Diet Ontogeny of Yellow Perch (*Perca flavescens*) in Northern Michigan Lakes

BIOS 569 - Practicum in Aquatic Biology

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ABSTRACT

Results from two northern Michigan lakes demonstrates that diets of yellow perch, *Perca flavescens*, are highly variable. This research suggests that changes in diet composition are related to age class, total length, and biomass of perch. Certain food items, such as chironomid larvae, are present in nearly all fish stomachs regardless of the age of the fish. Such items likely provide nutritional value that can be found in no other food item. Other items, including dipteran pupae and amphipods, are present only in younger fish and either fill a specific nutritional requirement for these fish or are selected for because of gape size. Fish prey and odonates make up a large proportion of the diet of older fish presumably when the perch are not limited by morphological factors.

INTRODUCTION

Fish generally display a large amount of variety in their diet. The diet of yellow perch, *Perca flavescens*, consists of a wide assortment of items depending on geographical location, season, and availability. In a study by Couey (1935) of 24 Wisconsin lakes, insects predominated in the diet of yellow perch but isopods were the primary food of a similar yellow perch population in Lake Opinicon in Ontario (Elrod et al., 1981). Feeding habits may vary from year-to-year within the same environment. For example, in another study conducted by Couey (1932), other fish comprised 90% of the food consumed by yellow perch, whereas in 1931, in the same lake, fish made up only 6.5% of the volume of food consumed with the majority of the diet being insects (Becker, 1983).

Bluegill and pumpkinseed sunfish demonstrate ontogenetic shifts that result from interspecific competition and morphological adaptation (Osenberg et al., 1988). Black surfperch (*Embiotoca jacksoni*) and striped surfperch (*E. lateralis*) show prey size selectivity based on gape limitations and foraging tactics. The tactic of picking prey from the benthos is gradually replaced by winnowing behavior, a change that may result in a prey-size selection shift (Schmitt and Holbrook, 1984).

A number of studies have attempted to relate diet shifts to different factors such as: light intensity (Jansen and Mackay, 1992), time of year (Anderson and Smith, 1971), and reproductive strategy (Hayes and Taylor, 1990). The present study examined perch populations in two lakes in the upper peninsula of Michigan and attempts to correlate diet with age, length, and weight. In Northern Wisconsin, near the proposed location of this study, young perch eat primarily zooplankton and then quickly change to a diet of insects. Fish do not become a major food item until perch reach 180 mm in length. Diets of large perch may include Diptera larvae, mayflies, caddisflies, dragonfly nymphs, and to a lesser extent, crayfish, oligochaetes, mollusks, and plant material (Becker, 1983).

MATERIALS AND METHODS

Study sites

The two study lakes were selected because of their accessibility and large perch populations. Morris Lake (ML) and Bay Lake (BL) are on the property of The University of Notre Dame Environmental Research Center in Gogebic County, Michigan. Both lakes have low nitrate and phosphate content, low alkalinity and conductivity, as well as similar temperature and dissolved oxygen profiles. Morris Lake has an area of 4.9 hectares and a muddy bottom that gives rise to extensive macrophyte growth including *Elodea* and *Potamogeton*. It sustains bluegill (*Lepomis macrochirus*), pumpkinseed sunfish (*L. gibbosus*), yellow perch and a large population of northern pike (*Esox luscius*). Bay Lake is considerably larger, with an area of 68.9 hectares. It has a small littoral zone and its fish population includes both smallmouth bass (*Micropterus dolomieu*) and largemouth bass (*M. salmoides*), rockbass (*Ambloplites rupestris*), bluegill, pumpkinseed sunfish, yellow perch and some northern pike (UNDERC, 1992).

Field procedures

Perch were collected from ML and BL on 25 days between May 17, 1993 to July 21, 1993. Four methods of collection were employed: hook and line sampling, fyke netting, minnow traps, and electrofishing. Hook and line sampling was the primary method used at the onset of the project. Baiting with night crawlers and using a bobber was successful in BL and continued to be the primary method of collection throughout the summer. Minnow traps were used to collect young-of-the-year perch. Fyke netting was expected to be the most successful collection method. However, the catch rate was very low and it was determined to be an inefficient method in this lake. A wide range of sizes and ages of perch were collected. A total of 81 yellow perch were collected in BL.

In ML, hook and line sampling was less successful than in BL. The high numbers of northern pike present in the lake were readily sampled using worms even though this sit-and-wait predator is more likely to take moving bait. Fyke netting in areas of the shoreline with submersed structure yielded a few large perch but was inefficient for the time, effort, and manpower required.

On July 8, 1993, ML was electroshocked. In a period of four hours, over one hundred fish were collected. At the completion of this study, 149 yellow perch were collected from Morris Lake.

The data collection process for each perch was consistent throughout the study. Upon collection, fish were immediately measured using a standard measuring board and weighed using one of two Pesola spring scales. Scale samples for aging were taken ventral to the lateral line below the operculum. Caudal fins were marked with a small hole punch to distinguish recaptures and prevent reanalysis. Perch stomachs were pumped using a small, pressurized (4-5 liters) chemical sprayer filled with tap water. The spray nozzle was fitted with a pipet tip to achieve a directed spray. The tip was attached to the end of the nozzle by wrapping the junction with Parafilm to form a tight seal. Stomach contents were collected using a gastric lavage technique (Light et.al., 1983) and were pumped into a collection jar through a funnel made from a milk jug. Upon completion of data collection, perch were released in the water. At the end of the day, the sample was washed in a zooplankton net and then stored in 70% ethanol.

