6, which suggests that there was no significant overlap. In June, AD tended to eat more odonates and BR. The YOY ate

Table 5. Schoener's index values of diet overlap between adult and young trout in Hasse Lake for the summer months, with 1984 and 1985 data combined. p_{xi} and p_{yi} are the proportions of food category i in species x and y, a is the absolute value of p_{xi} minus p_{yi}.

PREY CATEGORIES	June AD p_{xi}	June YOY p_{yi}	June a	July AD p_{xi}	July YOY p_{yi}	July a	August AD p_{xi}	August YOY p_{yi}	August a
3SPINE STKB	7.86		7.86	24.53	2.16	22.37	24.79	11.40	13.39
BROOK STKB	41.06	10.74	30.32	4.81	36.90	32.09	0.95	17.49	16.54
FAT. MINNOW	6.60		6.60	6.03		6.03	2.86	0.81	2.05
RAIN. TR.	0.79		0.79						
OSTRACODA									
CLADOCERA				0.69		0.69	4.67	[illegible]	[illegible]
COPEPODA									
HYDRACRINA	0.07	[illegible]	5.30	0.01	0.98	0.97		0.32	0.32
DIPTERA	0.05	5.41	5.36	0.02	6.27	6.25	0.01	3.77	3.76
CORIXIDAE	2.93	26.97	24.04	0.99	4.17	3.18	5.54	9.79	4.25
NOTONECTIDAE				0.07		0.07	22.64	1.01	21.63
COLEOPTERA	0.01	3.47	3.46	0.14	2.03	1.89	0.10	3.53	3.43
AMPHIPODA		2.52	2.52		1.09	1.09	0.08	0.38	0.30
HIRUDENIA	0.05		0.05	1.15	0.41	0.74		0.86	0.86
TRICHOPTERA	2.46	7.85	5.39	1.13	0.59	0.54		0.62	0.62
EPHEMEROPTERA	0.09	2.22	2.13		2.90	2.90		2.60	2.60
ODONATA	16.81	1.35	15.46	26.56	4.39	22.17	18.62	4.29	14.33
GASTROPODA	6.11	6.32	0.21	9.73	5.67	4.06	6.17	22.98	16.81
PELECYPODA		0.02	0.02					0.07	0.07
TERR.INS	5.24	22.59	17.35	7.49	29.87	22.38	7.36	17.45	10.09
EGGS	2.87	0.21	2.66	0.14		0.14		0.63	0.63
INDEX VALUE			0.352			0.362			0.424

immature corixids and terrestrial drift which were rarely found in adult stomachs. In July there was also little overlap, although it was slightly higher than in June. Fish were consumed by both groups, but they consumed different species; AD ate TS and YOY ate BR. AD were still eating odonates and the YOY were not; the reverse was true for terrestrial drift.

When prey categories that accounted for less than 5% of the diet for both groups were removed from the analysis, the overlap values increased (0.411 for June, 0.423 for and July, and 0.487 for August), but were still below 0.60.

B) Young trout and threespine stickleback

Diet overlap between YOY and TS was even less than that of AD and YOY. The overlap index values were 0.269 for June, 0.179 for July and 0.244 for August (Table 6). Prey items that were abundant in the diet of TS, dipteran larvae and small fish eggs, were rarely consumed by trout. The reverse was also true; important food items for YOY were BR, terrestrial insects, corixids and gastropods, and these were used infrequently by sticklebacks.

C) Threespine and brook sticklebacks

Both sticklebacks were compared over the summer months from May to August. The strong overlap in all months can be attributed to the reliance of both species on dipteran larvae and pupae (Table 7). Throughout the year BR tended

Table 6. Schoener's index of diet overlap between young trout and threespine sticklebacks in Hasse Lake for the summer months, with 1984 and 1985 data combined. See Table 5 for definition of formulas.

PREY CATEGORIES	June TS P_{xi}	June YOY P_{yi}	June •	July TS P_{xi}	July YOY P_{yi}	July •	August TS P_{xi}	August YOY P_{yi}	August •
3SPINE STKB					2.16	2.16		11.40	11.40
BROOK STKB		10.74	10.74		36.90	36.40		17.49	17.49
FAT. MINNOW								0.81	0.81
OSTRACODA	1.97		1.97	1.86		1.86	3.76		3.76
CLADOCERA	12.86		12.86	8.77		8.77	8.11	1.23	9.34
COPEPODA	7.97		7.97	4.18		4.18	4.06		4.06
HYDRACRINA		5.37	5.37		0.98	0.98		0.32	0.32
DIPTERA	44.44	5.41	39.03	56.74	6.27	50.47	40.64	3.77	36.87
CORIXIDAE	1.39	26.97	25.58	0.73	4.17	3.44	0.87	9.79	8.92
NOTONECTIDAE								1.01	1.01
COLEOPTERA		3.47	3.47		2.03	2.03		3.53	3.53
AMPHIPODA	1.55	2.52	0.97	0.74	1.09	0.35	2.49	0.38	2.11
HIRUDENIA					0.41	0.41		0.86	0.86
TRICHOPTERA	1.05	7.85	6.80	1.02	0.59	0.43		0.62	0.62
EPHEMEROPTERA	2.64	2.22	0.42	1.64	2.90	1.26	0.48	2.60	2.12
ODONATA	1.08	1.35	0.27	0.09	4.39	4.30		4.29	4.29
GASTROPODA	3.45	6.32	2.87	2.62	5.67	3.05	9.46	22.98	13.52
PELECYPODA	2.00	0.02	1.98	0.50		0.50	4.54	0.07	4.47
TERR.INS	6.01	22.59	16.58	1.14	29.87	28.73	2.77	17.45	14.68
EGGS	9.47	0.21	9.26	14.83		14.83	11.70	0.63	11.07
INDEX VALUE			0.269			0.179			0.244

Table 7. Schoener's index of diet overlap between threespine and brook sticklebacks in Hasse Lake for the summer months, with 1984 and 1985 data combined. See Table 5 for definition of formulas.

PREY CATEGORIES	May TS p_{xi}	May BR p_{yi}	May a	June TS p_{xi}	June BR p_{yi}	June a	July TS p_{xi}	July BR p_{yi}	July a	August TS p_{xi}	August BR p_{yi}	August a
OSTRACODA	2.11	9.82	7.71	1.97	1.43	0.54	1.86	8.12	6.26	3.76	5.63	1.87
CLADOCERA	4.95	7.17	2.22	12.86	6.41	6.45	8.77	3.92	4.85	8.11	5.16	2.95
COPEPODA	5.51	7.57	2.06	7.97	9.84	1.87	4.18	2.09	2.09	4.06	2.64	1.42
HYDRACRINA	0.01	0.08	0.07		0.09	0.09					0.01	0.01
DIPTERA	49.07	60.66	11.59	44.44	39.44	5.00	56.74	72.41	15.67	40.64	72.14	31.50
CORIXIDAE	0.01	0.58	0.57	[illegible]	0.18	1.21	0.73		0.73	0.87		0.87
NOTONECTIDAE												
COLEOPTERA	0.01		0.01									
AMPHIPODA	1.18	5.38	4.20	1.[illegible]	[illegible].72	0.17	0.74	0.64	0.10	2.49		2.49
HIRUDINEA												
TRICHOPTERA	0.30		0.30	1.05	0.10	0.95	1.02	0.48	0.54			
EPHEMEROPTERA	0.69	0.06	0.63	2.64	11.40	8.76	1.64	0.40	1.24	0.48	0.03	0.45
ODONATA	0.94		0.94	1.08	0.32	0.76	0.09		0.09			
GASTROPODA	3.14	0.01	3.13	3.45	8.96	5.51	2.62	5.41	2.79	9.46	3.47	5.99
PELECYPODA	14.56	2.37	12.19	2.00	0.22	1.78	0.50		0.50	4.54		4.54
TERR.INS	2.24		2.24	6.01	2.91	3.10	1.14		1.14	2.77		2.77
EGGS	4.82	5.02	0.20	9.47	15.41	5.94	14.83	4.18	10.65	11.70	8.20	3.50
Index(value)			0.760			0.789			0.767			0.708

to rely heavily on dipterans than did TS. That was not true in June, when both species fed more on other food groups and less on dipterans. June was also the month with the highest overlap (0.789). In the other months TS fed on other prey items and tended to have a broader diet than BR, which tended to reduce the overlap. When prey types that accounted for less than 5% of the diet of either species were removed the value of overlap went up and approached that of June (0.799 for May and July, and 0.771 for August). All values for overlap for these two species should be considered underestimates of the overlap, because of the high dependence of the two species on dipteran larvae and pupae. Both species of sticklebacks had very similar diets and a high degree of overlap.

Canonical Variate Analysis

The overlap in diet between the four groups of fish were examined using canonical variate analysis (CVA). The results are expressed in a quantitative manner by frequency distributions of canonical scores. The distribution of the different groups is very important; if the two *a priori* groups are widely separated it suggests that the two groups can be readily distinguished from each other using the generated function. If the two groups have similar distributions there is little distinction between them. The unknown groups distributions are superimposed on the *a priori* groups. If a similar distribution is noted, then the unknowns are overlapping in diet with the known groups. If the distributions are different then there is no similarity in diet. The degree of similarity estimates the degree of overlap. Another facet of CVA is the classification of individuals based on their canonical scores; an individual is classified into one of the two *a priori* groups based on its distance from the two group centroids. This determines whether the diet of the individual is similar to one of the *a priori* groups.

There was good separation between AD and TS during June; the means were separated by four standard deviation units (Fig. 8). The distribution was strongly trimodal with YOY being intermediate to AD and TS, suggesting little overlap between YOY and either TS or AD. Brook stickleback were virtually identical to TS in their distribution. The derived function was strong in that AD were correctly classified 86.5% of the time, and TS were correctly classified 97.6% of the time (Table 8). Based on canonical scores BR were classified 99% of the time as TS, and YOY were classified as AD 27% of the time and as TS for the other 73%. The diet of YOY and BR appeared to be more similar to TS than to AD. There was no strong overlap between YOY and the two *a priori* groups; this was shown by YOY's intermediate distribution.

Table 8. Identification success from canonical variate analysis, for all three months of the summers of 1984 and 1985. Adult trout (AD) and threespine sticklebacks (TS) were used as *a priori* groups.

June

Group	%Correct	AD	TS	n
AD	86.5	64	10	74
TS	97.6	3	122	125
BR	0.0	1	66	67
YOY	0.0	11	29	40

July

Group	%Correct	AD	TS	n
AD	88.9	24	3	27
TS	100.0	0	137	137
BR	0.0	0	57	57
YOY	0.0	103	21	124

August

Group	%Correct	AD	TS	n
AD	86.4	19	3	22
TS	100.0	0	150	150
BR	0.0	0	35	35
YOY	0.0	29	80	109

Table 9. Discriminating characters for CVAs on June, July, and August. Characters are in order of decreasing importance with F ratio for inclusion and coefficients. Adult trout (AD) and threespine (TS) sticklebacks were used as *a priori* groups.

June

Rank	Variable	F	Coefficient	Degrees	of Freedom
1	BR	124.32	0.67	1	196
2	Odo	118.72	0.59	2	195
3	TS	107.82	0.66	3	194
4	Fath	110.05	0.63	4	193
5	Dipt	101.05	-0.07	5	192
6	Gast	91.99	0.34	6	191
7	Cole	85.11	65.52	7	190
8	Corix	76.80	0.23	8	189
9	Trich	70.30	0.21	9	188
10	Terrin	65.02	0.15	10	187
		Constant = -1.40016			

July

Rank	Variable	F	Coefficient	Degrees	of Freedom
1	Odo	75.60	0.07	1	158
2	TS	135.16	0.07	2	157
3	BR	110.76	0.11	3	156
4	Terrin	103.45	0.06	4	155
5	Fath	105.97	0.06	5	154
6	Cole	102.05	1.38	6	153
7	Dipt	92.56	-0.02	7	152
8	Eggs	84.97	-0.02	8	151
9	Clad	80.06	-0.02	9	150
10	Cope	76.42	-0.02	10	149
11	Ostra	78.02	-0.03	11	148
12	Eph	73.88	-0.02	12	147
		Constant = 0.98067			

August

Rank	Variable	F	Coefficient	Degrees	of Freedom
1	TS	69.15	0.08	1	170
2	Noto	117.23	0.09	2	169
3	Odo	159.21	0.08	3	168
4	Fath	141.68	0.10	4	167
5	Corix	136.33	0.05	5	166
6	Terrin	117.38	0.01	6	165
		Constant = -0.86991			

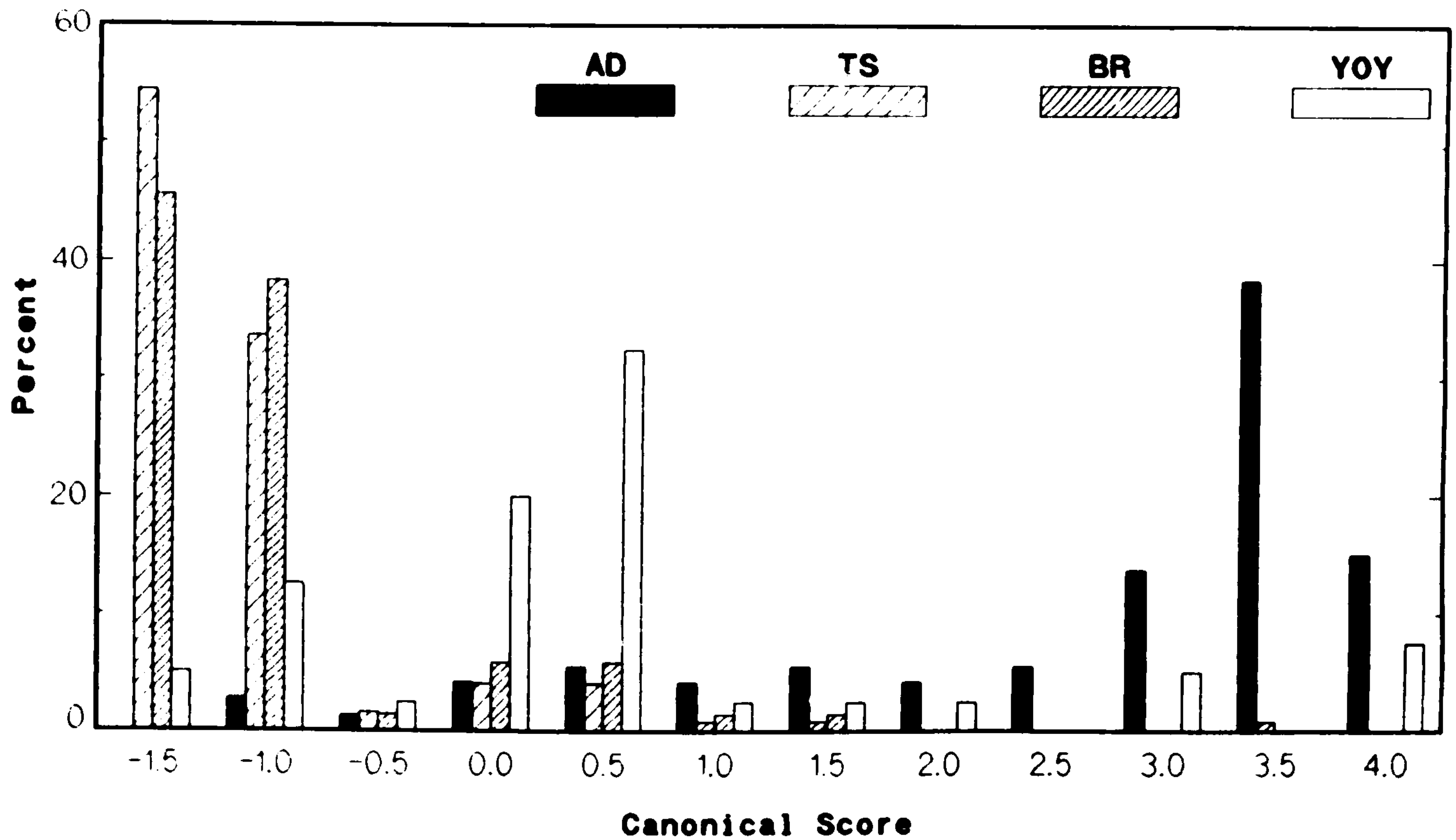


Fig. 8. Frequency distributions of canonical scores of all four groups for the month of June, 1984 and 1985 data combined. Adult trout (AD) and threespine stickleback (TS) as known groups.

