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Food habits of Salmo trutta and Salvelinus fontinalis (Pisces: Salmonidae) in relation to seasonal changes and mitigative liming effects in Dogway Fork of the Cranberry River, West Virginia.

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Food habits of *Salmo trutta* and *Salvelinus fontinalis* (Pisces: Salmonidae) in relation to seasonal changes and mitigative liming effects in Dogway Fork of the Cranberry River, West Virginia.

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ABSTRACT

Dogway Fork, a tributary of the Cranberry River in West Virginia, is acidic due to acid precipitation and poorly buffered soils. This study is part of a long-term investigation involving the effects of continuous limestone neutralization on the fishes and benthos of an acid stream. Prior to treatment in 1988, the stream had a pH of 4.5 and there were no fish present. Since treatment began, the pH of the stream has risen to 6.8. Nine species of fish have been collected and six species have reproduced following the improvement in water quality. Densities of specific acid-sensitive benthic macroinvertebrates have also increased after treatment. For the food habit study, brook and brown trout were collected seasonally by electrofishing and stomach contents were removed by flushing with a bulb pipette. Benthic samples were collected in duplicates using a modified Surber sampler. Statistical analyses were done to determine which taxa were the most abundant or most common in the diet and which taxa were most preferred by both trout species. Ivlev's electivity index was used to determine which taxa each trout species was selecting for in the diet. Percent similarity among seasons and Morisita's and Horn's indices were calculated to determine the overlap in diet between seasons for brook and brown trout. Chironomid midges were the most abundant, common, and preferred taxon by both trout species in the spring season. Mayfly nymphs and hymenopterans were the most abundant components of the diet of both trout species in the summer and fall seasons. Mayfly nymphs, stonefly nymphs, and caddisfly larvae were the most important food items in the winter diets of both trout. Nematodes were also very abundant in the brook trout diet in the fall and winter. Mayfly nymphs and hymenopterans, as a whole, appeared to be the most important food items in the diet of both trout species for the year. Chironomid midges also appeared to be important components of the diet of both trout species.

Many of the organisms found within the diet of both trout species were not found in Dogway Fork before treatment began. Based on similarities with other studies, it appeared that mitigative liming changed the water quality allowing more species of macroinvertebrates to inhabit the stream and be utilized by brook and brown trout as food.

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CHAPTER I

INTRODUCTION

In 1985, the West Virginia Division of Natural Resources (WVDNR) in cooperation with the United States Fish and Wildlife Service (USFWS) agreed to acquire information on the mitigation of acidified waters (Zurbuch et al. 1996). The agreement was part of a national effort known as the Acid Precipitation Mitigation Program (APMP) which determined treatment goals and scientific methods (Schreiber 1996). Dogway Fork was chosen as a study site because it met prerequisites for the USFWS study and because it is a major tributary of the Cranberry River. One of the major objectives of the APMP was to test the effectiveness of stream dosing and effects on fish and macroinvertebrate populations (Zurbuch et al. 1996). Menendez et al. (1996) estimate that 25 percent (625 km) of streams in West Virginia with native brook trout have been degraded by acid deposition or are at risk.

Prior to limestone treatment of Dogway Fork in 1988, no fish species were found and the pH was around 4.5. After treatment began, nine species of fish have been collected and six of those species are known to be reproducing (Table 1) (Menendez and Clayton 1999). Brook and brown trout are the two most abundant fish species and their biomass has increased greatly since treatment began. In 1989, brook trout biomass was 3.4 kg/ha and increased to 37.6 kg/ha in 1998. In 1989, brown trout biomass was 0.6 kg/ha and increased to 14.1 kg/ha in 1998. Brook trout comprised 65.5 percent and brown trout comprised 24.5 percent of the total numbers of fish collected in 1998 (Menendez and Clayton 1999). Only 36 taxa of macroinvertebrates were collected from

Table 1. Fish species collected and reproducing after treatment (Menendez and Clayton 1999).

	Phase I				Phase II			Phase III			
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Reproducing
Brook Trout *(Salvelinus fontinalis)*	X	X	X	X	X	X	X	X	X	X	X
Brown trout *(Salmo trutta)*	X	X	X	X	X	X	X	X	X	X	X
Rainbow trout *(Oncorhynchus mykiss)*	X	X	X	X	X		X	X[1]	X	X	X
Tiger trout[2]									X		
Creek Chub *(Semotilus atromaculatus)*	X	X	X	X	X	X	X				X
White sucker *(Catostomus commorsoni)*	X	X	X	X	X						
Fantail darter *(Etheostoma flabellare)*	X	X	X	X	X	X	X	X	X	X	X
Blacknose dace *(Rhinichthys atratulus)*			X	X	X	X	X		X	X	X
Longnose dace *(Rhinichthys cataractae)*			X								
Rosyside dace *(Clinostomus funduloides)*							X				

1/ Collected above Station T-1. Not collected during regular population sampling.

2/ Brook trout x Brown trout hybrid.

Dogway Fork in the pretreatment years 1986 -1988. During Phase I treatment with two limestone drums operating (1989-1992), 64 taxa were collected; 46 from control segment and 58 from the treated segment (Menendez and Clayton 1999). During Phase II treatment with three limestone drums operating (1993-1995), 64 taxa were collected; 40 from control segment and 60 from the treated segment (Menendez and Clayton 1999). During Phase III treatment with three limestone drums operating and instream limestone sand treatment (1996-1998), 64 taxa were collected; 58 from the treated segment (three drums) and 50 from the original control segment that was treated with limestone sand at the end of Phase II (Menendez and Clayton 1999).

Many studies have looked at the diets and feeding habits of both brook and brown trout (Bridcut and Giller 1995, Frankiewicz et al. 1993, Magnan et al. 1994, McLaughlin et al. 1994, and Sagar and Glova 1995). This study differs from previous ones in that it includes the effects of mitigative liming on food availability. The objectives of this study were: (1) to analyze fish stomach contents during four seasons and determine changes due to availability and variability of macroinvertebrates, (2) to compile quantitative and qualitative data on the macroinvertebrates during the four seasons, and (3) to determine the major diet components of brook and brown trout in a stream treated with limestone.

CHAPTER II

REVIEW OF THE LITERATURE

Essential information to maintain a stable stream trout population is to know what foods are present and utilized by trout. Maintaining a stable water chemistry is also essential to trout survival. These two factors have been the most frequently studied in relation to trout streams. The review of literature for this study focused on the research that has been related to feeding habits and diet variability of brook and brown trout.

Brown trout commonly prey on insect larvae, crustaceans, frogs, small fish, and fish eggs (Stauffer et al. 1995). Some larger brown trout have even been known to eat small mammals and turtles (Becker 1983). Brown trout are primarily nocturnal feeders, but do feed during the day as well. They are voracious feeders and are commonly known to out compete brook trout for food (Dewald and Wilzbach 1992, Waters 1983, and Fausch and White 1981). Brook trout are almost entirely insectivores feeding on adult and immature aquatic insects, terrestrial insects, and crustaceans. Larger brook trout have been known to eat small fish (Ricker 1932). They are also voracious feeders, but usually do not compete well against other trout such as browns and rainbows (DeWald and Wilzbach 1992, Moore et al. 1983).

Cada et al. (1986) examined the feeding preference of rainbow and brown trout in southern streams during the summer and fall. In the early summer, they found that mayflies (Ephemeroptera) and caddisflies (Trichoptera) comprised over half of the brown trout diet. In late summer, hymenopterans comprised one-fifth and mayflies and caddisflies together comprised one-fourth of the total diet of brown trout. The fall diet was very similar to early summer with mayflies and caddisflies comprising 40 percent of the diet. Terrestrial hymenopterans were the most preferred taxa and aquatic midges (Diptera) were the most avoided taxa in the diet during the summer and fall.

Tebo and Hassler (1963) studied the food of brook, brown, and rainbow trout from streams in western North Carolina. They found that various terrestrial insects, caddisfly larvae, and mayfly nymphs were the most abundant items in the diet of brook trout, comprising over 85 percent of the total for the months of April through August. Terrestrial insects and aquatic adults comprised over 51 percent of the total organisms consumed indicating that brook trout feed equally on surface and subsurface foods during those months. Terrestrial beetles (Coleoptera), larval caddisflies, mayfly nymphs, and snails (Gastropoda) were the most abundant organisms in the diet of brown trout comprising 82 percent of the total diet. Terrestrial insects and aquatic insect adults made up 54 percent of the total diet illustrating their importance whereas immature aquatic insects comprised only 26 percent of the total diet, suggesting that brown trout prefer to feed on surface foods during that time of the year. Of the aquatic foods consumed, the most active or exposed individuals seemed to be the most frequent.

In a similar study on brook trout in a Colorado stream, Allen (1981) found that larval and emerging mayflies and midges dominated the diet in the months of June and July. The diet shifted toward surface drift and terrestrial insects for the months of August and September. His assumptions were similar to those of Tebo and Hassler (1963) in that the more active and visible an organism was, the greater the chance of it being consumed.

Duffield and Nelson (1993) studied the seasonal changes of the stonefly (Plecoptera) component of brown trout in a stream in Maryland. They found that in the months of December through March stoneflies comprised an average of 60 percent of the diet of brown trout. These findings demonstrated the importance of stoneflies in the winter diets of brown trout.

Duffield and Nelson (1998) also studied the stonefly component of brook trout in a subalpine stream in Wyoming in the months of May through August. They found that stoneflies constituted over 10 percent of the total diet of brook trout during the summer. While their study focused on stoneflies, they also found that midges comprised over 57 percent, mayflies comprised over 8 percent, and caddisflies comprised 6 percent of the total diet. Terrestrial beetles, hymenopterans, and hemipterans were also found to be most prevalent in the diet in the months of July and August. Midges were the most abundant food items, but they might not be the most important dietary component due to their small size in terms of biomass.

Hunt (1975) reviewed the feeding habits of salmonids (trout). He found that during particular times of the year, especially late summer and autumn, terrestrial insects constituted as much as 35 percent of the diet and played a very important role in the diet of trout.

Redd and Benson (1962) found that caddisflies were the most abundant organisms in the diet of brook trout throughout the year. They also found, from July to September, that terrestrial and emergent organisms composed from 59 to 80 percent of the organisms consumed. They stated that this could be expected since most stream insects emerge during the summer.

CHAPTER III

TAXONOMY AND DISTRIBUTION

Taxonomy

The genus *Salmo* currently includes the Atlantic salmon, brown trout, and other European trout species. It originally included many species of Pacific trout, but Smith and Stearley removed those in 1989. The only *Salmo* species occurring in West Virginia is the brown trout (*Salmo trutta*). The generic name *Salmo* is Latin for "Atlantic salmon" and the specific name *trutta* is Latin for "trout" (Etnier and Starnes 1993). Distinguishing characteristics for brown trout include black spots on the top and sides of the head and body and on the dorsal and adipose fins as well as brick red spots on the lower sides of the body (Fig. 1) (Etnier and Starnes 1993). Brown trout generally obtain average lengths of 35 to 40 cm and average weights of 5 to 10 kg.

The genus *Salvelinus* includes the chars and many char-like fish. The only *Salvelinus* species in West Virginia is the brook trout (*Salvelinus fontinalis*). The generic name *Salvelinus* is a derivation of the vernacular name for "char" and the specific name *fontinalis* is Latin for "of springs" (Etnier and Starnes 1993). Distinguishing characteristics for brook trout include worm-like vermiculations on the back, small pale red spots on the sides of the body, and white margins on the anterior portions of the pectoral, pelvic, and anal fins (Fig. 2) (Etnier and Starnes 1993). Brook trout generally obtain average lengths of 30 cm and average weights of 1 to 2 kg.

Figure 1. Brown trout (Internet, see references).

Figure 2. Brook trout (Internet, see references).

Distribution

Brown trout are native to Euro[illegible] have widely been introduced throughout the world [illegible] Brown trout are now distributed throughout the northern Unite[illegible] found in the mountains of West Virginia (Fig. 3). In West Virginia, finger[illegible] as catchable brown trout have been stocked intensively, especially in the [illegible] of the state (Stauffer et al. 1995).

Brook trout are native to eastern [illegible] are found in the mountains of West Virginia (Fig. 4). Some hatchery [illegible] catchable size brook trout are also stocked into West Virginia waters that [illegible] natural populations (Stauffer et al. 1995). Exotic introductions and reduc[illegible] continually reduce their range. Brook trout are now [illegible] northeastern United States (Ensler and Starnes 1995).

Habitat

Brook and brown trout occu[illegible] habitats are cold mountain streams and rivers with te[illegible] 18°C (Trautman 1981). These streams generally have a high[illegible] and a pH of around 6.5 to 7.0, however this pH range is not co[illegible] trout streams. The substrate is composed of boulders an[illegible] riffle areas and deeper pool areas.

Distribution

Brown trout are native to Europe and western Asia, but have widely been introduced throughout the world (Etnier and Starnes 1993). Brown trout are now distributed throughout the northern United States and are found in the mountains of West Virginia (Fig. 3). In West Virginia, fingerlings as well as catchable brown trout have been stocked intensively, especially in the eastern part of the state (Stauffer et al. 1995).

Brook trout are native to eastern North America and are found in the mountains of West Virginia (Fig. 4). Some hatchery fingerlings and catchable size brook trout are also stocked into West Virginia waters that cannot sustain natural populations (Stauffer et al. 1995). Exotic introductions and reductions in water quality continually reduce their range. Brook trout are now being introduced to much of the northwestern United States (Etnier and Starnes 1993).

Habitat

Brook and brown trout occur in similar habitats. Common habitats are cold mountain streams and rivers with temperatures that rarely exceed 18°C (Trautman 1981). These streams generally have a high level of dissolved oxygen and a pH of around 6.5 to 7.0, however this pH range is not common in West Virginia brook trout streams. The substrate is composed of boulders and cobble with shallow riffle areas and deeper pool areas.

Figure 3. Distribution of brown trout in West Virginia (Stauffer et al. 1995).

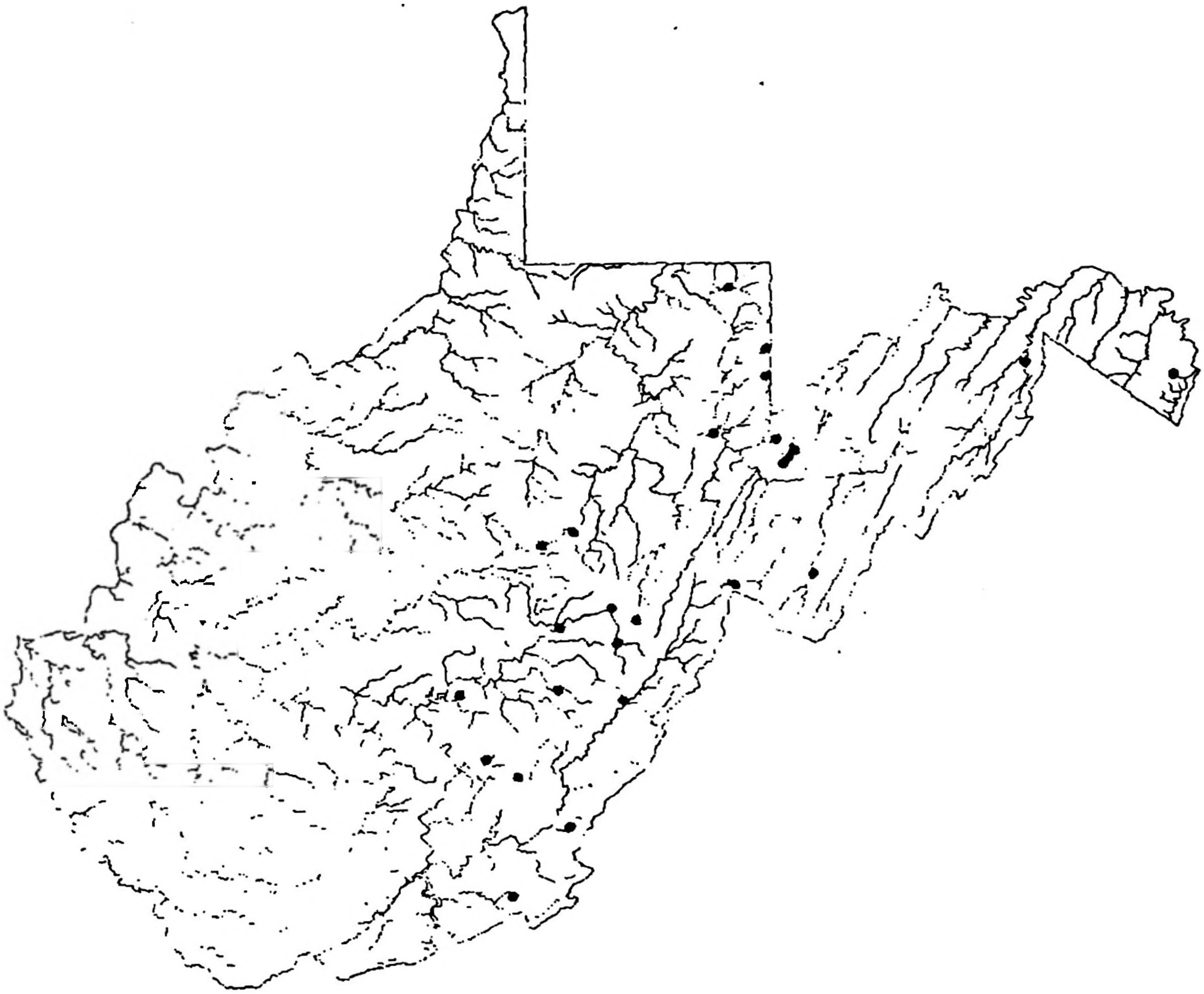
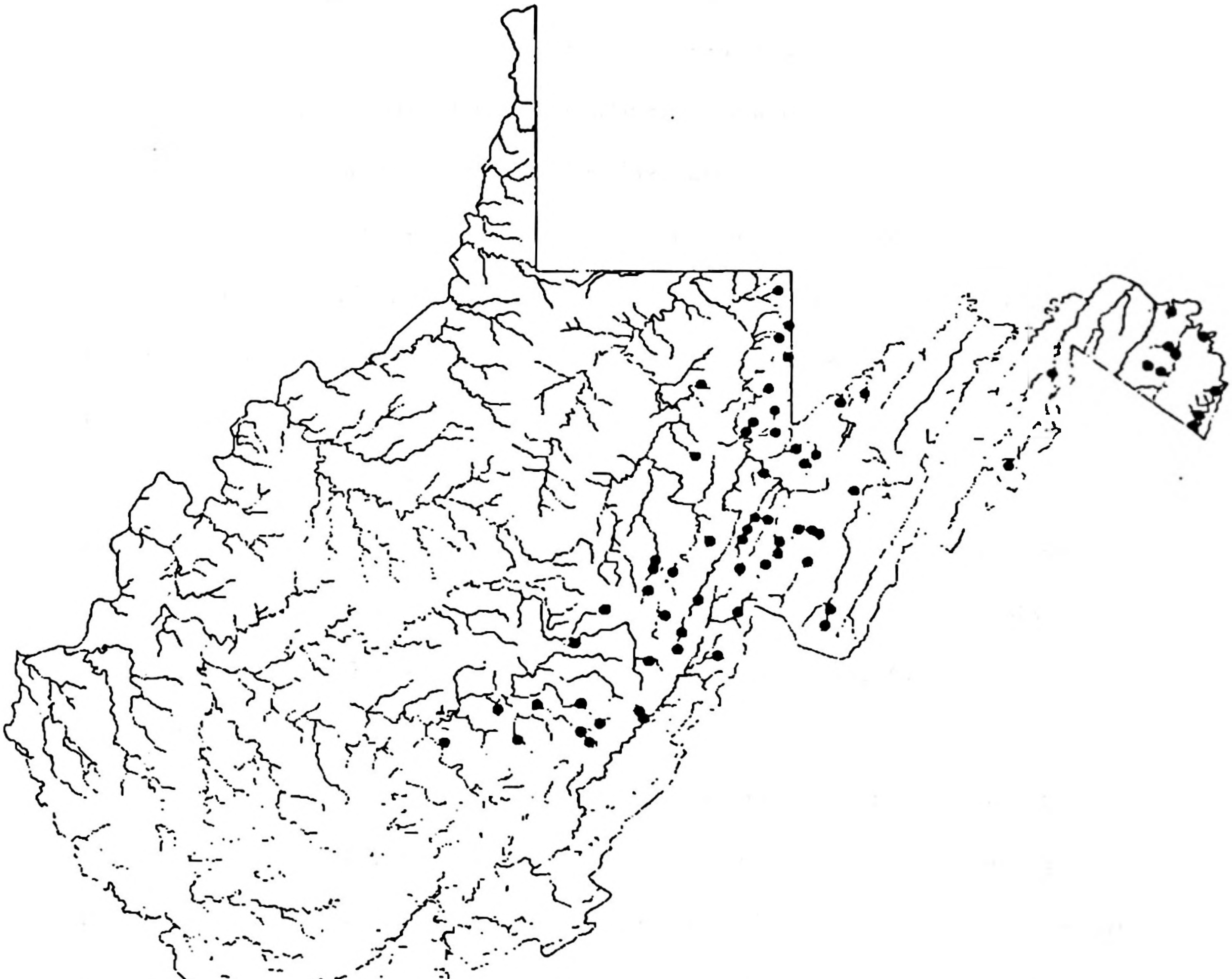


Figure 4. Distribution of brook trout in West Virginia (Stauffer et al. 1995).



CHAPTER IV

DESCRIPTION OF STUDY SITE

Dogway Fork is a second order stream located in the mountains of eastern West Virginia (Fig. 5). It is 13.7 km long, has a 2719 ha watershed, and is a major tributary of the Cranberry River (Zurbuch et al. 1996). The acidification of Dogway Fork is due to the geologic makeup of the watershed and acid rain deposition. The stream mostly drains the Pottsville geologic strata composed of the Kanawha and New River groups. These are sandstone shales, which produce an acid reaction. These shales contain very little buffer capacity and therefore lack the ability to neutralize acid precipitation (Janet Clayton, pers. comm.). In 1986, the stream had a pH of 4.5 (Menendez and Clayton 1999). In 1988, a mitigative limestone treatment station was constructed 2.9 km upstream from the mouth. Three study stations were selected for this study: T-1 located 2.5 km below the liming station, T-2 located 250 m below the liming station, and C-2a located approximately 2.5 km upstream from the liming station (Fig. 6).

Limestone Station Description

The rotary drum system was a unique type of treatment that adequately met treating requirements (Fig. 7). The station originally had two drums in 1988 (Phase I). In 1993, a third drum was installed and utilized to handle heavier flows (Phase II). Water is fed through a wier and sluice into the drums, which contain limestone gravel. The gravel is continuously ground in the drums into a slurry mixed with water and pours out the bottom of the drums (Fig. 8). In the spillway below the drums, the slurry travels into the stream and mixes with untreated water (Fig. 9). This area is known as the mixing zone (Zurbuch et al. 1996). The station was designed to treat the water with enough limestone to keep the pH above 6.5. In 1996, Phase III treatment began above station C-2a, approximately 10.9 km above the mouth. This involved dumping limestone sand directly into the stream with a dumptruck (Menendez and Clayton 1999). Presently, both treatment methods are being utilized on Dogway Fork successfully.

Figure 5. Map of West Virginia showing location of Dogway Fork (Zurbuch et al. 1996).

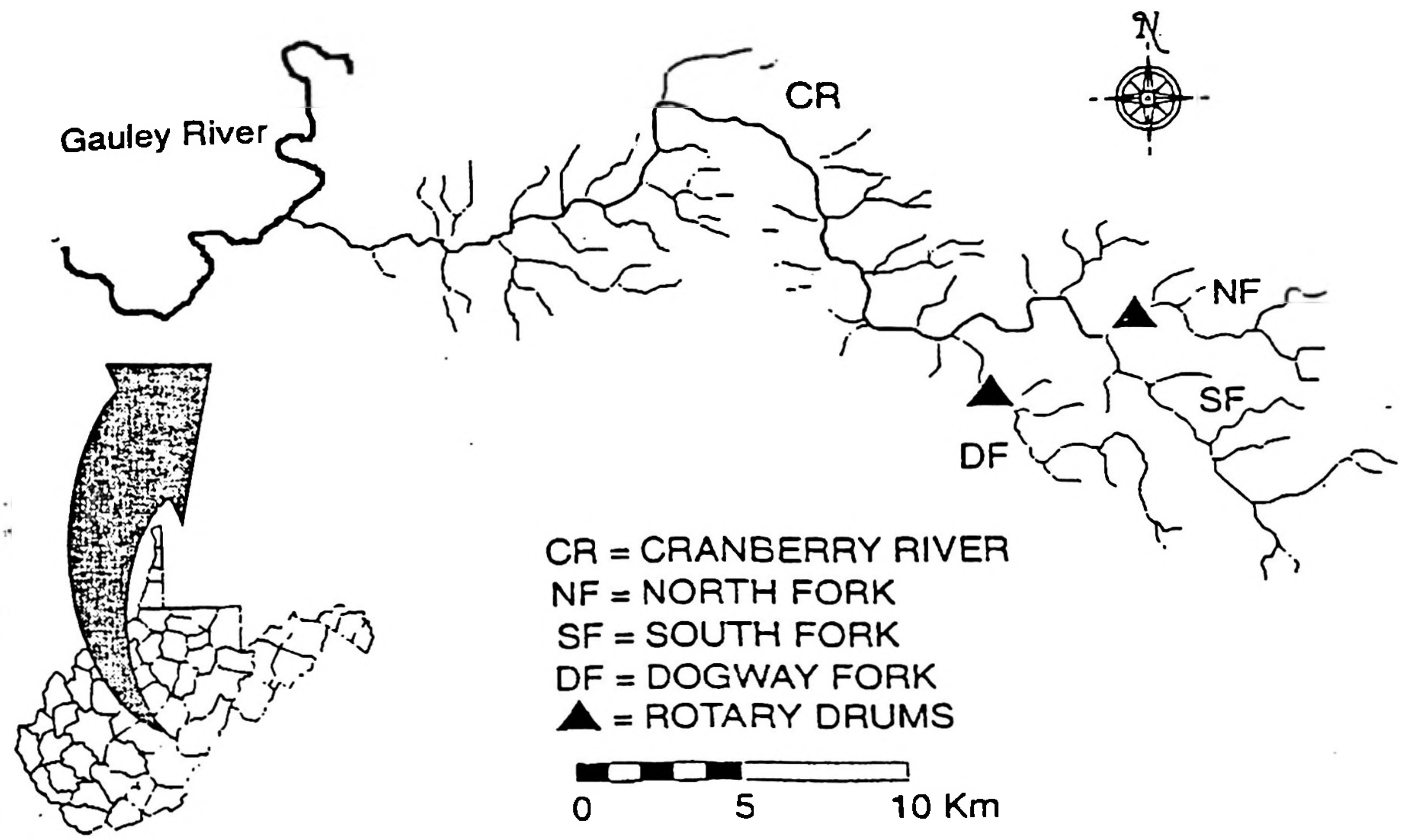

Gauley River
CR
NF
SF
DF
N
CR = CRANBERRY RIVER
NF = NORTH FORK
SF = SOUTH FORK
DF = DOGWAY FORK
= ROTARY DRUMS
0
5
10 Km

Figure 6. Map of Dogway Fork showing doser, study station, and limestone sand treatment locations (Menendez and Clayton 1999).

