PROJECT REPORT

On

A COMPARISON AND ANALYSIS OF MACROINVERTEBRATE COMMUNITY HEALTH BETWEEN THE TYSON AND ALCAN BRANCHES (PETTIS CO., MISSOURI)

Prepared by the Central Plains Center for Bioassessment (CPCB)
Kansas Biological Survey, University of Kansas, Lawrence, Kansas

Submitted to:

Missouri Department of Natural Resources
Division of Environmental Quality
1110 S College Ave
Columbia, MO 65201

by

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Dr. Donald G. Huggins
and
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Report Number 110 of the Kansas Biological Survey

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Introduction

The Central Plains Center for Bioassessment (CPCB), a non-regulatory, non-management research organization established to provide biological expertise for the Central Plains and United States Environmental Protection Agency Region 7, was asked to participate in the analysis of invertebrate samples from the Alcan and Tyson Branches in Missouri in order to identify possible impact. Samples were sorted, identified and analyzed in a double blind manner in which we were not involved in sampling or aware of sampling methods. Conversely, field personnel from the Missouri Department of Natural Resources have not participated in identification and analysis. Herein, we report on the results of this study.

Methods and Data Analysis

Four (6 square foot) benthos samples collected in July and August from the Tyson and Alcan Branches were sorted and identified using Johannsen (1935a, 1935b), Johannsen & Thomsen (1937), Mackie & Huggins (1983), Merrit & Cummins (1996), Pennak (1978), Pflieger (1996) and Thorp & Covich (1991). Chironomidae larvae and pupae were slide mounted and identified to genus using Coffman & Ferrington (1996), Epler (1995), Johannsen (1936), Johannsen & Thomsen (1937), Wiederholm (1983) and Wiederholm (1986). Nine invertebrate and six Chironomidae metrics (Table 1) from the "Development of Biological Criteria for the Macroinvertebrates of the Western Corn Belt Plains Ecoregion" (Donley 1999) were calculated. These metrics were selected because they have been shown to be reliable measures of invertebrate communities and stream health in the Midwest. Semi-aquatic and terrestrial specimens were not included in the calculation of metrics since they are not a part of the aquatic community or are only partially dependant upon water quality conditions associated with the stream ecosystem because they often rely on atmospheric oxygen as a primary source of oxygen, are mobile taxa and may or may not live fully exposed to ambient stream conditions. Specimens were identified to genus when possible, but due to the difficulty of identifying some immatures without rearing or comparisons, some taxa (Corduliidae/Libellulidae, Corixidae, Veliidae, Dytiscidae, Ephydridae, Muscoidea, Stratiomyidae, Tabanidae, Copepoda, Oligochaeta, Glossiphoniidae, Annelida and Physa) were separated into morphotaxa (distinct taxa in the collections based on differences in morphological characteristics (Rosenberg & Resh 1996)) and

included in the analysis. Specimens that could not be designated as distinct taxa (Tanypodinae) were only included in total abundance metrics.

Two changes were made to the original list of metrics from the Donley (1999) study. Sensitive Taxa Richness was replaced with Nutrient and Oxygen Demanding Substance (NOD) Sensitive Taxa Richness for both the invertebrates and Chironomidae because NOD tolerances are better at identifying possible point source pollution. Tolerance values were taken from Huggins and Moffett (1988). Taxa with NOD tolerances below 3 (0-5 scale) were considered sensitive. A second change was the replacement of Percent Tribe Tanytarsini for Percent *Chironomus riparius* (Meigen) because of the small number of Tanytarsini in the collections. *Chironomus riparius* is often the dominant insect species found in the effluent of sewage treatment plants and in streams enriched with organic nutrients (Epler 1995). It's high tolerance to sedimentation and low oxygen levels make it's presence a good indicator of stream impairment (Ferrington 1990).

The Invertebrate Community Index (ICI) (OEPA 1987) was also computed for each sample. The ICI was calculated as the sum of individual scores from each of the nine invertebrate metrics. Each metric was scored on a scale of 1, 3, or 5 and the sum of these scores produced a value (ICI) between 9 and 45 (9 = most impacted and 45 = least impacted).