There were 10 prey categories that provided the best discrimination of AD and TS; three fish species (fatheads, brook, and threespines) were the top discriminators along with dragonflies, dipterans, snails, and water beetles (Table 9). Only dipterans was an important prey category for TS, all the other discriminators were important for AD. Both sticklebacks had virtually identical diets for the month of June; YOY appeared to have little overlap with either TS or AD although their diet appeared more aligned to TS than AD.

In July the results were different from those of June; the distribution was still trimodal, but YOY instead of being intermediate was separate from both AD and TS (Fig. 9). There was strong discrimination of the two known groups with the means separated by seven standard deviation units. Again, BR clustered with TS, and were classified as TS 100% of the time (Table 8). Some 83% of the YOY were classified as AD and the other 17% were classified as TS. All major prey categories (those over 1% of the diet of any of the predators) were important discriminators with fish again being very important and dragonflies and terrestrial drift also being important (Table 9). The diet overlap in July appears dissimilar to June. The YOY had little overlap with either *a priori* groups

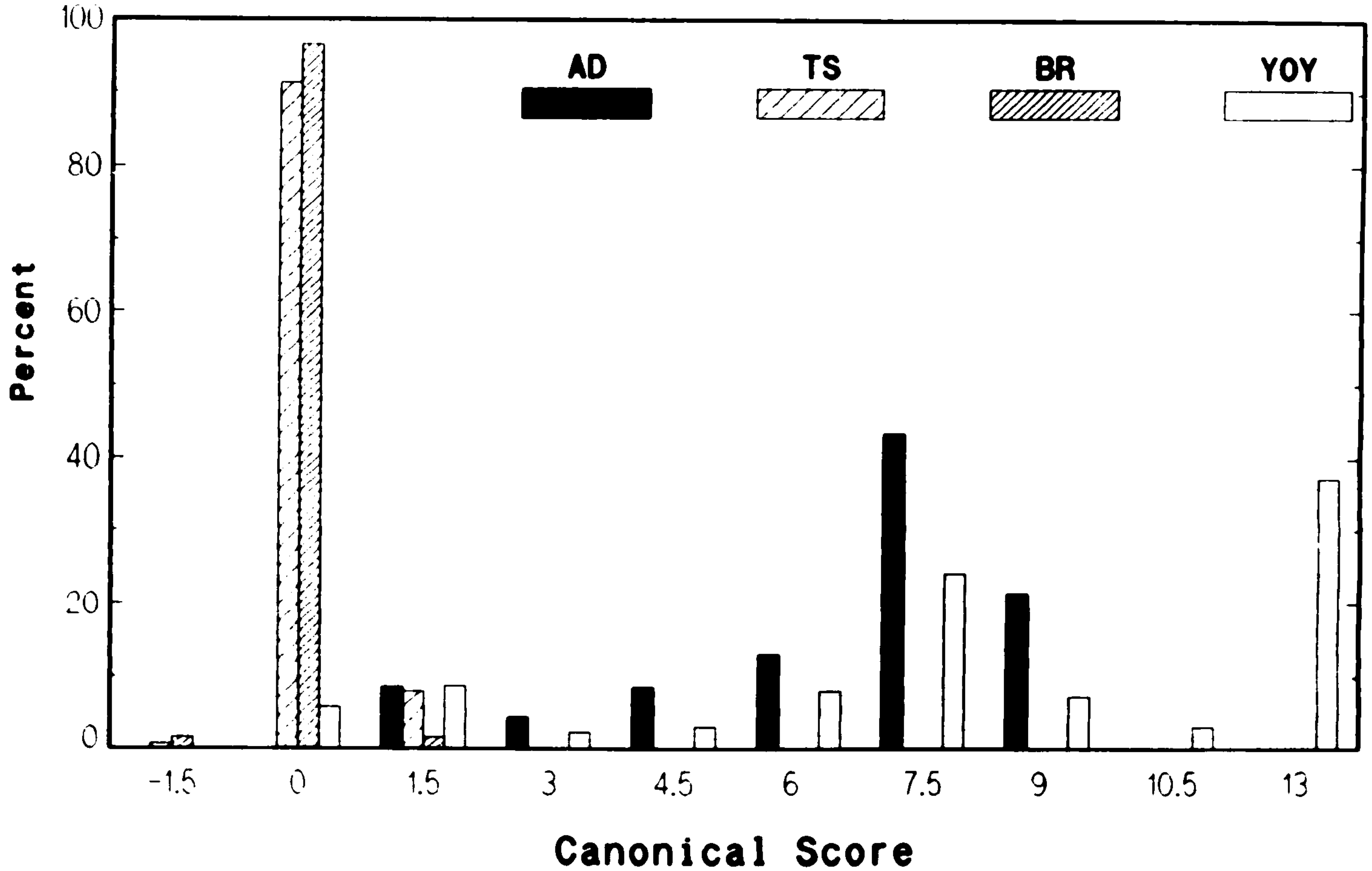


Fig. 9. Frequency distribution of canonical scores of all four fish groups for the month of July, 1984 and 1985 data combined. Adult trout (AD) and threespine stickleback (TS) as known groups.

but were more closely aligned with AD rather than TS.

The distribution for August was bimodal rather than trimodal, and there were few fish intermediate to AD and TS in diet (Fig. 10). BR were still wholly classified as TS in August, but 73% of YOY classified as TS and only 27% as AD, which was the reverse of July and similar to June (Table 8). The distribution suggested that YOY had a diet similar to TS, but this was not the case (Table 9). There were only six discriminators in the August analysis. Threespine stickleback and fathead minnow were the only fish found, all the other variables were important only in the diet of AD and were not present in the diet of sticklebacks. If a fish consumed even a small amount of these prey types they were classified as AD and not as TS. Few of these prey categories were important to YOY; therefore, there was a suggestion of diet overlap between YOY and TS. However, diet overlap should be based on the presence of prey types in the diet and not the absence of a prey type.

Although it may appear that there was diet overlap between TS and YOY in August this was not the case due to the problems with the variables used to make up the discriminant function. To deal with this problem the data were analyzed by generating a discriminant function that used all four fish groups as *a priori* groups, DFA.

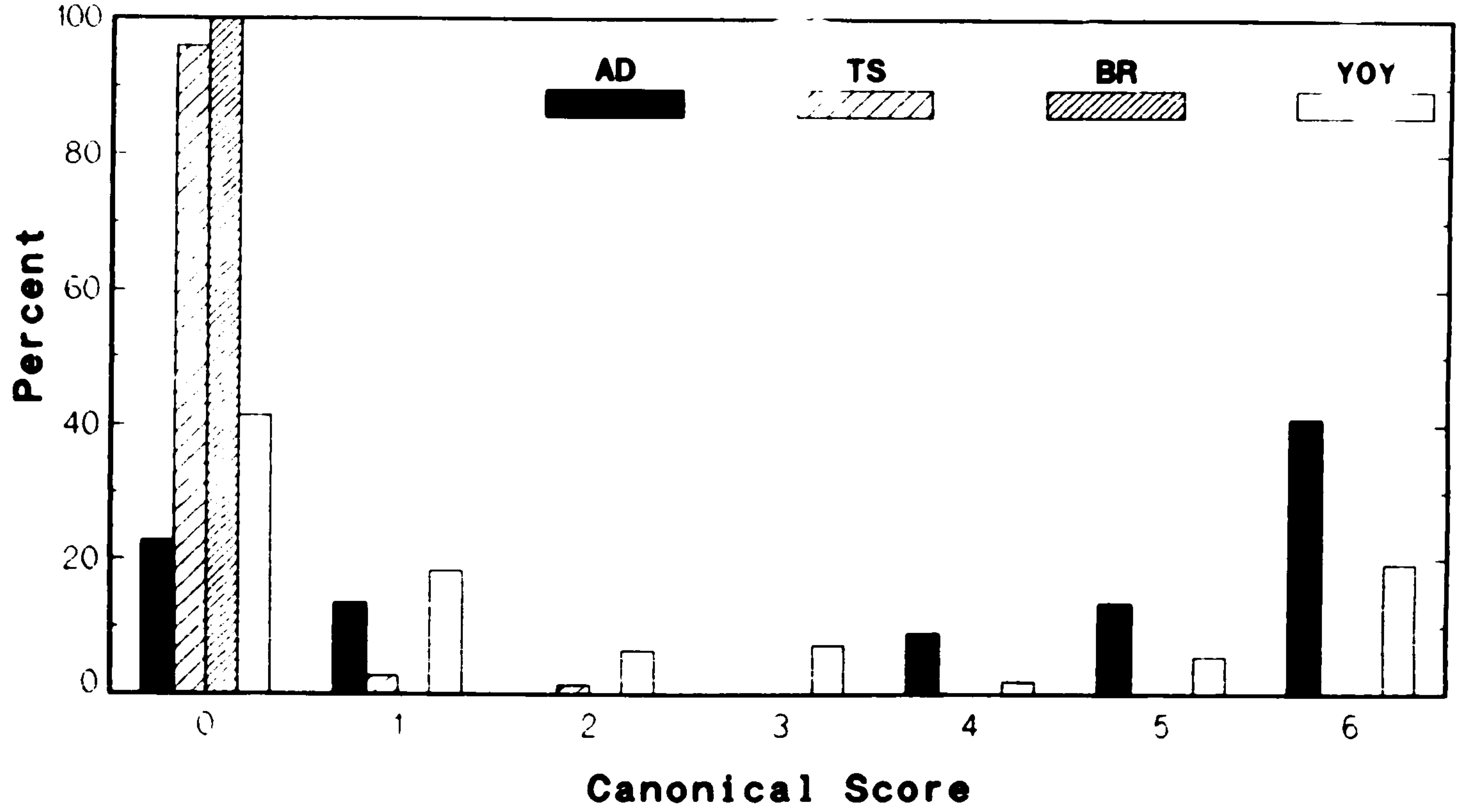


Fig. 10. Frequency distributions of canonical scores of all four fish groups for the month of August, 1984 and 1985 data combined. Adult trout (AD) and threespine stickleback (TS) as known groups.

<u>Discriminant Function Analysis</u>

In June, discriminant function analysis (DFA) provided separation of all but two of the populations. Neither BR nor TS were separated but AD and YOY trout were separated from each other and the sticklebacks (Fig. 11). The two canonical axes used accounted for 100% of the variation, with CV I accounting for 83% and CV II for 17% (Table 10). The first axis separated AD from the rest of the groups and the second axis separated YOY from the sticklebacks. Seventeen possible prey categories were used in the analysis, but only eight were good discriminators, with BR, water boatmen, fatheads, and dragonflies being the most important. Classification over all groups averaged 55% correct classification; a large proportion of the misgrouping were TS classified as BR (Table 11). To validate the functions generated, the centroids of the randomly generated groups (NTAD, NTTS, NTBR, NTYOY) were compared to the centroids of the four main groups (AD, TS, BR, YOY), which were also randomly generated. There was a significant difference between AD and NTAD ($p<0.001$), and a significant difference between YOY and NTYOY ($p<0.05$ but $p>0.01$). The plots for July and August are similar to that of June. AD and YOY were distinct from each other and the sticklebacks were distinct from each other (F-test, $p<0.001$) (Fig. 12 and Fig. 13). The first two canonical axes

Table 10. Discriminating characters in DFA for June, July, and August. Characters are in order of decreasing importance.

June

Rank	Variable	F-Statistic	CV I	CV II
1	BR	43.93	0.053	-0.002
2	Corix	30.49	0.016	-0.048
3	Fath	25.89	0.059	0.010
4	Odo	26.40	0.061	0.005
5	TS	23.79	0.060	0.010
6	Trich	21.77	0.020	-0.055
7	Cole	19.59	0.022	-0.062
8	Terrin	18.07	0.014	-0.009
Eigenvalues			3.467	0.713
Cumulative Dispersion(%)			82.79	99.81

July

Rank	Variable	F-Statistic	CV I	CV II
1	Diptl	49.59	-0.040	0.015
2	TS	35.04	0.025	0.094
3	Eggs	30.63	-0.040	0.014
4	Ostra	28.41	-0.057	0.023
5	Odo	26.02	0.016	0.047
6	Fath	24.78	0.021	0.086
7	Clad	23.53	-0.043	0.019
8	Cope	23.18	-0.040	0.015
9	Gast	21.48	-0.012	0.017
Eigenvalues			3.119	0.949
Cumulative Dispersion(%)			72.84	95.01

August

Rank	Variable	F-Statistic	CV I	CV II
1	Diptl	26.21	-0.052	0.013
2	Eggs	20.30	-0.052	0.013
3	Clad	18.79	-0.053	0.013
4	Ostra	17.85	-0.052	0.013
5	Pelec	16.76	-0.055	0.013
6	Cope	16.58	-0.054	0.013
7	Noto	16.14	0.017	0.088
8	TS	16.03	0.009	0.041
9	Fath	15.93	0.025	0.134
10	Gast	15.31	-0.018	0.002
11	Amph	15.15	-0.045	0.010
Eigenvalues			5.029	0.604
Cumulative Dispersion(%)			88.39	99.00

Table 11. Identification success from discriminate analysis, for all three months of the summer 1984 and 85. All groups were divided into two groups randomly and were classified separately (NT represents new groups).

June Classification Matrix

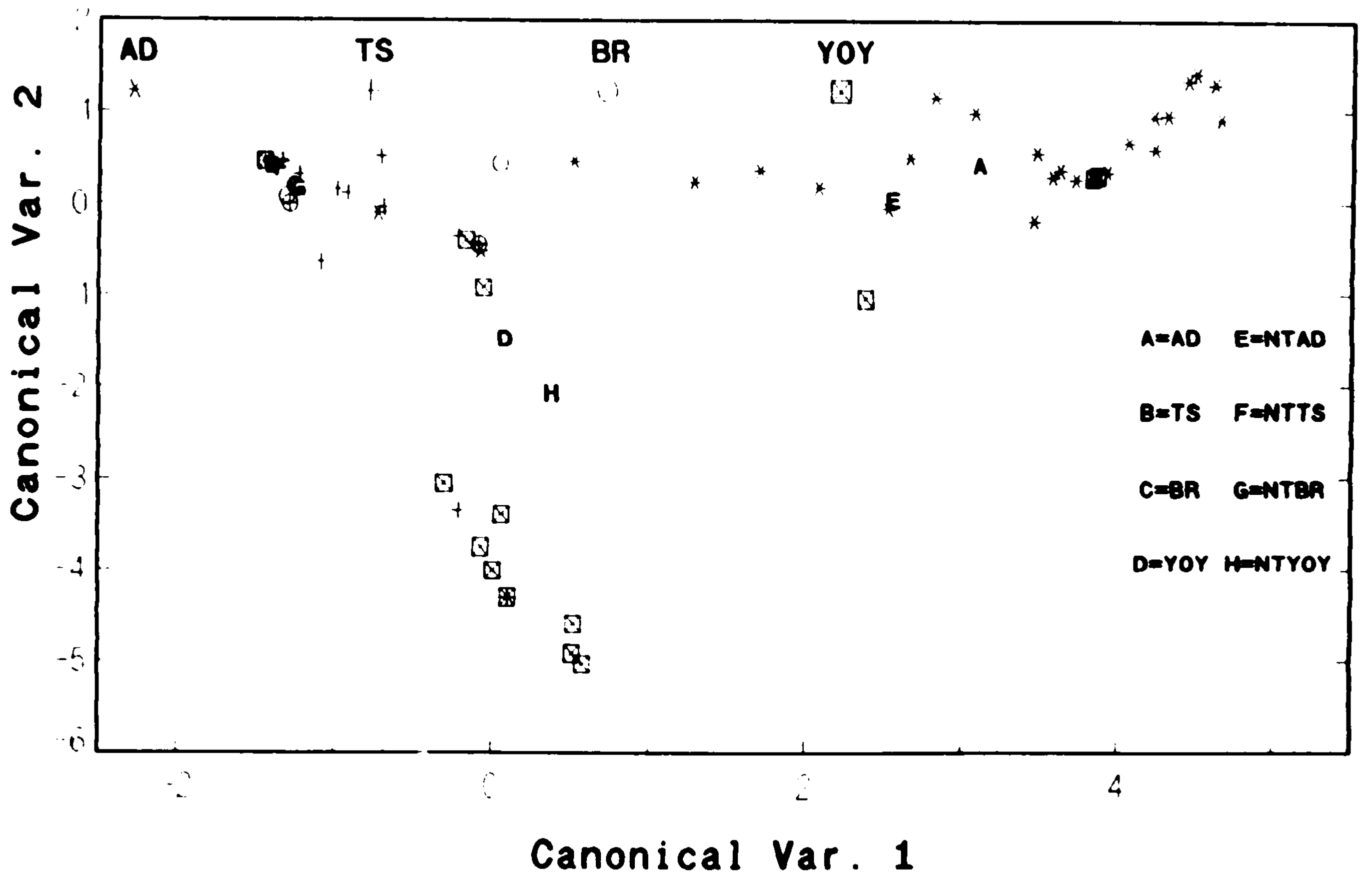
Species	AD	TS	BR	YOY	n	%Cor.Clas.
AD	34	3	1	0	38	89.5
TS	0	10	51	2	63	15.9
BR	0	3	31	0	34	91.2
YOY	4	1	5	12	22	54.5
NTAD	24	3	3	4	34	70.6
NTTS	1	2	56	3	62	3.2
NTBR	0	2	32	0	34	94.1
NTYOY	2	6	2	6	14	42.9