On the evening of the electrofishing portion of the experiment, the stomach contents were pumped directly into the bucket of a Wisconsin plankton net with 63 micron mesh screening and washed with ethanol into a vial. Fish were held in a holding pen set up within ML until completion of electrofishing. At the end of the collection period, these fish were released.

Laboratory procedures

The identification and quantification of stomach contents were analyzed under a dissecting microscope. The following items were identified from perch stomach contents: Anisoptera, Zygoptera, chironomid larvae, amphipods, Ephemeroptera, Trichoptera, dipteran pupae, mollusks, fish, and leeches. Odonates (Anisoptera and Zygoptera) were easily recognized by their labium which was one of the last parts to be digested. The caudal lamellae of anisopterans were also useful indicators. Ephemeroptera were distinguished by the presence of three caudal cerci and their gills. Chironomid larvae and dipteran pupae (including chironomid pupae) were counted

The population structure shown in Fig. 1 is probably representative of the actual size structure in the lake. During electroshocking, an attempt was made to collect all perch regardless of size. Perch in ML are heavily preyed upon by northern pike. Many of the perch collected had bites taken out of their caudal fin, some others had bloody tooth marks in their flesh. This predation pattern accounts for the high number of young-of-the-year perch and proportionately fewer older fish.

Figures 3-7 attempt to identify any age-specific size differences. The average lengths in all comparable age classes in the two populations are similar. This suggests that there may not be much variability among perch length in different lakes in close geographic regions, a theory suggested by the research of Willis et al.' (1991).

The average weights of 0+, 1+, 2+, and 3+ in both lakes are similar. A discrepancy in the weights occurs in the 4+ fish. An even greater difference occurs between the 5+ age classes in the two lakes. This suggests that within the same age class, there is the potential for variance in weights of perch in different lakes. Willis et al. (1991) discussed the difficulty in comparing weight values across different populations, especially for small fish. They attempted to formulate a standard weight equation for comparing the weights of perch in different geographical regions. The relative weight of yellow perch (found by dividing the actual weight of the fish by a standard weight for a fish of that length and multiplying the quotient by 100) in Wisconsin or Michigan, according to their study, is always less than 100. This means that the weight of perch in this geographical area is less than the standard weight for perch of that length.

Diet composition

Analyses of stomach contents of perch in ML showed distinct diet ontogeny. Trichoptera and Ephemeroptera were present in nearly all of the age classes but did not consistently comprise a substantial proportion of the diet. Trichoptera appeared in all but the 5+ age class, reached a maximum in 6+ at 18.7%, but generally was less than 10%. Similarly, Ephemeroptera never rose above 20% and was usually under 10%. These two food items contribute to the diet of perch but explanations concerning preference cannot be proposed because prey availability was not assessed. However, judging from the number of both larval and adult caddisflies and mayflies, they were likely very abundant.

Dipteran pupae made up 21% of the diet of the 0+ fish and decreased in importance in subsequent age classes until they disappeared altogether in the 4+ age class. Amphipods were present in low numbers in all but the 6+ and 7+ age class. Mollusks were present in low numbers in all but 5+ and 7+ age class but never exceeded 10% of the diet (Figure 16 represents the stomach contents of only one 7+ fish and does not provide a good basis for comparison). Neither crustaceans or mollusks were a major proportion of the diet. Leeches appeared in stomach contents occasionally and can not be considered a major proportion of the diet. Chironomid larvae were the only food item that appeared in large proportions in all of the age classes. They comprised from 30% to 50% of all perch diets.

Odonates appeared in the stomach contents of perch in all ages except 7+ and increased from 5% in 0+ to around 20% of the diet of 3+-6+ fish. Jansen and Mackay (1992), in their study of perch foraging and diel periodicity in Alberta, note that amphipods and chironomids made up a large percentage of the diet of perch ranging from 90-250 mm. They noted that Trichoptera appeared in many stomachs but varied temporally. They do not refer to odonates. Perhaps odonates were preyed upon in ML due their relative abundance in the benthos. It is beyond the scope of this study to determine whether or not perch select for this food item or if they eat it only because it is readily available.

Fish did not appear as part of the diet of perch until the age of 3+ but from that point on were a significant contributor to diets. This is consistent with the findings of Hayes and Taylor (1990) who found that fish prey do not become a principal food item until perch reach 150-200 mm. They concluded that fish replaced benthos in the diet when perch reach this critical length. However, even at this length, in the present study fish did not replace benthos as the preferred food item but instead complements the diet of benthic organisms.

The few observations of stomach contents from BL exhibit similar trends to those established in ML. Fish are present in the diets of 3+ and 4+ perch, making up 33% and 22%, respectively, and absent in the diets of 1+ age class. Odonates are present in all three age classes and make up a greater proportion of the diet in older fish.