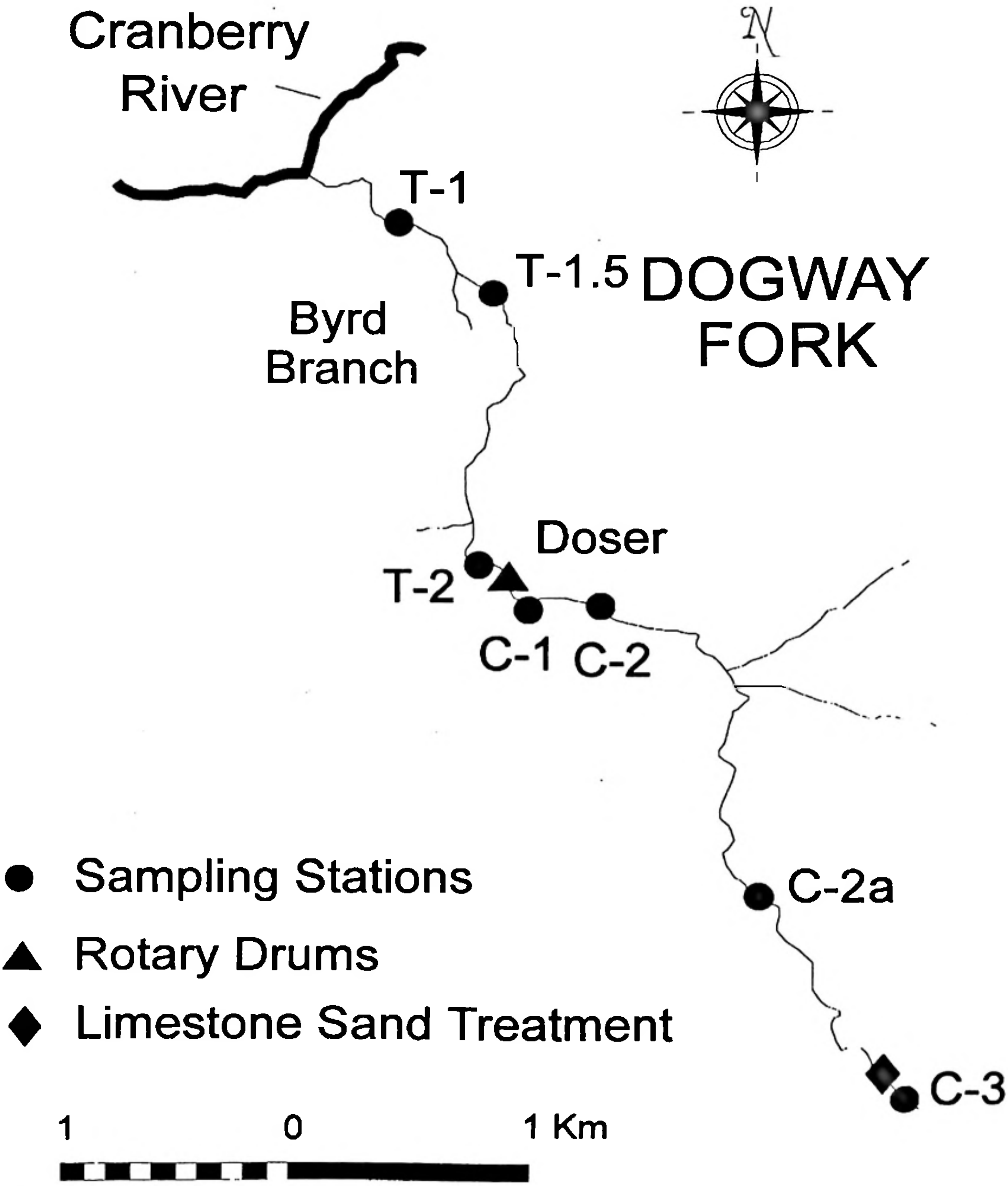

Cranberry River
N
T-1
T-1.5
DOGWAY FORK
Byrd Branch
Doser
T-2
C-1
C-2
C-2a
C-3
Sampling Stations
Rotary Drums
Limestone Sand Treatment
1
0
1 Km

Figure 7. Limestone station.

Figure 8. Slurry and spillway of liming station.

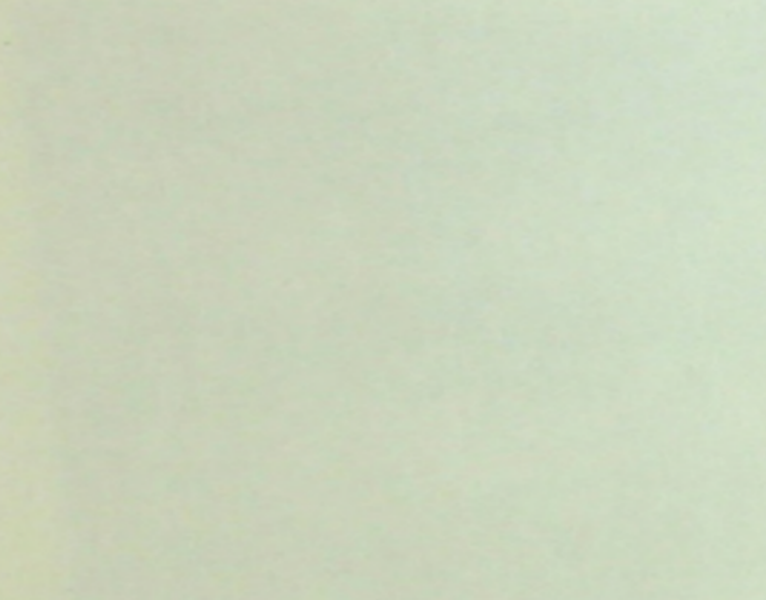


Figure 9. Spillway and mixing zone.

CHAPTER V

MATERIALS AND METHODS

Water Chemistry

Water samples were collected in a one-liter container from each station in April, June, September, and December of 1998. The following parameters were tested in the laboratory: pH, total calcium (mg/L), alkalinity (mg/L $CaCO_3$), conductivity (umhos/cm),

Fi

Trout were collected from Dogway Fork from April of 1998 through December of 1998. Spring samples were collected in April, summer in June, fall in September, and winter in December. Brook trout were collected from all three stations: T-1, T-2, and C-2a. Brown trout were only collected from stations T-1 and T-2. Trout were collected by shocking with a 110 AC backpack electroshocker and caught in dip nets (Fig. 10). They were held in a five-gallon bucket until stomach pumping was performed. All trout collected were measured for length and weight. Trout were then sedated with the chemical MS - 222. After sedation, a bulb pipette full of water was inserted into the stomach via the esophagus (Fig. 12). The pipette was squeezed and the water flushed out the contents of the stomach. This procedure was repeated for each fish until all contents were removed. Contents were collected in a small bucket of water and strained through a sieve with a screen size of 250 μm. They were then washed into an 18 ounce Whirl-Pak bag and returned to the lab for identification. All trout were returned to the stream.

Benthic samples were also collected the same time as fish samples. A modified Surber sampler (1 ft^2) with a 595 μm mesh net was used (Fig. 11). Duplicate samples were taken for each station, preserved in 10 percent formalin, and returned to the lab.

Laboratory Methods

Benthic samples were identified under a dissecting microscope to the lowest taxonomic level possible using Merritt and Cummins (1996) and Peckarsky et al. (1990). Stomach contents were preserved in 70 percent ethanol in the lab. They were identified to the lowest taxonomic level possible using Merritt and Cummins (1996), Peckarsky et al. (1990), Borror et al. (1976), Dillon and Dillon (1961), Swain (1948), and Wiggins (1996).

Statistical Analyses

Seven statistical measurements were performed using the contents of the stomachs and benthic samples. The percent frequency occurrence (PFO) was determined for each aquatic taxon found within the stomachs. The PFO was only calculated on the aquatic taxa because they were the only ones used in the electivity index. The PFO was

Figure 10. Electrofishing method.

Figure 11. Modified Surber sampling method.

Figure 12. Extraction of stomach contents using a bulb pipette.

calculated by dividing the number of stomachs the taxon was found in by the total number of stomachs. PFO's were determined for brook and brown trout at each station for all seasons.

Ivlev's electivity index (1961) was used to determine which taxa both trout were actively selecting for at each station for all seasons. The electivity is determined by dividing (Ri - Pi) by (Ri + Pi). Ri is the abundance of an individual taxon in the stomach and Pi is the abundance of each taxon in the combined benthic sample from that station.

because they were the only ones used in the electivity index. The RA for each taxon was calculated by dividing the number of that taxon by the total number of all taxa. The relative abundances were determined for brook and brown trout at each station for all seasons.

Percent similarity determines how close seasons are related based on how many and what taxa were consumed during those seasons. For each season, taxon abundance calculated by dividing the number of stomachs the taxon was found in by the total number of stomachs. PFO's were determined for brook and brown trout at each station for all seasons.

Ivlev's electivity index (1961) was used to determine which taxa both trout were actively selecting for at each station for all seasons. The electivity is determined by dividing (Ri - Pi) by (Ri + Pi). Ri is the abundance of an individual taxon in the stomach and Pi is the abundance of each taxon in the combined benthic sample from that station. Abundances are determined by dividing the number of an individual taxa in the sample by the total number of all individuals in the sample. A positive index value indicates taxa are being actively selected for by the trout, a negative value indicates taxa are not being selected for, and a zero value indicates random selection for the taxa. Hess and Rainwater (1939) suggested that the digestion rate for different taxa should be determined because this rate would affect which taxa remain present in the stomach over a period of time. The digestion rate was not determined in this study, so discrepancies in the data may have occurred.

The relative abundance (RA) was determined for each aquatic taxon found within the stomach samples. Again, only the RA's of the aquatic taxon were determined because they were the only ones used in the electivity index. The RA for each taxon was calculated by dividing the number of that taxon by the total number of all taxa. The relative abundances were determined for brook and brown trout at each station for all seasons.

Percent similarity determines how close seasons are related based on how many and what taxa were consumed during those seasons. For each season, taxon abundance was tabulated as a percentage. For each taxon, the lowest percentage between any two seasons was summed to calculate the percent similarity. This was determined at each station for all seasons for brook trout and at station T-1 for all seasons for brown trout due to the fact that brown trout were only collected each season at T-1. Percent similarity was also determined comparing brook and brown trout diets for the year.

Morisita's index (1959) was also used to determine the similarity and overlap among seasons. Morisita's index values range from 0 to 1. As the value approaches 0 the seasons are more distinct and as the value approaches 1 the seasons are more similar. Horn (1966) stated that Morisita's index suggests that the probability that two individuals drawn randomly from two different populations (seasons) will both belong to the same species, relative to the probability of randomly drawing two individuals of the same species from one of the two seasons alone. Wolda (1981) found that the Morisita index was unique in that species richness or sample size did not influence it. However, Magurran (1988) stated that a disadvantage of the Morisita index was that it was highly sensitive to the abundance of the most abundant species. Horn's index (1966) was also used to determine the similarity and overlap between seasons. Horn's index differs from Morisita's index in that it only uses ratios of the measures of information rather than the measures themselves. Horn's index values also range from 0 to 1. As the value approaches 0 the seasons are more distinct and as the value approaches 1 the seasons are more similar. Both Morisita's and Horn's indices were determined for brook trout at each station for all seasons and at station T-1 for brown trout for all seasons. Morisita's and Horn's indices were also used to compare brook and brown trout diets for the year.

The percent abundance for all taxa, both aquatic and terrestrial, was calculated for each order to determine which orders were most prevalent in the diets of both trout at each station for the year.

CHAPTER VI

RESULTS

Water Chemistry

Water chemistry values for each station and season are listed in Table 2. Varying flow rates probably caused any fluctuations in the values from season to season. Flow rate changes allow for varying contact times of the limestone treatments, which can alter the water chemistry.

Field Collections

Brook and brown trout collected by electrofishing at each station in each season are shown in Tables 3 – 6. The average length and weight of both species for each station are shown in the tables.

Laboratory Results and Statistical Analyses

Macroinvertebrates collected from all four seasons by Surber sampling at each station are shown in Tables 7 - 10. Prey items taken from both brook and brown trout for all seasons at each station are shown in Tables 11 - 14.

Spring

Benthic Samples

Ephemeropterans (mayflies) were the most abundant taxa collected in the benthic samples at station T-1. Plecopterans (stoneflies) were the most abundant taxa collected at stations T-2 and C-2a. A higher number of chironomid midges were collected at station C-2a than any other station.

Stomach Samples

Chironomid midges were by far the most abundant taxon preyed upon by both trout species at station T-1. Heptageniid mayflies were the second highest taxa for brook trout with all other taxa showing little difference in number for both fish species.

Chironomid midges were the most abundant taxon taken by brook trout at station T-2, but higher numbers of mayflies, stoneflies, and caddisflies were seen. Beetles make up a larger portion of the diet of brook trout. Chironomid midges were the most abundant taxon within brown trout stomachs although no single taxon dominated the diet. Several taxa were present in station T-2 stomachs that were not present at station T-1, indicating a higher diversity of insects taken by both trout species at T-2.

Chironomid midges once again were the most abundant taxon at C-2a, but mayflies, stoneflies, and caddisflies were found in the highest abundances from any site. Beetles were also more abundant in the diets of the trout taken at station C-2a.

Statistical Analyses

The percent frequency of occurrence (PFO) and relative abundance for each aquatic family and terrestrial order in the diet of both trout species at each station are listed in Table 15. PFO's by order for each station are illustrated in Figures 13 - 15. Results of Ivlev's electivity index for each station are illustrated in Figures 25 - 29. PFO's were only illustrated for the aquatic orders in the diet of both trout species, and electivity values were only determined for aquatic taxa that were present in the benthic and stomach samples.

The PFO of each order was relatively the same in the diet of brook trout at T-1. Heptageniid mayflies, elmid beetles, and chironomid midges were the most common families. Chironomid midges were the highest in relative abundance while heptageniid mayflies and hydropsychid caddisflies were the next most abundant, respectively, in the diet of brook trout at T-1. Chironomid midges were the only taxon actively selected for by brook trout at T-1. The PFO of each order was also relatively the same in the diet of brook trout at T-2. Chironomid midges, ameletid mayflies, nemourid stoneflies, and hydropsychid caddisflies were the most frequently occurring families. Chironomid midges were again highest in relative abundance, ameletid mayflies were the second most abundant, and nemourid stoneflies and hydropsychid caddisflies were equal at third most abundant in the diet of brook trout at T-2. Chironomid midges were the most selected taxon and ameletid mayflies were also slightly selected for in the diet. Dipterans dominated the diet of brook trout at C-2a with 100 percent occurrence, but the occurrences of mayflies, stoneflies, caddisflies, and beetles were found to be high as well. A new order, water mites (Hydracarina), were also found occurring 50 percent of the time. Chironomid midges, curculionid beetles, and ameletid mayflies were the most frequently occurring families. Chironomid midges were highest in relative abundance, while curculionid beetles and ameletid mayflies were the next most abundant in the diet of brook trout at C-2a. Chironomid midges and elmid beetles were the most actively selected for taxa, but mayfly, stonefly, and two caddisfly families were also actively selected for in the diet. This increase in family number indicated that more insects were possibly available for consumption by brook trout at C-2a.

Dipterans were the most frequently occurring order at 100 percent in the brown trout diet at T-1. Chironomid midges and heptageniid and baetid mayflies were the most frequently occurring families. Chironomid midges were the highest in relative abundance comprising nearly 98 percent of the total diet and were the only taxon actively selected for by brown trout at T-1. Any taxon occurring in the diet of brown trout at T-2 had a 100 percent frequency of occurrence due to the fact that only one trout was collected. Hymenopterans and chironomid midges were the highest in relative abundance. Chironomid midges and hydropsychid caddisflies were the only two taxa to be actively selected by brown trout at T-2.

Summer

Benthic Samples

Mayflies were the most abundant taxon and stoneflies were the second most abundant taxon collected at all three stations within benthic samples. Higher numbers of caddisflies were collected from station C-2a and the highest numbers of mayflies were collected at C-2a. These numbers indicated that the water quality at C-2a was good enough to support acid-intolerant organisms.

Stomach Samples

Mayfly nymphs were the most abundant aquatic organism in the diet of both trout species from station T-1. Adult caddisflies and hymenopterans were the most abundant terrestrial organisms in the diet of brook trout at station T-1. Except for mayflies, no taxon was noticeably more abundant than any other for brown trout at T-1. Hymenopterans were the most abundant taxon in the diet of brook trout at T-2. Adult caddisflies were the second most abundant terrestrial prey item. Mayfly nymphs were the most abundant aquatic taxon and a higher number of chrysomelid beetles were seen in the diet of brook trout at T-2. Caddisfly adults were the most abundant taxon in the diet of brook trout at station C-2a. Mayfly nymphs and hymenopterans were nearly equal as the second most abundant organisms preyed upon. The highest numbers of caddisfly larvae were also seen at station C-2a.

Statistical Analyses

The percent frequency of occurrence (PFO) and relative abundance for each aquatic family and terrestrial order in the diet of both trout species at each station are listed in Table 16. PFO's by order for each station are illustrated in Figures 16 - 18. Results of Ivlev's electivity index for each station are illustrated in Figures 30 - 33. PFO's were only illustrated for the aquatic orders in the diets of both trout species, and electivity values were only determined for aquatic taxa that were present in the benthic and stomach samples.

Mayflies and hymenopterans were the most frequently occurring orders in the diet of brook trout at all stations. Baetid and heptageniid mayflies were the most frequently occurring families at T-1. Baetid mayflies were highest in relative abundance in the diet, while hymenopterans and caddisfly adults were the next most abundant. Ephemerellid mayflies were the only taxon actively selected by brook trout at T-1. Hymenopterans had the highest relative abundance of all terrestrial taxa comprising nearly one-third of the total diet at T-2 for brook trout. Caddisfly adults and adult dipterans were the next most abundant. Heptageniid mayflies were the most actively selected aquatic prey and had the highest relative abundance of all aquatic taxa in the diet. Nemourid and perlid stoneflies were found to be actively selected for the first time. Caddisfly adults, hymenopterans, and baetid mayflies were the most frequently occurring taxa and caddisflies (33.8) and hymenopterans (17.2) had the highest relative abundances of any taxa at C-2a. Cambarid crayfishes were the only moderately selected for taxon and their frequency of occurrence was the highest at C-2a for the summer.

Mayflies were the most frequently occurring order in the diet of brown trout at T-1. Heptageniid and baetid mayflies comprised over two-thirds of the total diet. Heptageniid mayflies were also the most actively selected taxon. Even though baetid mayflies were found in high abundance in the diet, they were not selected for and were probably found in the diet only because they were very abundant in the stream at station T-1.

Fall

Benthic Samples

Mayflies again were the most abundant taxon collected at each station within benthic samples. Chironomid midges were the second most abundant taxon at stations T-1 and T-2, and stoneflies were the second most abundant taxon at C-2a.

Stomach Samples

Aquatic nematodes were the most abundant taxon preyed upon by brook trout at station T-1 and mayfly nymphs were the second most abundant aquatic organisms. Hymenopterans were the most abundant terrestrial prey items in the diet of brook trout at T-1 and adult dipterans were the most abundant taxon preyed upon by brown trout at T-1. Mayfly nymphs were the next most abundant taxon. Mayfly nymphs were the most abundant taxon and nematodes were the second most abundant taxon consumed by brook trout at T-2. Mayfly nymphs were also the most abundant taxon consumed by brown trout at T-2. Mayfly nymphs were the most abundant taxon consumed by brook trout at station C-2a, but heteropterans were found in much higher numbers than at any other station.

Statistical Analyses

The percent frequency of occurrence (PFO) and relative abundance for each aquatic family and terrestrial order in the diet of both trout at each station are listed in Table 17. PFO's by order for each station are illustrated in Figures 19 - 21. Results of Ivlev's electivity index for each station are illustrated in figures 34 - 38. PFO's were only illustrated for the aquatic orders in the diet of both trout species, and electivity values were only determined for aquatic taxa that were present in the benthic and stomach samples.

Mayfly nymphs and hymenopterans were the most frequently occurring taxa in the diet of brook trout at T-1. Nematodes had the highest relative abundance at nearly 33 percent. Hymenopterans and adult caddisflies were next in relative abundance.

Heptageniid mayflies were slightly selected, but no taxon was actively selected for by brook trout at T-1. Mayflies and nematodes were the two most frequently occurring taxa and were the highest in relative abundance for brook trout at T-2. Hydropsychid and philopotamid caddisflies were the only two aquatic taxa actively selected for in the diet. Both taxa were not abundant in benthic samples at this station and this was the first time that they were actively selected. Mayflies, hymenopterans, and heteropterans were the most frequently occurring taxa in brook trout at C-2a. Nematodes occurred in 70 percent of the diet as well. Baetid mayflies, heteropterans, and hymenopterans were the most abundant taxa in the diet comprising over one-half of the total. No taxon was actively selected by brook trout at C-2a.

Mayflies and adult dipterans were the most frequently occurring taxa in the diet of brown trout at T-1. Adult dipterans had the highest relative abundance comprising nearly one-half of the total diet. Heptageniid mayflies and five caddisfly families were actively selected for in the diet. Any taxon present in the diet of brown trout at T-2 had a 100 percent frequency of occurrence because only one trout was collected. Baetid mayflies were the most abundant taxon comprising two-thirds of the total diet. Hydropsychid caddisflies were next in abundance and were the most actively selected taxon.

Winter

Benthic Samples

Mayflies were the most abundant taxon collected at stations T-1 and T-2 within the benthic samples. Chironomid midges were the most abundant taxon collected at station C-2a.

Stomach Samples

Mayfly and stonefly nymphs were nearly equal in number as the most consumed organisms by brook trout at station T-1. Caddisfly larvae were the second most abundant taxon consumed. Mayfly nymphs were also the most consumed taxon for brown trout at T-1 and stonefly nymphs were the second most consumed taxon. Nematodes were the most consumed taxon at T-2 for brook trout and mayfly nymphs and caddisfly larvae were nearly equal as the second most consumed taxa. The highest numbers of adult dipterans were also consumed this season by brook trout at T-2. Mayfly nymphs were the most abundant taxon in the diet of brown trout at T-2. Stonefly nymphs were the most abundant taxon and caddisfly larvae were the second most abundant taxon consumed by brook trout at C-2a. The highest numbers of chironomid midges were consumed by brook trout at C-2a, which corresponded to an increase in the numbers present in the benthic samples.

Statistical Analysis

The percent frequency of occurrence (PFO) and relative abundance for each aquatic family and terrestrial order in the diet of both trout species at each station are listed in Table 18. PFO's by order for each station are illustrated in Figures 22 - 24. Results of Ivlev's electivity index for each station are illustrated in Figures 39 - 43. PFO's were only illustrated for the aquatic orders in the diet of both trout species, and electivity values were only determined for aquatic taxa that were present in the benthic and stomach samples.

Mayflies, stoneflies, caddisflies, and nematodes were the most frequently occurring taxa in the diet of brook trout at station T-1. Heptageniid mayflies comprised over one-fifth of the total diet while leuctrid and perlodid stoneflies were the next most abundant. Many families were actively selected for in the diet. Heptageniid mayflies and limnephilid caddisflies were the most frequently occurring taxa in the diet of brook trout at T-2. Nematodes were the most abundant taxon comprising one-fifth of the total diet while heptageniid mayflies and adult dipterans made up nearly one-third of the total diet. No taxon was very highly selected for by brook trout, but leuctrid stoneflies were the most actively selected taxon. Heptageniid mayflies, leuctrid stoneflies, and chironomid midges were the most frequently occurring taxa in the diet of brook trout at C-2a. Leuctrid stoneflies were the most abundant taxon in the diet. Chironomid midges were also relatively abundant. Many families were actively selected by brook trout at C-2a.

Mayflies and stoneflies were the most frequently occurring taxa in the diet of brown trout at T-1. Heptageniid mayflies and taeniopterygid stoneflies were the most abundant taxa comprising over one-half of the total diet. Caddisflies were the most actively selected taxon at T-1. Any taxon present in the diet of brown trout at T-2 occurred at 100 percent due to the fact that only one trout was collected. Heptageniid mayflies were the most abundant taxon, although hymenopterans and adult dipterans were also abundant indicating that brown trout continued to feed on terrestrial insects in the winter. Ephemerellid mayflies were the most actively selected taxon.

Yearly Comparisons and Trends

Percent similarity values among seasons were calculated for brook trout at all three stations and for brown trout at station T-1. These values are listed in Table 19. Brown trout were not collected each season for stations T-2 and C-2a, so similarities could not be calculated.

Numbers and percentages of the total for each order, both aquatic and terrestrial, for the year are listed in Table 22. Feeding habits for each trout species were determined for the year by deriving which taxa comprised the largest percentage of each diet at each station.

Summer and fall were the most similar seasons for brook trout at T-1. Mayfly nymphs and hymenopterans comprised the majority of the diet in those two seasons. Fall and winter were the next most similar seasons. Mayfly nymphs and nematodes were the most abundant taxa in the diet in these two seasons. Spring and summer, and spring and fall were nearly equal as the least similar seasons where a dietary shift away from chironomid midges occurred. Chironomid midges were the dominant taxon in the spring, but were not a substantial component of the diet in the summer or fall.

Fall and winter were the most similar seasons for brook trout at T-2. Mayfly nymphs and nematodes were common as the most abundant taxa in the diet those seasons. Spring and fall were the least similar seasons for the same reason as T-1. Chironomid midges were the dominant taxon in the spring, but comprised very little of the diet in the fall.

Summer and fall were the most similar seasons for brook trout at C-2a. Mayfly nymphs and hymenopterans comprised the majority of the diet in these seasons. Fall and spring were the least similar seasons again. Chironomid midges dominated the diet in the spring, but comprised very little of the diet in the fall.

Summer and winter were the most similar seasons for brown trout at T-1. The only reasonable explanation for their similarity is that mayfly nymphs were by far the primary component of the diet in these two seasons. Spring and summer were the least similar seasons. Brown trout fed almost entirely on chironomid midges in the spring, but fed on a wider variety of taxa in the summer.

The percent similarity was also calculated between brook and brown trout diets for the year. There was a 46.8 percent similarity between the diets of the two trout species.