July Classification Matrix

Species	AD	TS	BR	YOY	n	%Cor.Clas.
AD	7	0	0	3	10	70.0
TS	0	53	8	6	67	79.1
BR	0	14	18	1	33	54.5
YOY	3	4	1	62	70	88.6
NTAD	8	0	0	5	13	61.5
NTTS	0	54	10	6	70	77.1
NTBR	0	13	11	0	24	45.8
NTYOY	4	1	0	49	54	90.7

August Classification Matrix

Species	AD	TS	BR	YOY	n	%Cor.Clas.
AD	6	0	0	2	8	75.0
TS	0	37	27	7	71	52.1
BR	0	6	15	0	21	71.4
YOY	5	1	1	48	55	87.3
NTAD	7	1	0	5	13	53.8
NTTS	0	25	26	11	62	40.3
NTBR	0	2	12	0	14	85.7
NTYOY	10	3	1	40	54	74.1



[illegible] scores for all four fish groups based on the first and second canonical variates [illegible] 1984 and 1985 data combined, based on four known groups. [illegible] for each group are presented. See Table 10 and 11 for canonical [illegible]

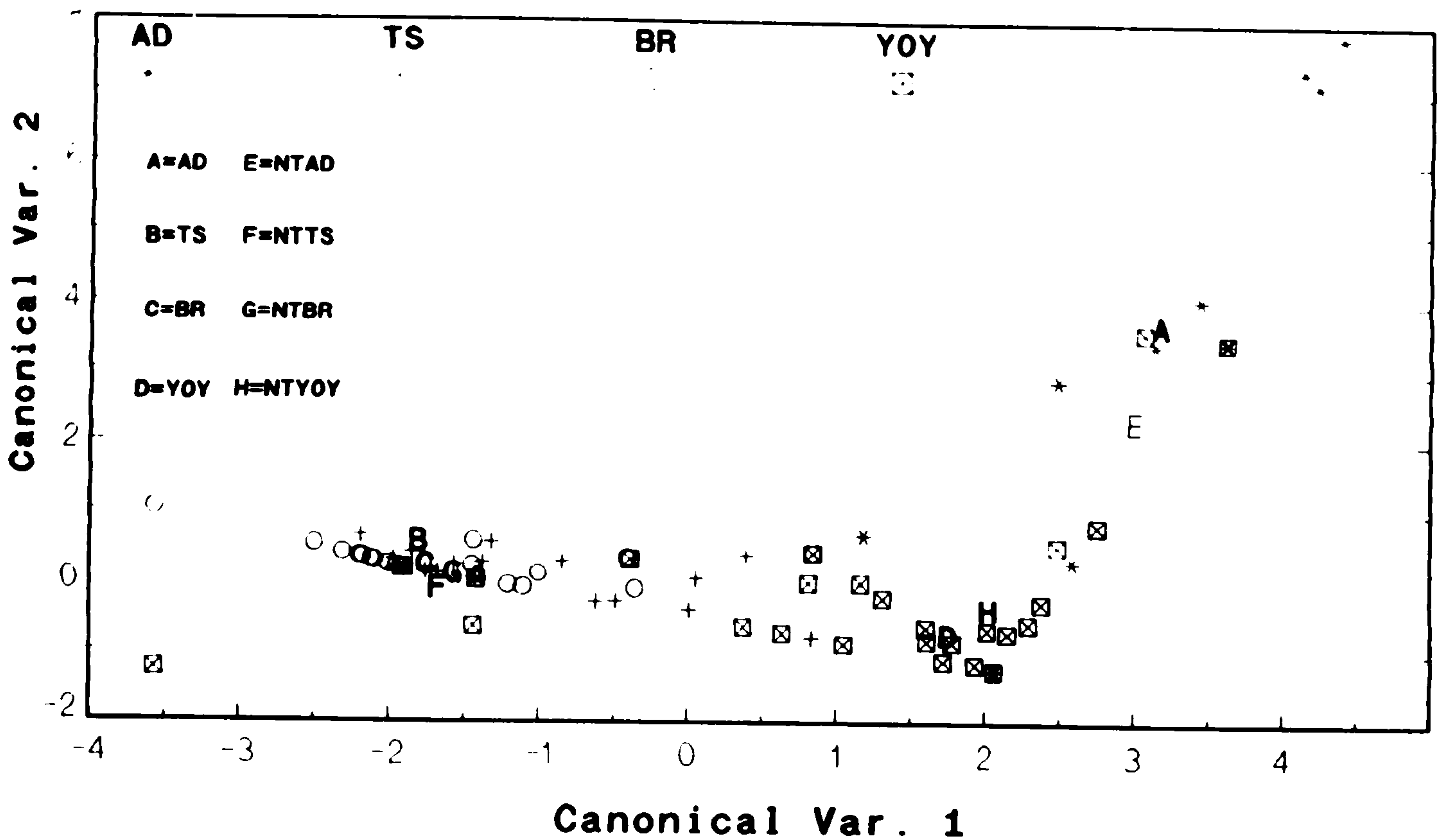


Fig. 12. A plot of canonical scores for all four fish groups based on the first and second canonical variates from a DFA for July, 1984 and 1985 data combined, based on four known groups. Centroids for each groups are presented. See Table 10 and 11 canonical coefficients and classification matrix

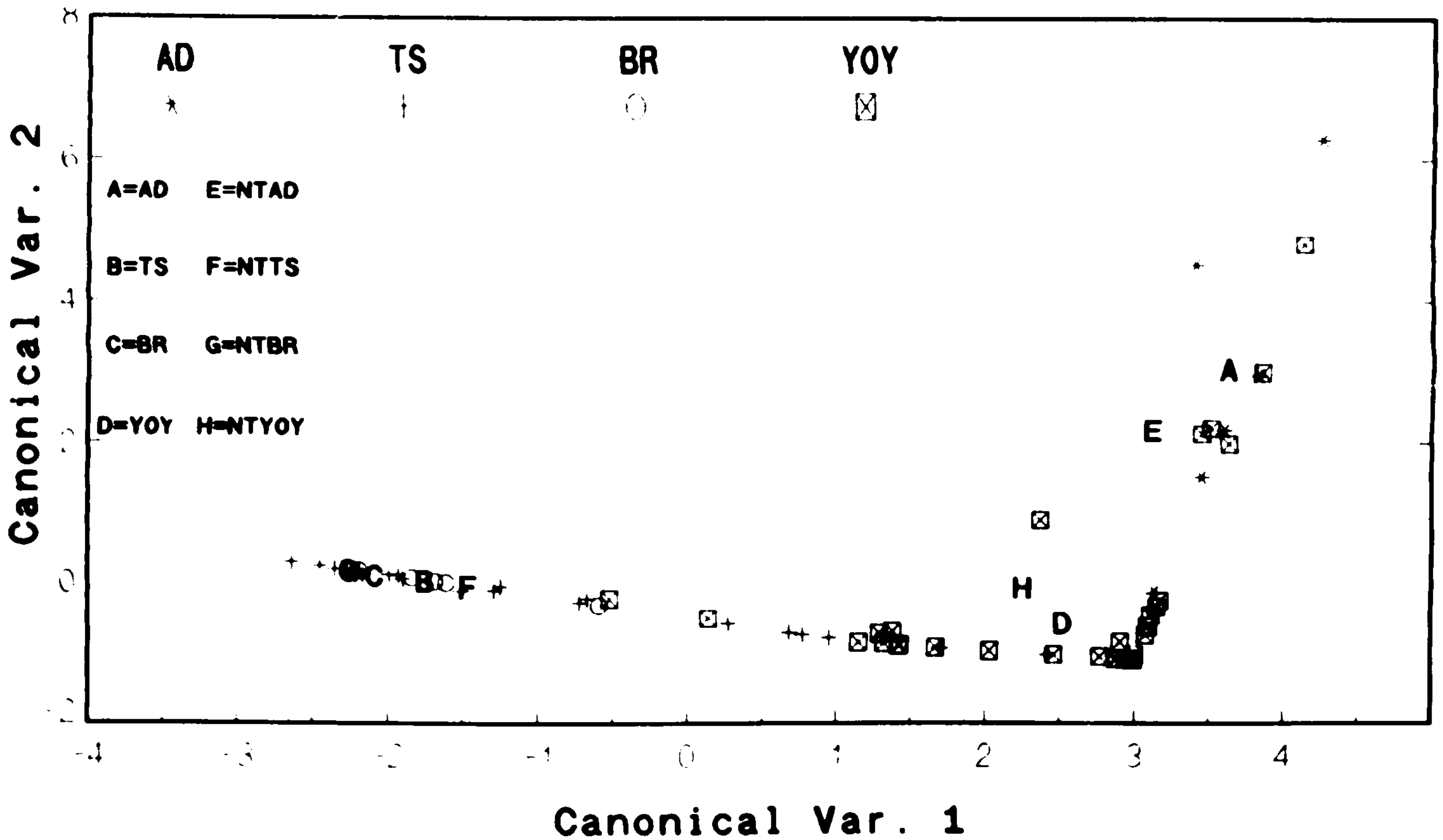


Fig. 15. A plot of canonical scores for all four fish groups based on the first and second canonical variates from a DFA of August, 1984 and 1985 data combined, based on four known groups. Centroids for each group are presented. See Table 10 and 11 for canonical coefficients and classification matrices.

accounted for 95% and 99% of the variation respectively, CV I 73% and CV II 22% for July and CV I 88% and CV II 11% of August (Table 10). The first axis separated trout from the sticklebacks and the second axis separated AD from the YOY. Of the 16 prey categories entered in the analysis for July, 9 were major discriminators: dipteran larvae and TS were most important. The rest of the 9 prey categories were of similar ranking except for cladocerans and gastropods which were the lowest. Seventeen prey categories were used for August, 10 of which were important discriminators. They were all the most important prey items of sticklebacks. Correct classification averaged 78% in July and 68% in August; again this was similar to June and would be higher except for cross classification of the sticklebacks (Table 11). There was no significant difference between the discriminative groups (AD, YOY, TS, and BR) and the randomly generated groups (NTAD, NTYOY, NTTS, and NTBR) ($p>0.05$) for either month.

The findings based on DFA were similar to those of CVA. The two sticklebacks had similar food habits. The two trout groups were separated in distribution and diets from the two sticklebacks and each other. The comparison of the groups used to generate the function and the random groups, suggests that except for June the functions correctly represented the distribution of the four groups.

GROWTH OF TROUT

Trout were stocked in June of both years; the fish were stocked at a mean total length of 90 mm in both 1984 and 1985. Stocking in 1984 was in two lots. The fish grew rapidly over the summer of 1984 and in an August sample had reached a mean total body length of 136 mm and a weight of 35 g (Table 12). The length distribution of trout for the stocking was a unimodal curve; by August a bimodal sample was obtained. The two modes were around 110 mm and 170 mm (Fig 14) and the bimodal distribution continued into the winter. However, little importance can be given to the bimodality because the sample size was low (n=14). Samples in June 1985 were not bimodal (Fig. 14) and the mean length had increased to 293 mm and the mean weight was 326 g (Table 12). There was a rapid increase in the mean size even during the winter ice-on period with low water temperatures, for the first year of growth in the lake (Fig. 16). Examination of angler caught fish in June 1985 showed large amounts of mesenteric fat suggesting the fish were in very good condition.

In 1985 an effort was made to catch more fish during the summer to look more closely at the apparent bimodality and to study growth during the initial months of residence in the lake. Bimodality became apparent by the second week after stocking (Fig. 15). The mode for the two groups was 90 mm and

Table 12. Mean length, weight, and sample size for samples of YOY during the summer of 1984 and 85. Samples for the 1984 stock covers June 1984 to June 1985. The sample for the 1985 stock only cover the period from June (stocking date) to August.

1984

Time	Length(mm)	Weight(g)	n
June, 1984	93.24	8.71	209
August	136.92	35.05	64
January	229.93	171.97	14
June, 1985	292.66	326.46	57

1985

Time	Length(mm)	Weight(g)	n
June 11	93.95	8.95	495
June 25	111.93	17.01	43
July 9	115.08	19.17	76
July 23	152.41	51.96	57
August 20	167.77	68.26	70

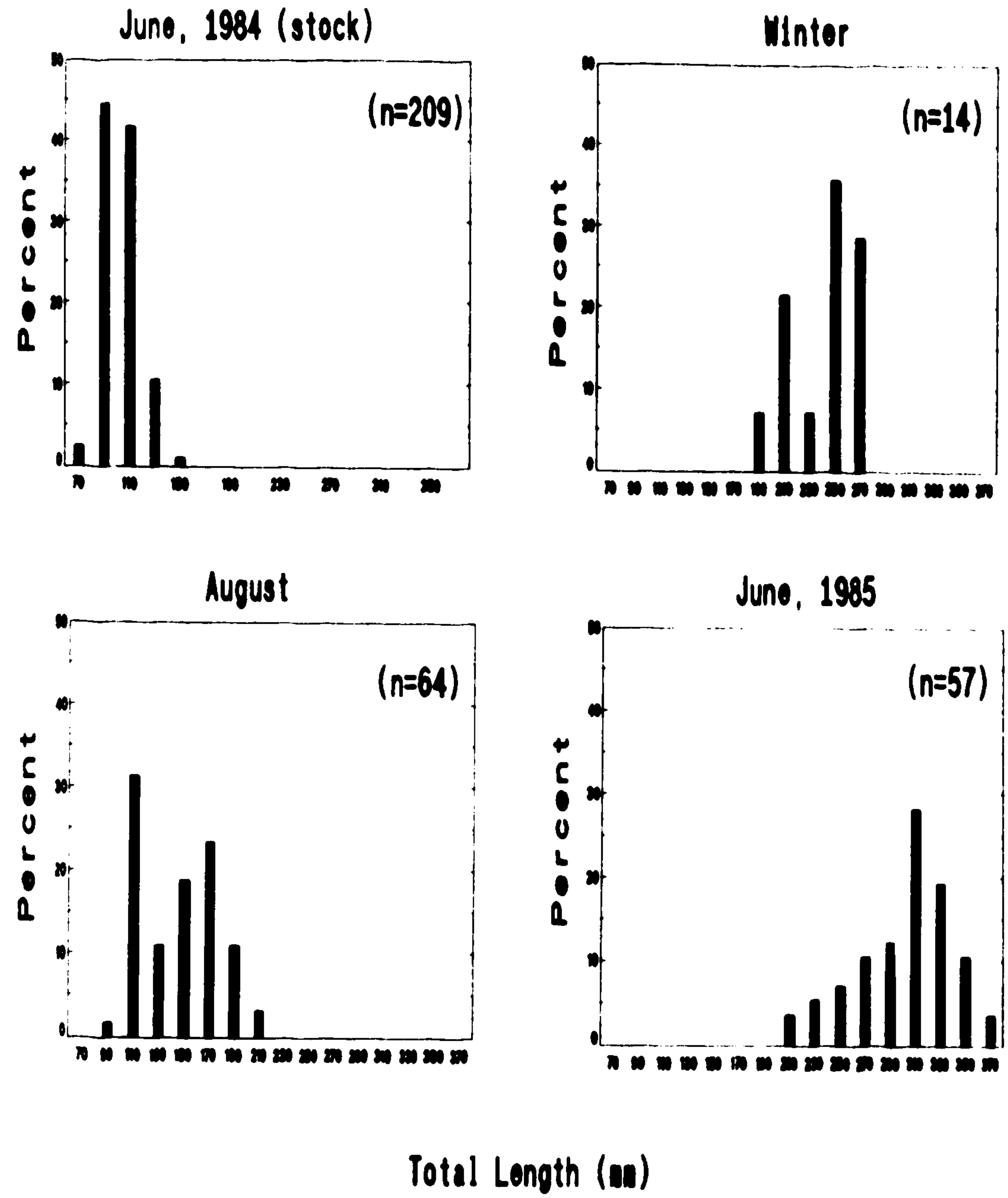


Fig. 14. Total length frequency distribution of YOY for samples of the 1984 stocking, from the time of stocking, June, and for August, 1984, January, 1985, and June, 1985. Samples sizes are indicated.