A large amount of plant material was observed in 90% of all stomachs. The proportional contribution was not quantified. Only a small amount of this material was green whereas the majority was brown. Most of the plant material appeared to be *Potamogeton* and *Elodea*. It is likely that the brown plant material has settled to the lake bottom and was ingested incidentally when the perch is feeding on benthos. Regardless of whether or not the perch select for this material, they do consume it, and in great quantities. This suggests that even if only a small fraction of it is digested, it is likely to contribute to the overall nutrition of the fish. It would be interesting determine what benefit the perch gain, if any, from this potentially incidental consumption of plant material.

Results from a study by Hanson and Leggett (1986) show that when perch are stocked with a pumpkinseed sunfish, a superior competitor, perch show no change in gut fullness but do demonstrate a change in the type of food item eaten. In their study, microcrustaceans comprised 30-53% of the diet of perch reared with pumpkinseed but <1% of the diet of perch reared alone. Perch alter their diet to exploit the food base (Hanson and Leggett, 1986). In ML, perch may compete with pumpkinseed sunfish and northern pike which could result in perch eating energetically inferior food. Perch diet could be affected not only by weight and length trends but also by interspecific competition in ML.

Gape size can be an important factor influencing the diet ontogeny of yellow perch (Schael et al. 1991). Prey is expected to increase with gape size. A fish with a large gape size could consume smaller food items but chooses larger items, such as fish prey. This suggests that food items found in the stomachs of larger fish are items preferred by the fish. Small chironomid larvae, however, continue to comprise a large proportion of the diet of large fish and leads to the conclusion that perch rely on this food item regardless of the small size. Chironomid larvae likely offer some nutritional benefit that cannot be filled by another food item. However, chironomid larvae, due to their availability and small size, are likely to be consumed when the perch ingest random mouthfuls of benthos, a foraging tactic termed winnowing. This could also account for the frequency with which they appear in the stomach contents.

Results suggest that perch do have a diet ontogeny which correlate to age, length, and weight. Some prey groups, including chironomids, are found throughout the life cycle, while other items, such as amphipods and minnows, are found only in the early and late stages, respectively. These results generally are consistent with those of Jansen and Mackay (1992) as well as Hayes and Taylor (1990) with a few variations.

ACKNOWLEDGEMENTS

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FIGURE LEGENDS

Figure 1. Total number of perch caught in each age class in Morris Lake.

Figure 2. Total number of perch caught in each age class in Bay Lake.

Figure 3. The average length of all perch caught in a given age class in Morris Lake (vertical bars represent standard deviation).

Figure 4. The average length of all perch caught in a given age class in Bay Lake (vertical bars represent standard deviation).

Figure 5. The average weight of all perch caught in a given age class in Morris Lake (vertical bars represent standard deviation).

Figure 6. The average weight of all perch caught in a given age class in Bay Lake (vertical bars represent standard deviation).

Figure 7. Average weight v. average length for perch in Morris Lake (horizontal and vertical bars represent standard deviation).

Figure 8. Average weight v. average length for perch in Bay Lake (horizontal and vertical bars represent standard deviation).

Figure 9. Diet composition for 0+ perch (n=9) in Morris Lake.

Figure 10. Diet composition for 1+ perch (n=19) in Morris Lake.

Figure 11. Diet composition for 2+ perch (n=9) in Morris Lake.

Figure 12. Diet composition for 3+ perch (n=19) in Morris Lake.

Diet ontogeny...yellow perch

Figure 13. Diet composition for 4+ perch (n=14) in Morris Lake.

Figure 14. Diet composition for 5+ perch (n=10) in Morris Lake.

Figure 15. Diet composition for 6+ perch (n=6) in Morris Lake.

Figure 16. Diet composition for 7+ perch (n=1) in Morris Lake.

Figure 17. Diet composition for 1+ perch (n=3) in Bay Lake.

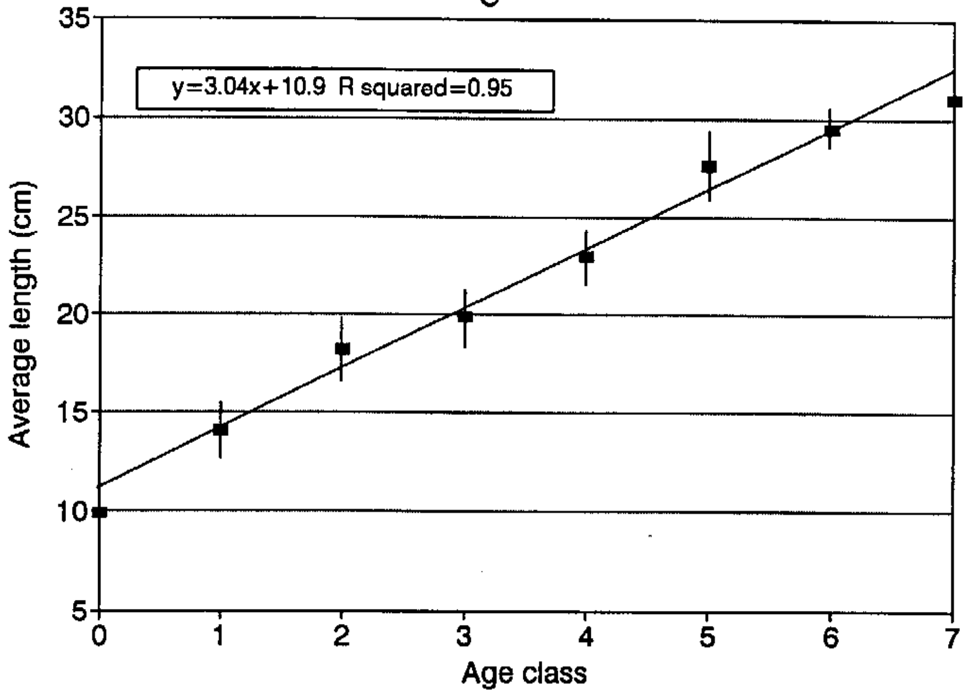
Figure 18. Diet composition for 3+ perch (n=4) in Bay Lake.