Proportional Similarity (Kane 1990) was calculated in order to compare invertebrate samples between the Alcan Branch and Tyson Branch and to compare samples from the same site between July and August. This index was calculated to determine how different the sites are from each other and how much variation is present within the sites at different sampling dates.

The metrics, ICI and Proportional Similarity were calculated using Microsoft Excel®.

In order to compare Alcan and Tyson Branch samples, the 15 metrics and the ICI were graphed as a high/low box plots by combining the values from both dates (Appendix). Box plots were created in Sigma Plot 2000®.

Results

A total of 4074 aquatic invertebrates comprising 44 taxa were identified from four samples (Table 2). Of this total, 247 specimens the dipteran family Chironomidae were identified and placed in 9 taxa. Tyson Branch was dominated by the dipteran genera *Culex* (mosquito), *Psycoda* (moth fly) and *Chironomus* (midge-fly) (Table 3). Oligochaete annelids

were also abundant taxa in the Tyson Branch. The number of *Culex* in the Tyson Branch August sample was greater than the total number of individuals from both Alcan Branch samples. The Alcan Branch was dominated by *Stenacron* (mayfly), *Argia* (damselfly), *Stenelmis* (riffle beetle) and Oligochaeta taxa. Taxa Richness, Ephemeroptera, Plecoptera, and Trichoptera (EPT) Richness, Total EPT Abundance, Margelef's Diversity Index, Margelef's Chironomidae Diversity Index and Shannon's Chironomidae Diversity Index were highest in the Alcan Branch during August (Table 2). NOD Sensitive Taxa Richness, Shannon's Diversity Index, Chironomidae Richness and NOD Sensitive Chironomidae Richness was greatest in the Alcan Branch during July. Ephemeroptera Richness was greatest during both collection dates in the Alcan Branch. Diptera Richness, Total Invertebrate Richness, Percent Dominant Chironomidae and Percent *Chironomus riparius* were highest at the Tyson Branch during August. The Alcan Branch scored a 31 on Invertebrate Community Index for both collection dates while Tyson Branch scored a 17 and 19 for July and August respectively. The Alcan and Tyson Branch communities were very different and had a Proportional Similarity between 16 and 21 percent (Table 4). The Alcan Branch had a similarity of 71 percent between the July and August sample while Tyson Branch's similarity was 41 percent between to two collection dates.

Discussion

All but three metrics and indices (Diptera Richness, Total Invertebrate Abundance and Chironomidae NOD Sensitive Taxa Richness) clearly identify impact in the Tyson Branch when compared to the Alcan Branch. Since neither watershed or water quality data were available to us, we can not say that the Alcan Branch represents reference conditions, however the community composition and diversity of Tyson Branch is drastically different from Alcan Branch and indicative of an impaired community based on the remaining 13 metrics.

In aquatic systems where nutrient loading creates a large amount of biomass, there is a huge demand for dissolved oxygen (DO) known as Biological Oxygen Demand (BOD) (Novotny & Chesters 1981). An increase in the BOD from a sewage treatment plant, farm waste or agriculture often contributes to decreased DO levels and a shift in the biota to a less diverse community capable of surviving in an environment low in DO (Johnson et al. 1993). Alcan Branch and Tyson Branch have two very different invertebrate communities as illustrated by the low Proportional Similarity values found in Table 4. Ephemeroptera and Elmidae, taxa which

require a relatively large amount of DO, dominate the Alcan Branch while the Tyson Branch is dominated by Diptera taxa and Oligochaeta (Table 3) which are capable of surviving at very low levels of DO. The shift from organisms requiring high levels of DO in the Alcan Branch to those adapted very low levels of DO in the Tyson Branch indicates that Tyson Branch is a perturbed ecosystem. The total lack of EPT in the Tyson Branch (Figure 5 & 7, Appendix) is a sign that Tyson branch is severely impacted (Gaufin et al. 1974). Diversity indices measure the richness and evenness of a community thus the decrease in diversity from the Alcan to the Tyson Branch is strongly suggestive of a disturbed system (Figures 8, 9, 15, & 16, Appendix) (Magurran 1988). Another sign of perturbation is the abundance of *Chironomus riparius* (Ferrington & Crisp 1989) in the Tyson Branch since this species is completely absent from the Alcan Branch (Figure 14, Appendix). Alcan Branch also scored considerably higher (12-14 points) on the ICI (Figure 10, Appendix) than did Tyson Branch.