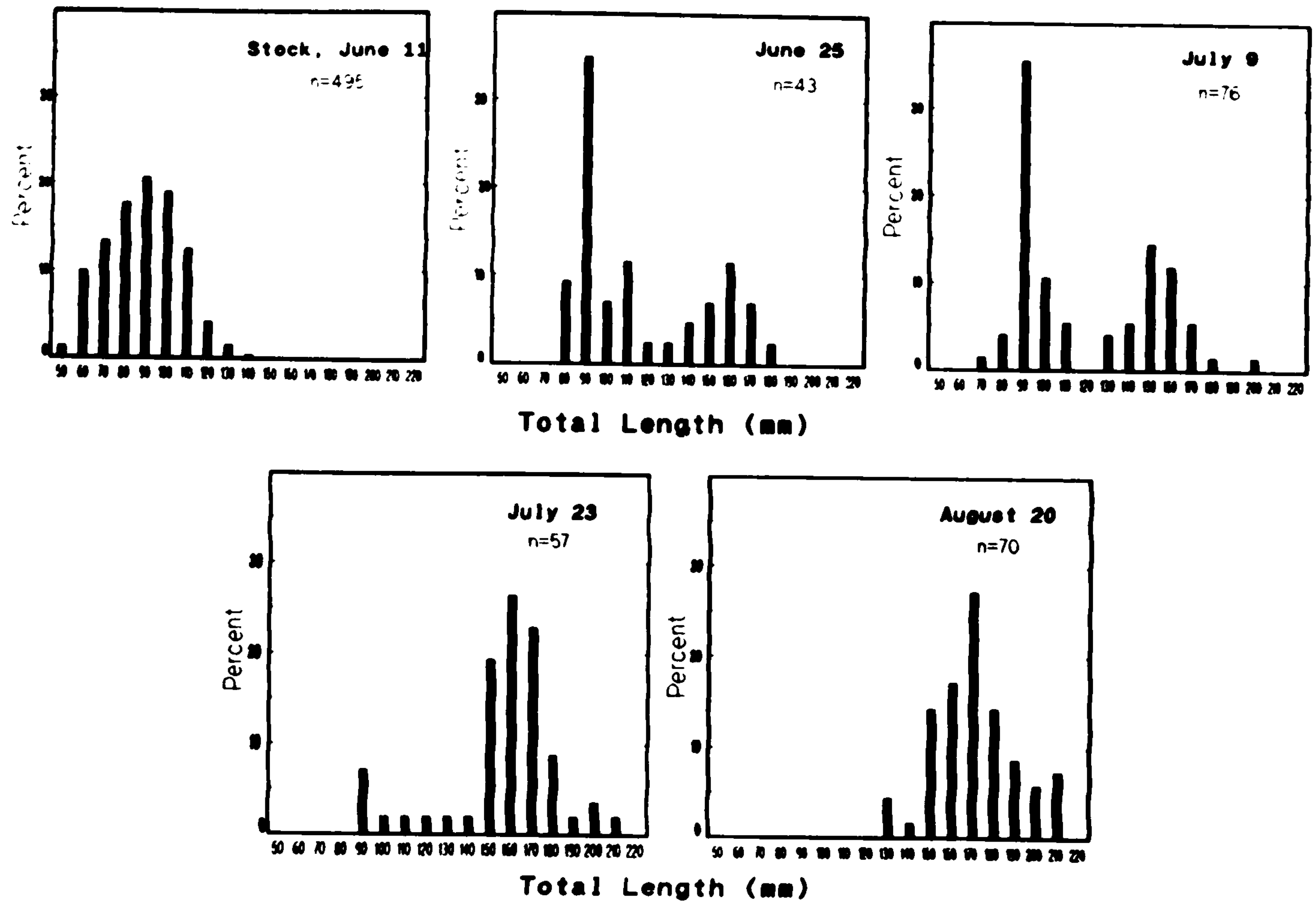


Fig. 15. Total length frequency distribution for samples of YOY for the summer of 1985 stocking. Samples are for the date of stocking; June, 11, 2 weeks after, 4 weeks after, 6 weeks after, and 9 weeks after. Sample sizes are indicated.

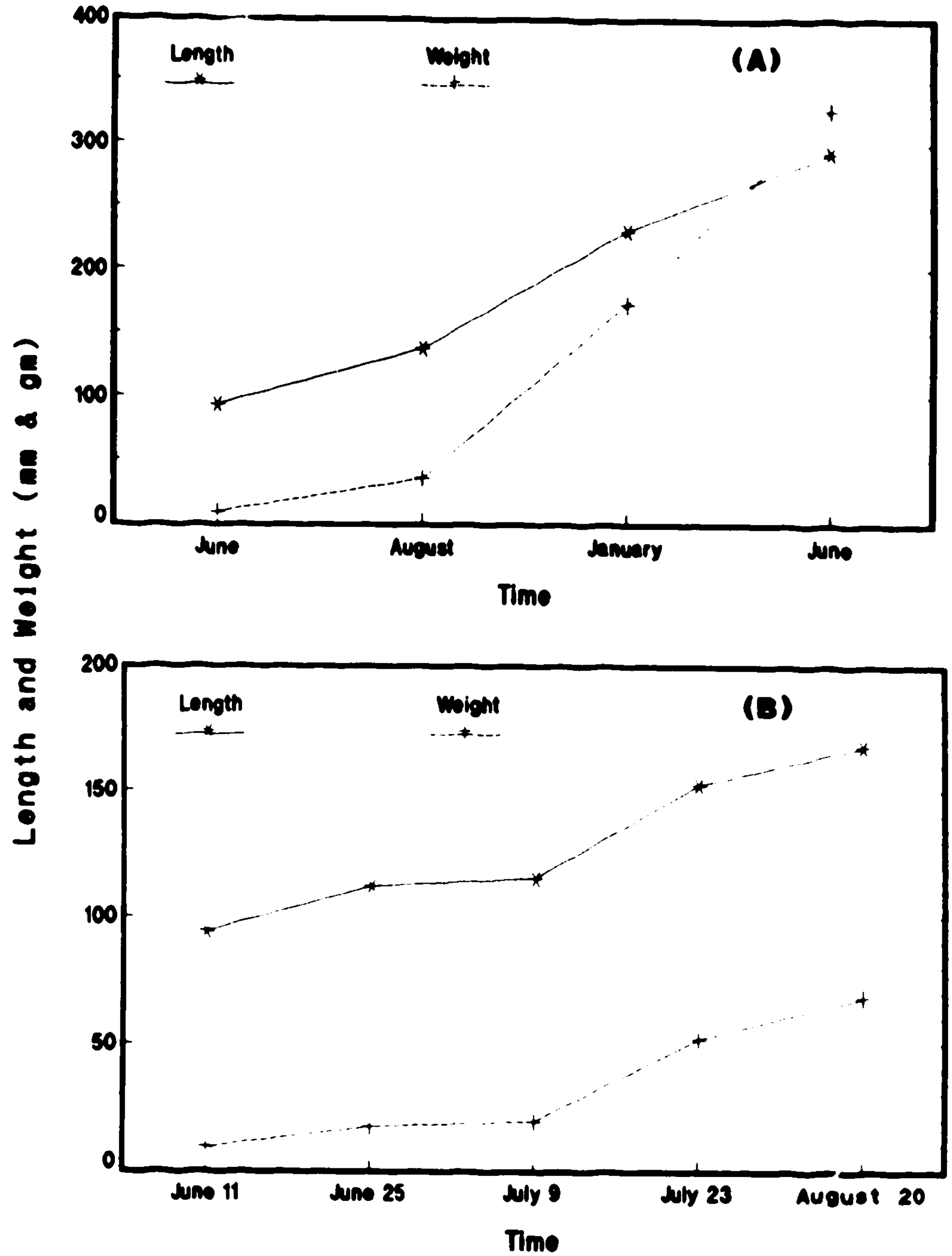


Fig. 16. Mean length and weight data for the growth of YOY stocked in Hasse Lake, June 1984 (A) and June 1985 (B).

160 mm, the larger fish represented a very small proportion of the fish collected. The bimodality remained in the fourth week of sampling. The modes remained the same and large fish still constituted the less numerous part of the sample. The mean length for the fourth week was 115 mm, showing an increase of only 4 mm . The sixth week sample showed a decrease in the bimodality; the shorter group consisted of only 9 fish. The majority of fish were longer than 150 mm, with a mean length of 152 mm, a large increase over the previous two weeks. By August the bimodality had disappeared and there was a single mode of 170 mm and a mean of 168 mm. The mean length and weight of fish caught in August 1985 were larger than the fish from 1984, 168 mm and 68 g, respectively, for 1985 and 137 mm and 35 g, respectively, for 1984 (Table 12 and Fig. 16). The fish caught in August already had a large amount of fat and probably continued to grow throughout the winter.

Weights used in the study were generated using a regression equation developed using angler caught fish. Accurate individual weights were very difficult to obtain without damaging the fish and keeping them out of water for a long period of time. Polynomial regression was used to generate equation (2) and provided the best fit of the data (Table 13).

$$W = 0.00636L^2 - 0.861L + 33.7 \quad r=.99 \qquad (2)$$

Table 13. Table of F-statistic for polynomial regression of length and weight for angler caught fish in the summer of 1985. SS-sum of squares, DF-degrees of freedom, L-length.

Degree	SS	DF	Mean Square	F	Probability
L	44075.29	2	22037.65	2034.38	0.00
L^2	3915.10	1	2915.10	361.42	0.00
Residual	628.29	58	10.83		

5. DISCUSSION

FOOD HABITS AND DIET OVERLAP

Competition and predation are considered to be the major biological interactions between species and can determine the number of species that coexist in a body of water, the relative size of individuals, and the number of individuals of different species (Wootton 1984). The food habits of the fish of Hasse Lake suggest that predation is more important than competition. Examination of the different diets of the fish showed that there was little diet overlap between the trout and sticklebacks or the two different size classes of trout. There was a high degree of overlap in the diets of the two stickleback species.

The food habits of Hasse Lake fish were not unique but were based on the types and presence of different prey items. Adult trout fed on fish and large invertebrates, such as snails, dragonflies, back swimmers, and water boatman. All species of fish in the lake were eaten by AD, the least important were stocked rainbow fingerlings. Only once did a fry appear in the stomach of a trout. Although cannibalism occurred it was not a frequent mode of predation. This supports similar observations in Fairfax Lake (Hawrylak 1973) and the Clearwater River (W. Roberts pers. comm.). The three other fish species were consumed often, with the two sticklebacks being the most important. Although highly piscivorous, AD also ate large numbers of invertebrates. Especially in the fall, the diet was dominated by back swimmers, corixids, snails, and dragonflies. Individual AD showed selectivity in their diet; individual AD that had eaten invertebrates were likely to have more invertebrates than fish in their stomachs and the opposite was true for adults that had eaten fish. This supports the idea that individual fish specialize in certain prey items or types and possible modes of hunting (Bryan and Larkin 1972).

The diet of AD in Hasse Lake was more piscivorous than rainbow trout from other stocked lakes, but there are reports of rainbows eating fish ranging from cyprinids to perch (Crossman and Larkin 1959, Johannes and Larkin 1961, Larkin *et al.* 1956, Leonard and Leonard 1949, Roberts 1975). Most reports portray rainbows as insectivours, eating mostly aquatic and terrestrial drift (Boag 1987, Dietz 1971). Although drift was abundant on the lake it was rarely eaten by AD.

Rainbow trout are considered to be opportunistic feeders (Bernard and Holstrom 1978, Ware 1972) and this was supported by this study. Sticklebacks were very abundant and consumed by trout of all sizes. The invertebrates commonly consumed by AD were also abundant in the lake; back swimmers were only found in large numbers in the late summer and fall and were correspondingly found in large numbers in the diet at these times. Snails and dragonflies were abundant throughout the summer and were found in stomachs over that period.

Young trout were also piscivorous, even after a short time in the lake. Fingerling trout over 120 mm total length had BR and young-of-the-year TS in their stomachs. Fish became a more important prey source as the YOY grew. In the late summer, sticklebacks accounted for almost 40% of the diet. Most studies of trout in pothole lakes suggest that a diet strongly based on fish was unusual; the lack of amphipods in the lake, which were normally the main source of food for pothole lake YOY, may be the reason for this difference. When there were sticklebacks available in pothole lakes with trout, the trout readily consumed them (Bernard and Holstrom 1978, Tavarutmaneegul 1978). Leonard and Leonard (1949), in a study on an eastern lake, described young rainbow trout that ate fish, but these were mostly small cyprinids, even though stickleback were present.

In other populations, YOY fed mainly on invertebrates (Bernard and Holstrom 1978, Bryan and Larkin 1972, Crossman and Larkin 1959, Dietz 1971, Johannes and Larkin 1961, Johnson 1981, Leonard and Leonard 1949, Myers 1973, Tavarutmaneegul 1978, Wagner 1975, Wurtsbaugh et al. 1975). The invertebrates were most commonly the aquatic larvae of insects (dipterans and ephemeropterans), amphipods, and terrestrial drift.

Terrestrial drift was the common invertebrate food of Hasse Lake YOY. Drift was highly abundant and came from the poplar grove lining the west side of the lake (prevailing wind direction). Large numbers of aphids were found on the surface of the lake and in the stomachs of YOY. Other invertebrates were consumed but accounted for a very small part of the diet. The YOY of Hasse Lake had a unique diet based on fish and terrestrial drift, which separated them from other populations of stocked trout in North America.

There was little diet overlap between the different size classes of trout. All three methods of determining overlap, Schoener's index, CVA, and DFA, showed that the diets were very different during the early summer. The small amount of overlap observed in the early summer would be reduced to almost zero if the size of prey consumed was factored in. As the mean size of YOY increased, the similarity of diet increased. Fingerling trout shifted from small particle size prey items to larger items similar to those consumed by AD. By August the similarity of diet had increased but was not significant (<0.60). If sufficient numbers of the two groups of trout could be caught in the winter it is likely that the diets and the size of food consumed by the groups would be similar. The diet of YOY in the summer was sufficiently different from AD that there was no reason to assume that the two groups were competing for food.

The sticklebacks of the lake fed mostly on dipteran larvae and pupae, and other aquatic insect larvae. Small crustaceans were important in the winter and spring. Brook sticklebacks consumed mostly benthic organisms with cladocerans and ostracods dominating in January. Chironomids dominated for the rest of the year. The BR fed on two unusual prey types: amphipods in January and mayfly larvae in June. Other reports suggest that other populations of BR consumed both prey types (Held and Peterka 1974, Robinson 1972). These two prey types were large and not abundant at any time of the year based on dredges and dip net samples. Two possible explanations were considered for the occurrence of amphipods in the diet in January: 1)with BR predation concentrated on benthic prey during the winter, chances of encountering amphipods would be increased, or 2) with low prey availability a fish may expend more energy to capture larger prey (Ware 1972). Therefore, in the summer a fish would not be expected to expend energy for large prey items if smaller, more easily captured prey, were more abundant. The feeding on mayflies only in June was also unusual and difficult to explain. During June mayfly larvae began to emerge, it was possible that the larvae become more susceptible to predation at metamorphosis.

Dipteran larvae were more important to TS during the early part of the year (January to May) than they were to

BR. During the winter TS consumed cladocerans and copepods to a greater extent than chironomids. In the summer chironomids were so dominant that few other food groups exceeded 10% of the diet. Eggs were the only group that remained over 10% in mean percent dry weight. The eggs were assumed to be stickleback eggs; egg predation and cannibalism are common occurrences (Wootton 1984). The prey category "other" was a dominant group during March. The major constituent was plant material. The plant material was most likely consumed along with prey items; the most likely sources were chironomids and pelecypods. Both prey types were commonly found on vegetation or coated with plant material; chironomids were frequently found in cases constructed of plant material. Other researchers have shown that the diet of TS and BR in Canada and the world are very similar, with only slight differences depending on food types available in the lake or stream (Bentzen and McPhail 1984, Held and Peterka 1975, Hynes 1950, Larson 1976, Maitland 1965, Manzer 1976, Robinson 1972, Ryan 1984, Stinson 1983, Wootton 1984).