Figure 19. Diet composition for 4+ perch (n=5) in Bay Lake.

Fig. 1

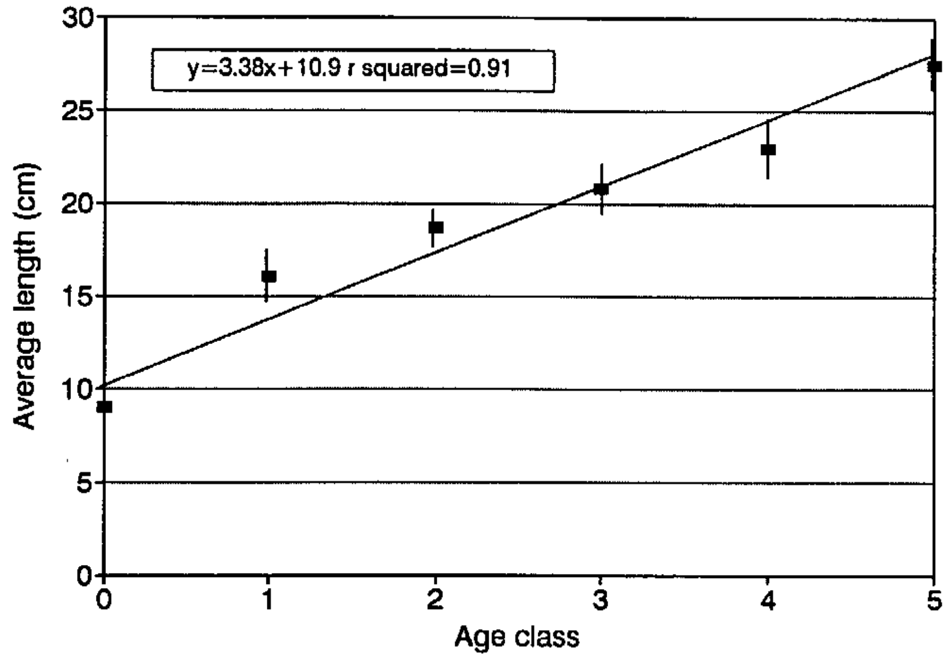
Fig. 2

Fig. 3



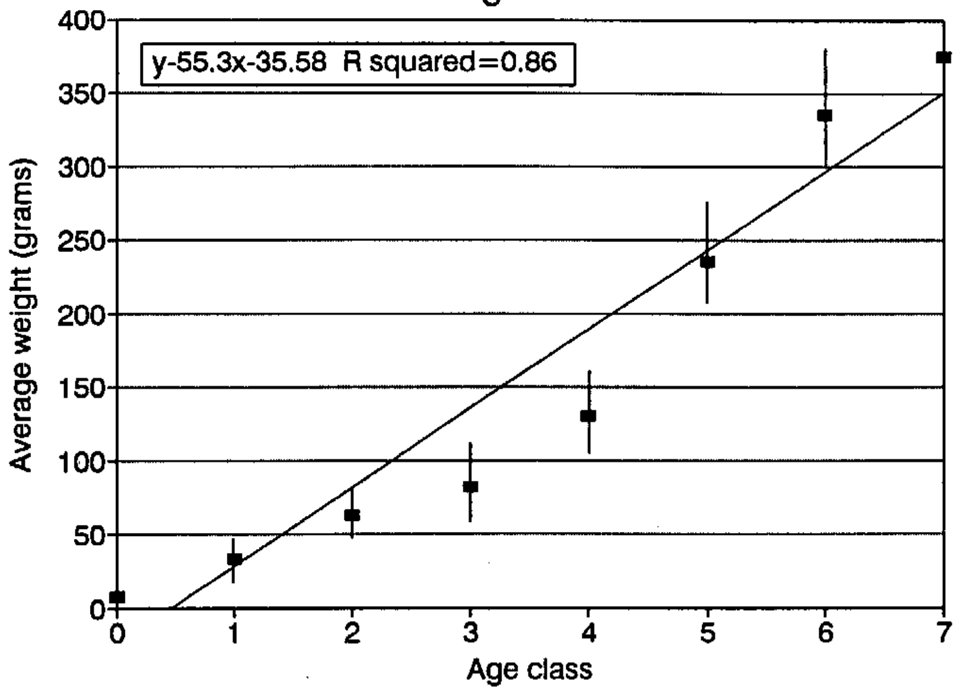
y=3.04x+10.9 R squared=0.95
Average length (cm)
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
Age class