Comparisons of Morisita's and Horn's indices values generally resulted in the same seasons being most and least similar for both trout at each station. The values of these indices are listed in Tables 20 and 21.

Feeding habits for each trout species were determined for the year by deriving which taxa comprised the largest percentage of each diet at each station.

Mayfly nymphs were the primary food item of brook trout at T-1 comprising over 30 percent of the total. Larval dipterans, primarily chironomid midges, and hymenopterans were the next most abundant food items. Mayfly nymphs were also the primary food item of brook trout at T-2 comprising nearly one-fourth of the total. Hymenopterans and chironomid midges were the next most abundant food items, respectively. Caddisfly adults and mayfly nymphs were nearly equal in percentage comprising nearly 40 percent combined of the total diet for brook trout at C-2a. Hymenopterans were the next most abundant food item at nearly 13 percent.

Larval dipterans were the most abundant food item at nearly 60 percent for brown trout at T-1. This percentage is misleading, though, due to the fact that one trout consumed nearly all of the dipterans in the spring. Mayfly nymphs, therefore, were probably the most abundant food item at 17.3 percent in the majority of brown trout at T-1. Adult dipterans were the next most abundant taxa at 8.1 percent. Mayfly nymphs were also the most abundant food item for brown trout at station T-2 and hymenopterans were the next most abundant taxon. Beetles were also very abundant at nearly 12 percent in the diet of brown trout at T-2. They were not found in any substantial abundance at any other stations for either trout species.

CHAPTER VII

DISCUSSION

Prior to limestone treatment of Dogway Fork in 1988 no fish species were present and only acid-tolerant macroinvertebrates were present (Menendez and Clayton 1999). Since treatment began, water quality has increased significantly and greater numbers of taxa and individuals of both fish and macroinvertebrates have been found. Brook and brown trout are the two most abundant fish species in Dogway Fork. The biomass of both trout species has increased greatly throughout the stream (Menendez and Clayton 1999). The highest increase in biomass for both species occurred at stations T-1 and T-2, which have been treated since 1988. Biomass of brook trout has also increased at C-2a, but not as great because C-2a has only been treated with limestone sand since 1996 (Menendez and Clayton 1999). Many new taxa of acid-sensitive macroinvertebrates were also found after treatment began. There was a gradual increase in the beginning, but as the water quality stabilized the number of new macroinvertebrates increased more rapidly. Many of these new organisms, such as heptageniid and baetid mayflies, became important food items for the trout. Stoneflies, especially the families Nemouridae and Leuctridae, seemed to be the least affected by limestone treatment (Menendez and Clayton 1999). Their numbers remained fairly constant and they were common items in the diet of both trout species.

Spring

Chironomid midges were the most frequently occurring and most abundant taxon in the diet of both trout species in the spring. They were also the most actively selected for taxon by both trout species. The net size of the Surber sampler was more than two times as large as that of the sieve used to strain the stomach samples. This could have caused an error in the calculation of the electivity index due to loss of some of the very small organisms. Mayflies, stoneflies, and caddisflies also comprised a moderate portion of the diet. Some of the heptageniid mayflies and hydropsychid caddisflies were not present in substantial numbers in the stream before treatment began (Menendez and Clayton 1999). A substantial spring hatch of any of these three taxa would probably have resulted in fewer midges being consumed. A dietary shift away from chironomid midges was observed in the summer season.

Summer

Mayfly nymphs were the most frequently occurring taxon for both trout species at all stations in the summer. They were also found in the highest abundance and were most often the taxon selected by both trout species. Some of the baetid and heptageniid mayflies in the diet were not present in substantial numbers in the stream before treatment began (Menendez and Clayton 1999). Perlid stoneflies, which were found in the diet, were also not found in Dogway Fork before treatment (Menendez and Clayton 1999). Hymenopterans and caddisflies comprised a major portion of the diet of brook trout at each station. These trends are very similar to those found by Cada et al. (1986), Tebo and Hassler (1963), Allen (1981), and Hunt (1975) for the summer season.

Fall

Mayfly nymphs were among the most frequently occurring taxon in the diet of both trout species at all stations in the fall. Some of the baetid and heptageniid mayflies were not present in substantial numbers in the stream before treatment began (Menendez and Clayton 1999). Mayfly nymphs and hymenopterans were primarily the most abundant taxa in the diet of both trout species. Nematodes were very abundant in the diet of brook trout at stations T-1 and T-2, and adult dipterans were very abundant in the diet of brown trout at T-1. Nematodes were not found in Dogway Fork before treatment began (Menendez and Clayton 1999). Nematodes did not make up a significant portion of the diet due to their small size, and hymenopterans and adult caddisflies comprised the most significant portion of the diet of brook trout at T-1 and T-2. Caddisflies were primarily the most actively selected taxon by both trout species at each station. Cada et al. (1986) also found mayflies and caddisflies to be the preferred food item of brown trout in the fall. They also found that hymenopterans were very abundant in the brown trout diet in the fall. Hunt (1975) also found that terrestrial insects such as hymenopterans were an important component of trout diets in the fall.

Winter

Mayfly nymphs were the most frequently occurring taxon in the diet of both trout species at all stations in the winter. Some of the heptageniid and baetid mayflies found in the diet were not present in substantial numbers in the stream before treatment began (Menendez and Clayton 1999). Stoneflies and caddisflies also occurred very frequently in the diet of both trout species. The fact that stoneflies were more abundant in the diet indicated that they became a more important prey item in the winter. This was possibly due to fact that several species of stoneflies emerge in the winter. Duffield and Nelson (1993) also found that stoneflies comprised a substantial portion of the diet of brown trout in the winter. Nematodes appeared to be important components of the brook trout diet at stations T-1 and T-2, and terrestrial insects appeared to be important components of the brown trout diet at T-2. Many more organisms were actively selected by both trout species at various stations, which indicated a more opportunistic feeding habit in the winter.

Yearly Comparisons and Trends

Mayfly nymphs and hymenopterans, as a whole, appeared to be the most important food items in diets of both brook and brown trout in Dogway Fork. As mentioned before, some of the mayflies found in the diet as well as various other organisms were not present in substantial numbers in the stream before treatment began. Larval dipterans, primarily chironomid midges, also appeared to be an important food item in both trout's diet. No other studies were found with similar data for a complete year to compare to these results. However, based on the similarities with other studies by season, it appeared that mitigative liming changed the water quality allowing many organisms to survive that are utilized by brook and brown trout as food in Dogway Fork.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

Feeding habit studies of brook and brown trout at Dogway Fork, West Virginia, were conducted in 1998. The studies were done to determine which taxa, both aquatic and terrestrial, were the most important components of the diet of brook and brown trout each season and for the year. Additionally, an attempt was made to determine if mitigative liming procedures affected the feeding habits of the trout.

Dogway Fork is acidified due to acid precipitation and the fact that the substrate is composed primarily of sandstone shale, which has a poor buffering capacity. In 1986, the stream had a pH of 4.5 (Menendez and Clayton 1999). In 1988, a mitigative limestone treatment station was constructed 2.9 km upstream from the mouth. Three study stations were selected for this study: T-1 located 2.5 km below the liming station, T-2 located 250 m below the liming station, and C-2a located approximately 2.5 km upstream from the liming station. Brook and brown trout were collected in the months of April, June, September, and December from the three stations on Dogway Fork. The stomach samples from both trout species were removed by flushing the stomach. Benthic macroinvertebrates samples were also collected to compare to the stomach samples.

Statistical analyses performed (percent frequency of occurrence, relative abundance, Ivlev's electivity index, percent similarity, Morisita's index, Horn's index, and percent abundance) showed the following results.

Chironomid midges were the most frequently occurring (x = 94%) and most abundant taxon (x = 47.6%) in the diet of both trout species in the spring season. They were also the most actively selected taxon. Mayflies, stoneflies, and caddisflies comprised a small portion of the diet of both trout species in the spring.

Mayfly nymphs were the most frequently occurring (x = 71.8%) and most abundant taxon (x = 23.9%) in the diet of both trout species in the summer season. They were also the taxon most often selected by both trout species. Hymenopterans and caddisflies also were a major component of the diet of brook trout at each station.

Mayfly nymphs were commonly the most frequently occurring taxon (x = 66.4%) in the diet of both trout species at each station in the fall season. Mayfly nymphs (x = 22.9%) and hymenopterans (x = 12.4%) were primarily the most abundant taxa in the diet. Nematodes were found to be very abundant (x = 31.9%) in the brook trout diet at stations T-1 and T-2. Caddisflies were generally the most actively selected taxon by both trout species in the fall, but were not abundant in the stream and therefore did not comprise a high abundance of the diet.

Mayfly nymphs were the most frequently occurring taxon (x = 59.8%) in the diet of both trout species in the winter season. Stonefly nymphs and caddisfly larvae were also found frequently in the diet. Nematodes (x = 13.7%) were important components of the brook trout diet at T-1 and T-2, and terrestrial organisms (x = 34%) remained important components of the brown trout diet at T-2.

Mayfly nymphs and hymenopterans appeared to be the most important food items in the diets of both trout species for the year. Mayfly nymphs comprised an average of 22.4 percent and hymenopterans comprised an average of 11.6 percent of the total diet. Larval dipterans, primarily chironomid midges, also appeared to be important components of the diet. Based on similarities with other studies by season, it appeared that mitigative liming changed the water quality allowing many organisms to survive that are utilized by brook and brown trout as food in Dogway Fork.

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APPENDIX

Table 2. Water chemistry parameters at each station for each collection date.

	Station																	
	T-1						T-2						C-2a					
Date	pH	Temp	Cond.	Alka.	Cold Acidity	Total Calcium	pH	Temp.	Cond.	Alka.	Cold Acidity	Total Calcium	pH	Temp.	Cond	Alka	Cold Acidity	Total Calcium
4/29/98	7.23	8	N/A	23	3	10.56	8.28	8	N/A	22	<1	12.4	7.43	8	N/A	23	3	13.2
6/9/98	6.85	12	47.8	24	2	10.08	6.89	12	35.1	13	1	6.88	7.12	12	49.5	24	2	11.2
9/1/98	7.17	14	73.8	51	<1	10.32	6.83	14	37	25	2	5.12	7.04	14	83	46	<1	10.4
12/8/98	6.87	4	50.3	26	2	8.8	6.77	4	41.5	17	2	7.2	6.25	4	37.8	10	4	5.8
Yearly range	6.7-7.85	1 - 17				3.84 – 19.92	6.5-9.04	1 - 17				3.84 – 9.76	6.2-7.64	1 - 17				2.96 – 23.92

	Units
Temperature :	°C
Conductivity:	µmhos/cm
Alkalinity:	mg/L $CaCO_3$
Cold Acidity:	mg/L
Total Calcium:	mg/L

Table 3. Brook and brown trout collected at each station in April 1998.

	Brook Trout (n=10)		Brown Trout (n=4)	
Station	Length (mm)	Weight (g)	Length (mm)	Weight (g)
T- 1	171	14	313	278
	175	43	104	8
	90	6	139	20
	109	8	107	9
	111	11		
	113	12		
	227	109		
	115	13		
	172	46		
	85	7		
Average	136.8	26.9	165.8	78.8
T- 2	**(n=10)**		**(n=1)**	
	102	9	269	189
	85	5		
	195	65		
	185	6		
	108	13		
	115	12		
	120	14		
	105	12		
	104	12		
	110	12		
Average	122.9	16	269	189
C- 2a	**(n=10)**		**(n=0)**	
	110	13		
	154	34		
	108	14		
	114	14		
	140	23		
	112	12		
	136	25		
	142	24		
	285	258		
	149	22		
Average	145	43.9		

Table 4. Brook and brown trout collected at each station in June 1998.

	Brook Trout (n=10)		Brown Trout (n=5)	
Station	Length (mm)	Weight (g)	Length (mm)	Weight (g)
T- 1	117	16	142	30
	117	17	285	224
	185	59	211	105
	117	15	246	151
	120	18	120	29
	219	97		
	160	41		
	177	51		
	187	64		
	140	23		
Average	153.9	40.1	200.8	107.8
T- 2	(n=10)		(n=0)	
	224	118		
	123	17		
	189	72		
	155	31		
	125	19		
	112	11		
	205	80		
	98	7		
	115	13		
	123	18		
Average	146.9	38.6		
C- 2a	(n=10)		(n=0)	
	131	21		
	132	21		
	115	14		
	117	19		
	148	33		
	134	23		
	162	41		
	144	25		
	122	17		
	110	13		
Average	131.5	22.7		

Table 5. Brook and brown trout collected from each station in September 1998.

	Brook Trout (n=10)		Brown Trout (n=10)	
Station	Length (mm)	Weight (g)	Length (mm)	Weight (g)
T- 1	131	19	172	49
	131	21	231	102
	184	61	130	20
	227	106	169	47
	162	36	147	25
	95	9	269	188
	139	24	212	87
	148	30	150	33
	86	7	174	53
	222	96	200	79
Average	152.5	40.9	185.4	68.3
T- 2	(n=10)		(n=1)	
	165	34	275	215
	95	9		
	202	69		
	262	175		
	245	178		
	123	15		
	140	23		
	150	31		
	170	46		
	108	8		
Average	166	58.8	275	215
C- 2a	(n=10)		(n=0)	
	124	19		
	100	9		
	174	56		
	128	20		
	137	22		
	123	18		
	145	29		
	132	21		
	166	47		
	178	56		
Average	140.7	29.7		

Table 6. Brook and brown trout collected from each station in December 1998.

	Brook Trout (n=10)		Brown Trout (n=4)	
Station	Length (mm)	Weight (g)	Length (mm)	Weight (g)
T-1	222	87	206	76
	145	28	199	67
	145	27	271	166
	106	11	157	28
	91	7		
	135	25		
	199	68		
	123	15		
	90	7		
	168	43		
Average	142.4	31.8	208.3	84.3
T-2	(n=10)		(n=1)	
	105	11	280	192
	230	107		
	134	22		
	136	24		
	173	48		
	141	21		
	148	27		
	159	36		
	123	14		
	140	22		
Average	148.9	33.2	280	192
C-2a	(n=10)		(n=0)	
	109	9		
	127	15		
	113	11		
	151	26		
	189	52		
	158	36		
	175	46		
	160	35		
	116	10		
	110	9		
Average	140.8	24.9		

Table 7. Macroinvertebrates collected from stations T-1, T-2, and C-2a in April 1998. (total of 2 Surber samples = 2 ft^2)

	T- 1	T- 2	C - 2a
Family			
Heptageniidae	7	4	14
Ameletidae	0	4	7
Ephemerellidae	2	0	0
Baetidae	2	0	0
Nemouridae	6	11	13
Capniidae	0	3	7
Perlodidae	1	0	4
Leuctridae	0	5	67
Chloroperlidae	2	0	0
Taeniopterygidae	0	0	1
Hydropsychidae	3	2	2
Philopotamidae	0	0	1
Polycentropodidae	0	0	1
Rhyacophilidae	1	0	5
Chironomidae	5	5	15
Elmidae	0	0	1
Staphylinidae	1	1	1
Dixidae	1	0	0

Table 8. Macroinvertebrates collected from stations T-1, T-2, and C-2a in June 1998. (total of 2 Surber samples = 2 ft^2)

	T-1	T-2	C-2a
Family			
Heptageniidae	19	7	45
Baetidae	47	47	48
Ephemerellidae	2	5	0
Leptophlebiidae	7	1	0
Leuctridae	12	25	22
Nemouridae	0	3	0
Perlodidae	1	5	3
Perlidae	1	1	0
Taeniopterygidae	0	3	0
Hydropsychidae	0	1	1
Lepidostomatidae	0	2	3
Philopotamidae	11	3	29
Rhyacophilidae	0	2	1
Polycentropodidae	0	0	2
Chironomidae	6	10	3
Simulidae	0	13	0
Ceratopogonidae	2	0	0
Cambaridae	0	0	1
Corydalidae	1	0	0

Table 9. Macroinvertebrates collected from stations T-1, T-2, and C-2a in September 1998. (total of 2 Surber samples = 2 ft^2)

	T-1	T-2	C-2a
Family			
Heptageniidae	10	6	0
Baetidae	31	56	79
Ephemerellidae	1	2	1
Leptophlebiidae	35	2	1
Ameletidae	0	0	2
Leuctridae	6	6	24
Nemouridae	0	2	2
Perlodidae	0	5	5
Capniidae	0	0	1
Hydropsychidae	1	1	0
Lepidostomatidae	2	0	0
Philopotamidae	2	1	3
Rhyacophilidae	1	0	0
Polycentropodidae	1	0	0
Glossosomatidae	0	0	3
Staphylinidae	0	1	0
Chironomidae	29	29	9
Ceratopogonidae	6	0	0
Corydalidae	3	2	0

Table 10. Macroinvertebrates collected from stations T-1, T-2, and C-2a in December 1998. (total of 2 Surber samples = 2 ft^2)

	T-1	T-2	C-2a
Family			
Heptageniidae	168	42	31
Baetidae	6	9	5
Ephemerellidae	3	1	0
Leptophlebiidae	30	1	0
Leuctridae	8	3	10
Nemouridae	21	2	8
Perlodidae	31	18	9
Perlidae	0	1	1
Hydropsychidae	1	3	1
Lepidostomatidae	7	0	1
Philopotamidae	0	3	0
Rhyacophilidae	2	2	0
Polycentropodidae	4	0	1
Limnephilidae	5	0	1
Staphylinidae	1	0	0
Hydrophilidae	1	0	0
Curculionidae	0	1	0
Chironomidae	5	13	136
Ceratopogonidae	3	0	16
Empididae	1	1	0
Corydalidae	2	2	0

Table 11. Prey items taken from brook and brown trout in April 1998.

	T-1	T-1	T-2	T-2	C-2a
	Brook	Brown	Brook	Brown	Brook
Number of trout	10	4	10	1	10
Aquatic					
Family					
Heptageniidae	23	2	5	5	21
Baetidae	2	3	1	0	0
Ameletidae	3	0	67	0	23
Leptophlebiidae	1	0	0	0	0
Ephemerellidae	0	0	1	1	3
Leuctridae	0	0	7	1	0
Nemouridae	3	1	20	4	12
Capniidae	8	2	5	1	3
Perlodidae	2	0	3	1	19
Hydropsychidae	11	1	20	5	11
Goeridae	0	1	0	0	0
Limnephilidae	3	0	15	4	16
Philopotamidae	2	0	1	0	3
Rhyacophilidae	1	1	1	1	1
Polycentropodidae	0	0	0	0	1
Elmidae	9	0	3	9	6
Staphylinidae	6	0	0	0	0
Chrysomelidae	0	0	3	2	7
Curculionidae	0	0	4	3	30
Hydrophilidae	0	0	1	0	0
Dryopidae	0	0	0	0	1
Chironomidae	108	650	147	13	117
Ceratopogonidae	4	0	0	0	0
Tipulidae	1	0	1	0	0
Simulidae	1	0	0	0	0
Empididae	0	0	1	0	0
Corydalidae	2	1	0	0	0
Gerridae	0	0	0	2	0
Hydracarina	0	0	0	0	9
Cambaridae	0	0	0	0	1
Adults and Terrs.					
Order					
Ephemeroptera	1	1	8	7	0
Plecoptera	3	1	14	7	11
Trichoptera	4	0	18	8	5
Diptera	8	1	15	6	0
Hymenoptera	0	0	12	13	18
Homoptera	0	0	1	1	0
Araneida	3	0	1	2	1

Table 12. Prey items taken from brook and brown trout in June 1998.

	T-1	T-1	T-2	C-2a
	Brook	**Brown**	**Brook**	**Brook**
Number of trout	10	5	10	10
Aquatic				
Family				
Heptageniidae	29	76	44	65
Baetidae	180	32	54	119
Ameletidae	1	0	0	0
Leptophlebiidae	0	3	0	0
Ephemerellidae	36	3	7	5
Leuctridae	3	0	8	11
Nemouridae	1	0	11	1
Taeniopterygidae	0	0	1	0
Perlodidae	1	3	6	3
Perlidae	0	0	3	2
Hydropsychidae	2	0	2	0
Lepidostomatidae	5	2	1	0
Limnephilidae	3	0	3	67
Philopotamidae	21	3	5	6
Rhyacophilidae	4	1	0	1
Polycentropodidae	0	0	0	2
Leptoceridae	1	0	1	0
Elmidae	9	0	16	8
Staphylinidae	8	1	1	7
Chrysomelidae	13	1	30	12
Curculionidae	5	0	5	0
Hydrophilidae	1	1	0	0
Chironomidae	7	0	12	5
Dixidae	0	0	2	0
Tipulidae	0	0	1	6
Simulidae	3	11	0	0
Empididae	1	1	24	4
Hydracarina	3	1	0	2
Cambaridae	0	0	0	5
Aeshnidae	1	0	0	0
Gomphidae	0	0	1	0
Adults and Terr.				
Order				
Ephemeroptera	18	1	19	44
Plecoptera	10	0	4	9
Trichoptera	86	7	79	346
Diptera	13	2	13	80
Hymenoptera	98	6	193	185
Homoptera	4	0	16	17
Araneida	6	0	8	4
Orthoptera	1	0	0	1
Heteroptera	0	1	2	1
Neuroptera	0	0	1	0
Lepidoptera	0	0	1	0

Table 13. Prey items taken from brook and brown trout in September 1998.

	T-1	T-1	T-2	T-2	C-2a
	Brook	Brown	Brook	Brown	Brook
Number of trout	10	10	10	1	10
Aquatic					
Family					
Heptageniidae	13	15	7	0	6
Baetidae	8	12	108	12	67
Ephemerellidae	1	0	0	0	0
Leuctridae	2	1	2	0	6
Perlodidae	0	0	1	1	0
Hydropsychidae	0	1	3	2	5
Lepidostomatidae	0	2	0	0	0
Limnephilidae	0	2	1	0	4
Philopotamidae	0	4	5	1	0
Rhyacophilidae	0	2	0	0	0
Polycentropodidae	0	1	0	0	0
Elmidae	1	2	1	0	2
Staphylinidae	2	1	0	1	4
Chrysomelidae	2	1	4	1	3
Curculionidae	1	0	0	0	0
Hydrophilidae	2	0	0	0	0
Chironomidae	1	1	0	0	1
Dixidae	1	0	0	0	10
Tipulidae	5	1	0	0	5
Ceratopogonidae	0	0	0	0	1
Empididae	0	0	0	0	1
Cambaridae	0	0	1	0	0
Gerridae	0	2	2	0	0
Nematoda	57	4	76	0	18
Corydalidae	0	0	2	0	0
Adults and Terr.					
Order					
Ephemeroptera	4	5	2	0	6
Plecoptera	11	5	1	0	0
Trichoptera	17	3	9	0	16
Diptera	12	86	1	0	18
Hymenoptera	27	31	13	2	36
Homoptera	2	1	2	0	2
Araneida	1	0	1	0	2
Heteroptera	2	2	0	0	45

Table 14. Prey items taken from brook and brown trout in December 1998.

	T-1	T-1	T-2	T-2	C-2a
	Brook	Brown	Brook	Brown	Brook
Number of trout	10	4	10	1	10
Aquatic					
Family					
Heptageniidae	78	45	37	11	28
Baetidae	19	2	3	0	18
Ephemerellidae	1	0	2	2	0
Leptophlebiidae	0	0	2	0	0
Ameletidae	0	0	1	0	9
Leuctridae	34	6	10	1	46
Nemouridae	16	1	1	0	4
Perlodidae	43	10	7	0	23
Capniidae	1	0	0	0	0
Perlidae	2	0	2	0	3
Taeniopterygidae	0	12	9	1	11
Hydropsychidae	20	2	3	0	11
Lepidostomatidae	12	4	1	0	0
Limnephilidae	15	5	27	2	22
Philopotamidae	4	0	4	0	30
Rhyacophilidae	2	0	0	0	0
Polycentropodidae	0	0	0	0	2
Elmidae	6	0	2	0	0
Staphylinidae	3	0	2	1	2
Chrysomelidae	9	0	6	0	4
Curculionidae	1	0	0	0	0
Chironomidae	6	1	2	0	28
Dixidae	2	0	0	0	0
Tipulidae	1	0	0	0	0
Ceratopogonidae	0	0	0	0	1
Nematoda	22	6	48	0	16
Corydalidae	1	0	0	0	2
Adults and Terr.					
Order					
Ephemeroptera	2	0	0	0	0
Plecoptera	0	0	0	0	1
Trichoptera	16	12	9	1	3
Diptera	19	1	37	4	2
Hymenoptera	14	2	15	6	5
Homoptera	1	0	0	0	15
Araneida	2	0	2	0	4
Chelonethida	0	0	0	0	3

Table 15. Percent frequency of occurrence and relative abundance for prey items taken in April 1998 by brook and brown trout.

	T-1	T-1	T-1	T-1	T-2	T-2	T-2	T-2	C-2a	C-2a
	Brook	Brook	Brown	Brown	Brook	Brook	Brown	Brown	Brook	Brook
	PFO	RA	PFO	RA	PFO	RA	PFO	RA	PFO	RA
Family										
Heptageniidae	80	10.8	50	0.3	40	1.3	100	5.2	40	6.6
Baetidae	20	0.9	50	0.5	10	0.3	0	0	0	0
Ephemerellidae	0	0	0	0	10	0.3	100	1.1	30	0.9
Leptophlebiidae	10	0.5	0	0	0	0	0	0	0	0
Ameletidae	30	1.4	0	0	70	17.8	0	0	60	7.3
Ephemeroptera adult	10	0.5	25	0.2	20	2.1	100	7.3	0	0
Leuctridae	0	0	0	0	40	1.9	100	1.1	0	0
Perlodidae	20	0.9	0	0	30	0.8	100	1.1	70	5.9
Nemouridae	30	1.4	25	0.2	70	5.3	100	4.2	70	3.8
Capniidae	60	3.8	25	0.3	30	1.3	100	1.1	30	0.9
Plecoptera adult	20	1.4	25	0.2	30	3.7	100	7.3	70	3.5
Hydropsychidae	50	5.2	25	0.2	70	5.3	100	5.2	50	3.5
Philopotamidae	20	0.9	0	0	10	0.3	0	0	30	0.9
Polycentropodidae	0	0	0	0	0	0	0	0	10	0.3
Limnephilidae	10	1.4	0	0	30	3.9	100	4.2	60	5.1
Rhyacophilidae	10	0.4	25	0.2	10	0.3	100	1.1	10	0.3
Goeridae	0	0	25	0.2	0	0	0	0	0	0
Trichoptera adult	30	1.9	0	0	20	4.8	100	8.3	30	1.6
Elmidae	70	4.2	0	0	20	0.8	100	9.4	50	1.9
Chrysomelidae	0	0	0	0	20	0.8	100	2.1	50	2.2
Staphylinidae	10	2.8	0	0	0	0	0	0	0	0
Curculionidae	0	0	0	0	20	1.1	100	3.1	80	9.5
Hydrophilidae	0	0	0	0	10	0.3	0	0	0	0
Chironomidae	80	50.7	100	97.7	90	39.1	100	13.5	100	36.9
Tipulidae	10	0.4	0	0	10	0.3	0	0	0	0
Simulidae	10	0.4	0	0	0	0	0	0	0	0
Empididae	0	0	0	0	10	0.3	0	0	0	0
Ceratopogonidae	20	1.9	0	0	0	0	0	0	0	0
Diptera adult	40	3.8	25	0.2	40	3.9	100	6.3	0	0
Corydalidae	20	0.9	25	0.2	0	0	0	0	0	0
Cambaridae	0	0	0	0	0	0	0	0	10	0.3
Hymenoptera	0	0	0	0	60	3.2	100	13.5	60	5.7
Homoptera	0	0	0	0	10	0.3	0	0	0	0
Araneida	20	1.4	0	0	10	0.3	0	0	10	0.3
Gerridae	0	0	0	0	0	0	100	2.1	0	0

Table 16. Percent frequency of occurrence and relative abundance for prey items taken in June 1998 by brook and brown trout.