Diet overlap between TS and YOY was consistently low throughout June, July, and August. There were few prey types eaten in common by both species. Young trout became piscivorous within two weeks of stocking and became predators on BR in June and on TS by July. Possible competition was greatly reduced when YOY eliminated potential competition by predation. The results here are supported by other studies that show TS do not compete with salmonids for food (Maitland 1965, Manzer 1976, Ryan 1984) and that TS may actually be adversely affected by the presence of salmonids (Rogers 1973).

Diet overlap was significant when the diets of TS and BR were compared. All three forms of analysis, Schoener's index, CVA, and DFA showed substantial overlap in diet. The overlap was due mostly to the reliance of both species on chironomid larvae. Chironomid larvae made up at least 20% of both species diets throughout the year. Ostracods, copepods, and cladocerans were important in the overlap. Competition for food was probably not an important factor affecting TS and BR, since all of the major prey groups were very abundant in the lake. Due to this high abundance it was likely that there was also a very high availability, and therefore, little chance for competition to be detrimental. Brook stickleback were negatively affected by the presence of TS (Nelson and Harris 1987), but the negative impact was probably through factors other than food competition. The competition may be direct, since TS were more aggressive than BR, or indirect through competition for nesting sites. Little information was available on the areas used for reproduction by sticklebacks in Hasse Lake, and this would be of interest for further study.

GROWTH

Some overlap was evident in the diets of the different groups of fish in Hasse Lake, but the effect on trout was minimal. Both age classes of trout grew rapidly, both in weight and length. The YOY grew as fast or faster than fish from Manitoba prairie pothole lakes, which are considered to be some of the fastest growing trout (Lawler *et al.* 1974, Miller and Thomas 1956, Tavarutmaneegul 1978). The Manitoba trout match the rate of growth found in intensive culture, fish grown under "optimum" conditions (Bernard and Holstrom 1978). Young trout consumed very few of the same prey types as the fish in Manitoba, but the high consumption of fish equalled or exceeded the benefits of a high amphipod diet. Adults also showed rapid growth, comparable to rainbow trout from some of the fastest growing trout in B.C. (Larkin, Terpenning, and Parker 1956). The growth rate of Hasse Lake trout can be attributed to the high consumption of sticklebacks and the high availability of these fish in the lake.

The length-frequency distribution of YOY in their first summer of growth showed a bimodality. The bimodality was apparent shortly after stocking and disappeared in late summer or fall. The bimodality may have been caused by one of two factors: a biological phenomenon or an artifact of sampling. The biological explanation is that predation by birds may have selected against a certain size class or classes of YOY. Common loons (*Gavia immer*) and to some extent red-necked grebes (*Po..ceps grisegena*) may have removed the fish between 100 mm and 130 mm and cre..ted the bimodal distribution. Possibly the small fish were below a preferred prey size for the birds and the larger fish were growing fast enough to escape predation. The second explanation involves the sampling method used, which was gangs of gill nets. Sampling using gangs of gill nets tends to be unbiased. Possibly the smaller mesh gill nets were more effective at capturing small fish while both the larger mesh and smaller mesh nets were less efficient at capturing larger f . If this were the case, there would be more small fish in the sample than in the population. Thus a skewed distribution towards shorter fish, although not necessarily a bimodality, would be observed. A comp ca .. factor was the small sample sizes obtained during the summer.

COMPARISON OF METHODS FOR DETERMINING DIET OVERLAP

In this study an overlap index and two forms of discriminant analysis were used to examine the extent of dietary overlap. There was general agreement between the three different forms of analysis: Schoener's index, CVA, and DFA. The major difference between discriminant analysis and overlap indices is convenience of analysis. With discriminant analysis the researcher can examine many possible relationships with one data set. Different groups can be assigned *a priori* as discriminators to examine the different relationships; the specimens of interest can then be compared to the *a priori* groups. In contrast, only pairwise comparisons can be made with indices. From this study it appears that there may be a problem with using a small number of *a priori* groups, as seen in Fig. 10 and Tables 9 and 10. More than two *a priori* groups removes the problem encountered in August (Fig 13). In that month only TS and AD were used to generate the function, and YOY were classified mostly as AD, even though their diet was only minimally similar to AD. All of the discriminators were AD prey categories; YOY only consumed some of those categories and were thus classified as AD, even though the bulk of their diet was different from both AD and TS. From this analysis, diet overlap would be assumed but little overlap occurred. When many groups were used as discriminators the chance of misclassification was reduced (Table 11 and 12).

The most common complaint with overlap studies is that they do not incorporate food availability (Hulbert 1978, Wallace 1981). There are two main reasons for this: no method is presently accepted for use in determining food availability, and even if relative prey availabilities are used they are difficult to incorporate into indices. Using discriminant analysis, prey availability can be incorporated as character weighting. Abundant categories receive a small weighting while rare prey types receive a large weighting. Therefore, the important prey categories in regards to competition are given higher weighting. In this way, discriminant analysis can provide a better understanding of overlap than indices.

6. CONCLUSION

Hasse Lake has poor survivorship of newly stocked fingerlings (Berry 1986). The results of this study indicated that the survivorship was not strongly affected by food availability or competition with other fish for food. Competition may not be occurring between YOY and the other fish due to the low stocking densities now used. The lake now receives two thirds the stocking received in the 1970's, while the fishing pressure has increased since 1980. At low stocking densities the effects of competition are not evident (Bernard and Holstrom 1978).

Berry (1986) proposed that survivorship is governed by the condition and stress factors encountered by the stocked fish. The fish arrive at the lake in a highly stressed state and can become further stressed if temperature differences between the transport tanks and the lake are high.

A further factor that commonly affects stocked lakes is avian predation (Ayles et al. 1976, Myers and Peterka 1976). Hasse Lake has a high population of fish-eating birds: loons, grebes, terns, gulls, kingfishers, and herons. The only birds with a large resident population are the red-necked grebes, but large numbers of loons, herons, and terns were observed to visit the lake daily from neighbouring lakes. Therefore, it is possible that the piscivorous birds reduce the survivorship of YOY.

If predation by birds and low survivorship due to stocking stress reduce the total number of fingerlings in a eutrophic lake, food stress should not be a problem. The finger'ings should grow at a rapid rate and have no difficulty obtaining sufficient food. The large population of TS in Hasse Lake provide the trout with an ideal nutrient source. In the future, if the density of AD and YOY increase, food competition may become a factor in determining growth and survival.

SUMMARY:

1. The food habits of fish in Hasse Lake were similar to other populations, but the presence and abundance of prey types within the lake contributed to some variation from other populations.

2. No significant overlap existed between adult and fingerling trout or young trout and threespine stickleback. There was a strong overlap between the two stickleback species.

3. Based on the high abundance of the major prey types no diet overlap was considered to be significant.

4. Cannibalism of adult trout on fingerling trout was not important.

5. The growth of fingerling trout were rapid during their first summer. The rapid growth usually extended through the winter.

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APPENDIX 1. Diet data for adult trout (AD) for the months sampled during 1984 and 1985. Data is in the form of mean % dry weight, percent occurrence, number, and percent number.

Mean % dry weight for all months with 1984 and 85 combined.

PREY CATEGORIES	JANUARY	MAY	JUNE	JULY	AUGUST	OCTOBER
THREESPINE STKB	51.06	27.21	7.86	24.53	24.79	14.58
BROOK STKB	0.00	21.98	41.06	4.81	0.95	0.00
FATHEAD MINNOW	0.00	0.00	6.60	6.03	2.86	1.15
RAINBOW TROUT	0.00	0.00	0.79	0.00	0.00	0.00
UNIDENT. FISH	0.00	0.00	2.86	11.74	2.03	2.13
OSTRACODA	0.00	0.00	0.00	0.00	0.00	0.00
CLADOCERA	0.00	0.00	0.00	0.69	4.67	0.00
COPEPODA	0.00	0.00	0.00	0.00	0.00	0.00
HYDRACARINA	0.00	0.01	0.07	0.01	0.00	0.00
DIPTERA	0.00	0.00	0.05	0.02	0.01	0.01
CORIXIDAE	0.06	1.75	2.93	0.99	5.54	16.90
NOTONECTIDAE	0.00	0.00	0.00	0.07	22.64	4.89
COLEOPTERA	0.00	0.00	0.01	0.14	0.10	11.16
AMPHIPODA	0.75	0.00	0.00	0.00	0.08	2.74
HIRUDINEA	0.00	0.00	0.05	1.15	0.00	2.03
TRICHOPTERA	13.30	0.28	2.46	1.13	0.00	2.88
EPHEMEROPTERA	0.C	0.00	0.09	0.00	0.00	0.01
ODONATA	29.96	3.88	16.81	26.56	18.62	9.29
GASTROPODA	1.24	36.29	6.11	9.73	6.17	30.55
PELECYPODA	0.00	0.00	0.00	0.00	0.00	0.00
TERRESTRIAL INS	0.00	6.72	5.24	7.49	7.36	1.69
EGGS	0.00	0.00	2.87	0.14	0.00	0.00
OTHER	3.63	1.89	3.70	4.78	4.39	0.01
n	8	18	74	27	22	31

January 84

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
THREESPINE STKB	51.06	75.00	(6)	64	49.23
BROOK STKB					
FATHEAD MINNOW					
RAINBOW TROUT					
UNIDENT.FISH					
OSTRACODA					
CLADOCERA					
COPEPODA					
HYDRACRINA					
DIPTERA					
CORIXIDAE	0.06	12.50	(1)	1	0.77
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA	0.75	37.50	(3)	10	7.69
HIRUDINEA					
TRICHOPTERA	13.30	25.00	(2)	4	3.08
EPHEMEROPTERA					
ODONATA	29.96	50.00	(4)	42	32.31
GASTROPODA	1.24	12.50	(1)	1	0.77
PELECYPODA					
TERRESTRIAL INS					
EGGS					
OTHER	3.63	12.50	(1)	8	6.15
n	8	8		130	130

May, years combined.

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
THREESPINE STKB	27.21	27.78	(5)	38	20.77
BROOK STKB	21.98	27.78	(5)	14	7.65
FATHEAD MINNOW					
RAINBOW TROUT					
UNIDENT.FISH					
OSTRACODA					
CLADOCERA					
COPEPODA					
HYDRACRINA	0.01	5.56	(1)	1	0.55
[illegible]TERA					
[illegible]IDAE	1.75	27.78	(5)	13	7.10
[illegible]ONECTIDAE					
COLEOPTERA					
AMPHIPODA					
HIRUDINEA					
TRICHOPTERA	0.28	5.56	(1)	1	0.55
EPHEMEROPTERA					
ODONATA	3.88	22.22	(4)	8	4.37
GASTROPODA	36.29	55.56	(10)	91	49.73
PELECYPODA					
TERRESTRIAL INS	6.72	11.11	(2)	10	5.46
EGGS					
OTHER	1.89	11.11	(2)	7	3.83
n	18	18		183	100.01

May 84

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
THREESPINE STKB	60.00	60.00	(3)	25	30.12
BROOK STKB					
FATHEAD MINNOW					
RAINBOW TROUT					
UNIDENT.FISH					
OSTRACODA					
CLADOCERA					
COPEPODA					
HYDRACRINA					
DIPTERA					
CORIXIDAE					
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA					
HIRUDINEA					
TRICHOPTERA	1.00	20.00	(1)	1	1.20
EPHEMEROPTERA					
ODONATA	4.0[illegible]	40.00	(2)	6	7.23
GASTROPODA	27.60	40.00	(2)	46	55.42
PELECYPODA					
TERRESTRIAL INS					
EGGS					
OTHER	6.46	20.00	(1)	5	6.02
n	5	5		83	83

May 85

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
THREESPINE STKB	14.59	15.38	(2)	13	15.38
BROOK STKB	30.44	38.46	(5)	14	14.00
FATHEAD MINNOW					
RAINBOW TROUT					
UNIDENT.FISH					
OSTRACODA					
CLADOCERA					
COPEPODA					
HYDRACRINA	0.01	7.69	(1)	1	1.00
DIPTERA					
CORIXIDAE	2.42	38.46	(5)	13	13.00
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA					
HIRUDINEA					
TRICHOPTERA					
EPHEMEROPTERA					
ODONATA	3.47	15.38	(2)	2	2.00
GASTROPODA	39.63	61.54	(8)	45	45.00
PELECYPODA					
TERRESTRIAL INS	9.30	30.77	(4)	10	10.00
EGGS					
OTHER	0.13	7.69	(1)	2	2.00
n	13	13		100	100

June, years combined.

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
THREESPINE STKB	7.86	12.16	(9)	25	2.71
BROOK STKB	41.06	59.46	(44)	347	37.59
FATHEAD MINNOW	6.60	9.46	(7)	17	1.84
RAINBOW TROUT	0.79	1.35	(1)	1	0.11
UNIDENT.FISH	2.86	9.46	(7)	32	3.47
OSTRACODA					
CLADOCERA					
COPEPODA					
HYDRACRINA	0.07	9.46	(7)	21	2.28
DIPTERA	0.05	8.11	(6)	17	1.84
CORIXIDAE	2.93	22.97	(17)	61	6.61
NOTONECTIDAE					
COLEOPTERA	0.01	1.35	(1)	1	0.11
AMPHIPODA					
HIRUDINEA	0.05	1.35	(1)	1	0.11
TRICHOPTERA	2.46	9.46	(7)	69	7.48
EPHEMEROPTERA	0.09	2.70	(2)	25	2.71
ODONATA	16.81	32.43	(24)	79	8.56
GASTROPODA	6.11	29.73	(22)	47	5.09
PELECYPODA					
TERRESTRIAL INS	5.24	32.43	(24)	152	16.47
EGGS	2.87	6.76	(5)	5	0.54
OTHER	3.70	13.51	(10)	23	2.49
n	74	74		923	100.01

June 83

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
THREESPINE STKB					
BROOK STKB	12.47	33.33	(3)	6	5.77
FATHEAD MINNOW					
RAINBOW TROUT					
UNIDENT.FISH	20.28	44.44	(4)	10	9.62
OSTRACODA					
CLADOCERA					
COPEPODA					
HYDRACRINA	0.04	44.44	(4)	6	5.77
DIPTERA	0.03	22.22	(2)	5	4.81
CORIXIDAE	0.24	11.11	(1)	1	0.96
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA					
HIRUDINEA	0.44	11.11	(1)	1	0.96
TRICHOPTERA	2.09	33.33	(3)	6	5.77
EPHEMEROPTERA	0.71	11.11	(1)	24	23.08
ODONATA	30.50	55.56	(5)	22	21.15
GASTROPODA	28.48	33.33	(3)	14	13.46
PELECYPODA					
TERRESTRIAL INS	0.72	66.67	(6)	9	8.65
EGGS					
OTHER					
n	9	9		104	104

June 84

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
THREESPINE STKB	18.72	27.27	(3)	13	8.50
BROOK STKB	40.74	72.73	(8)	97	63.40
FATHEAD MINNOW	22.62	45.45	(5)	12	7.84
RAINBOW TROUT	5.31	9.09	(1)	1	0.65
UNIDENT.FISH	2.65	27.27	(3)	22	14.38
OSTRACODA					
CLADOCERA					
COPEPODA					
HYDRACRINA					
DIPTERA					
CORIXIDAE					
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA					
HIRUDINEA					
TRICHOPTERA	0.03	9.09	(1)	1	0.65
EPHEMEROPTERA					
ODONATA	6.35	18.18	(2)	4	2.61
GASTROPODA	3.61	18.18	(2)	2	1.31
PELECYPODA					
TERRESTRIAL INS	0.02	9.09	(1)	1	0.65
EGGS					
OTHER					
n	11	11		153	153

June 85

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
THREESPINE STKB	6.95	11.11	(6)	12	1.80
BROOK STKB	45.89	61.11	(33)	244	36.64
FATHEAD MINNOW	4.44	3.70	(2)	5	0.75
RAINBOW TROUT					
UNIDENT.FISH					
OSTRACODA					
CLADOCERA					
COPEPODA					
HYDRACRINA	0.09	5.56	(3)	15	2.25
DIPTERA	0.07	7.41	(4)	12	1.80
CORIXIDAE	3.98	29.63	(16)	60	9.01
NOTONECTIDAE					
COLEOPTERA	0.01	1.85	(1)	1	0.15
AMPHIPODA					
HIRUDINEA					
TRICHOPTERA	3.02	5.56	(3)	62	9.31
EPHEMEROPTERA	0.01	1.85	(1)	1	0.15
ODONATA	16.65	31.48	(17)	53	7.96
GASTROPODA	2.89	31.48	(17)	31	4.65
PELECYPODA					
TERRESTRIAL INS	7.05	31.48	(17)	142	21.32
EGGS	3.93	9.26	(5)	5	0.75
OTHER	5.07	18.52	(10)	23	3.45
n	54	54		666	666

July, years combined.