Fig. 4



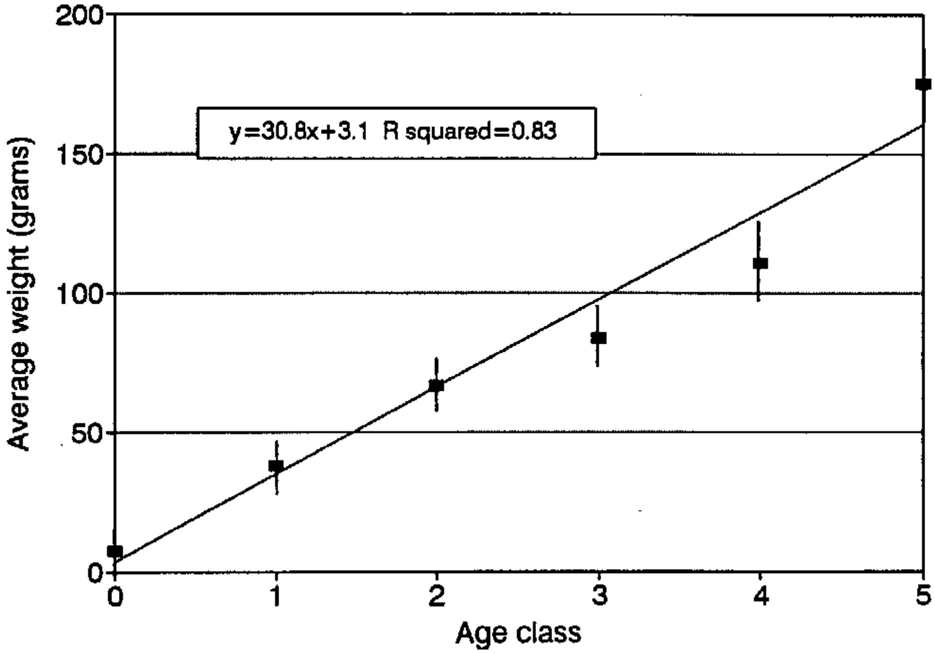
y=3.38x+10.9 r squared=0.91
30
25
20
15
10
5
0
Average length (cm)
0
1
2
3
4
5
Age class

Fig. 5



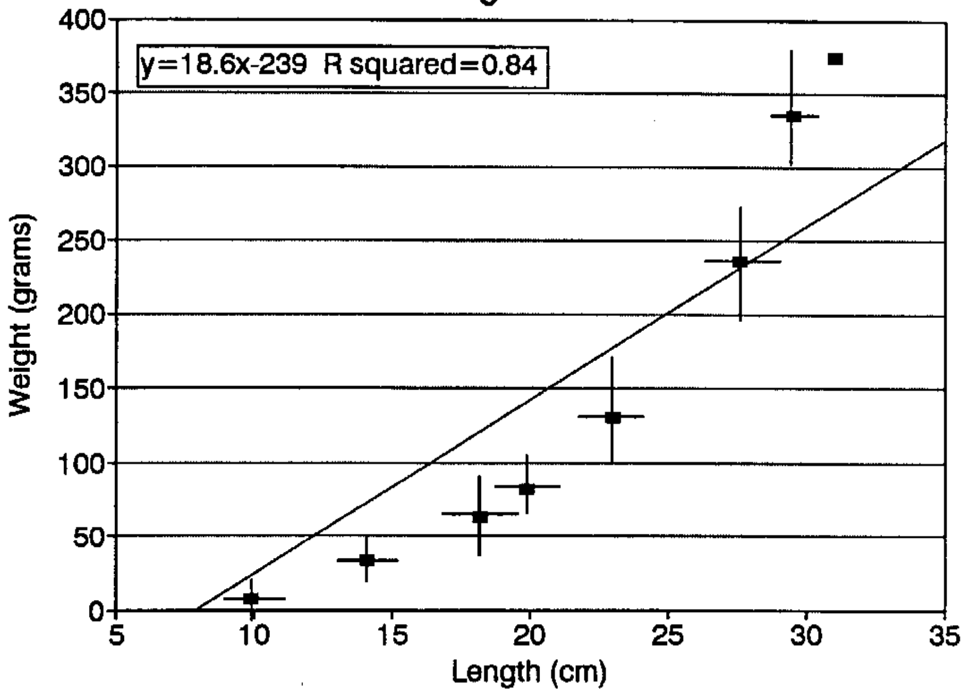
y-55.3x-35.58 R squared=0.86
400
350
300
250
200
150
100
50
0
Average weight (grams)
0
1
2
3
4
5
6
7
Age class