	T-1	T-1	T-1	T-1	T-2	T-2	C-2a	C-2a
	Brook	Brook	Brown	Brown	Brook	Brook	Brook	Brook
	PFO	RA	PFO	RA	PFO	RA	PFO	RA
Family								
Heptageniidae	80	5.8	100	47.1	100	7.1	100	6.8
Baetidae, (adult)	90,(10)	31.7,(0.8)	100,(0)	20.7,(0)	80,(0)	8.6,(0)	90,(0)	11.8,(0)
Ephemerellidae	100	6.7	40	1.7	60	1.1	20	0.2
Ameletidae	10	0.1	0	0	0	0	0	0
Leptophlebiidae	0	0	40	1.7	0	0	0	0
Ephemeroptera adult	20	1.7	0	0	50	3.1	90	4.7
Leuctridae, (adult)	30,(30)	0.7,(0.7)	0,(0)	0,(0)	30,(10)	1.2,(0.3)	60,(0)	1.2,(0)
Nemouridae, (adult)	10,(20)	0.1,(0.7)	0,(0)	0,(0)	60,(20)	1.8,(0.3)	10,(0)	0.1,(0)
Capniidae	10	0.1	0	0	0	0	0	0
Perlodidae	10	0.1	40	1.7	30	1	20	0.2
Taeniopterygidae,(adult)	0,(10)	0,(0.1)	0	0	10,(0)	0.2,(0)	0,(0)	0,(0)
Perlidae, (adult)	0,(10)	0,(0.1)	0	0	20,(0)	0.5,(0)	20,(0)	0.2,(0)
Hydropsychidae	20	0.8	0	0	0	0	0	0
Lepidostomatidae	40	0.8	40	1.7	10	0.2	0	0
Philopotamidae	80	3.8	40	1.7	50	0.8	50	0.3
Rhyacophilidae, (adult)	30,(10)	0.8,(0.1)	20,(0)	0.7,(0)	0,(0)	0,(0)	10,(0)	0.1,(0)
Polycentropodidae	0	0	0	0	0	0	20	0.2
Limnephilidae	20	0.8	0	0	30	0.5	100	6.8
Leptoceridae	10	0.1	0	0	10	0.2	0	0
Trichoptera adult	50	14.7	80	1.5	90	12.6	100	33.8
Elmidae	60	1.7	0	0	60	2.6	20	0.8
Chrysomelidae	50	1.2	20	0.7	80	4.8	70	1.2
Staphylinidae	40	1.1	20	0.7	10	0.2	30	0.7
Hydrophilidae	10	0.1	20	0.7	0	0	0	0
Curculionidae	20	0.8	0	0	40	0.8	0	0
Chironomidae	40	1.2	0	0	40	1.9	40	0.2
Simulidae	30	0.7	60	7.8	0	0	0	0
Dixidae	0	0	0	0	20	0.3	0	0
Tipulidae	0	0	0	0	10	0.2	20	0.3
Empididae	10	0.1	20	0.7	40	3.8	30	0.2
Diptera adult	30	1.2	40	1.4	60	10.6	90	7.8
Aeshnidae	10	0.1	0	0	0	0	0	0
Gomphidae	0	0	0	0	10	0.2	0	0
Cambaridae	0	0	0	0	0	0	30	0.2
Hymenoptera	90	17.2	60	3.8	100	30.8	100	17.2
Homoptera	10	0.7	0	0	40	2.6	30	1.7
Heteroptera	0	0	20	0.7	20	0.3	10	0.1
Araneida	20	1.8	0	0	40	1.3	10	0.2
Acarina	0	0	0	0	0	0	10	0.1
Lepidoptera	0	0	0	0	10	0.2	0	0
Orthoptera	10	0.1	0	0	0	0	10	0.1
Neuroptera	0	0	0	0	10	0.2	0	0
Hydracarina	20	0.7	20	0.7	0	0	20	0.2

Table 17. Percent frequency of occurrence and relative abundance for prey items taken in September 1998 by brook and brown trout.

	T-1	T-1	T-1	T-1	T-2	T-2	T-2	T-2	C-2a	C-2a
	Brook	Brook	Brown	Brown	Brook	Brook	Brown	Brown	Brook	Brook
	PFO	RA	PFO	RA	PFO	RA	PFO	RA	PFO	RA
Family										
Heptageniidae	70	7.1	80	7.8	40	2.8	0	0	40	2.7
Baetidae	60	4.7	40	6.9	90	41.3	100	66.7	100	25.8
Ephemerellidae	10	0.7	0	0	0	0	0	0	0	0
Ephemeroptera adult	30	2.7	40	2.8	20	0.7	0	0	40	2.7
Leuctridae, (adult)	20,(50)	1.2,(6.8)	10,(40)	0.7, (2.8)	20, (10)	0.7, (0.3)	0,(0)	0,(0)	50,(0)	2.7,(0)
Perlodidae	0	0	0	0	10	0.3	100	5.5	0	0
Hydropsychidae	0	0	10	0.7	20	1.2	100	11.1	50	1.7
Lepidostomatidae	0	0	10	1.3	0	0	0	0	0	0
Philopotamidae	0	0	30	2.4	30	2.7	100	0	0	0
Polycentropodidae	0	0	10	0.7	0	0	0	0	0	0
Limnephilidae	0	0	10	1.3	10	0.3	0	0	30	1.4
Trichoptera adult	60	9.7	20	2.2	40	3.8	0	0	60	6.2
Elmidae	10	0.7	20	1.3	10	0.3	0	0	40	1.4
Chrysomelidae	20	1.2	10	0.7	30	1.7	100	5.5	30	1.2
Staphylinidae	20	1.2	10	0.7	0	0	100	5.5	20	0.8
Hydrophilidae	20	1.2	0	0	0	0	0	0	0	0
Curculionidae	10	0.7	0	0	0	0	0	0	0	0
Chironomidae	10	0.7	10	0.7	0	0	0	0	10	0.4
Dixidae	10	0.7	0	0	0	0	0	0	30	3.7
Tipulidae	30	2.8	10	0	0	0	0	0	30	1.7
Ceratopogonidae	10	0.7	0	0	0	0	0	0	20	1.2
Empididae	0	0	0	0	0	0	0	0	10	0.4
Diptera adult	70	6.7	60	45.8	10	0.3	0	0	50	6.7
Cambaridae	0	0	0	0	10	0.3	0	0	0	0
Corydalidae	0	0	0	0	10	0.7	0	0	0	0
Gerridae	0	0	0	0	10	0.7	0	0	0	0
Hymenoptera	80	15.7	60	16.2	70	5.7	100	11.1	80	13.2
Homoptera	10	1.2	10	0.7	0	0	0	0	20	0.8
Heteroptera	20	1.2	10	1.3	10	0.7	0	0	80	17.7
Araneida	10	0.7	0	0	10	0.3	0	0	20	0.8
Nematoda	40	32.7	30	2.1	100	31.1	0	0	70	6.7
Etheostoma flabellare	0	0	20	1.8	10	0.3	0	0	0	0

Table 18. Percent frequency of occurrence and relative abundance for prey items taken in December 1998 by brook and brown trout.

	T-1	T-1	T-1	T-1	T-2	T-2	T-2	T-2	C-2a	C-2a
	Brook	Brook	Brown	Brown	Brook	Brook	Brown	Brown	Brook	Brook
	PFO	RA	PFO	RA	PFO	RA	PFO	RA	PFO	RA
Family										
Heptageniidae	100	22.7	100	41.8	90	15.7	100	37.7	70	9.7
Baetidae	60	5.8	25	1.7	20	1.3	0	0	70	5.8
Ephemerellidae	10	0.3	0	0	20	0.8	100	6.8	0	0
Leptophlebiidae	10	0.3	0	0	20	0.8	0	0	0	0
Ameletidae	0	0	0	0	10	0.1	0	0	40	2.8
Ephemeroptera adult	10	0.8	0	0	0	0	0	0	0	0
Leuctridae	80	9.7	75	5.7	60	4.7	100	3.1	70	17.2
Perlodidae	70	12.1	100	9.2	50	0.8	0	0	80	7.6
Nemouridae	60	1.5	25	0.7	10	0.1	0	0	40	1.7
Capniidae	10	0.3	0	0	0	0	0	0	0	0
Perlidae	10	0.8	0	0	10	1.3	0	0	30	0.8
Taeniopterygidae	0	0	100	11.7	60	3.8	100	3.1	60	7.7
Hydropsychidae	50	5.7	50	1.7	30	1.3	0	0	50	7.7
Lepidostomatidae	50	3.8	50	3.5	10	0.1	0	0	0	0
Philopotamidae	40	1.1	0	0	40	1.7	0	0	70	9.8
Polycentropodidae	0	0	0	0	0	0	0	0	10	0.3
Limnephilidae	60	4.7	75	4.2	90	11.6	100	6.8	70	7.7
Rhyacophilidae	20	0.8	0	0	0	0	0	0	0	0
Trichoptera adult	50	1.5	25	11.7	20	3.8	100	3.1	20	0.8
Elmidae	40	1.3	0	0	20	0.8	0	0	0	0
Chrysomelidae	50	2.7	0	0	40	2.2	0	0	40	1.7
Staphylinidae	20	0.7	0	0	20	0.8	100	3.1	20	0.7
Curculionidae	10	0.3	0	0	0	0	0	0	0	0
Chironomidae	40	1.3	25	0.7	20	0.8	0	0	70	9.7
Dixidae	10	0.8	0	0	0	0	0	0	0	0
Tipulidae	10	0.3	0	0	0	0	0	0	0	0
Ceratopogonidae	0	0	0	0	0	0	0	0	10	0.7
Diptera adult	60	5.8	25	0.7	50	15.7	100	13.8	20	0.7
Corydalidae	10	0.3	0	0	0	0	0	0	10	0.7
Hymenoptera	50	3.8	50	1.7	40	5.7	100	20.2	20	1.3
Homoptera	10	0.3	0	0	0	0	0	0	0	0
Heteroptera	0	0	0	0	0	0	0	0	80	4.8
Araneida	20	0.8	0	0	20	0.8	0	0	30	1.7
Nematoda	50	6.7	50	5.7	60	20.7	0	0	50	5.7
Chelonethida	0	0	0	0	0	0	0	0	10	0.7
Etheostoma flabellare	10	0.3	0	0	0	0	0	0	0	0

Table 19. Percent similarity values of seasons for brook and brown trout and for both species of trout for the year.

a. Brook T-1

Season	Spring	Summer	Fall	Winter
Spring		20.6	19.6	34.4
Summer	20.6		48.2	33.4
Fall	19.6	48.2		39.6
Winter	34.4	33.4	39.6	

b. Brook T-2

Season	Spring	Summer	Fall	Winter
Spring		25.7	15.1	24.8
Summer	25.7		28.7	33.3
Fall	15.1	28.7		40.1
Winter	24.8	33.3	40.1	

c. Brook C-2a

Season	Spring	Summer	Fall	Winter
Spring		24.5	15.7	41.1
Summer	24.5		51.4	29.7
Fall	15.7	51.4		27.3
Winter	41.1	29.7	27.3	

d. Brown T-1

Season	Spring	Summer	Fall	Winter
Spring		1.2	2.1	2.1
Summer	1.2		27.4	53.6
Fall	2.1	27.4		20.3
Winter	2.1	53.6	20.3	

e. Year

Trout	Brook	Brown
Brook		46.8
Brown	46.8	

Table 20. Morisita's Index values of seasons for brook and brown trout and for both species of trout for the year.

a. Brook T-1

Season	Spring	Summer	Fall	Winter
Spring		0.094	0.081	0.228
Summer	0.094		0.406	0.366
Fall	0.081	0.406		0.446
Winter	0.228	0.366	0.446	

b. Brook T-2

Season	Spring	Summer	Fall	Winter
Spring		0.178	0.027	0.151
Summer	0.178		0.302	0.356
Fall	0.027	0.302		0.392
Winter	0.151	0.356	0.392	

c. Brook C-2a

Season	Spring	Summer	Fall	Winter
Spring		0.151	0.092	0.465
Summer	0.151		0.558	0.231
Fall	0.092	0.558		0.307
Winter	0.465	0.231	0.307	

d. Brown T-1

Season	Spring	Summer	Fall	Winter
Spring		0.004	0.011	0.018
Summer	0.004		0.247	0.862
Fall	0.011	0.247		0.201
Winter	0.018	0.862	0.201	

e. Year

Trout	Brook	Brown
Brook		0.486
Brown	0.486	

Table 21. Horn's Index values of seasons for brook and brown trout and for both species of trout for the year.

a. Brook T-1.

Season	Spring	Summer	Fall	Winter
Spring		0.374	0.307	0.511
Summer	0.374		0.618	0.575
Fall	0.307	0.618		0.625
Winter	0.511	0.575	0.625	

b. Brook T-2.

Season	Spring	Summer	Fall	Winter
Spring		0.463	0.222	0.431
Summer	0.463		0.516	0.561
Fall	0.222	0.516		0.553
Winter	0.431	0.561	0.553	

c. Brook C-2a.

Season	Spring	Summer	Fall	Winter
Spring		0.366	0.248	0.579
Summer	0.366		0.693	0.475
Fall	0.248	0.693		0.465
Winter	0.579	0.475	0.465	

d. Brown T-1.

Season	Spring	Summer	Fall	Winter
Spring		0.061	0.079	0.076
Summer	0.061		0.491	0.653
Fall	0.079	0.491		0.417
Winter	0.076	0.653	0.417	

e. Year

Trout	Brook	Brown
Brook		0.748
Brown	0.748	

Table 22. Yearly totals and percentages of taxa consumed by brook and brown trout.

			Brook						Brown		
ORDER	T-1		T-2		C-2a			T-1		T-2	
Aquatic	Total	%	Total	%	Total	%		Total	%	Total	%
Ephemeroptera	395	**30.2**	339	**23.8**	359	**19.1**		193	**17.3**	31	**21.4**
Plecoptera	116	8.9	96	6.7	144	7.6		36	3.2	10	6.9
Trichoptera	106	8.1	93	6.5	182	9.7		32	2.9	15	10.3
Diptera	141	**10.8**	190	**13.4**	179	9.5		665	**59.6**	13	8.9
Coleoptera	78	5.9	78	5.5	86	4.6		7	0.6	17	**11.7**
Megaloptera	3	0.2	2	0.1	2	0.1		1	0.1	0	0
Decapoda	0	0	1	0.1	6	0.3		0	0	0	0
Hemiptera	0	0	2	0.1	0	0		2	0.2	2	1.4
Odonata	1	0.1	1	0.1	0	0		0	0	0	0
Hydracarina	3	0.2	0	0	11	0.6		1	0.1	0	0
Nematoda	79	6.1	124	8.7	34	1.8		10	0.9	0	0
Adults and Terrestrials											
Ephemeroptera	25	1.9	29	2	50	2.7		7	0.6	7	4.8
Plecoptera	24	1.8	19	1.3	21	1.1		6	0.5	7	4.8
Trichoptera	123	9.4	115	8.1	370	**19.6**		22	1.9	9	6.2
Diptera	52	3.9	66	4.6	100	5.3		90	**8.1**	10	6.9
Hymenoptera	139	**10.6**	233	**16.4**	244	**12.9**		39	3.5	21	**14.5**
Homoptera	7	0.5	19	1.3	34	1.8		1	0.1	1	0.7
Heteroptera	2	0.2	2	0.1	46	2.4		3	0.3	0	0
Araneida	12	0.9	12	0.8	11	0.6		0	0	2	1.4
Orthoptera	1	0.1	0	0	1	0.1		0	0	0	0
Neuroptera	0	0	1	0.1	0	0		0	0	0	0
Lepidoptera	0	0	1	0.1	0	0		0	0	0	0
Chelonethida	0	0	0	0	3	0.2		0	0	0	0
TOTAL	1307		1423		1883			1115		145	
Total Trout	40		40		40			23		3	

Figure 13. Percent frequency occurrence of taxa taken from brook and brown trout at station T-1 in the spring.

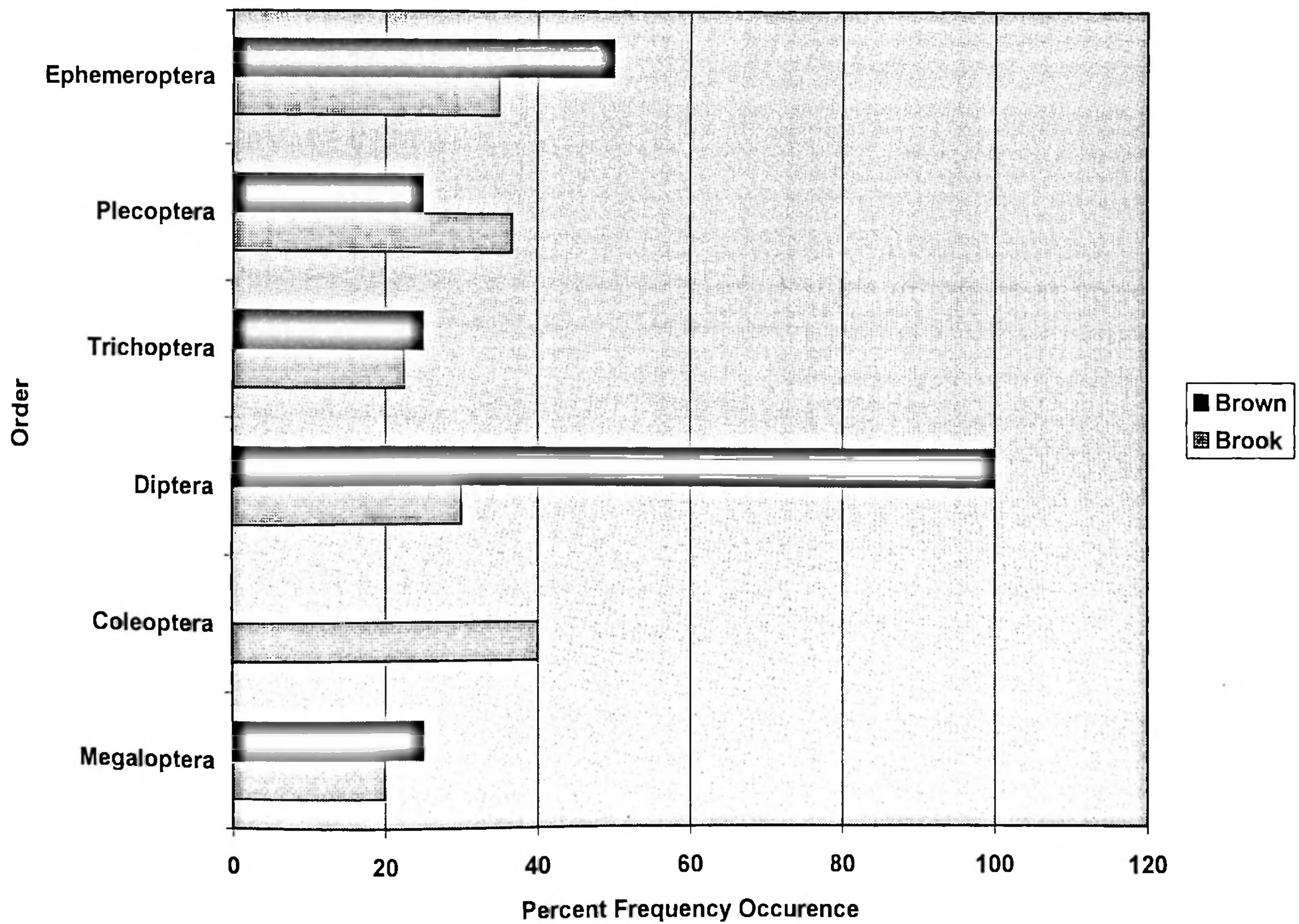

Ephemeroptera
Plecoptera
Trichoptera
Diptera
Coleoptera
Megaloptera
Order
0
20
40
60
80
100
120
Percent Frequency Occurence
Brown
Brook

Figure 14. Percent frequency occurrence of taxa taken from brook and brown trout at station T-2 in the spring.

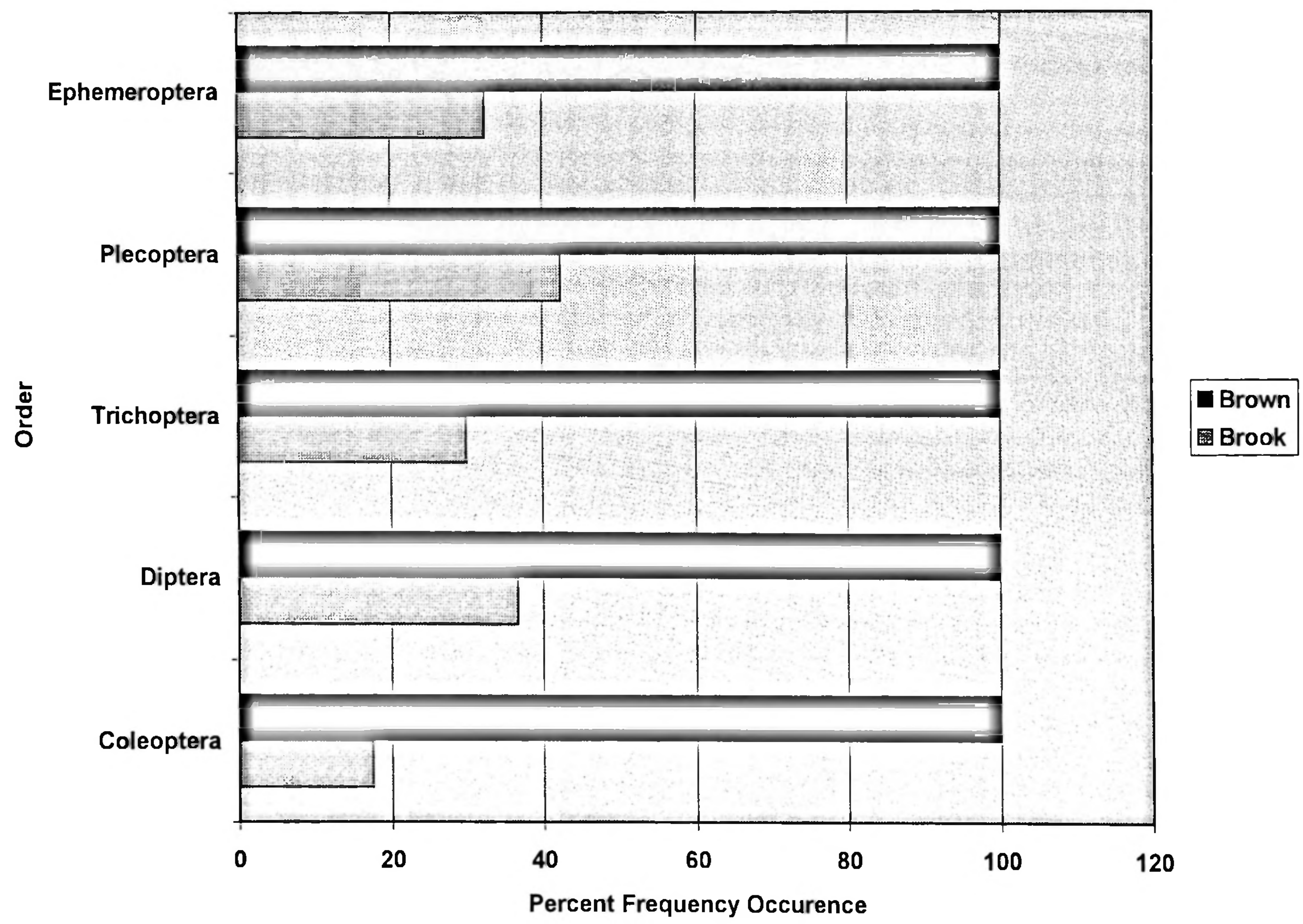

Ephemeroptera
Plecoptera
Trichoptera
Diptera
Coleoptera
Order
0
20
40
60
80
100
120
Percent Frequency Occurence
Brown
Brook

Figure 15. Percent frequency occurrence of taxa taken from brook trout at station C-2a in the spring.