Three metrics were unable to detect impairment because of the nature of the stream disturbance and sampling methods. Diptera Taxa Richness (Figure 3, Appendix) is affected by nutrient loading since many dipteran species are adapted to living in low oxygen conditions, thus Diptera richness can increase in nutrient enriched environments or environments with a large oxygen demand. Although the Tyson Branch is severely impaired, it is not sterile and is still able to support a tolerant invertebrate community. Many of the species in the Tyson samples are indirect air breathers (*Culex*, *Eristalis*, *Pericoma*, *Psycoda*) (Paine & Gaufin 1956 and Eriksen et al. 1996) or possess hemoglobin (*Chironomus*, *Oligochaeta*) (Weber 1980 and Eriksen et al. 1996) enabling them to survive in aquatic systems with low oxygen levels as a result of nutrient loading. Total Invertebrate Abundance (Figure 6, Appendix) is a variable metric, which may increase due to the input of nutrients into the system (Wiederholm 1984). An increase in abundance accompanied by a reduction in diversity, is often an indication of nutrient loading, explaining the high abundance in the Tyson Branch August sample. The Chironomidae NOD Sensitive Taxa Richness metric (Figure 12, Appendix) was unable to detect impairment due to the small sample size and the lack of intolerant Chironomidae species in both branches. Since many sensitive chironomid species are small, they may be missed during sampling (Storey & Pinder 1985 and Ferrington 1990), accounting for the small number of these species in the samples. Since we are not aware of sampling methods, little more can be said regarding this problem.

Whatever the cause of the perturbation, it is clear that the biological community of Tyson Branch represents an impaired community when compared to the Alcan Branch and the literature. Although our biological assessment indicated that decreases in DO due to a high nutrient load is the probable and principal cause of perturbation in the Tyson Branch, without further data we can not rule out increased sedimentation, habitat variation or toxic substances such as ammonia. However, it is unlikely that sediment or habitat alterations alone could cause the type of drastic invertebrate community shift seen in the Tyson Branch. The Tyson Branch did not support a diverse aquatic community most often associated with relatively unimpaired streams. The large number of Diptera in the Tyson Branch probably results in the occurrence of large numbers of nuisance insects such as mosquitoes and midges. Based on the invertebrate samples and our assessment of the metrics derived from them, we must conclude that the Tyson Branch is a very disturbed water body probably suffering from high organic loadings (or nutrient loading) and severe dissolved oxygen fluxes and oxygen depletions during some parts of the year.

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Table 1: Metrics and indices used in Alcan and Tyson study samples, July 22, 1999 and August 5, 1999 (Modified from Donley 1999).

Metric	Description of Metric	Response to Impact
Invertebrate Richness		
Taxa Richness	Total number of taxa	Decrease
NOD Sensitive Taxa Richness	Total number of taxa less tolerant to NOD	Decrease
Diptera Richness	Total number of "true fly" taxa	Decrease
Ephemeroptera Richness	Total number of mayfly taxa	Decrease
EPT Richness	Total number of EPT taxa	Decrease
Invertebrate Abundance		
Total Insect Abundance	Total number of insects	Variable
Total EPT Abundance	Total numbers of EPT	Decrease
Invertebrate Diversity		
Margelef's Diversity	Measure of taxa richness and evenness	Decrease
Shannon's Diversity	Measure of taxa richness and evenness	Decrease
Chironomidae Richness		
Chironomidae Richness	Total number of Chironomidae Genera	Decrease
NOD Sensitive Chironomidae Richness	Total number of Chironomidae taxa less tolerant to NOD	Decrease
Chironomidae Composition		
% Dominant Chironomidae	Measures dominance of most abundant taxon	Increase
% *Chironomus riparius*	Percent *Chironomus riparius*	Increase
Chironomidae Diversity		
Margelef's Chironomidae Diversity	Measure of Chironomidae taxa richness and evenness	Decrease
Shannon's Chironomidae Diversity	Measure of Chironomidae taxa richness and evenness	Decrease
Indices		
Invertebrate Community Index	Measure of insect community health	Decrease

* NOD = Nutrients and Oxygen Demanding Substances

** EPT = Ephemeroptera, Plecoptera and Trichoptera

Table 2: Metric scores for Alcan and Tyson Branches collected on July 22, 1999 and August 5, 1999.