Fig. 6



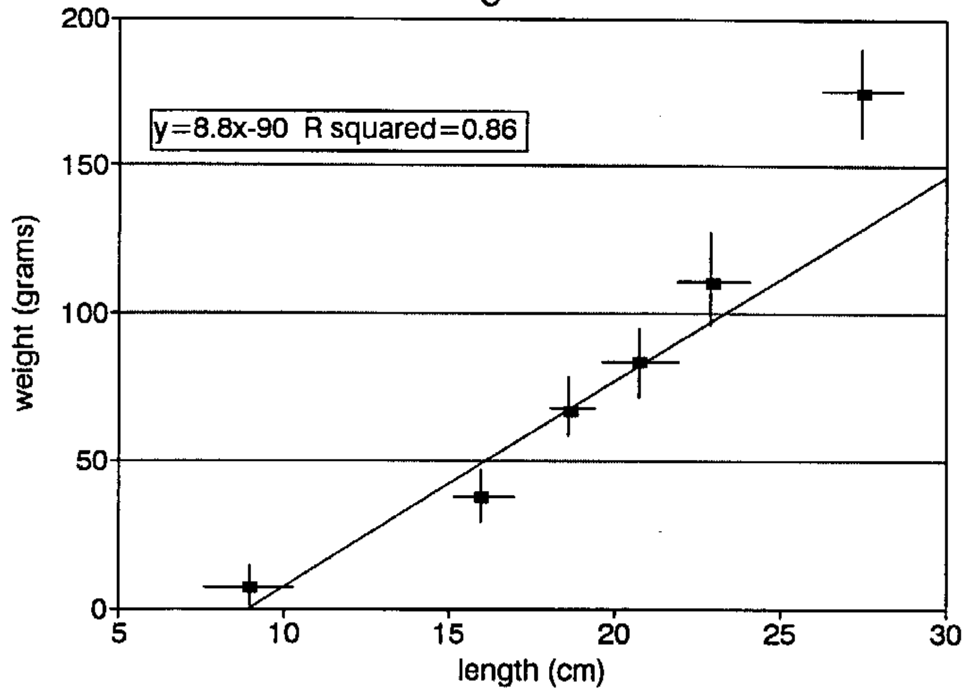
200
150
100
50
0
Average weight (grams)
y=30.8x+3.1 R squared=0.83
0
1
2
3
4
5
Age class

Fig. 7



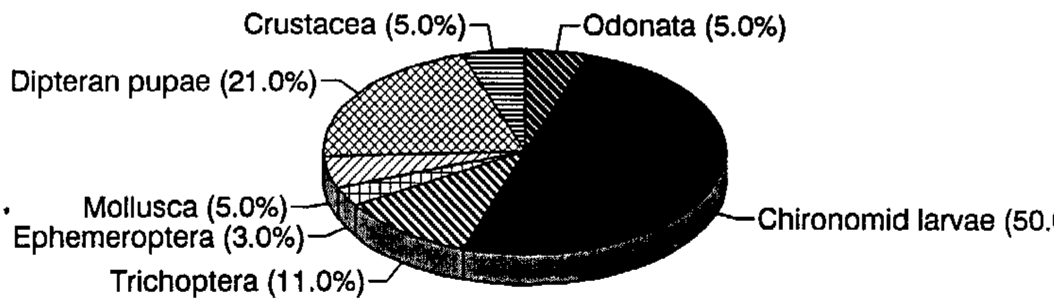
y=18.6x-239 R squared=0.84
400
350
300
250
200
150
100
50
0
Weight (grams)
5
10
15
20
25
30
35
Length (cm)

Fig. 8



y=8.8x-90 R squared=0.86
200
150
100
50
0
weight (grams)
5
10
15
20
25
30
length (cm)

Fig. 9



Crustacea (5.0%)
Odonata (5.0%)
Dipteran pupae (21.0%)
Mollusca (5.0%)
Ephemeroptera (3.0%)
Trichoptera (11.0%)
Chironomid larvae (50.

Fig. 10

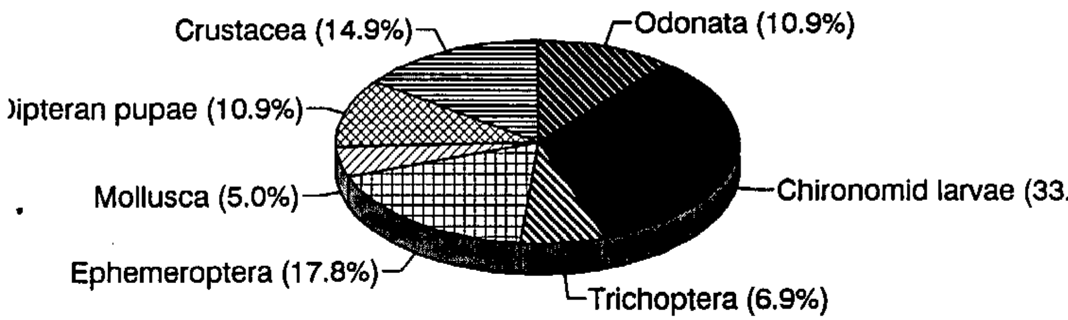
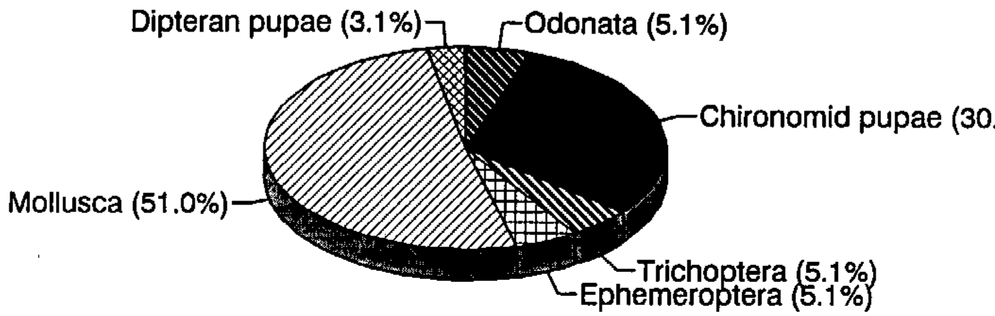