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE	NUMBER	% NUMBER
THREESPINE STKB	24.53	40.74 (11)	45	5.78
BROOK STKB	4.81	18.52 (5)	15	1.93
FATHEAD MINNOW	6.03	7.41 (2)	2	0.26
RAINBOW TROUT				
UNIDENT.FISH	11.74	33.33 (9)	29	3.73
OSTRACODA				
CLADOCERA	0.69	3.70 (1)	500	64.27
COPEPODA				
HYDRACRINA	0.01	11.11 (3)	55	7.07
DIPTERA	0.02	3.70 (1)	2	0.26
CORIXIDAE	0.99	29.63 (8)	14	1.80
NOTONECTIDAE	0.07	3.70 (1)	1	0.13
COLEOPTERA	0.14	3.70 (1)	1	0.13
AMPHIPODA				
HIRUDINEA	1.15	3.70 (1)	1	0.13
TRICHOPTERA	1.13	11.11 (3)	4	0.51
EPHEMEROPTERA				
ODONATA	26.56	51.85 (14)	34	4.37
GASTROPODA	9.73	25.93 (7)	37	4.76
PELECYPODA				
TERRESTRIAL INS	7.49	22.22 (6)	6	0.77
EGGS	0.14	11.11 (3)	31	3.98
OTHER	4.78	3.70 (1)	1	0.13
n	27	27	778	100.01

July 83

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
THREESPINE STKB	30.34	50.00	(9)	40	5.49
BROOK STKB	5.80	22.22	(4)	13	1.78
FATHEAD MINNOW					
RAINBOW TROUT					
UNIDENT.FISH	17.62	50.00	(9)	29	3.98
OSTRACODA					
CLADOCERA	1.03	5.55	(1)	500	68.59
COPEPODA					
HYDRACRINA	0.02	16.67	(3)	55	7.54
DIPTERA	0.02	5.55	(1)	2	0.27
CORIXIDAE	1.34	38.89	(7)	11	1.51
NOTONECTIDAE	0.11	5.55	(1)	1	0.13
COLEOPTERA					
AMPHIPODA					
HIRUDINEA	1.72	5.55	(1)	1	0.13
TRICHOPTERA	1.69	16.67	(3)	4	0.55
EPHEMEROPTERA					
ODONATA	28.46	55.56	(10)	28	3.84
GASTROPODA	5.97	16.67	(3)	10	1.37
PELECYPODA					
TERRESTRIAL INS	5.67	22.22	(4)	4	0.55
EGGS	0.21	16.67	(3)	31	4.25
OTHER					
n	18	18		729	729

July 85

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
THREESPINE STKB	12.90	22.22	(2)	5	10.20
BROOK STKB	2.82	11.11	(1)	2	4.08
FATHEAD MINNOW	18.10	22.22	(2)	2	4.08
RAINBOW TROUT					
UNIDENT.FISH					
OSTRACODA					
CLADOCERA					
COPEPODA					
HYDRACRINA					
DIPTERA					
CORIXIDAE	0.28	11.11	(1)	3	18.37
NOTONECTIDAE					
COLEOPTERA	0.42	11.11	(1)	1	2.04
AMPHIPODA					
HIRUDINEA					
TRICHOPTERA					
EPHEMEROPTERA					
ODONATA	22.78	44.44	(4)	6	12.24
GASTROPODA	17.24	44.44	(4)	27	55.10
PELECYPODA					
TERRESTRIAL INS	11.12	22.22	(2)	2	4.08
EGGS					
OTHER	14.33	11.11	(1)	1	2.04
n	9	9		49	49

August, years combined.

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE	NUMBER	% NUMBER
THREESPINE STKB	24.79	36.36 (8)	35	3.13
BROOK STKB	0.95	9.09 (2)	6	0.54
FATHEAD MINNOW	2.86	4.55 (1)	1	0.09
RAINBOW TROUT				
UNIDENT.FISH	2.03	13.64 (3)	9	0.81
OSTRACODA				
CLADOCERA	4.67	9.09 (2)	300	26.86
COPEPODA				
HYDRACRINA				
DIPTERA	0.01	4.55 (1)	2	0.18
CORIXIDAE	5.54	72.73 (16)	425	38.05
NOTONECTIDAE	22.64	45.45 (10)	178	15.94
COLEOPTERA	0.10	9.09 (2)	4	0.36
AMPHIPODA	0.09	4.55 (1)	1	0.09
HIRUDINEA				
TRICHOPTERA				
EPHEMEROPTERA				
ODONATA	18.63	40.91 (9)	109	9.76
GASTROPODA	6.17	36.36 (8)	36	3.22
PELECYPODA				
TERRESTRIAL INS	7.36	27.27 (6)	7	0.63
EGGS				
OTHER	4.39	4.55 (1)	4	0.36
n	2	22	1117	22

August 83

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE	NUMBER	% NUMBER
THREESPINE STKB	27.86	42.11 (8)	34	3.11
BROOK STKB	1.10	10.53 (2)	6	0.55
FATHEAD MINNOW				
RAINBOW TROUT				
UNIDENT.FISH	2.35	15.79 (3)	9	0.82
OSTRACODA				
CLADOCERA	5.41	10.53 (2)	300	27.42
COPEPODA				
HYDRACRINA				
DIPTERA	0.01	5.26 (1)	2	0.18
CORIXIDAE	6.28	78.95 (15)	422	38.57
NOTONECTIDAE	26.21	57.89 (11)	178	16.27
COLEOPTERA	0.12	10.53 (2)	4	0.37
AMPHIPODA	0.10	5.26 (1)	1	0.09
HIRUDINEA				
TRICHOPTERA				
EPHEMEROPTERA				
ODONATA	18.93	47.37 (9)	108	9.87
GASTROPODA	3.55	31.58 (6)	21	1.92
PELECYPODA				
TERRESTRIAL INS	3.25	21.05 (4)	5	0.46
EGGS				
OTHER	5.08	5.26 (1)	4	0.37
n	19	19	1094	1094

August 85

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE	NUMBER	% NUMBER
THREESPINE STKB	5.37	33.33	1	4.35
BROOK STKB				
FATHEAD MINNOW	20.97	33.33	1	4.35
RAINBOW TROUT				
UNIDENT.FISH				
OSTRACODA				
CLADOCERA				
COPEPODA				
HYDRACRINA				
DIPTERA				
CORIXIDAE	0.83	33.33	3	13.04
NOTONECTIDAE				
COLEOPTERA				
AMPHIPODA				
HIRUDINEA				
TRICHOPTERA				
EPHEMEROPTERA				
ODONATA	16.70	33.33	1	4.35
GASTROPODA	22.77	66.67	15	65.22
PELECYPODA				
TERRESTRIAL INS	33.37	66.67	2	8.70
EGGS				
OTHER				
n	3	3	23	23

October, years combined.

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
THREESPINE STKB	14.58	29.03	(9)	37	2.89
BROOK STKB					
FATHEAD MINNOW	1.15	3.23	(1)	1	0.08
RAINBOW TROUT					
UNIDENT.FISH	2.13	19.35	(6)	8	0.62
OSTRACODA					
CLADOCERA					
COPEPODA					
HYDRACRINA					
DIPTERA	0.01	9.68	(3)	5	0.39
CORIXIDAE	16.90	80.65	(25)	733	57.22
NOTONECTIDAE	4.89	41.94	(13)	48	3.75
COLEOPTERA	11.16	48.39	(15)	72	5.62
AMPHIPODA	2.74	25.81	(8)	37	2.89
HIRUDINEA	2.03	6.45	(2)	2	0.16
TRICHOPTERA	2.88	16.13	(5)	14	1.09
EPHEMEROPTERA	0.01	6.45	(2)	2	0.16
ODONATA	9.29	41.94	(13)	27	2.11
GASTROPODA	30.55	67.74	(21)	265	20.69
PELECYPODA					
TERRESTRIAL INS	1.69	29.03	(9)	28	2.19
EGGS					
OTHER	0.01	6.45	(2)	2	0.16
n	31	31		1281	100.02

October 83

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
THREESPINE STKB	10.50	22.22	(6)	26	2.12
BROOK STKB					
FATHEAD MINNOW	1.32	3.70	(1)	1	0.08
RAINBOW TROUT					
UNIDENT.FISH	1.65	14.81	(4)	4	0.33
OSTRACODA					
CLADOCERA					
COPEPODA					
HYDRACRINA					
DIPTERA	0.01	11.11	(3)	5	0.41
CORIXIDAE	19.41	92.59	(25)	733	59.69
NOTONECTIDAE	5.62	48.15	(13)	48	3.91
COLEOPTERA	10.08	48.15	(13)	67	5.46
AMPHIPODA	3.14	29.63	(8	37	3.01
HIRUDINEA	2.33	7.41	(2)	2	0.16
TRICHOPTERA	3.31	18.52	(5)	14	1.14
EPHEMEROPTERA	0.01	7.41	(2)	2	0.16
ODONATA	10.67	48.15	(13)	27	2.20
GASTROPODA	30.03	70.37	(19)	232	18.89
PELECYPODA					
TERRESTRIAL INS	1.94	33.33	(9)	28	2.28
EGGS					
OTHER	0.01	7.41	(2)	2	0.16
n	27	27		1228	1228

October 84

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
THREESPINE STKB	42.13	75.00	(3)	11	20.75
BROOK STKB					
FATHEAD MINNOW					
RAINBOW TROUT					
UNIDENT.FISH	5.40	50.00	(2)	4	7.55
OSTRACODA					
CLADOCERA					
COPEPODA					
HYDRACRINA					
DIPTERA					
CORIXIDAE					
NOTONECTIDAE					
COLEOPTERA	18.43	50.00	(2)	5	9.43
AMPHIPODA					
HIRUDINEA					
TRICHOPTERA					
EPHEMEROPTERA					
ODONATA					
GASTROPODA	34.05	50.00	(2)	33	62.26
PELECYPODA					
TERRESTRIAL INS					
EGGS					
OTHER					
n	4	4		53	53

Appendix 2. Diet data for trout fingerlings (YOY) for the months sampled during 1984 and 1985. Data is in the form of mean % dry weight, percent occurrence, number, and percent number.

Mean % dry weight for all months with 1984 and 85 data combined.

PREY CATEGORIES	JUNE	JULY	AUGUST
THREESPINE STKB	0.00	2.16	11.40
BROOK STKB	10.74	36.90	17.49
FATHEAD MINNOW	0.00	0.00	0.81
RAINBOW TROUT	0.00	0.00	0.00
UNIDENT.FISH	0.00	0.18	0.22
OSTRACODA	0.00	0.00	0.00
CLADOCERA	0.00	0.00	1.23
COPEPODA	0.00	0.00	0.00
HYDRACRINA	5.37	0.98	0.32
DIPTERA (larvae & pupae)	5.41	6.27	3.77
CORIXIDAE	26.97	4.17	9.79
NOTONECTIDAE	0.00	0.00	1.01
COLEOPTERA	3.47	2.03	3.53
AMPHIPODA	2.52	1.09	0.38
HIRUDINEA	0.00	0.41	0.86
TRICHOPTERA	7.85	0.59	0.62
EPHEMEROPTERA	2.22	2.90	2.60
ODONATA	1.35	4.39	4.29
GASTROPODA	6.32	5.67	22.98
PELECYPODA	0.02	0.00	0.07
TERRESTRIAL INS.	22.59	29.87	17.45
EGGS	0.21	0.00	0.63
OTHER	5.00	1.96	0.67
n	40	124	109

June 85

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE	NUMBER	% NUMBER
THREESPINE STKB				
BROOK STKB	10.74	12.50 (5)	16	7.66
FATHEAD MINNOW				
RAINBOW TROUT				
UNIDENT.FISH				
OSTRACODA	0.00	2.50 (1)	1	0.48
CLADOCERA				
COPEPODA				
HYDRACRINA	5.37	15.00 (6)	36	17.22
DIPTERA	5.41	17.50 (7)	17	8.13
CORIXIDAE	26.97	40.00 (16)	40	19.14
NOTONECTIDAE				
COLEOPTERA	3.4[illegible]	7.50 (3)	3	1.44
AMPHIPODA	2.52	5.00 (2)	2	0.96
HIRUDINEA				
TRICHOPTERA	7.85	10.00 (4)	10	4.78
EPHEMEROPTERA	2.22	7.50 (3)	7	3.35
ODONATA	1.35	5.00 (2)	3	1.44
GASTROPODA	6.32	12.50 (5)	28	13.40
PELECYPODA	0.02	2.50 (1)	1	0.48
TERRESTRIAL INS	22.59	32.50 (13)	42	20.10
EGGS	0.21	2.50 (1)	1	0.48
OTHER	5.00	5.00 (2)	2	0.96
n	40	40	209	

July, years combined.

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
THREESPINE STKB	2.16	4.80	(6)	6	0.33
BROOK STKB	36.90	43.32	(54)	120	6.61
FATHEAD MINNOW					
RAINBOW TROUT					
UNIDENT.FISH	0.18	0.80	(1)	1	0.06
OSTRACODA					
CLADOCERA	0	0.80	(1)	1	0.06
COPEPODA					
HYDRACRINA	0.98	8.00	(10)	46	2.53
DIPTERA	6.27	24.80	(31)	217	11.96
CORIXIDAE	4.17	24.80	(31)	93	5.12
NOTONECTIDAE					
COLEOPTERA	2.03	5.60	(7)	8	0.44
AMPHIPODA	1.09	5.60	(7)	26	1.43
HIRUDINEA	0.41	0.80	(1)	2	0.11
TRICHOPTERA	0.59	6.40	(8)	13	0.72
EPHEMEROPTERA	2.90	10.40	(13)	15	0.83
ODONATA	4.39	12.80	(16)	17	0.94
GASTROPODA	5.67	14.40	(18)	57	3.14
PELECYPODA					
TERRESTRIAL INS	29.87	47.20	(56)	1186	65.34
EGGS					
OTHER	1.96	5.60	(7)	7	0.39
n	124	124		1815	100.01

July 84

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
THREESPINE STKB					
BROOK STKB	12.50	12.50	(1)	1	2.27
FATHEAD MINNOW					
RAINBOW TROUT					
UNIDENT.FISH	2.74	12.50	(1)	1	2.27
OSTRACODA					
CLADOCERA					
COPEPODA					
HYDRACRINA					
DIPTERA	5.34	12.50	(1)	2	4.55
CORIXIDAE	3.25	25.00	(2)	2	4.55
NOTONECTIDAE					
COLEOPTERA	4.96	12.50	(1)	1	2.27
AMPHIPODA					
HIRUDINEA					
TRICHOPTERA	4.33	25.00	(2)	4	9.09
EPHEMEROPTERA	9.09	25.00	(2)	2	4.55
ODONATA	1.89	12.50	(1)	1	2.27
GASTROPODA					
PELECYPODA					
TERRESTRIAL INS	54.68	87.50	(7)	30	68.18
EGGS					
OTHER					
n	8	8		44	44

July 85

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
THREESPINE STKB	2.31	5.13	(6)	6	0.34
BROOK STKB	38.59	45.30	(53)	119	6.72
FATHEAD MINNOW					
RAINBOW TROUT					
UNIDENT.FISH					
OSTRACODA					
CLADOCERA	0.00	0.85	(1)	1	0.06
COPEPODA					
HYDRACRINA	1.04	8.55	(10)	46	2.60
DIPTERA	6.33	25.64	(30)	215	12.14
CORIXIDAE	4.23	24.79	(29)	91	5.14
NOTONECTIDAE					
COLEOPTERA	1.83	5.13	(6)	7	0.40
AMPHIPODA	1.17	5.98	(7)	26	1.47
HIRUDINEA	0.44	0.85	(1)	2	0.11
TRICHOPTERA	0.33	5.13	(6)	9	0.51
EPHEMEROPTERA	2.47	9.40	(11)	13	0.73
ODONATA	5.04	12.82	(15)	16	0.90
GASTROPODA	6.06	15.38	(18)	57	3.22
PELECYPODA					
TERRESTRIAL INS	28.16	41.88	(49)	1156	65.27
EGGS					
OTHER	2.09	5.98	(7)	7	0.40
n	117	117		1771	1771

August, years combined.