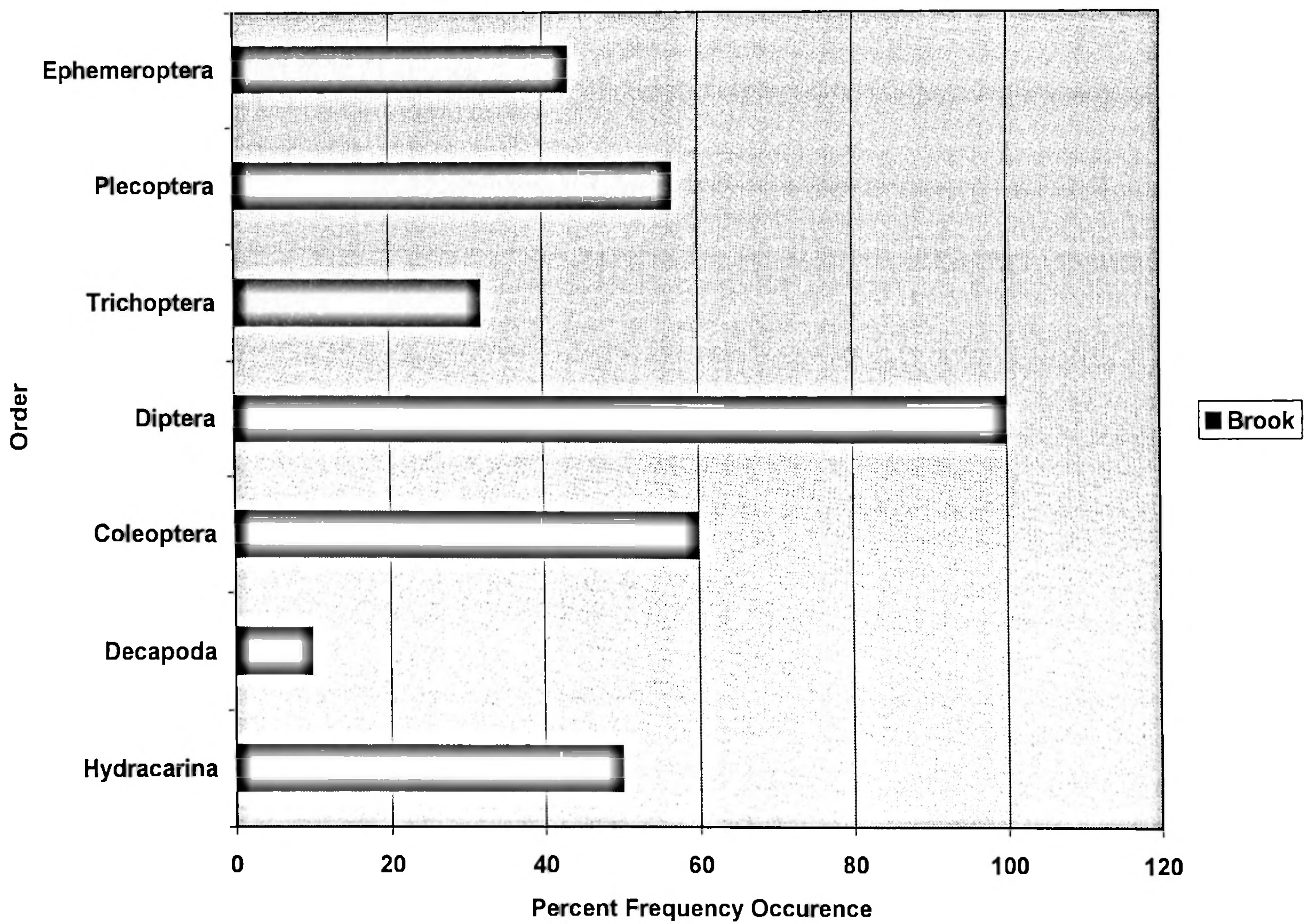

Ephemeroptera
Plecoptera
Trichoptera
Diptera
Coleoptera
Decapoda
Hydracarina
Order
0
20
40
60
80
100
120
Percent Frequency Occurence
Brook

Figure 16. Percent frequency occurrence of taxa taken from brook and brown trout at station T-1 in the summer.

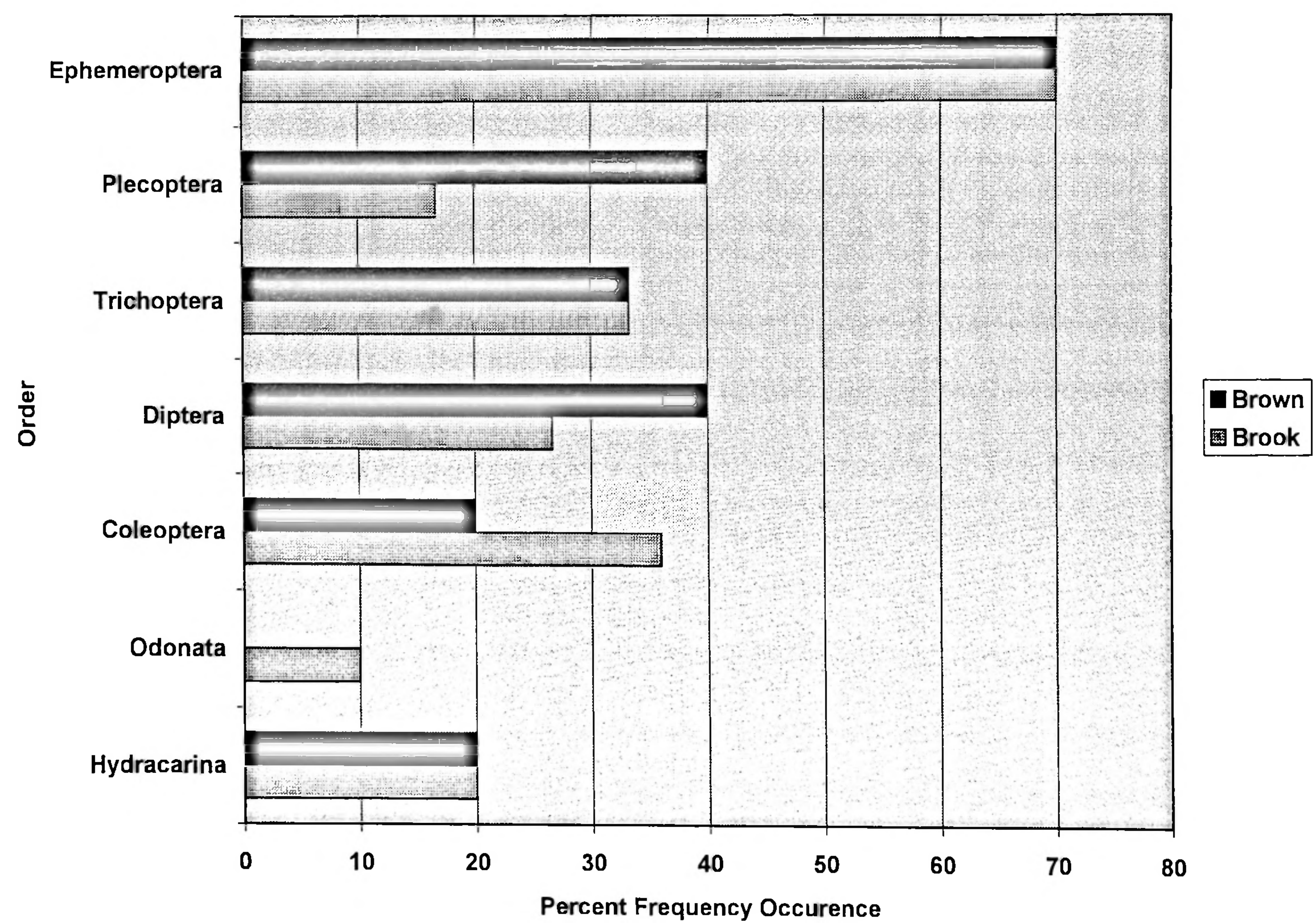
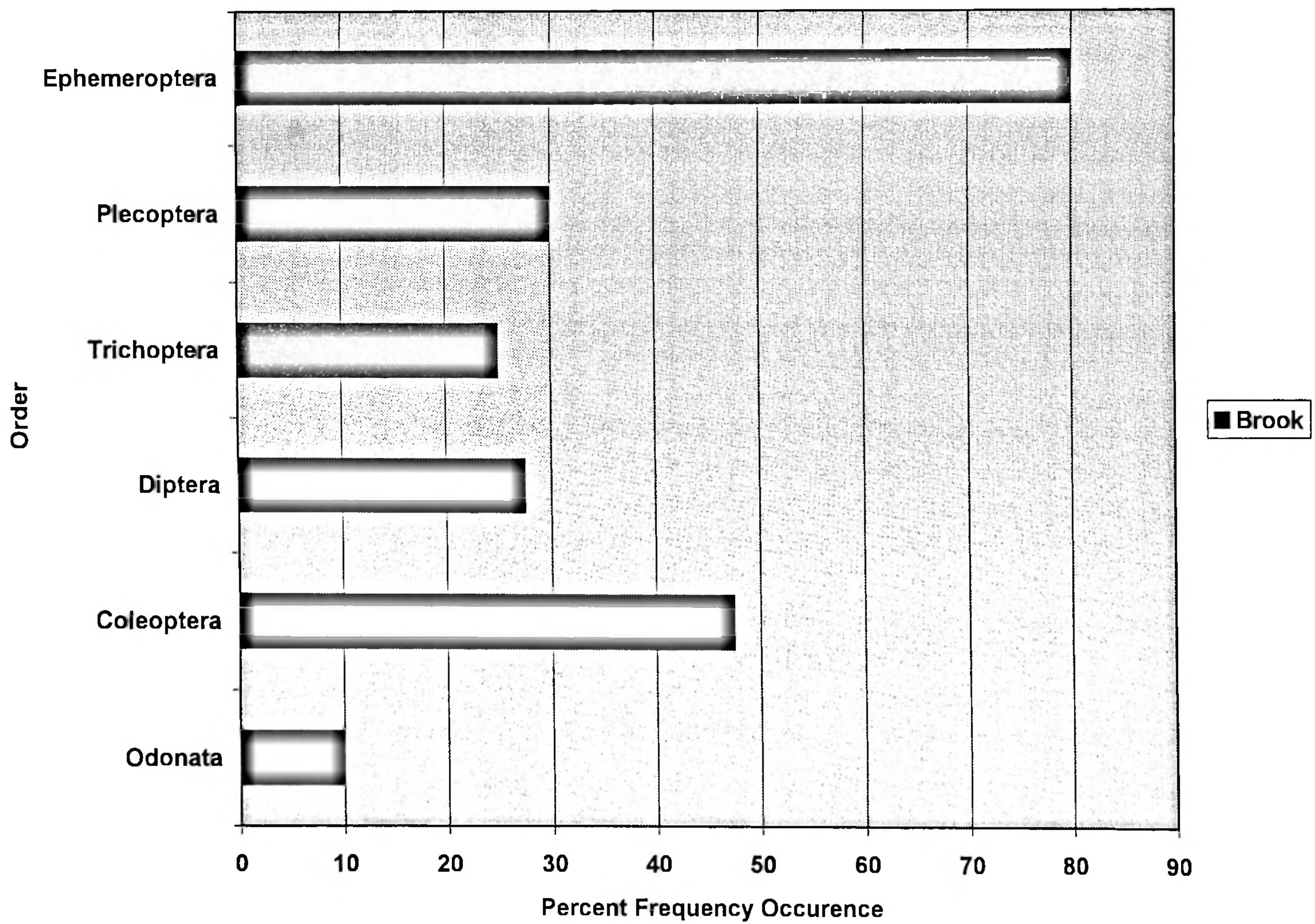
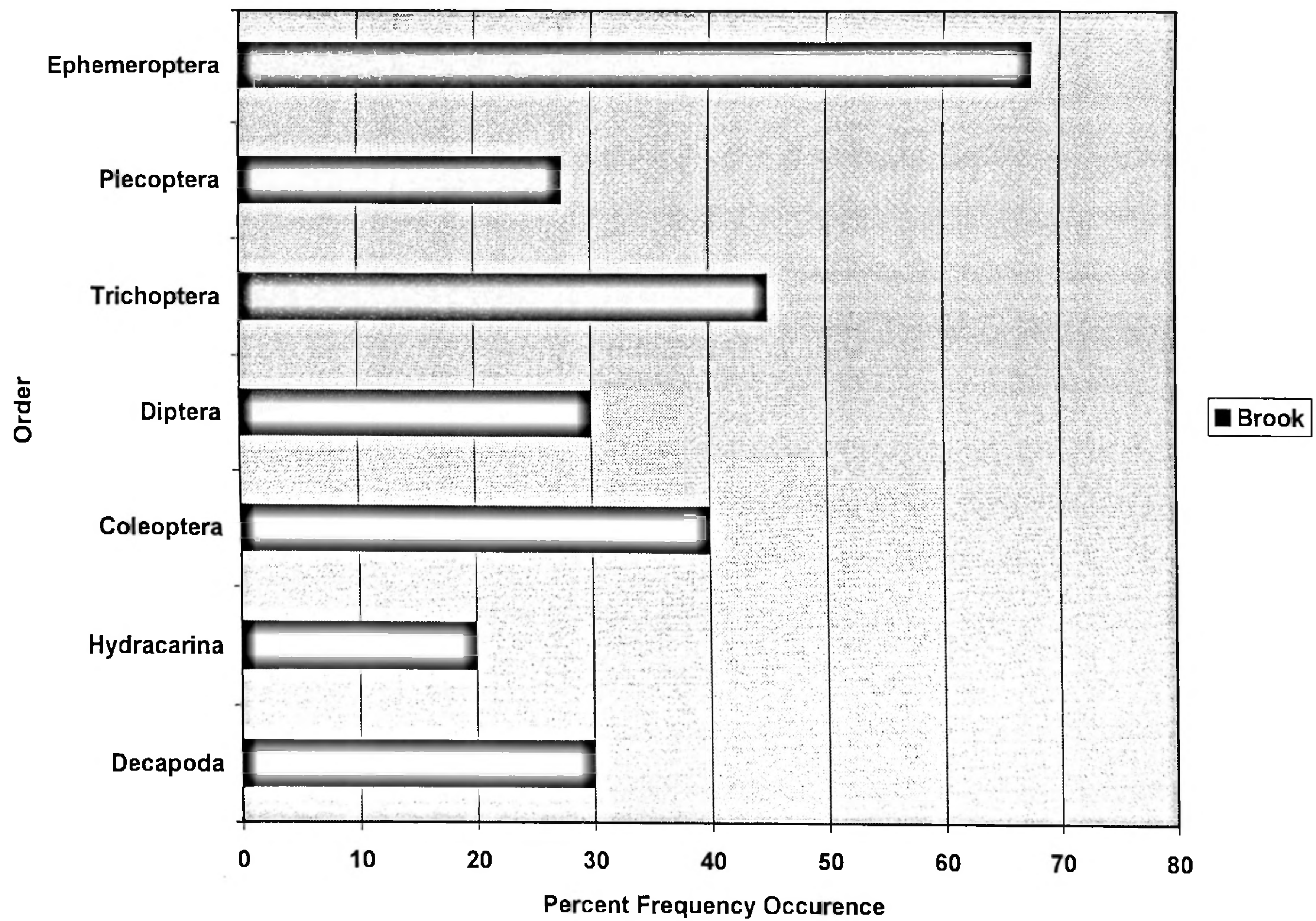

Order
Ephemeroptera
Plecoptera
Trichoptera
Diptera
Coleoptera
Odonata
Hydracarina
Brown
Brook
0
10
20
30
40
50
60
70
80
Percent Frequency Occurence

Figure 17. Percent frequency occurrence of taxa taken from brook trout at station T-2 in the summer.



Ephemeroptera
Plecoptera
Trichoptera
Diptera
Coleoptera
Odonata
Order
0
10
20
30
40
50
60
70
80
90
Percent Frequency Occurence
Brook

Figure 18. Percent frequency occurrence of taxa taken from brook trout at station C-2a in the summer.



Order
Ephemeroptera
Plecoptera
Trichoptera
Diptera
Coleoptera
Hydracarina
Decapoda
0
10
20
30
40
50
60
70
80
Percent Frequency Occurence
Brook

Figure 19. Percent frequency occurrence of taxa taken from brook and brown trout at station T-1 in the fall.

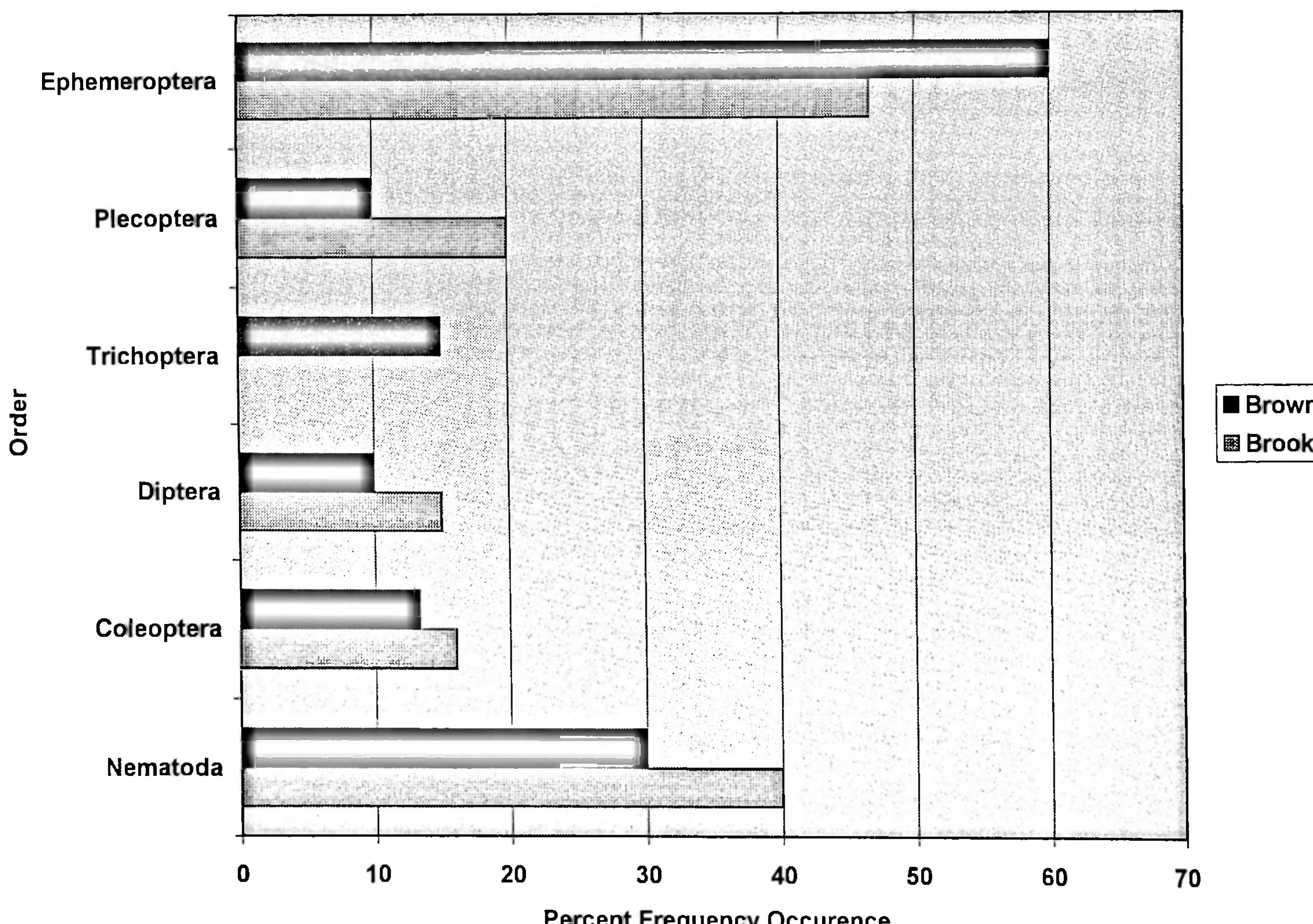
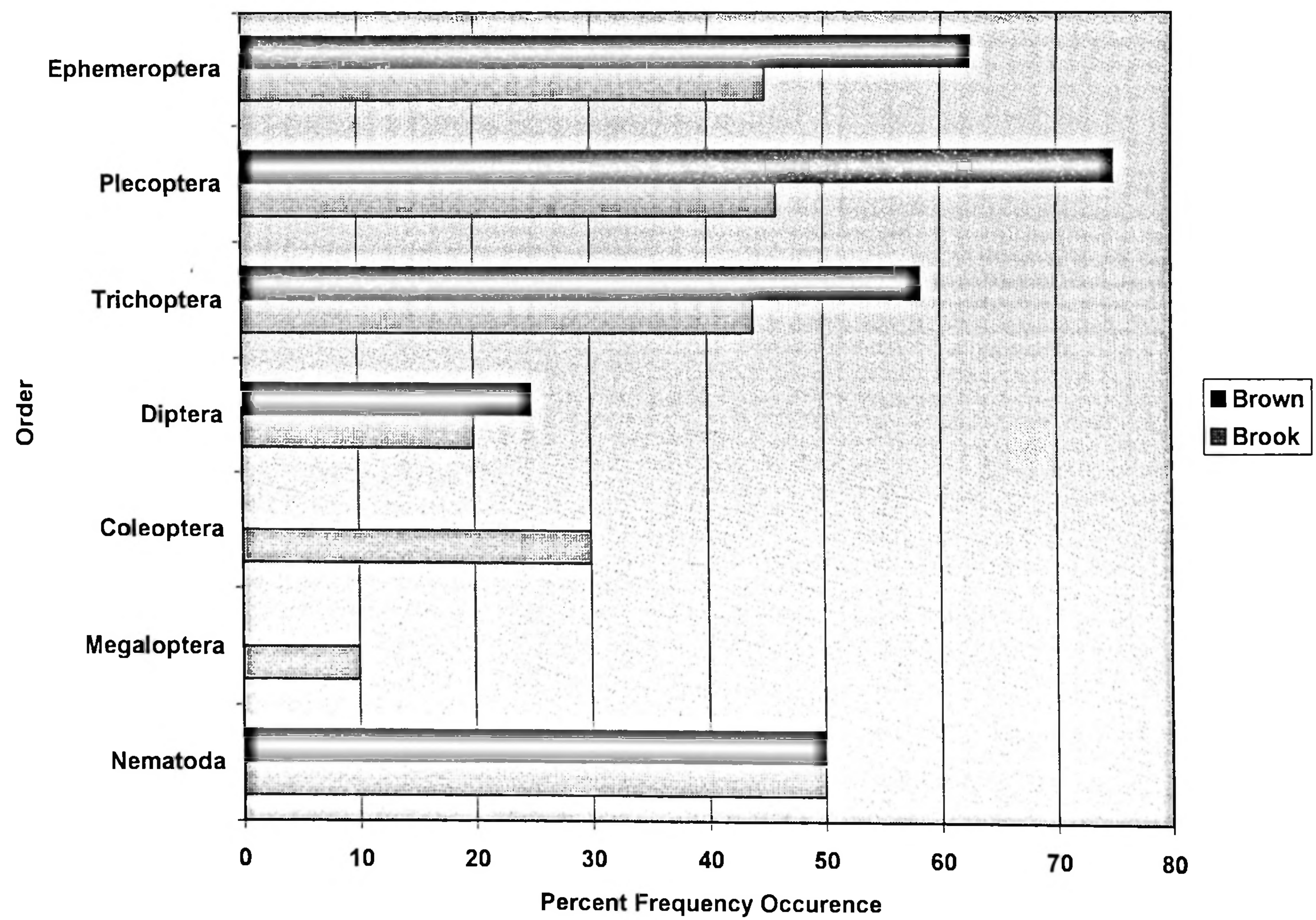

Ephemeroptera
Plecoptera
Trichoptera
Diptera
Coleoptera
Nematoda
Order
0
10
20
30
40
50
60
70
Percent Frequency Occurence
Brown
Brook

Figure 22. Percent frequency occurrence of taxa taken from brook and brown trout at station T-1 in the winter.



Ephemeroptera
Plecoptera
Trichoptera
Diptera
Coleoptera
Megaloptera
Nematoda
Order
0
10
20
30
40
50
60
70
80
Percent Frequency Occurence
Brown
Brook

Figure 23. Percent frequency occurrence of taxa taken from brook and brown trout at station T-2 in the winter.

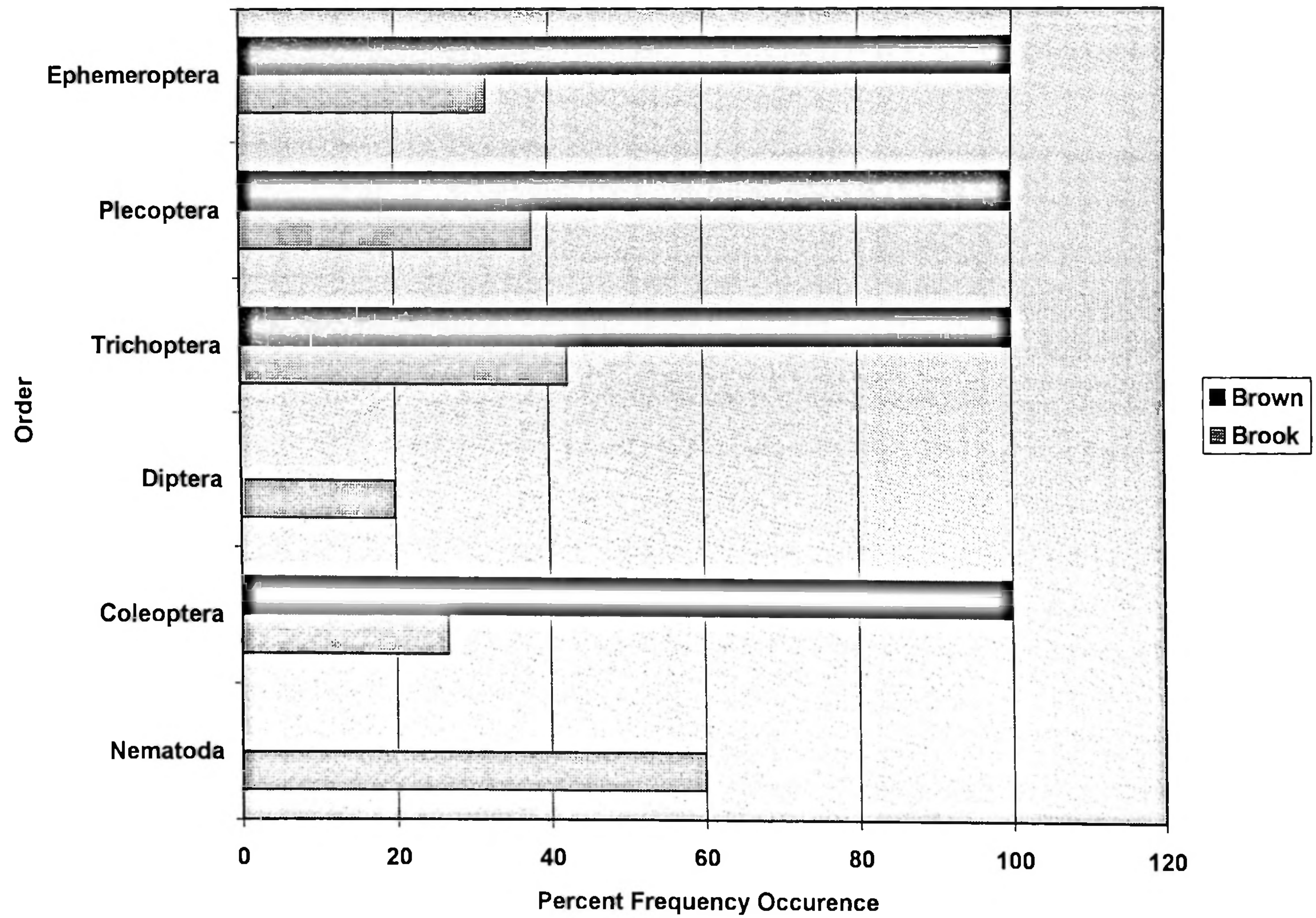

Ephemeroptera
Plecoptera
Trichoptera
Diptera
Coleoptera
Nematoda
Order
0
20
40
60
80
100
120
Percent Frequency Occurence
Brown
Brook

Figure 24. Percent frequency occurrence of taxa taken from brook trout at station C-2a in the winter.