Crustacea (14.9%)
Odonata (10.9%)
)ipteran pupae (10.9%)
Chironomid larvae (33.
Mollusca (5.0%)
Ephemeroptera (17.8%)
Trichoptera (6.9%)

Fig. 11



Dipteran pupae (3.1%)
Odonata (5.1%)
Chironomid pupae (30.
Mollusca (51.0%)
Trichoptera (5.1%)
Ephemeroptera (5.1%)

Fig. 12

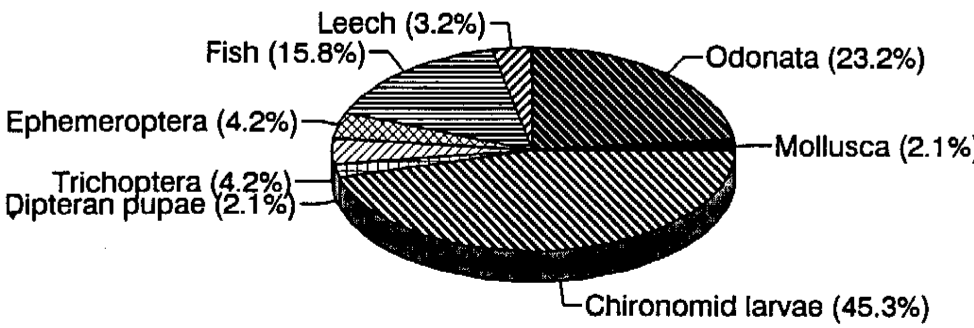

Leech (3.2%)
Fish (15.8%)
Odonata (23.2%)
Ephemeroptera (4.2%)
Mollusca (2.1%)
Trichoptera (4.2%)
Dipteran pupae (2.1%)
Chironomid larvae (45.3%)

Fig. 13

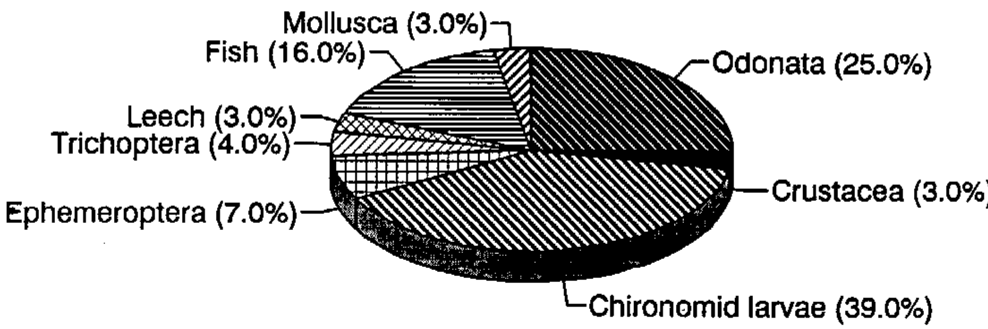
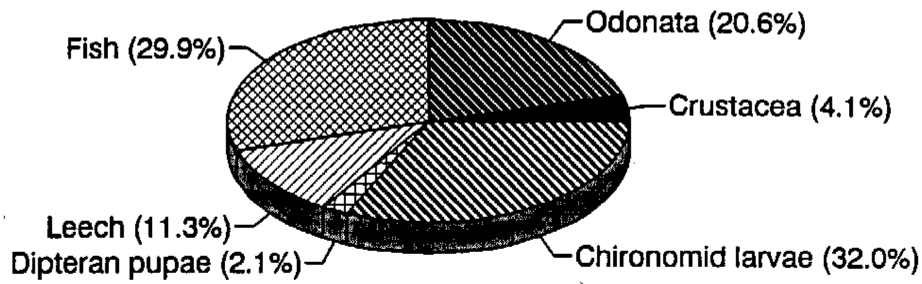
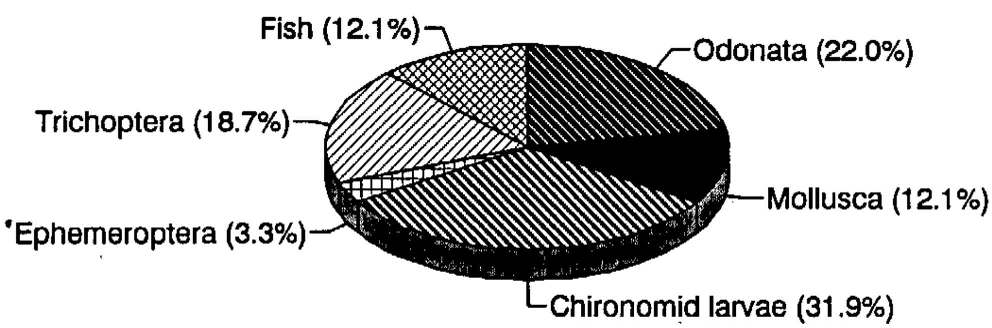

Mollusca (3.0%)
Fish (16.0%)
Odonata (25.0%)
Leech (3.0%)
Trichoptera (4.0%)
Crustacea (3.0%)
Ephemeroptera (7.0%)
Chironomid larvae (39.0%)