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
THREESPINE STKB	11.4	19.27	(21)	52	2.12
BROOK STKB	17.49	23.85	(26)	189	7.71
FATHEAD MINNOW	0.81	0.92	(1)	1	0.04
RAINBOW TROUT					
UNIDENT.FISH	0.22	2.75	(3)	28	1.14
OSTRACODA					
CLADOCERA	1.23	4.59	(5)	608	24.82
COPEPODA					
HYDRACRINA	0.32	2.75	(3)	7	0.29
DIPTERA	3.77	33.94	(37)	245	10.00
CORIXIDAE	9.79	34.86	(38)	205	8.37
NOTONECTIDAE	1.01	1.83	(2)	6	0.24
COLEOPTERA	3.53	8.26	(9)	14	0.57
AMPHIPODA	0.38	1.83	(2)	3	0.12
HIRUDINEA	0.86	0.92	(1)	1	0.04
TRICHOPTERA	0.62	1.83	(2)	6	0.24
EPHEMEROPTERA	2.6	14.68	(16)	25	1.02
ODONATA	4.29	20.18	(22)	28	1.14
GASTROPODA	22.98	34.86	(38)	145	5.92
PELECYPODA	0.07	0.92	(1)	1	0.04
TERRESTRIAL INS	17.45	45.87	(50)	871	35.55
EGGS	0.63	0.92	(1)	4	0.16
OTHER	0.67	3.67	(4)	11	0.45
n	109	109		2450	99.98

August 84

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
THREESPINE STKB	8.79	19.51	(8)	12	0.90
BROOK STKB	30.43	36.59	(15)	9	11.94
FATHEAD MINNOW					
RAINBOW TROUT					
UNIDENT.FISH	0.58	7.32	(3)	28	2.10
OSTRACODA					
CLADOCERA	3.26	12.20	(5)	608	45.65
COPEPODA					
HYDRACRINA	0.84	7.32	(3)	7	0.53
DIPTERA	5.33	39.02	(16)	122	9.16
CORIXIDAE	20.89	56.00	(23)	66	4.95
NOTONECTIDAE	2.67	4.88	(2)	6	0.45
COLEOPTERA	3.71	7.32	(3)	4	0.30
AMPHIPODA					
HIRUDINEA					
TRICHOPTERA					
EPHEMEROPTERA	2.50	19.51	(8)	14	1.05
ODONATA	5.42	29.27	(12)	14	1.05
GASTROPODA	5.53	7.32	(3)	17	1.28
PELECYPODA					
TERRESTRIAL INS	10.30	41.46	(17)	275	20.65
EGGS					
OTHER					
n	41	41		1332	1332

August 85

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
THREESPINE STKB	12.97	19.12	(13)	40	3.58
BROOK STKB	9.68	16.18	(11)	30	2.68
FATHEAD MINNOW	1.29	1.47	(1)	1	0.09
RAINBOW TROUT					
UNIDENT.FISH					
OSTRACODA					
CLADOCERA					
COPEPODA					
HYDRACRINA					
DIPTERA	2.83	30.88	(21)	123	11.00
CORIXIDAE	3.10	22.06	(15)	139	12.43
NOTONECTIDAE					
COLEOPTERA	3.42	8.82	(6)	10	0.89
AMPHIPODA	0.61	2.94	(2)	3	0.27
HIRUDINEA	1.38	1.47	(1)	1	0.09
TRICHOPTERA	1.00	2.94	(2)	6	0.54
EPHEMEROPTERA	2.66	11.76	(8)	11	0.98
ODONATA	3.61	14.71	(10)	14	1.25
GASTROPODA	33.49	51.47	(35)	128	11.45
PELECYPODA	0.11	1.47	(1)	1	0.09
TERRESTRIAL INS	21.76	48.53	(33)	596	53.31
EGGS	1.01	1.47	(1)	4	0.36
OTHER	1.07	5.88	(4)	11	0.98
n	68	68		1118	1118

Appendix 3. Diet data for brook sticklebacks (BR) for the months sampled during 1984 and 1985. Data is in the form of mean % dry weight, percent occurrence, number, and percent number.

Mean % dry weight for all months with years 1984 and 85 combined.

PREY CATEGORIES	JAN	MARCH	MAY	JUNE	JULY	AUG	OCT
OSTRACODA	0.00	40.23	9.82	1.43	8.12	5.63	1.93
CLADOCERA	60.04	0.00	7.17	6.41	3.92	5.16	15.28
COPEPODA	0.00	9.83	7.57	9.84	2.09	2.64	12.85
HYDRACRINA	0.00	0.00	0.08	0.09	0.00	0.01	0.00
DIPTERA	0.00	24.95	60.66	39.44	72.31	72.14	69.95
CORIXIDAE	0.00	0.00	0.58	0.18	0.00	0.00	0.00
NOTONECTIDAE	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COLEOPTERA	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AMPHIPODA	20.00	0.00	5.38	1.72	0.64	0.00	0.00
HIRUDINEA	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRICHOPTERA	0.00	0.00	0.00	0.10	0.48	0.00	0.00
EPHEMEROPTERA	0.00	0.00	0.06	11.40	0.40	0.03	0.00
ODONATA	0.00	0.00	0.00	0.32	0.00	0.00	0.00
GASTROPODA	0.00	0.00	0.01	8.96	5.41	3.47	0.00
PELECYPODA	0.00	0.00	2.37	0.22	2.31	2.72	0.00
TERR. INSCT.	0.00	0.00	0.00	2.91	0.00	0.00	0.00
EGGS	19.96	25.00	5.02	15.41	4.18	8.20	0.00
OTHER	0.00	0.00	1.31	1.58	0.16	0.00	0.00
n	5	4	76	67	57	35	4

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January 85

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
OSTRACODA					
CLADOCERA	60.04	66.67	(4)	32	88.89
COPEPODA					
HYDRACRINA					
DIPTERA					
CORIXIDAE					
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA	20.00	16.67	(1)	3	8.33
HIRUDINEA					
TRICHOPTERA					
EPHEMEROPTERA					
ODONATA					
GASTROPODA					
PELECYPODA					
TERRESTRIAL INS					
EGGS	19.96	16.67	(1)	1	2.78
OTHER					
n	6	6		36	36

March 85

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
OSTRACODA	40.23	75.00	(3)	21	63.64
CLADOCERA					
COPEPODA	9.83	25.00	(1)	1	3.03
HYDRACRINA					
DIPTERA	24.95	25.00	(1)	9	27.27
CORIXIDAE					
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA					
HIRUDINEA					
TRICHOPTERA					
EPHEMEROPTERA					
ODONATA					
GASTROPODA					
PELECYPODA					
TERRESTRIAL INS					
EGGS	25.00	25.00	(1)	2	6.06
OTHER					
n	4	4		33	33

May, years combined

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
OSTRACODA	9.82	36.84	(28)	255	21.25
CLADOCERA	7.17	34.21	(26)	412	34.33
COPEPODA	7.57	38.16	(29)	218	18.17
HYDRACRINA	0.08	2.63	(2)	3	0.25
DIPTERA	60.66	76.32	(58)	225	18.75
CORIXIDAE	0.58	2.63	(2)	3	0.25
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA	5.38	7.89	(6)	15	1.25
HIRUDINEA					
TRICHOPTERA					
EPHEMEROPTERA	0.06	2.63	(2)	22	1.83
ODONATA					
GASTROPODA	0.01	2.63	(2)	4	0.33
PELECYPODA	2.37	1.32	(1)	3	0.25
TERRESTRIAL INS					
EGGS	5.02	10.53	(8)	39	3.25
OTHER	1.31	1.32	(1)	1	0.08
n	76	76		1200	99.99

May 84

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
OSTRACODA	17.51	40.48	(17)	193	22.03
CLADOCERA	7.56	30.95	(13)	351	40.07
COPEPODA	9.27	42.86	(18)	154	17.58
HYDRACRINA	0.01	2.38	(1)	1	0.11
DIPTERA	53.73	71.43	(30)	116	13.24
CORIXIDAE	1.05	4.76	(2)	3	0.34
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA	3.84	7.14	(3)	6	0.68
HIRUDINEA					
TRICHOPTERA					
EPHEMEROPTERA	0.12	4.76	(2)	22	2.51
ODONATA					
GASTROPODA	0.02	4.76	(2)	4	0.46
PELECYPODA	4.29	2.38	(1)	3	0.34
TERRESTRIAL INS					
EGGS	0.33	9.52	(4)	22	2.51
OTHER	2.38	2.38	(1)	1	0.11
n	42	42		876	876

May 85

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
OSTRACODA	0.32	32.35	(11)	62	19.14
CLADOCERA	6.70	38.24	(13)	61	18.83
COPEPODA	5.47	32.35	(11)	64	19.75
HYDRACRINA	0.18	2.94	(1)	2	0.62
DIPTERA	69.22	82.35	(28)	109	33.64
CORIXIDAE					
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA	7.29	8.82	(3)	9	2.78
HIRUDINEA					
TRICHOPTERA					
EPHEMEROPTERA					
ODONATA					
GASTROPODA					
PELECYPODA					
TERRESTRIAL INS					
EGGS	10.81	11.76	(4)	17	5.25
OTHER					
n	34	34		324	324

June, years combined.

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
OSTRACODA	1.43	32.84	(22)	96	9.7
CLADOCERA	6.41	43.28	(29)	369	37.27
COPEPODA	9.84	55.22	(37)	236	23.84
HYDRACRINA	0.09	2.99	(2)	3	0.30
DIPTERA	39.44	64.18	(43)	80	8.08
CORIXIDAE	0.18	2.99	(2)	2	0.20
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA	1.72	11.94	(8)	16	1.62
HIRUDINEA					
TRICHOPTERA	0.10	1.49	(1)	1	0.10
EPHEMEROPTERA	11.4	17.91	(12)	26	2.63
ODONATA	0.32	1.49	(1)	1	0.10
GASTROPODA	8.96	14.93	(10)	14	1.41
PELECYPODA	0.22	1.49	(1)	5	0.51
TERRESTRIAL INS	2.91	5.97	(4)	4	0.40
EGGS	15.41	23.88	(16)	132	13.33
OTHER	1.58	4.48	(3)	5	0.51
n	67	67		990	100.00

June 84

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
OSTRACODA	1.80	31.37	(16)	65	8.00
CLADOCERA	6.40	43.14	(22)	347	42.68
COPEPODA	12.03	60.78	(31)	184	22.63
HYDRACRINA	0.00	1.96	(1)	1	0.01
DIPTERA	37.62	62.75	(32)	52	6.40
CORIXIDAE	0.23	3.92	(2)	2	0.24
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA	1.31	13.73	(7)	15	1.85
HIRUDINEA					
TRICHOPTERA	0.14	1.96	(1)	1	0.01
EPHEMEROPTERA	10.79	15.69	(8)	10	1.23
ODONATA	0.42	1.96	(1)	1	0.01
GASTROPODA	7.55	13.73	(7)	7	0.86
PELECYPODA	0.29	1.96	(1)	5	0.62
TERRESTRIAL INS	3.82	7.84	(4)	4	0.49
EGGS	15.54	23.53	(12)	114	14.02
OTHER	2.08	5.88	(3)	5	0.62
n	51	51		813	813

June 85

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
OSTRACODA	0.24	37.50	(6)	31	17.51
CLADOCERA	6.46	43.75	(7)	22	12.43
COPEPODA	2.86	37.50	(6)	52	29.38
HYDRACRINA	0.39	6.25	(1)	2	1.13
DIPTERA	45.26	68.75	(11)	28	15.82
CORIXIDAE					
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA	3.01	6.25	(1)	1	0.56
HIRUDINEA					
TRICHOPTERA					
EPHEMEROPTERA	13.33	25.00	(4)	16	9.04
ODONATA					
GASTROPODA	13.44	18.75	(3)	7	3.95
PELECYPODA					
TERRESTRIAL INS					
EGGS	14.97	25.00	(4)	18	10.17
OTHER					
n	16		16	177	177

July, years combined.

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
OSTRACODA	8.12	56.90	(33)	101	13.43
CLADOCERA	3.92	41.38	(24)	123	16.36
COPEPODA	2.09	39.66	(23)	146	19.41
HYDRACRINA					
DIPTERA	72.31	96.55	(56)	328	43.62
CORIXIDAE					
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA	0.64	1.72	(1)	1	0.13
HIRUDINEA					
TRICHOPTERA	0.48	1.72	(1)	1	0.13
EPHEMEROPTERA	0.4	1.72	(1)	1	0.13
ODONATA					
GASTROPODA	5.41	17.24	(10)	16	2.13
PELECYPODA	2.31	13.79	(8)	15	1.99
TERRESTRIAL INS					
EGGS	4.18	8.62	(5)	19	2.53
OTHER	0.16	1.72	(1)	1	0.13
n	57	57		752	99.99

July 84

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
OSTRACODA	5.40	55.30	(26)	76	11.99
CLADOCERA	3.21	42.60	(20)	108	17.03
COPEPODA	12.03	36.17	(17)	136	21.45
HYDRACRINA					
DIPTERA	75.82	100.00	(47	265	41.80
CORIXIDAE					
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA					
HIRUDINEA					
TRICHOPTERA					
EPHEMEROPTERA	0.49	2.13	(1)	1	0.16
ODONATA					
GASTROPODA	5.15	14.89	(7)	13	2.05
PELECYPODA	2.86	17.02	(8)	15	2.37
TERRESTRIAL INS					
EGGS	5.17	10.64	(5)	19	3.00
OTHER	0.19	2.13	(1)	1	0.16
n	47	47		634	634

July 85

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
OSTRACODA	19.47	63.64	(7)	25	21.19
CLADOCERA	6.90	36.36	(4)	15	12.71
COPEPODA	3.72	54.55	(6)	10	8.47
HYDRACRINA					
DIPTERA	57.62	81.82	(9)	63	53.39
CORIXIDAE					
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA	3.31	9.09	(1)	1	0.85
HIRUDINEA					
TRICHOPTERA	2.46	9.09	(1)	1	0.85
EPHEMEROPTERA					
ODONATA					
GASTROPODA	6.50	27.27	(3)	3	2.45
PELECYPODA					
TERRESTRIAL INS					
EGGS					
OTHER					
n	11	11		118	118

August 84

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
OSTRACODA	5.63	31.43	(11)	22	7.69
CLADOCERA	5.16	25.71	(9)	14	4.90
COPEPODA	2.64	14.29	(5)	23	8.04
HYDRACRINA	0.01	5.71	(2)	6	2.10
DIPTERA	72.14	85.71	(30)	181	63.29
CORIXIDAE					
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA					
HIRUDINEA					
TRICHOPTERA					
EPHEMEROPTERA	0.03	5.71	(2)	2	0.70
ODONATA					
GASTROPODA	3.47	17.14	(6)	8	2.80
PELECYPODA	2.72	2.86	(1)	3	1.05
TERRESTRIAL INS					
EGGS	8.20	20.00	(7)	27	9.44
OTHER					
n	35	35		286	286

October 84

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
OSTRACODA	1.93	25.00	(1)	1	2.50
CLADOCERA	15.28	100.00	(4	10	25.00
COPEPODA	12.85	25.00	(1)	8	20.00
HYDRACRINA					
DIPTERA	69.95	75.00	(3)	21	52.50
CORIXIDAE					
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA					
HIRUDINEA					
TRICHOPTERA					
EPHEMEROPTERA					
ODONATA					
GASTROPODA					
PELECYPODA					
TERRESTRIAL INS					
EGGS					
OTHER					
n	4	4		40	40

Appendix 4. Diet data for threespine sticklebacks (TS) for the months sampled during 1984 and 1985. Data is in the form of mean % dry weight, percent occurrence, number, and percent number.

Mean % dry weight for all months with 1984 and 1985 data combined.