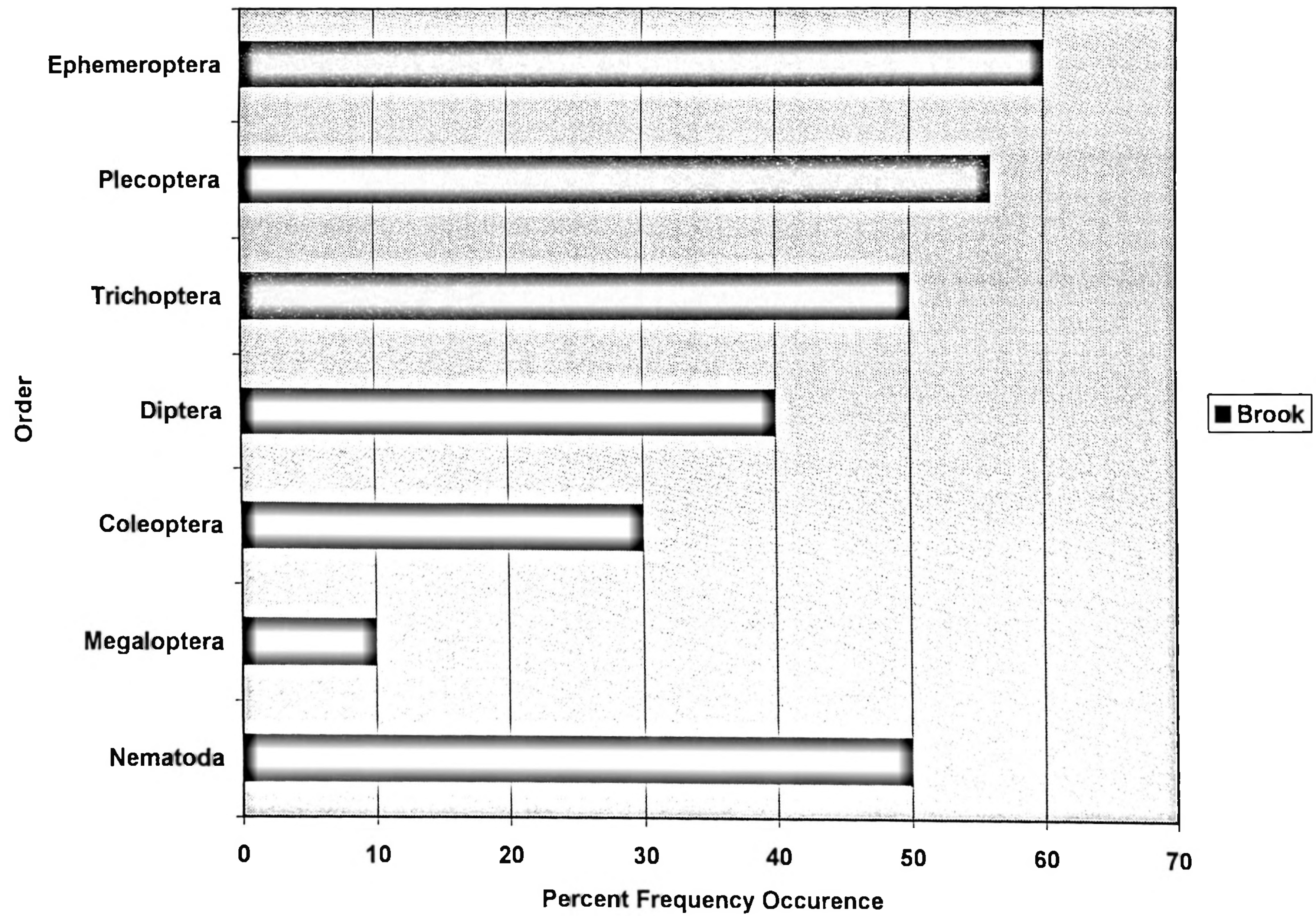
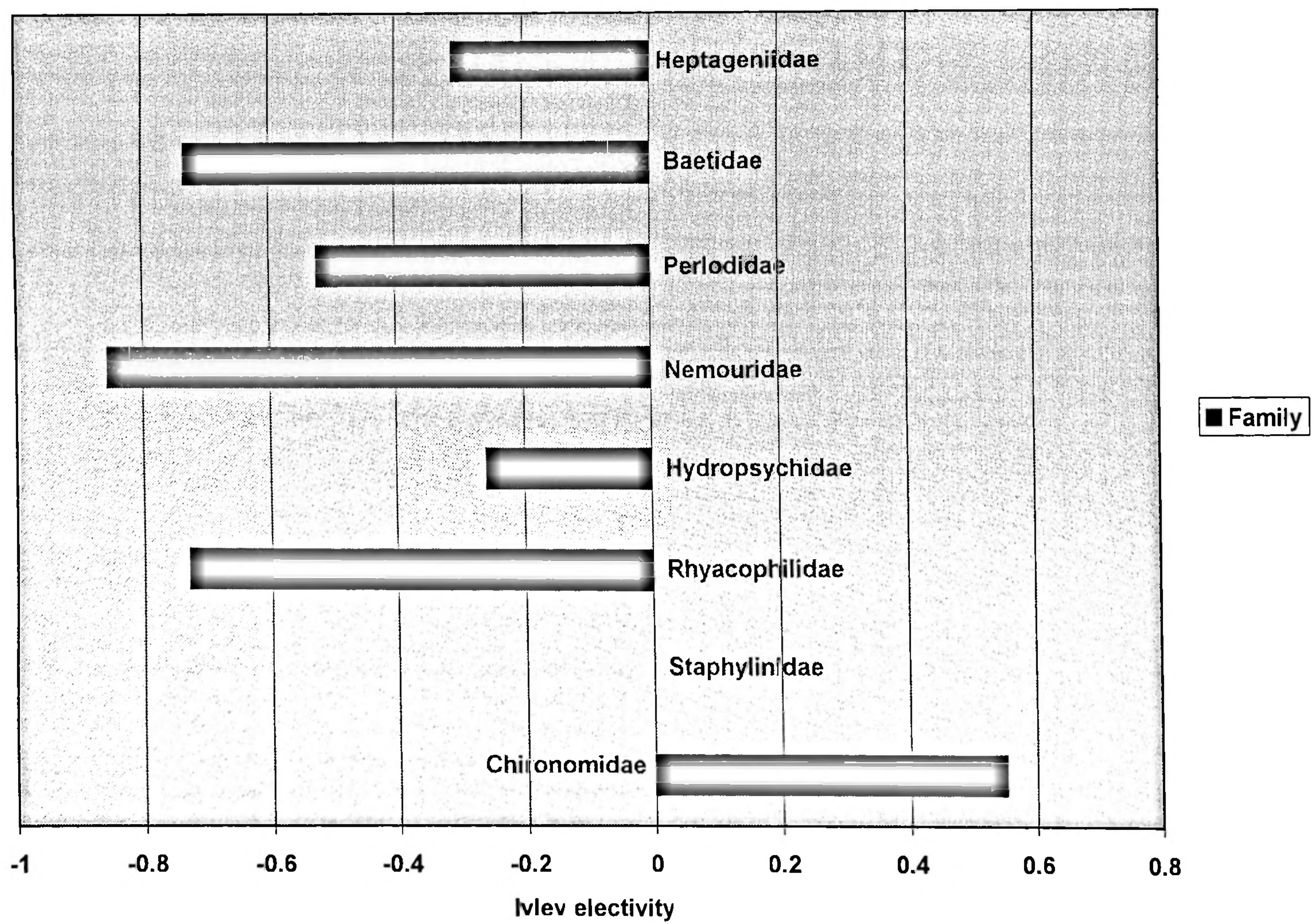

Ephemeroptera
Plecoptera
Trichoptera
Diptera
Coleoptera
Megaloptera
Nematoda
Order
0
10
20
30
40
50
60
70
Percent Frequency Occurence
Brook

Figure 25. Ivlev's electivity index results for brook trout at T-1 in the spring.



Heptageniidae
Baetidae
Perlodidae
Nemouridae
Hydropsychidae
Rhyacophilidae
Staphylinidae
Chironomidae
Family
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
Ivlev electivity

Figure 26. Ivlev's electivity index results for brook trout at T-2 in the spring.

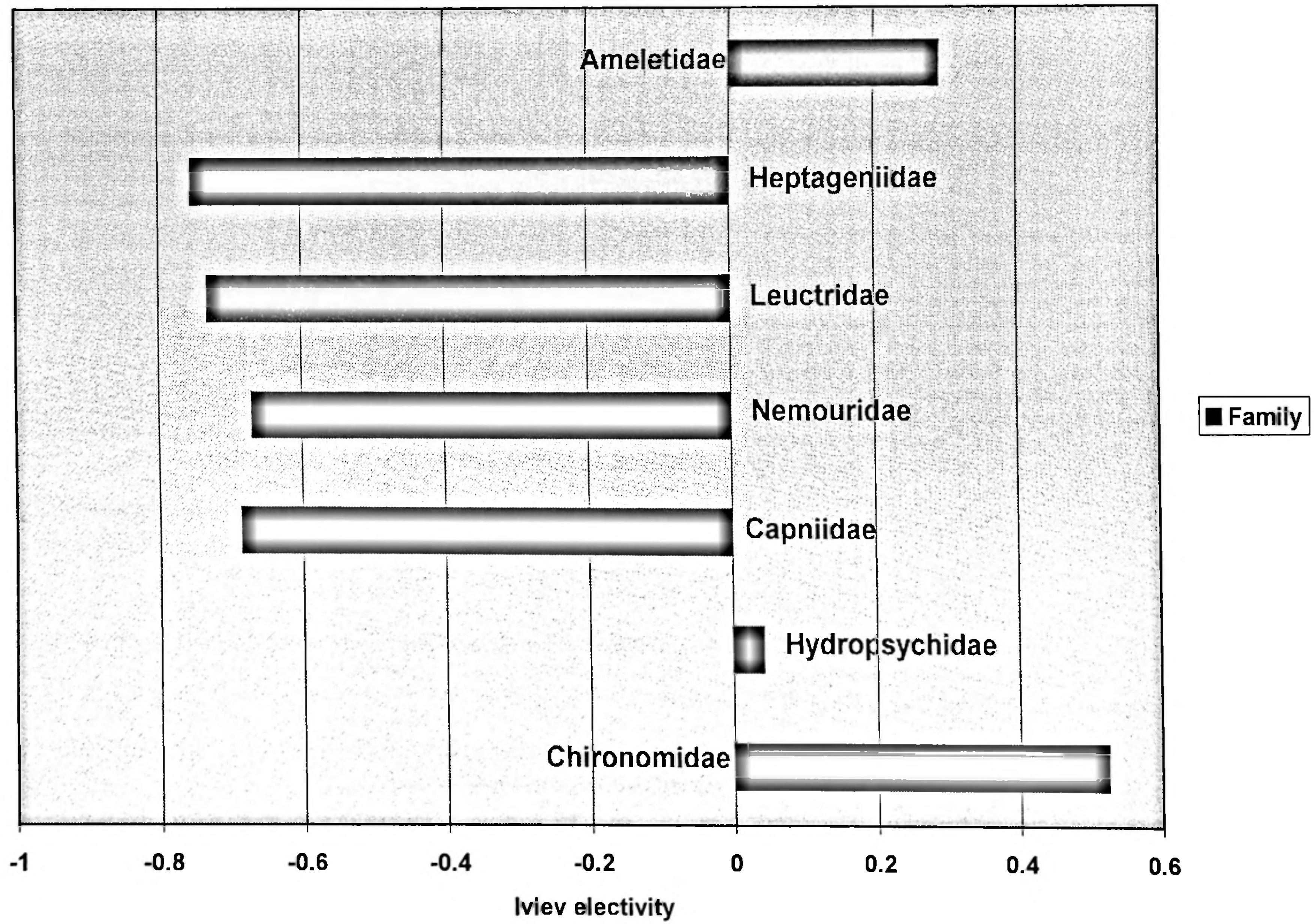

Ameletidae
Heptageniidae
Leuctridae
Nemouridae
Capniidae
Hydropsychidae
Chironomidae
Family
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
Iviev electivity

Figure 27. Ivlev's electivity index results for brook trout at C-2a in the spring.

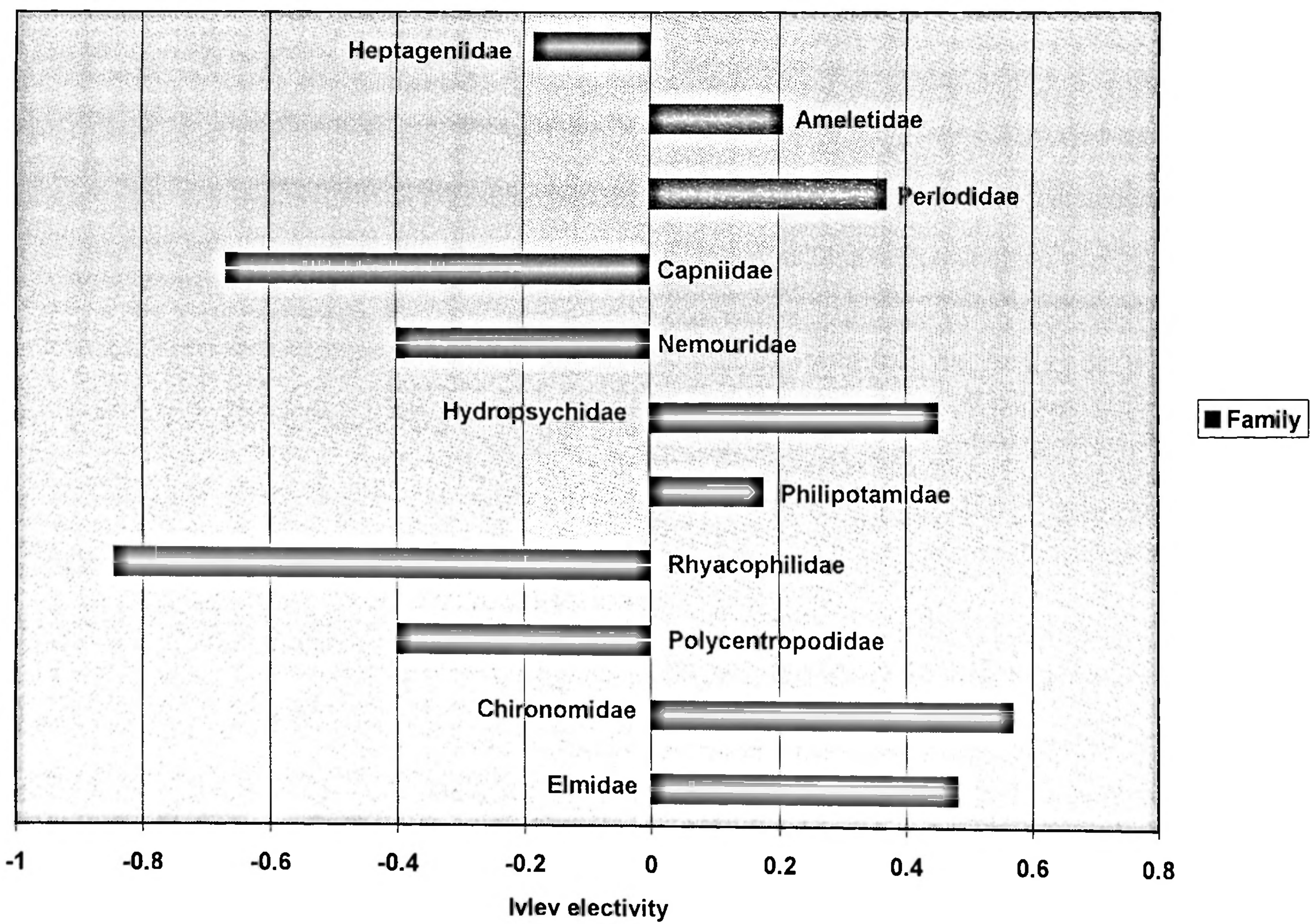

Heptageniidae
Ameletidae
Perlodidae
Capniidae
Nemouridae
Hydropsychidae
Philipotamidae
Rhyacophilidae
Polycentropodidae
Chironomidae
Elmidae
Family
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
Ivlev electivity

Figure 28. Ivlev's electivity index results for brown trout at T-1 in the spring.

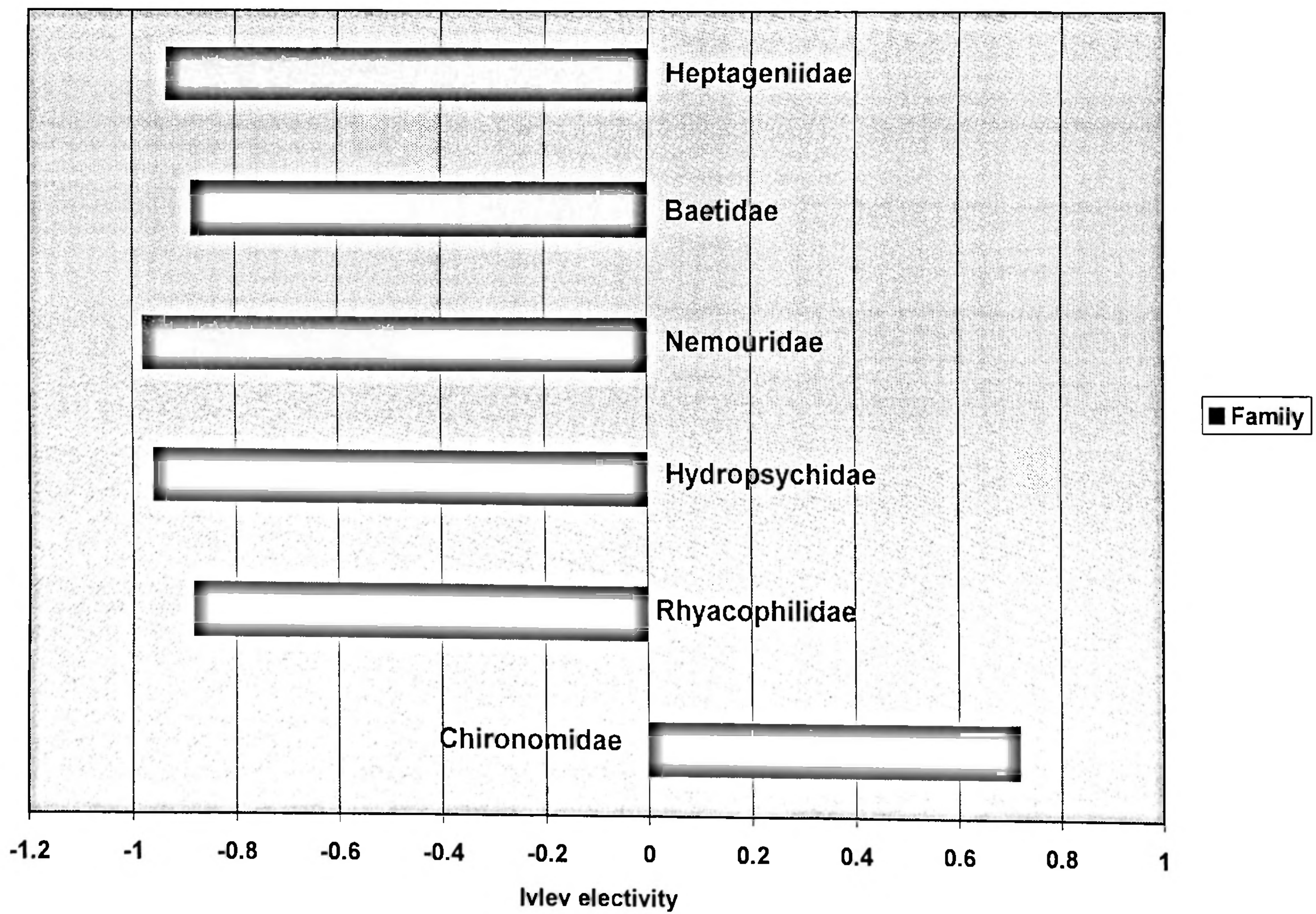

Heptageniidae
Baetidae
Nemouridae
Hydropsychidae
Rhyacophilidae
Chironomidae
-1.2
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
Ivlev electivity
Family

Figure 29. Ivlev's electivity index results for brown trout at T-2 in the spring.

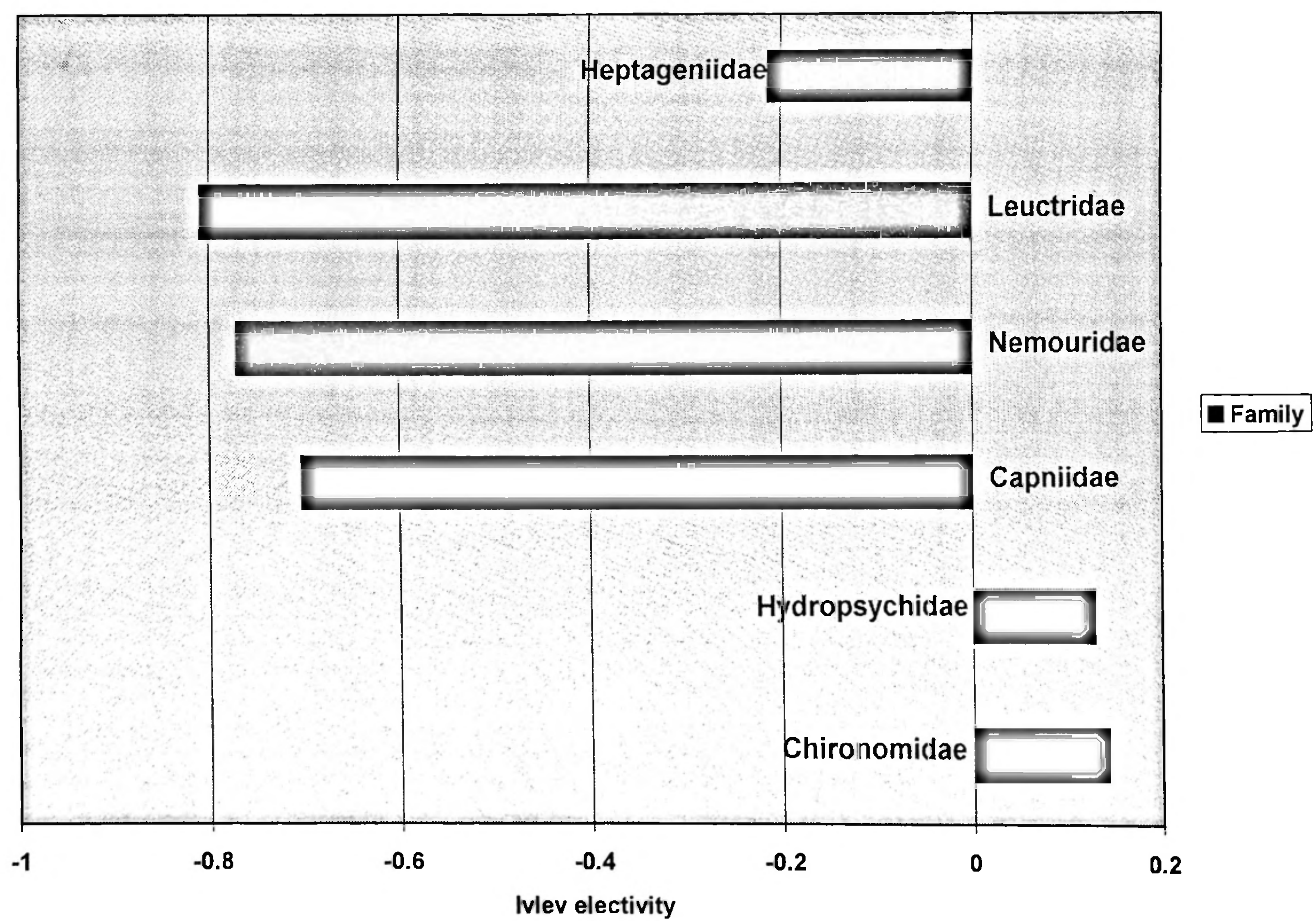

Heptageniidae
Leuctridae
Nemouridae
Capniidae
Hydropsychidae
Chironomidae
Family
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
Ivlev electivity

Figure 30. Ivlev's electivity index results for brook trout at T-1 in the summer.

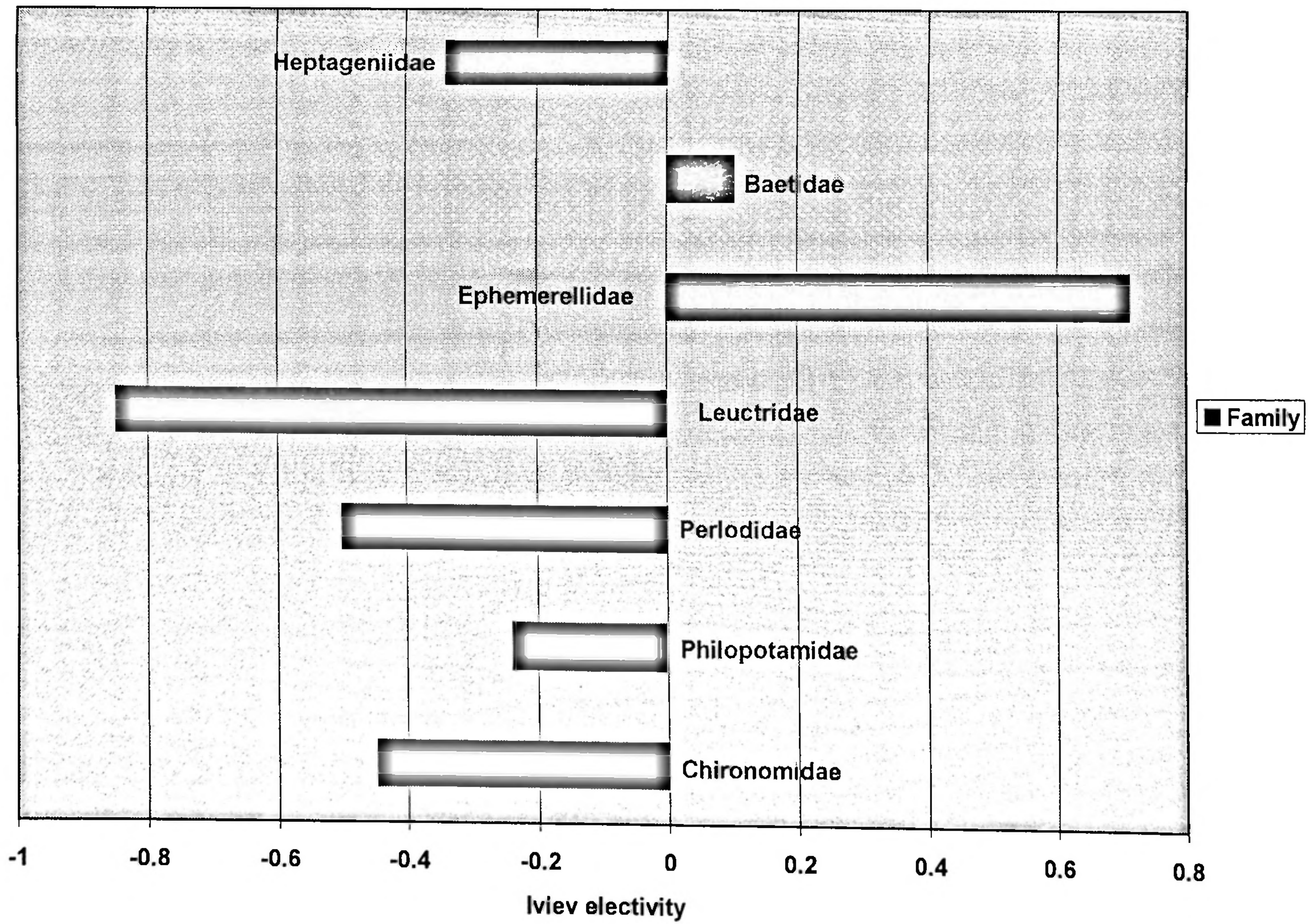

Heptageniidae
Baetidae
Ephemerellidae
Leuctridae
Perlodidae
Philopotamidae
Chironomidae
Family
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
Ivlev electivity

Figure 31. Ivlev's electivity index results for brook trout at T-2 in the summer.