Fig. 14



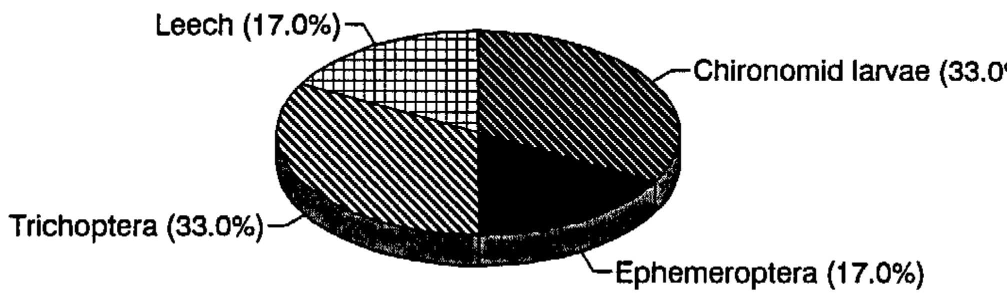
Fish (29.9%)
Odonata (20.6%)
Crustacea (4.1%)
Leech (11.3%)
Dipteran pupae (2.1%)
Chironomid larvae (32.0%)

Fig. 15



Fish (12.1%)
Odonata (22.0%)
Trichoptera (18.7%)
Mollusca (12.1%)
Ephemeroptera (3.3%)
Chironomid larvae (31.9%)

Fig. 16



Leech (17.0%)
Chironomid larvae (33.0
Trichoptera (33.0%)
Ephemeroptera (17.0%)

Fig. 17

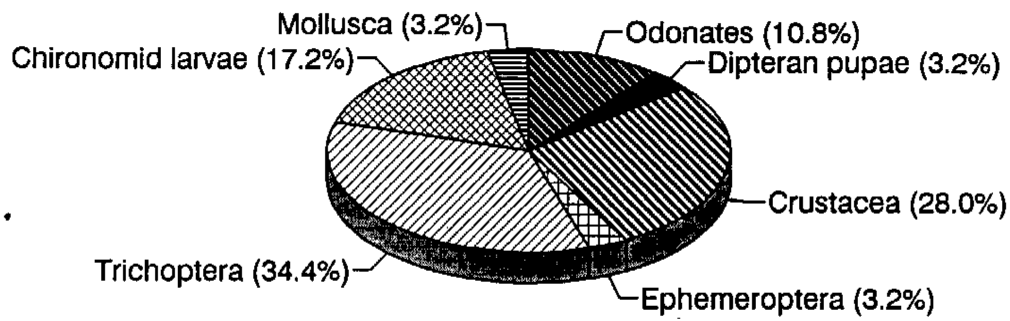
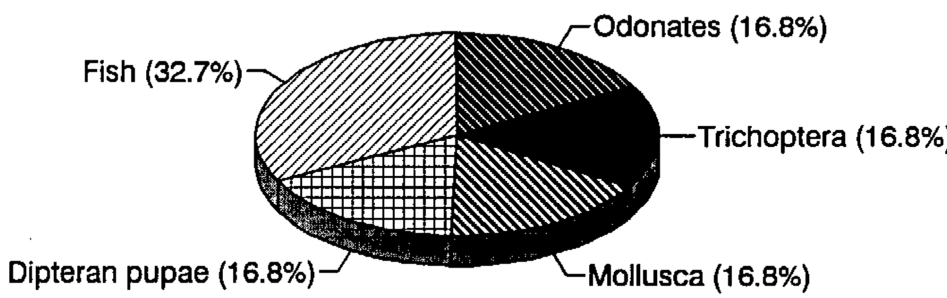
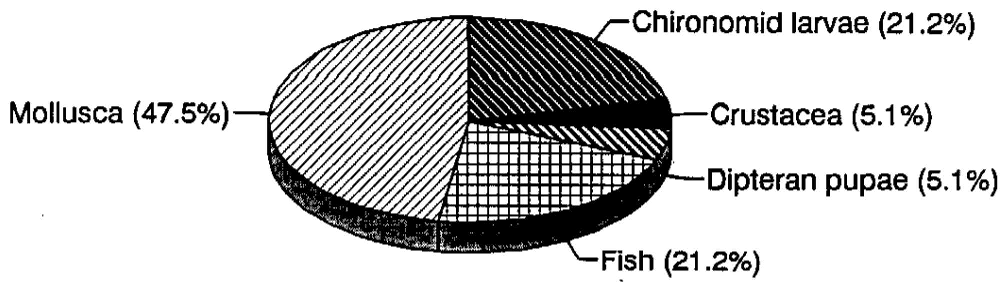

Mollusca (3.2%)
Odonates (10.8%)
Chironomid larvae (17.2%)
Dipteran pupae (3.2%)
Crustacea (28.0%)
Trichoptera (34.4%)
Ephemeroptera (3.2%)

Fig. 18



Odonates (16.8%)
Fish (32.7%)
Trichoptera (16.8%)
Dipteran pupae (16.8%)
Mollusca (16.8%)

Fig. 19



Chironomid larvae (21.2%)
Mollusca (47.5%)
Crustacea (5.1%)
Dipteran pupae (5.1%)
Fish (21.2%)