PREY CATEGORIES	JAN	MARCH	MAY	JUNE	JULY	AUG	OCT
OSTRACODA	1.14	1.04	2.11	1.97	1.86	3.76	14.90
CLADOCERA	32.36	0.14	4.95	12.86	8.77	8.11	1.97
COPEPODA	22.02	6.27	5.51	7.97	4.18	4.06	0.87
HYDRACRINA	0.00	0.00	0.01	0.00	0.00	0.00	0.00
DIPTERA	20.26	39.15	49.07	44.44	56.74	40.64	42.42
CORIXIDAE	0.00	0.00	0.01	1.39	0.73	0.87	0.00
NOTONECTIDAE	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COLEOPTERA	0.00	0.00	0.01	0.00	0.00	0.00	0.00
AMPHIPODA	0.00	0.00	1.18	1.55	0.74	2.49	1.06
HIRUDINEA	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRICHOPTERA	8.33	2.81	0.30	1.05	1.02	0.00	18.06
EPHEMEROPTERA	0.00	0.00	0.69	2.64	1.64	0.48	0.00
ODONATA	0.00	0.00	0.94	1.08	0.09	0.00	0.00
GASTROPODA	0.00	5.26	3.14	3.45	2.62	9.46	7.14
PELECYPODA	0.00	5.26	14.56	2.00	0.50	4.54	4.79
TERR.INS.	0.00	0.00	2.24	6.01	1.14	2.77	0.00
EGGS	0.00	0.00	4.82	9.47	14.83	11.70	0.00
OTHER	15.89	40.06	10.40	4.11	5.16	11.17	8.78
n	18	19	197	262	137	150	14

January 85

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE	NUMBER	% NUMBER
OSTRACODA	1.14	38.89 (7)	12	3.80
CLADOCERA	32.36	66.67 (12)	248	78.48
COPEPODA	22.02	33.33 (6)	31	9.81
HYDRACRINA				
DIPTERA	20.26	33.33 (6)	17	5.38
CORIXIDAE				
NOTONECTIDAE				
COLEOPTERA				
AMPHIPODA				
HIRUDINEA				
TRICHOPTERA	8.33	11.11 (2)	2	0.63
EPHEMEROPTERA				
ODONATA				
GASTROPODA				
PELECYPODA				
TERRESTRIAL INS				
EGGS				
OTHER	15.89	16.67 (3)	6	1.90
n	18	18	316	316

March 85

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE	NUMBER	% NUMBER
OSTRACODA	1.04	20.00 (4)	29	29.00
CLADOCERA	0.14	10.00 (2)	6	6.00
COPEPODA	6.27	35.00 (7)	25	25.00
HYDRACRINA				
DIPTERA	39.15	55.00 (11)	29	29.00
CORIXIDAE				
NOTONECTIDAE				
COLEOPTERA				
AMPHIPODA				
HIRUDINEA				
TRICHOPTERA	2.81	5.00 (1)	1	1.00
EPHEMEROPTERA				
ODONATA				
GASTROPODA	5.26	5.00 (1)	1	1.00
PELECYPODA	5.26	5.00 (1)	1	1.00
TERRESTRIAL INS				
EGGS				
OTHER	40.06	40.00 (8)	8	8.00
n	20	20	100	100

May, years combined.

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE	NUMBER	% NUMBER
OSTRACODA	2.11	27.92 (55)	250	4.53
CLADOCERA	4.95	29.44 (58)	3630	65.83
COPEPODA	5.51	38.58 (76)	364	6.60
HYDRACRINA	0.01	6.09 (12)	100	1.81
DIPTERA	49.07	78.17 (154)	717	13.00
CORIXIDAE	0.01	0.50 (1)	1	0.02
NOTONECTIDAE				
COLEOPTERA	0.01	0.50 (1)	1	0.02
AMPHIPODA	1.18	2.03 (4)	18	0.33
HIRUDINEA				
TRICHOPTERA	0.30	1.02 (2)	2	0.04
EPHEMEROPTERA	0.69	6.60 (13)	39	0.71
ODONATA	0.94	1.02 (2)	2	0.04
GASTROPODA	3.14	12.18 (24)	42	0.76
PELECYPODA	14.56	16.24 (32)	68	1.23
TERRESTRIAL INS	2.24	4.06 (8)	14	0.25
EGGS	4.82	14.72 (29)	228	4.13
OTHER	10.40	11.17 (22)	38	0.69
n	197	197	5514	99.99

May 84

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
OSTRACODA	2.61	32.06	(51)	241	5.11
CLADOCERA	6.10	33.33	(53)	3224	68.39
COPEPODA	4.97	40.88	(65)	251	5.32
HYDRACRINA	0.01	6.92	(11)	99	2.10
DIPTERA	49.50	76.73	(122)	573	12.16
CORIXIDAE					
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA	0.28	0.63	(1)	15	0.32
HIRUDINEA					
TRICHOPTERA					
EPHEMEROPTERA	0.80	7.74	(12)	38	0.81
ODONATA					
GASTROPODA	2.08	13.21	(21)	36	0.76
PELECYPODA	17.00	18.24	(29)	63	1.34
TERRESTRIAL INS	2.72	4.40	(7)	10	0.21
EGGS	2.29	14.47	(23)	132	2.80
OTHER	11.55	10.06	(16)	32	0.68
n	159		159	4714	4714

May 85

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE	NUMBER	% NUMBER
OSTRACODA	0.01	10.53 (4)	9	1.13
CLADOCERA	0.11	13.16 (5)	406	50.75
COPEPODA	7.80	28.95 (11)	113	14.13
HYDRACRINA	0.01	2.63 (1)	1	0.12
DIPTERA	47.26	83.72 (32)	144	18.00
CORIXIDAE	0.02	2.63 (1)	1	0.12
NOTONECTIDAE				
COLEOPTERA	0.05	2.63 (1)	1	0.12
AMPHIPODA	4.93	7.89 (3)	3	0.37
HIRUDINEA				
TRICHOPTERA	1.53	5.26 (2)	2	0.24
EPHEMEROPTERA	0.20	2.63 (1)	1	0.11
ODONATA	4.90	5.26 (2)	2	0.24
GASTROPODA	7.58	7.89 (3)	6	0.75
PELECYPODA	4.36	7.89 (3)	5	0.68
TERRESTRIAL INS	0.26	2.63 (1)	4	0.5
EGGS	15.40	15.79 (6)	96	12.00
OTHER	5.59	15.79 (6)	6	0.75
n	38	38	800	800

June, years combined.

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE	NUMBER	% NUMBER
OSTRACODA	1.97	29.39 (77)	271	2.95
CLADOCERA	12.86	48.47 (127)	6225	67.65
COPEPODA	7.97	48.85 (128)	1362	14.80
HYDRACRINA	0	1.15 (3)	3	0.03
DIPTERA	44.44	64.50 (169)	720	7.82
CORIXIDAE	1.39	3.44 (9)	11	0.12
NOTONECTIDAE				
COLEOPTERA				
AMPHIPODA	1.55	4.96 (13)	18	0.20
HIRUDINEA				
TRICHOPTERA	1.05	1.15 (3)	3	0.03
EPHEMEROPTERA	2.64	5.73 (15)	17	0.18
ODONATA	1.08	1.53 (4)	4	0.04
GASTROPODA	3.45	7.36 (20)	38	0.41
PELECYPODA	2	6.87 (18)	30	0.33
TERRESTRIAL INS	6.01	9.54 (25)	35	0.38
EGGS	9.47	14.50 (38)	427	4.64
OTHER	4.11	9.54 (25)	38	0.41
n	262	262	9202	99.99

June 84

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE	NUMBER	% NUMBER
OSTRACODA	2.02	32.20 (57)	215	3.29
CLADOCERA	17.05	61.58 (109)	4364	66.79
COPEPODA	11.07	60.45 (107)	1094	16.74
HYDRACRINA	0.00	1.13 (2)	2	0.03
DIPTERA	42.17	70.62 (125)	473	7.24
CORIXIDAE	1.28	4.52 (8)	10	0.15
NOTONECTIDAE				
COLEOPTERA				
AMPHIPODA	0.33	5.65 (10)	14	0.21
HIRUDINEA				
TRICHOPTERA				
EPHEMEROPTERA	12.13	5.65 (10)	11	0.17
ODONATA	0.97	1.13 (2)	2	0.03
GASTROPODA	5.10	10.17 (18)	33	0.51
PELECYPODA	1.86	7.91 (14)	22	0.34
TERRESTRIAL INS	7.44	10.73 (19)	24	0.37
EGGS	6.81	9.60 (17)	243	3.72
OTHER	1.77	9.60 (17)	27	0.41
n	177	177	6534	6534

June 85

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE	NUMBER	% NUMBER
OSTRACODA	1.89	28.24 (24)	56	2.10
CLADOCERA	4.14	29.42 (25)	1861	69.75
COPEPODA	1.50	31.76 (27)	268	10.04
HYDRACRINA	0.00	1.18 (1)	1	0.03
DIPTERA	49.17	60.00 (51)	247	9.26
CORIXIDAE	1.64	1.18 (1)	1	0.03
NOTONECTIDAE				
COLEOPTERA				
AMPHIPODA	4.09	4.72 (4)	4	0.15
HIRUDINEA				
TRICHOPTERA	3.23	3.54 (3)	3	0.11
EPHEMEROPTERA	3.71	7.08 (6)	6	0.22
ODONATA	1.32	2.36 (2)	2	0.07
GASTROPODA	0.04	3.54 (3)	5	0.19
PELECYPODA	2.27	5.90 (5)	8	0.30
TERRESTRIAL INS	3.04	8.26 (7)	11	0.41
EGGS	15.00	25.88 (22)	184	6.90
OTHER	8.97	10.62 (9)	11	0.41
n	85	85	2668	2668

July, years combined.

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE	NUMBER	% NUMBER
OSTRACODA	1.86	23.36 (32)	86	1.93
CLADOCERA	8.77	24.82 (34)	2089	46.92
COPEPODA	4.18	25.55 (35)	340	7.64
HYDRACRINA				
DIPTERA	56.74	75.91 (104)	1173	26.35
CORIXIDAE	0.73	0.73 (1)	3	0.07
NOTONECTIDAE				
COLEOPTERA				
AMPHIPODA	0.74	2.19 (3)	3	0.07
HIRUDINEA				
TRICHOPTERA	1.02	2.19 (3)	26	0.58
EPHEMEROPTERA	1.64	5.84 (8)	10	0.22
ODONATA	0.09	0.73 (1)	1	0.02
GASTROPODA	2.62	13.14 (18)	44	0.99
PELECYPODA	0.50	9.49 (13)	25	0.56
TERRESTRIAL INS	1.14	2.19 (3)	24	0.54
EGGS	14.83	18.98 (26)	477	10.71
OTHER	5.16	10.95 (15)	151	3.39
n	137	137	4452	99.99

July 84

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE	NUMBER	% NUMBER
OSTRACODA	1.78	27.78 (20)	52	2.16
CLADOCERA	11.29	30.56 (22)	1229	51.14
COPEPODA	3.57	33.33 (24)	100	4.16
HYDRACRINA				
DIPTERA	57.32	73.60 (53)	651	27.09
CORIXIDAE				
NOTONECTIDAE				
COLEOPTERA				
AMPHIPODA	0.01	1.39 (1)	1	0.04
HIRUDINEA				
TRICHOPTERA	1.93	4.17 (3)	26	1.08
EPHEMEROPTERA	2.73	8.33 (6)	7	0.29
ODONATA	0.16	1.39 (1)	1	0.04
GASTROPODA	4.16	20.83 (15)	38	1.58
PELECYPODA	0.64	13.89 (10)	13	0.54
TERRESTRIAL INS				
EGGS	9.18	9.72 (7)	142	5.91
OTHER	7.22	11.11 (8)	143	5.95
n	72	72	2403	2403

July 85

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
OSTRACODA	1.95	18.46	(12)	34	1.66
CLADOCERA	5.97	18.46	(12)	860	41.97
COPEPODA	4.85	16.92	(11)	240	11.71
HYDRACRINA					
DIPTERA	56.09	78.46	(51)	522	25.48
CORIXIDAE	1.54	1.54	(1)	3	0.15
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA	1.54	3.08	(2)	2	0.10
HIRUDINEA					
TRICHOPTERA					
EPHEMEROPTERA	0.43	3.08	(2)	3	0.15
ODONATA					
GASTROPODA	0.91	4.62	(3)	6	0.29
PELECYPODA	0.34	4.62	(3)	12	0.59
TERRESTRIAL INS	2.41	4.62	(3)	24	1.17
EGGS	21.10	29.23	(19)	335	16.35
OTHER	2.87	10.77	(7)	8	0.39
n	65		65	2049	2049

August, years combined.

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE		NUMBER	% NUMBER
OSTRACODA	3.76	18.67	(28)	198	7.12
CLADOCERA	8.11	20.00	(30)	690	24.81
COPEPODA	4.06	26.00	(39)	433	15.57
HYDRACRINA					
DIPTERA	40.64	56.00	(84)	1115	40.09
CORIXIDAE	0.87	4.67	(7)	41	1.47
NOTONECTIDAE					
COLEOPTERA					
AMPHIPODA	2.49	4.67	(7)	31	1.11
HIRUDINEA					
TRICHOPTERA					
EPHEMEROPTERA	0.48	1.33	(2)	3	0.11
ODONATA					
GASTROPODA	9.46	12.67	(19)	66	2.37
PELECYPODA	4.54	10.00	(15)	48	1.73
TERRESTRIAL INS	2.77	4.67	(7)	11	0.4
EGGS	11.70	10.00	(15)	89	3.2
OTHER	11.17	12.00	(18)	56	2.01
n	150	150		2781	99.99

August 84

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE	NUMBER	% NUMBER
OSTRACODA	4.24	25.19 (33)	193	22.03
CLADOCERA	8.34	29.77 (39)	351	40.07
COPEPODA	3.87	35.88 (47)	425	20.82
HYDRACRINA				
DIPTERA	37.88	70.99 (93)	898	44.00
CORIXIDAE	1.00	7.63 (10)	41	2.01
NOTONECTIDAE				
COLEOPTERA				
AMPHIPODA	1.55	3.05 (4)	5	0.24
HIRUDINEA				
TRICHOPTERA				
EPHEMEROPTERA	0.55	2.29 (3)	3	0.15
ODONATA				
GASTROPODA	10.37	17.55 (23)	60	2.94
PELECYPODA	5.15	13.74 (18)	46	2.25
TERRESTRIAL INS	3.18	7.63 (10)	11	0.54
EGGS	11.37	13.74 (18)	44	2.16
OTHER	12.57	16.03 (21)	52	2.55
n	131	131	2041	2041

August 85

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE	NUMBER	% NUMBER
OSTRACODA	0.46	21.05 (4)	5	0.77
CLADOCERA	6.49	10.53 (2)	339	51.99
COPEPODA	5.34	26.32 (5)	8	1.23
HYDRACRINA				
DIPTERA	59.68	84.21 (16)	217	33.28
CORIXIDAE				
NOTONECTIDAE				
COLEOPTERA				
AMPHIPODA	8.97	21.05 (4)	26	3.99
HIRUDINEA				
TRICHOPTERA				
EPHEMEROPTERA				
ODONATA				
GASTROPODA	3.22	10.53 (2)	6	0.92
PELECYPODA	0.34	10.53 (2)	2	0.31
TERRESTRIAL INS				
EGGS	13.97	10.53 (2)	45	6.90
OTHER	1.51	15.79 (3)	4	0.61
n	19	19	652	652

October 84

PREY CATEGORIES	MEAN % DRY WT	% OCCURRENCE	NUMBER	% NUMBER
OSTRACODA	14.90	35.71 (5)	60	32.79
CLADOCERA	1.97	42.86 (6)	18	9.84
COPEPODA	0.87	42.86 (6)	20	10.93
HYDRACRINA				
DIPTERA	42.42	78.57 (11)	52	28.42
CORIXIDAE				
NOTONECTIDAE				
COLEOPTERA				
AMPHIPODA	1.06	14.29 (2)	4	2.19
HIRUDINEA				
TRICHOPTERA	18.06	21.43 (3)	14	7.65
EPHEMEROPTERA				
ODONATA				
GASTROPODA	7.14	7.14 (1)	9	4.92
PELECYPODA	4.79	7.14 (1)	3	1.64
TERRESTRIAL INS				
EGGS				
OTHER	8.78	14.29 (2)	2	1.09
n	14	14	183	183