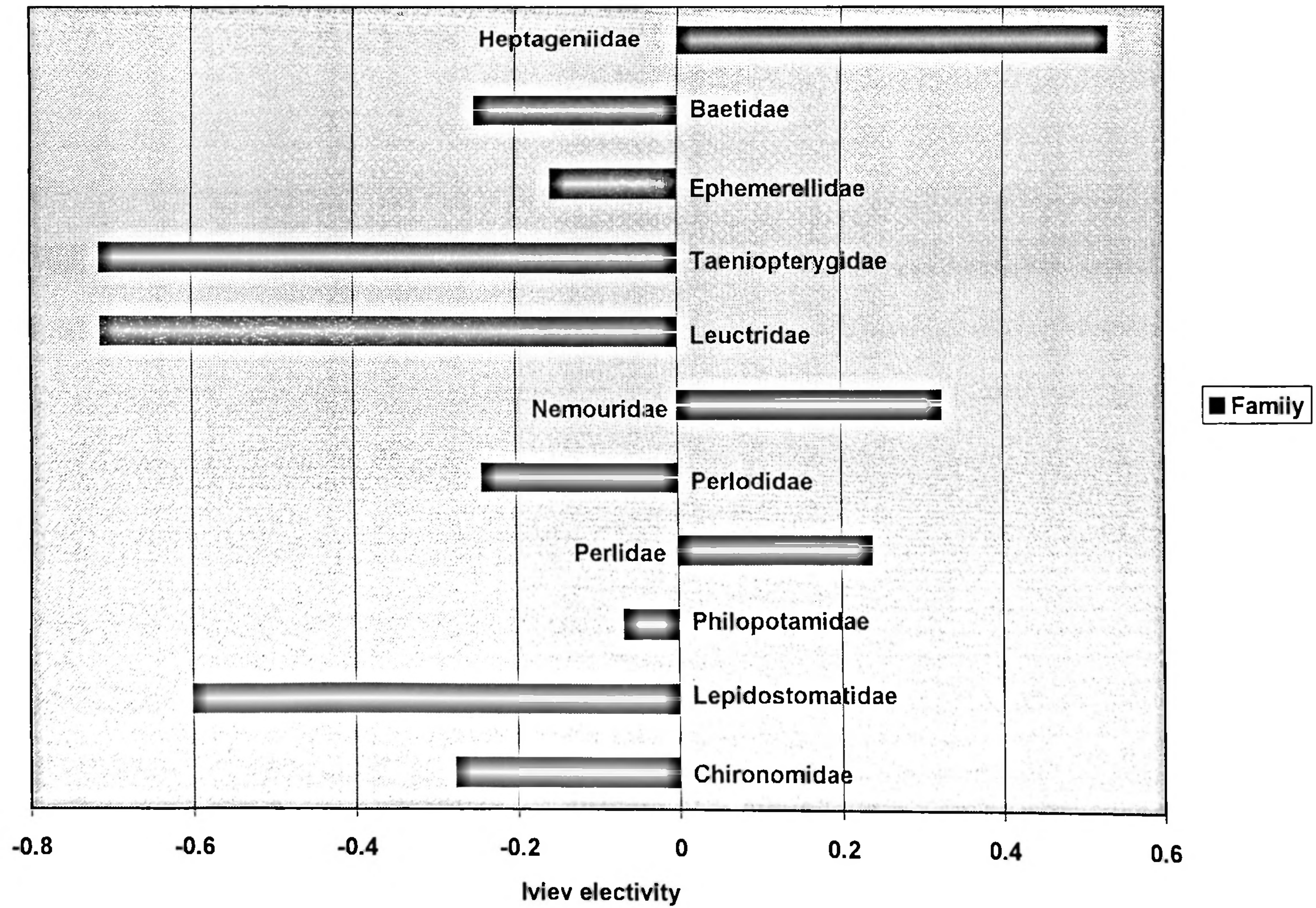

Heptageniidae
Baetidae
Ephemerellidae
Taeniopterygidae
Leuctridae
Nemouridae
Perlodidae
Perlidae
Philopotamidae
Lepidostomatidae
Chironomidae
Family
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
Iviev electivity

Figure 32. Ivlev's electivity index results for brook trout at C-2a in the summer.

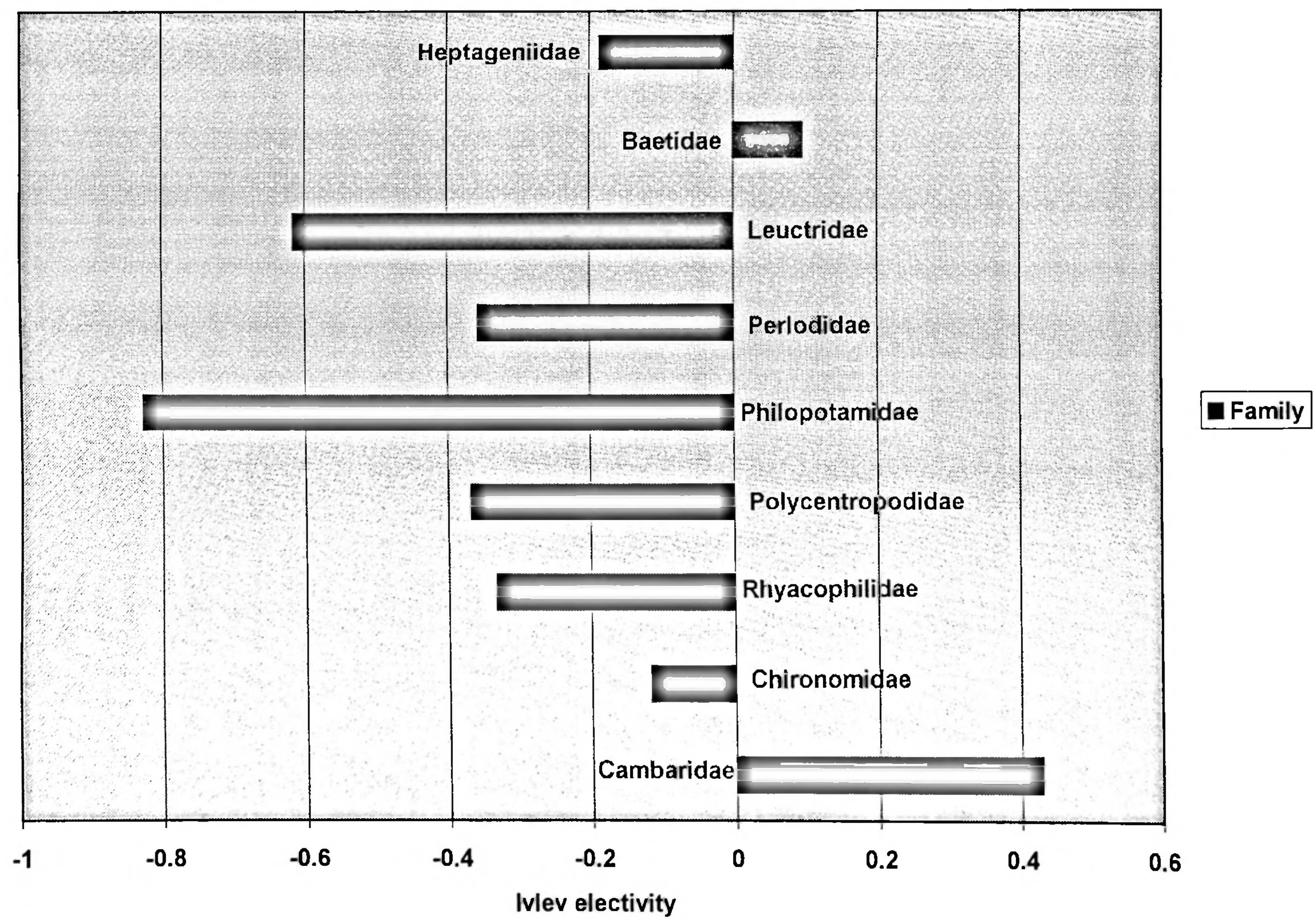

Heptageniidae
Baetidae
Leuctridae
Perlodidae
Philopotamidae
Polycentropodidae
Rhyacophilidae
Chironomidae
Cambaridae
Family
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
Ivlev electivity

Figure 33. Ivlev's electivity index results for brown trout at T-1 in the summer.

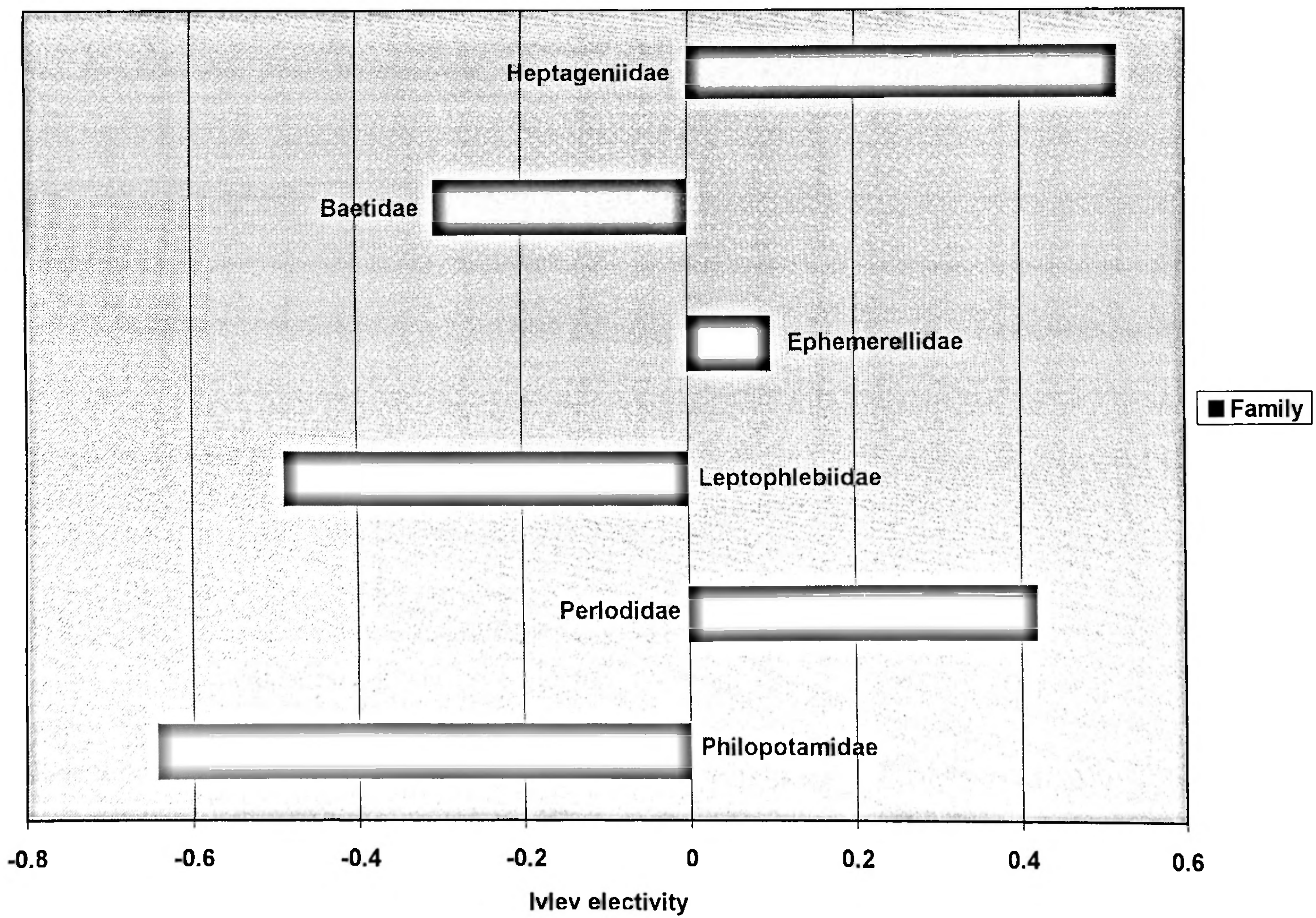

Heptageniidae
Baetidae
Ephemerellidae
Leptophlebiidae
Perlodidae
Philopotamidae
Family
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
Ivlev electivity

Figure 34. Ivlev's electivity index results for brook trout at T-1 in the fall.

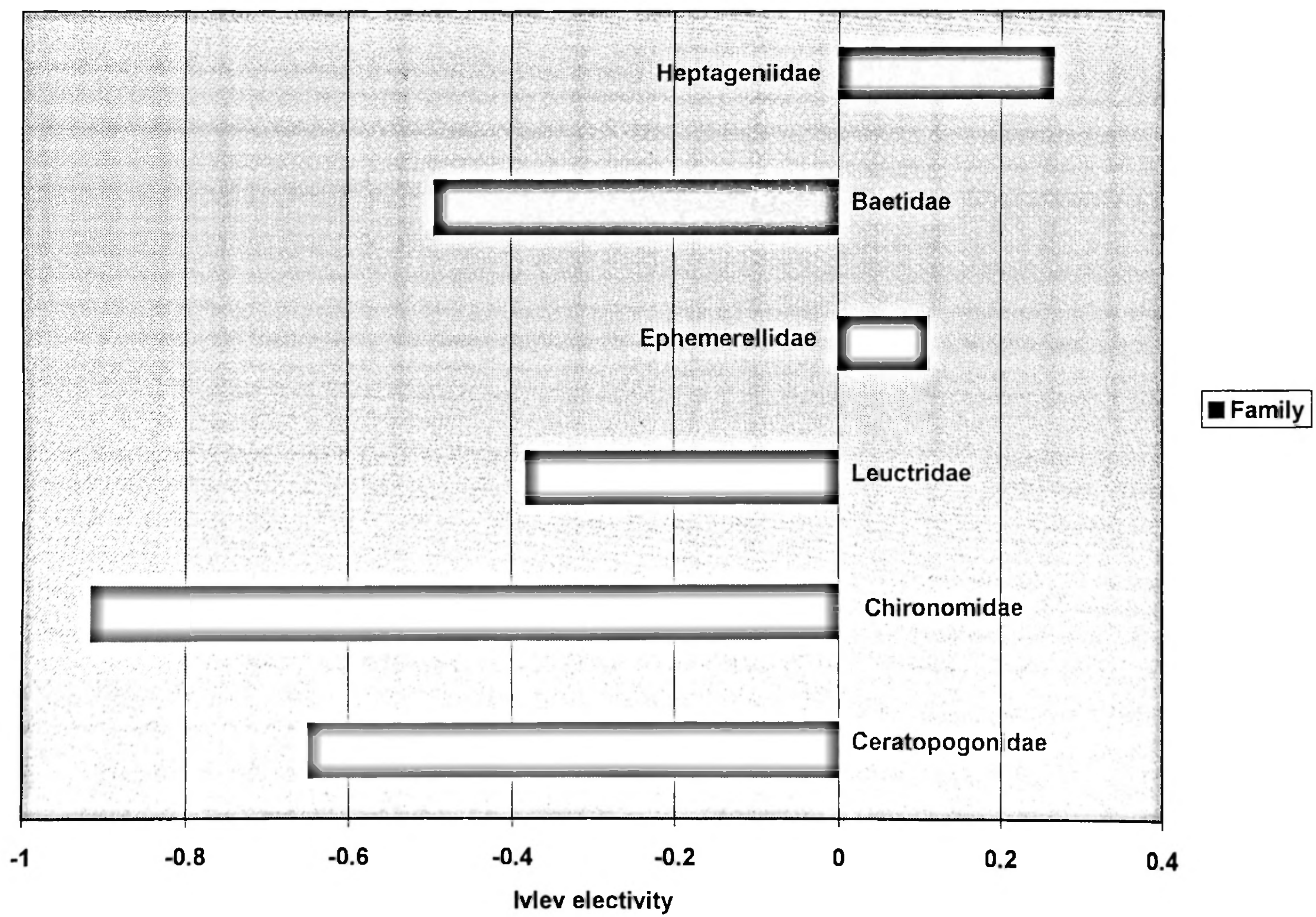

Heptageniidae
Baetidae
Ephemerellidae
Leuctridae
Chironomidae
Ceratopogonidae
Family
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
Ivlev electivity

Figure 35. Ivlev's electivity index results for brook trout at T-2 in the fall.

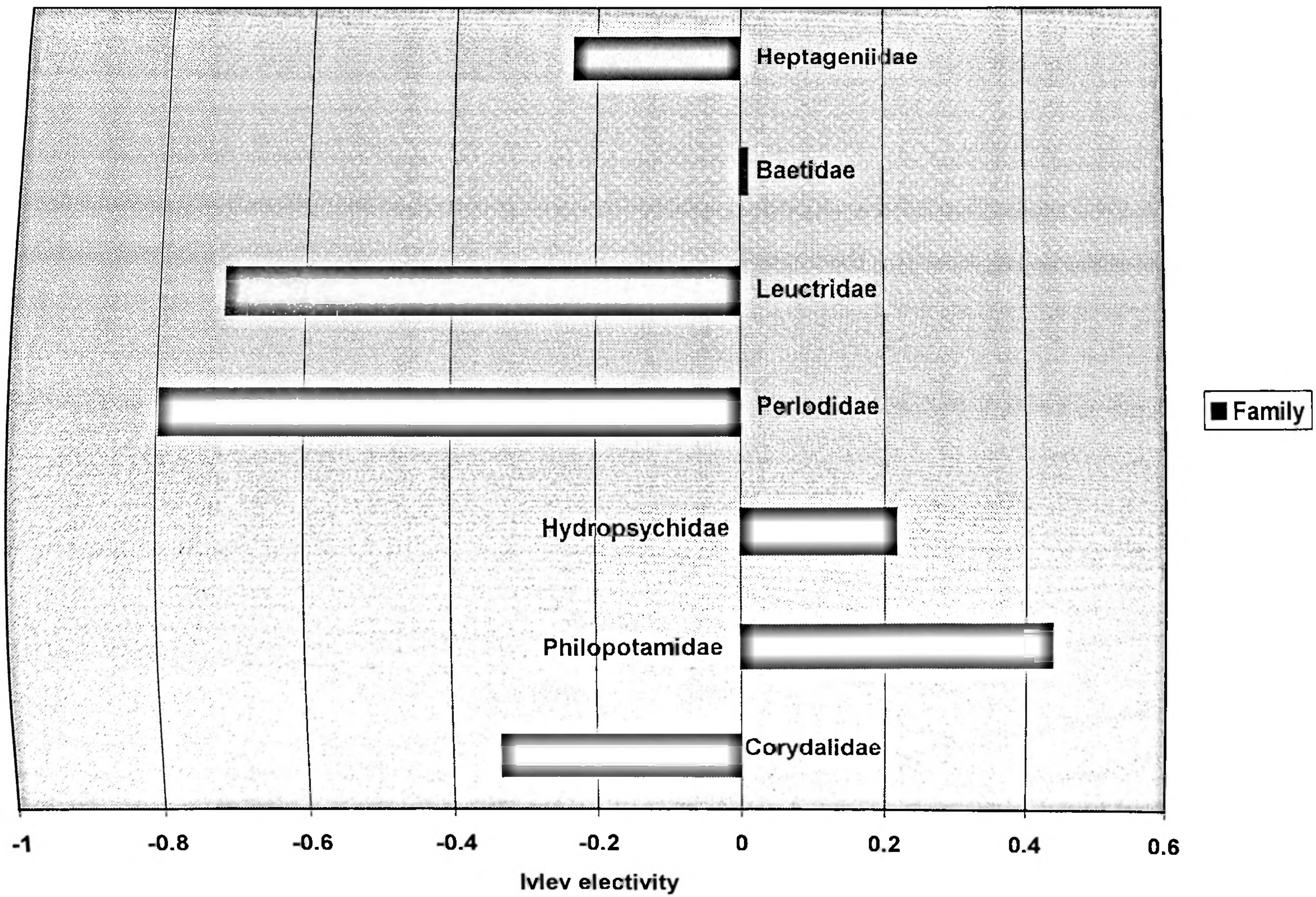
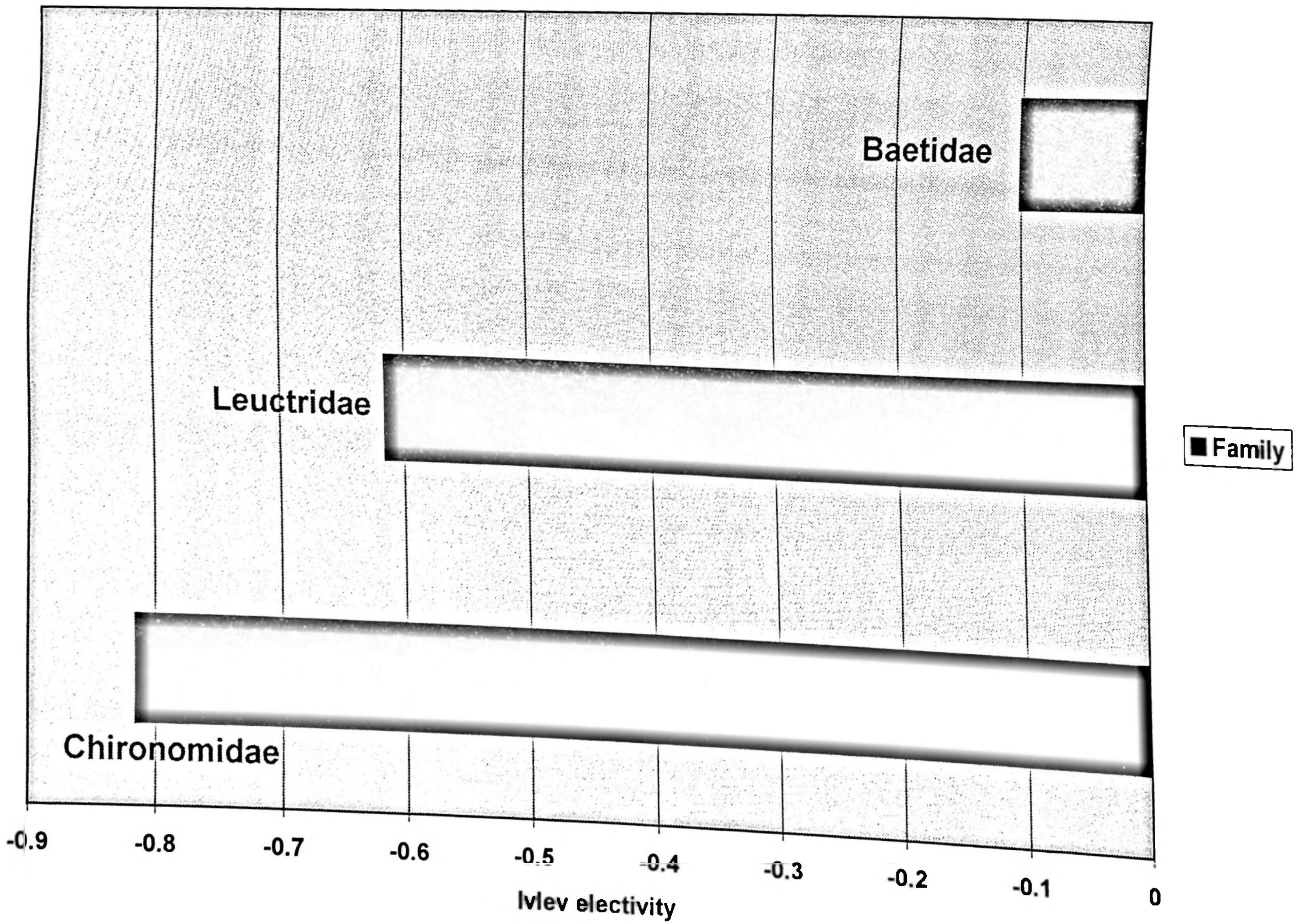

Heptageniidae
Baetidae
Leuctridae
Perlodidae
Hydropsychidae
Philopotamidae
Corydalidae
Family
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
Ivlev electivity

Figure 36. Ivlev's electivity index results for brook trout at C-2a in the fall.



Baetidae
Leuctridae
Chironomidae
Family
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0
Ivlev electivity

Figure 37. Ivlev's electivity index results for brown trout at T-1 in the fall.

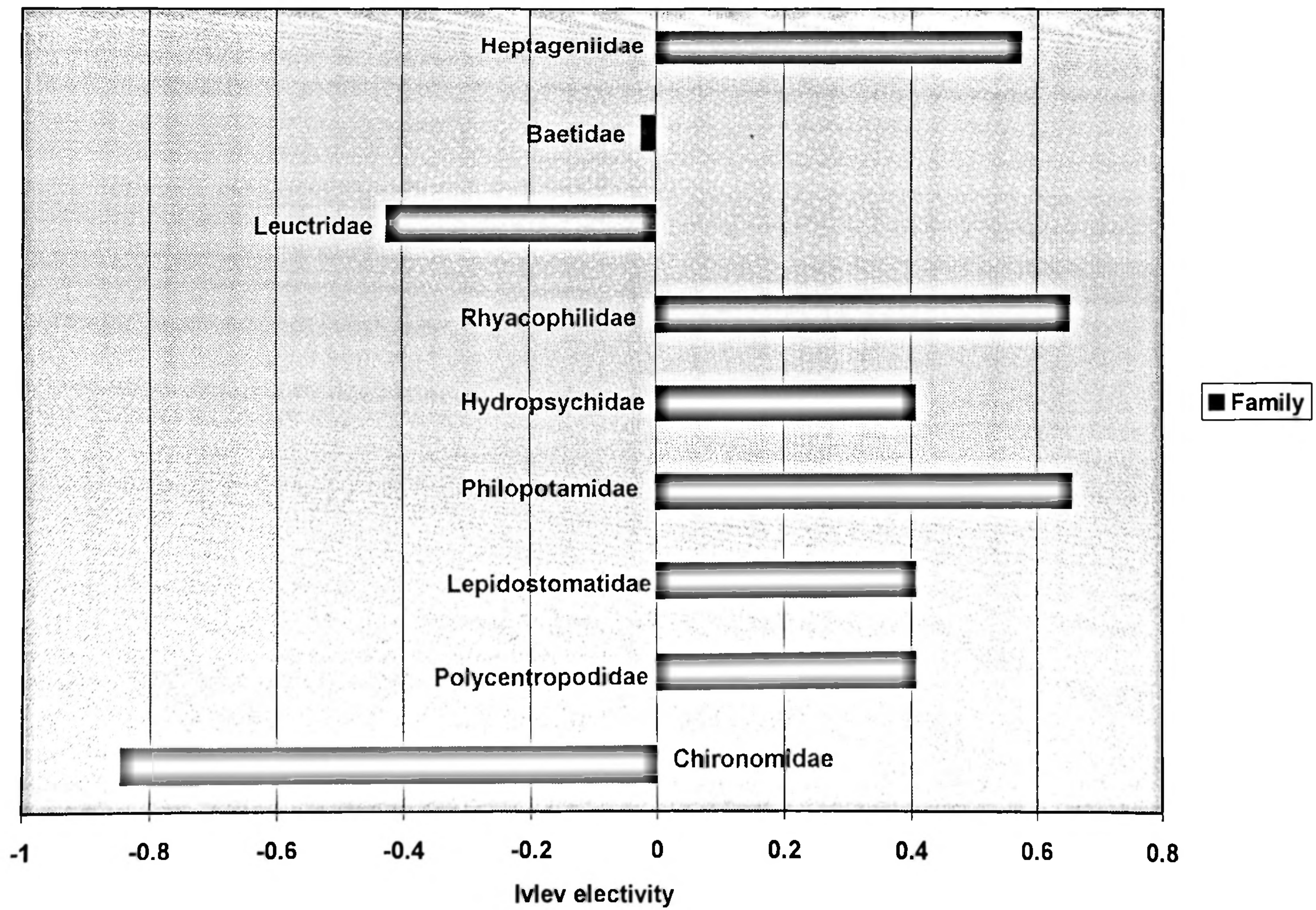

Heptageniidae
Baetidae
Leuctridae
Rhyacophilidae
Hydropsychidae
Philopotamidae
Lepidostomatidae
Polycentropodidae
Chironomidae
Family
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
Ivlev electivity

Figure 38. Ivlev's electivity index results for brown trout at T-2 in the fall.

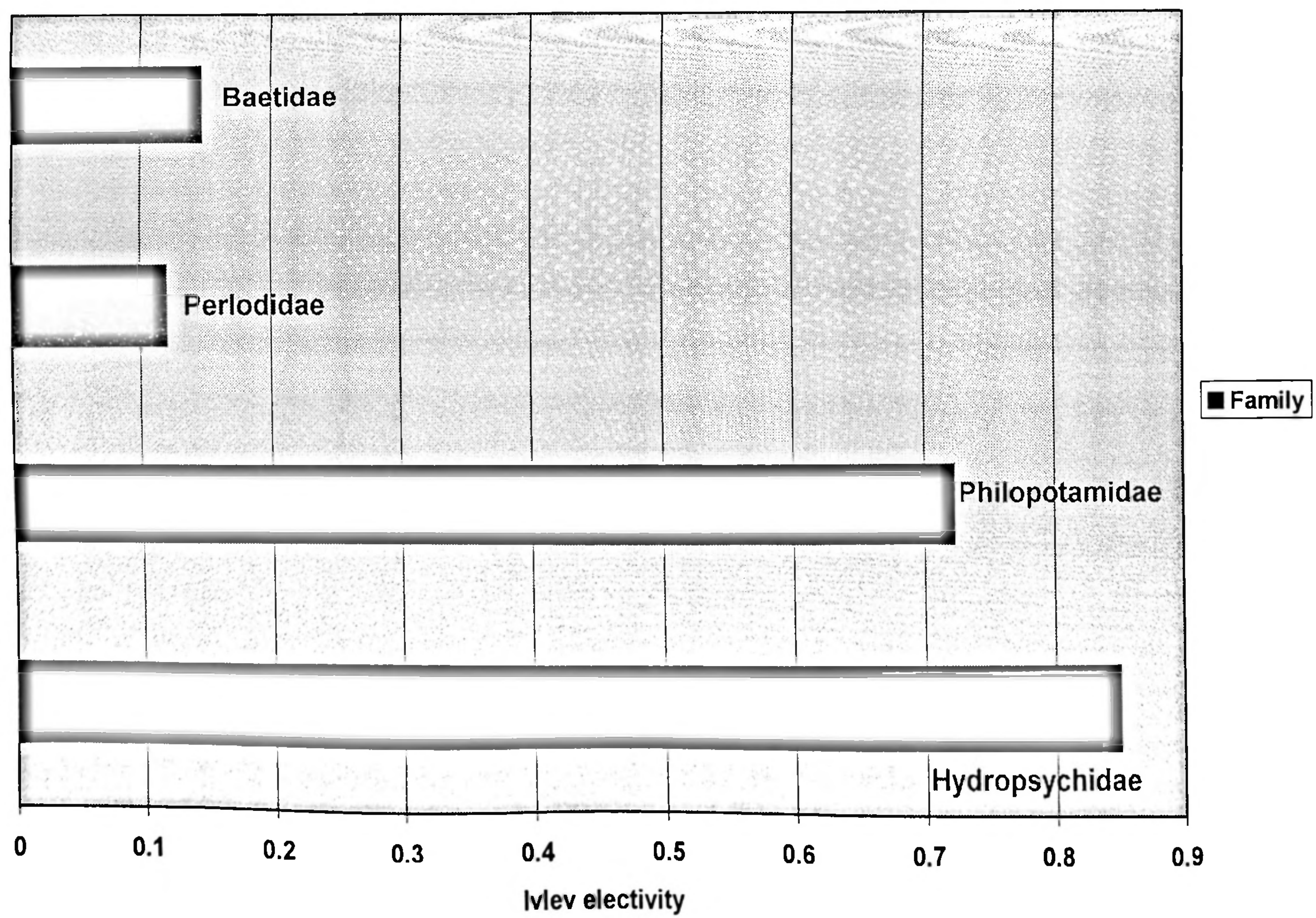

Baetidae
Perlodidae
Philopotamidae
Hydropsychidae
Family
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Ivlev electivity

Figure 39. Ivlev's electivity index results for brook trout at T-1 in the winter.

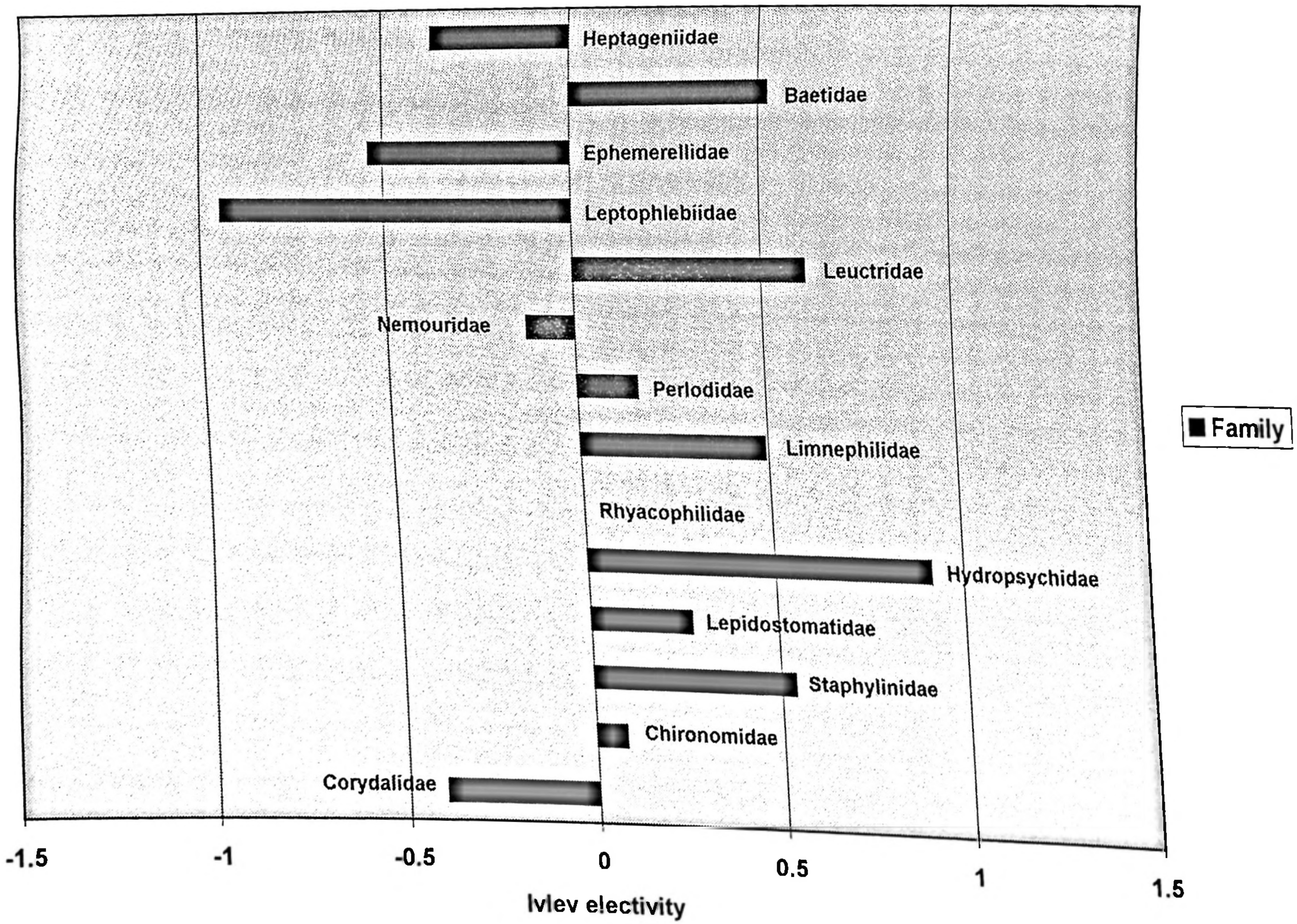

Heptageniidae
Baetidae
Ephemerellidae
Leptophlebiidae
Leuctridae
Nemouridae
Perlodidae
Limnephilidae
Rhyacophilidae
Hydropsychidae
Lepidostomatidae
Staphylinidae
Chironomidae
Corydalidae
Family
-1.5
-1
-0.5
0
0.5
1
1.5
Ivlev electivity

Figure 40. Ivlev's electivity index results for brook trout at T-2 in the winter.

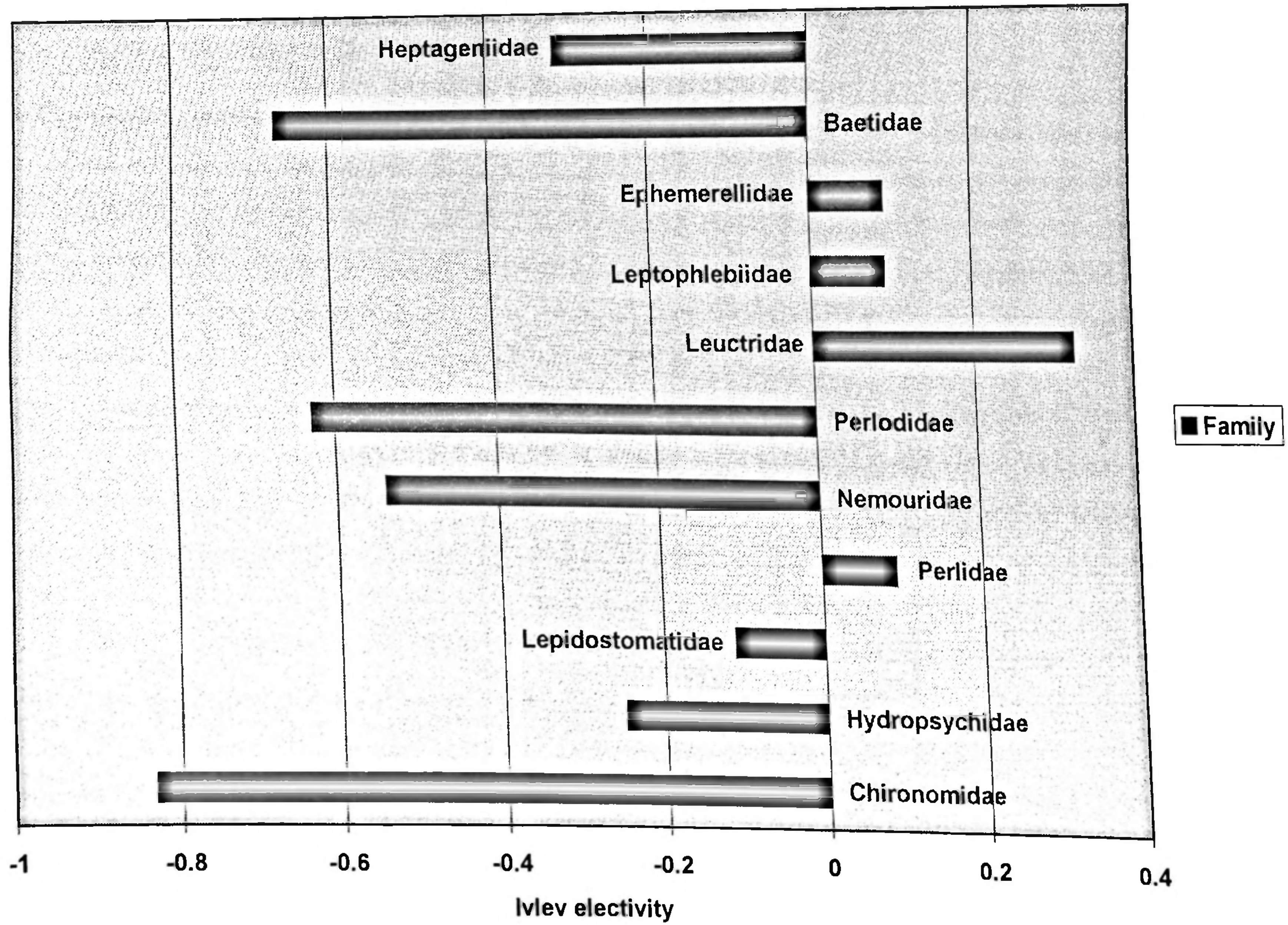
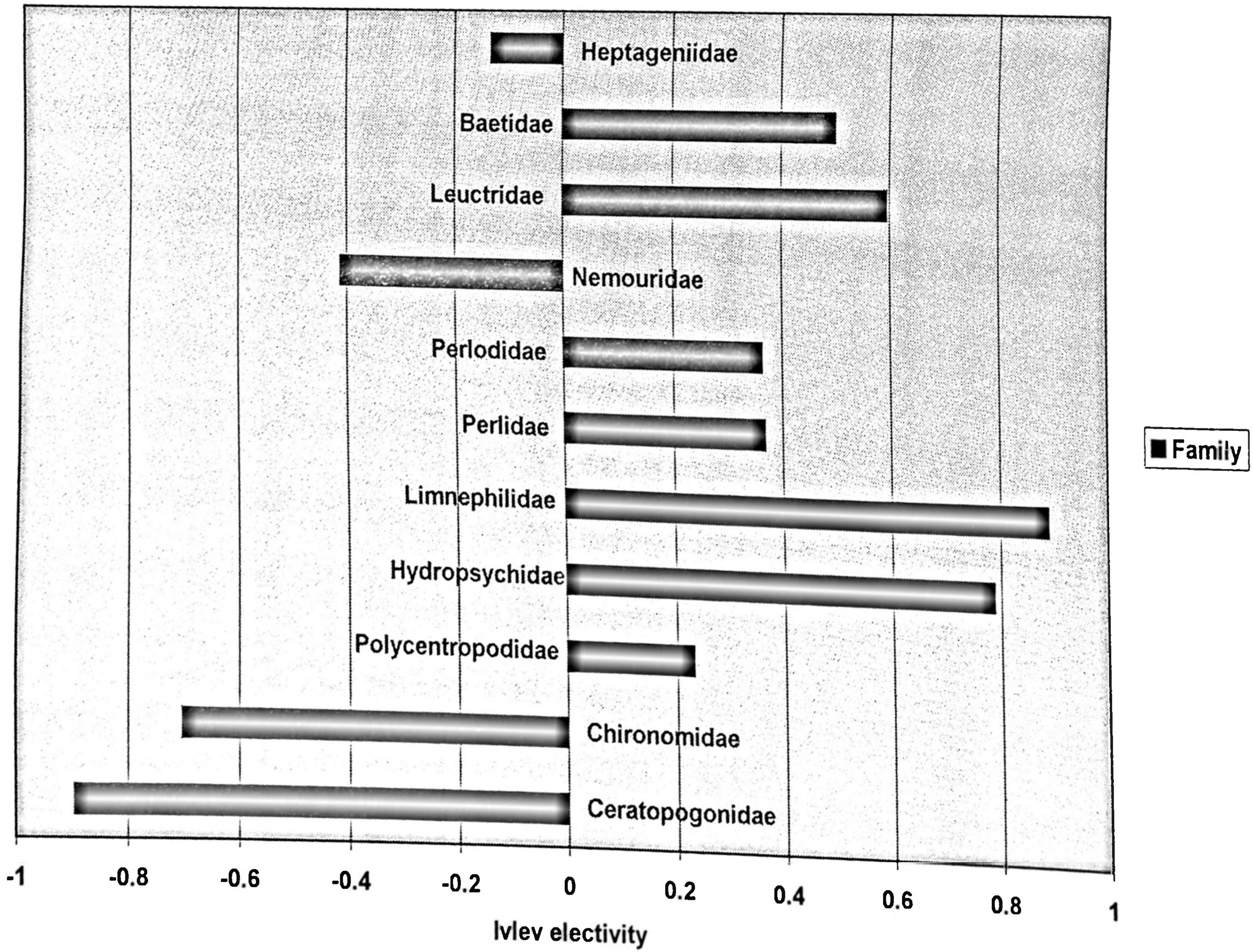

Heptageniidae
Baetidae
Ephemerellidae
Leptophlebiidae
Leuctridae
Perlodidae
Nemouridae
Perlidae
Lepidostomatidae
Hydropsychidae
Chironomidae
Family
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
Ivlev electivity

Figure 41. Ivlev's electivity index results for brook trout at C-2a in the winter.



Heptageniidae
Baetidae
Leuctridae
Nemouridae
Perlodidae
Perlidae
Limnephilidae
Hydropsychidae
Polycentropodidae
Chironomidae
Ceratopogonidae
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
Ivlev electivity
Family

Figure 42. Ivlev's electivity index results for brown trout at T-1 in the winter.

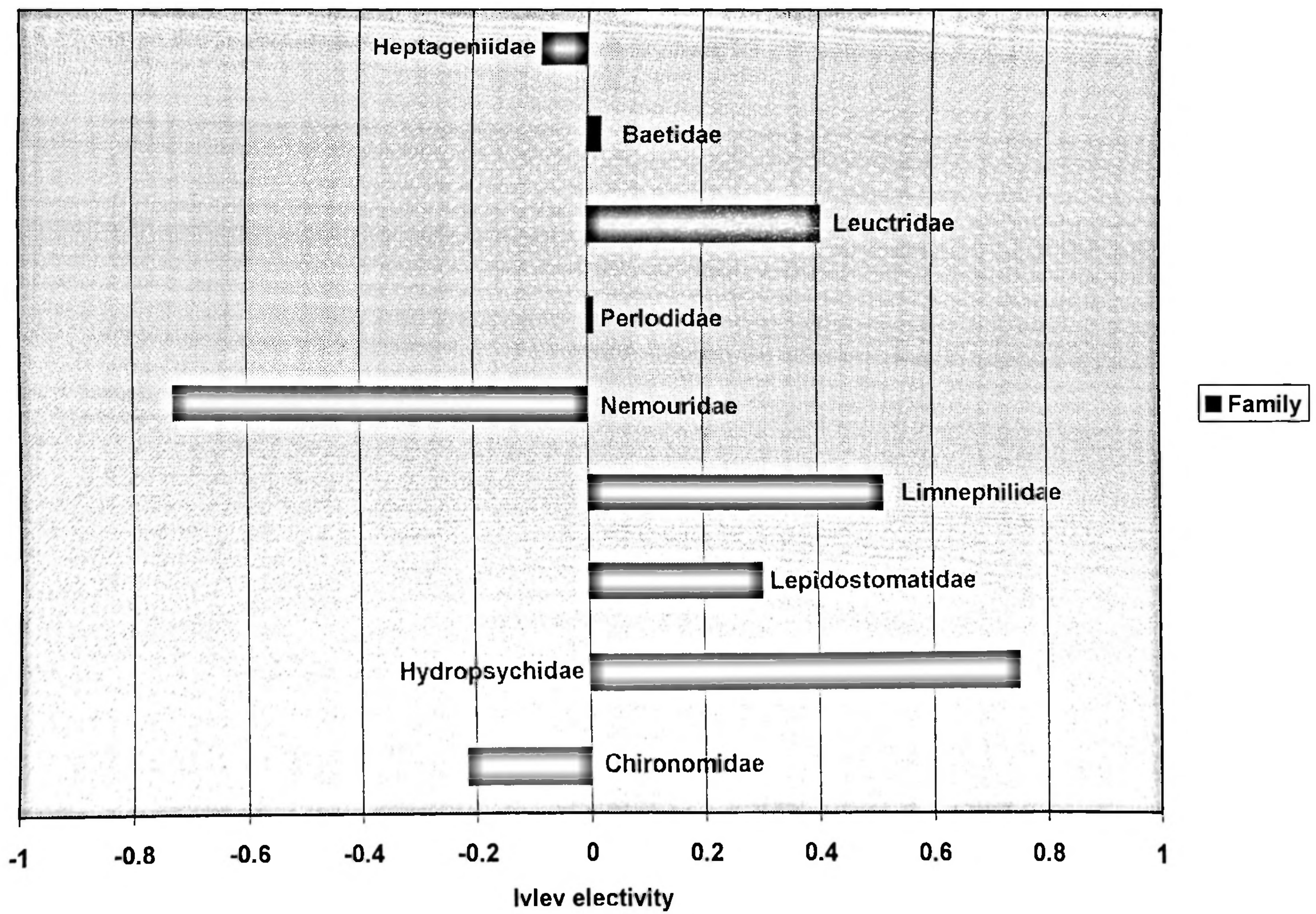
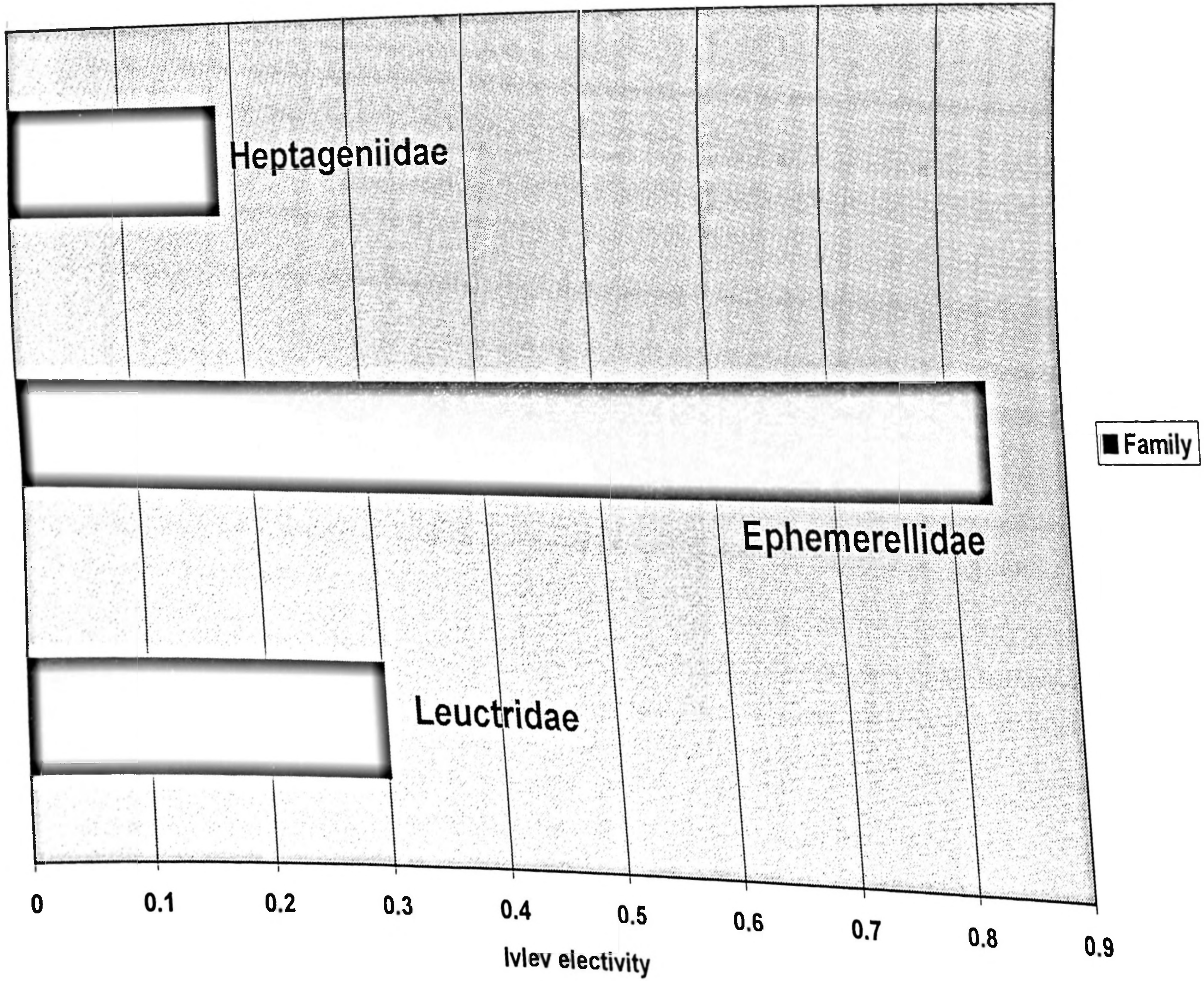

Heptageniidae
Baetidae
Leuctridae
Perlodidae
Nemouridae
Limnephilidae
Lepidostomatidae
Hydropsychidae
Chironomidae
Family
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
Ivlev electivity

Figure 43. Ivlev's electivity index results for brown trout at T-2 in the winter.


Heptageniidae
Ephemerellidae
Leuctridae
Family
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Ivlev electivity