Metric	Alcan July	Tyson July	Alcan August	Tyson August	Alcan Ave	Tyson Ave	Total
Taxa Richness	19	13	23	16	21.0	14.5	44
NOD Sensitive Taxa Richness	5	2	4	1	4.5	1.5	8
Diptera Richness	8	9	6	12	7.0	10.5	22
Ephemeroptera Richness	2	0	2	0	2.0	0.0	2
EPT Richness	2	0	3	0	2.5	0.0	3
Total Invertebrate Abundance	736	460	492	2386	614.0	1423.0	4073
Total EPT Abundance	231	0	242	0	236.5	0.0	473
Margelef's Diversity	2.73	1.96	3.55	1.93	3.14	1.94	*
Shannon's Diversity	1.71	1.54	1.68	1.04	1.69	1.29	*
ICI	31	17	31	19	31.0	18.0	*
Chironomidae Richness	6	2	5	2	5.5	2.0	9
NOD Sensitive Chironomidae Taxa Richness	2	0	0	0	1.0	0.0	2
% Dominant Chironomidae	46.2%	66.7%	36.4%	99.5%	41.3%	83.1%	*
% *Chironomus riparius*	0.0%	66.7%	0.0%	99.5%	0.0%	83.1%	*
Margelef's Chironomidae Diversity	1.53	0.46	1.67	0.19	1.60	0.32	*
Shannon's Chironomidae Diversity	1.34	0.64	1.39	0.03	1.36	0.33	*

*Total values for diversity and composition metrics are not included because they do not reflect actual communities.

Table 3: Raw invertebrate data from Tyson and Alcan Branches collected July 22, 1999 and August 5, 1999.

Taxon*	Alcan July	Tyson July	Alcan August	Tyson August
INSECTA				
Ephemeroptera				
Baetidae				
Baetis	1	-	2	-
Heptageniidae				
Stenacron	230	-	239	-
Ondonata				
Coenagrionidae				
Argia	28	-	53	-
Corduliidae/Libellulidae	-	1	-	-
Hemiptera				
Corixidae	-	-	1	-
Veliidae	-	-	2	-
Notonectidae				
Notonecta	-	-	1	-
Gerridae				
Trepobates	-	-	-	1
Trichoptera				
Philopotamidae				
Chimarra	-	-	1	-
Coleoptera (sp 1) [SA] (L)	-	1	-	-
Coleoptera (sp 2) [SA] (L)	-	1	-	-
Dytiscidae (L)	1	-	-	-
Laccophilus (L)	-	-	-	2
Oreodytes (L)	-	-	1	-
Elmidae				
Stenelmis (L)	210	5	59	-
Stenelmis (A)	25	-	2	-
Hydrophiloidea [SA] (L)	-	4	-	-
Staphylinidae [SA] (A)	-	-	1	-
Diptera				
Stratiomyidae (L)	-	-	1	-
Allognosta (L)	-	-	-	2
Ceratopogonidae				
Atrichopogon (L)	-	1	-	1
Bezzia (*Palp*.) (L)	1	-	-	-
Stilobezzia (P)	-	-	-	-
Ephydridae (L)	-	-	-	1
Brachydeutera (L)	-	5	-	2
Brachydeutera (P)	-	2	-	-
Culicidae				
Culex (L)	-	72	-	982
Culex (P)	-	34	-	311

Table 3 (Continued): Raw invertebrate data from Tyson and Alcan Branches collected July 22, 1999 and August 5, 1999.

Taxon	Alcan July	Tyson July	Alcan August	Tyson August
Syrphidae				
Eristalis (L)	-	1	-	1
Psycodidae				
Pericoma (*Telm.*) (L)	1	64	-	2
Psycoda (L)	-	100	-	4
Psycoda (P)	-	88	-	5
Chironomidae				
Tanypodinae (L)	2	-	-	-
Helopelopia (L)	12	-	4	-
Krenopelopia (L)	4	3	1	-
Larsia (P)	-	-	-	1
Polypedilum (L)	5	-	4	-
Chironomus riparius (L)	-	6	-	195
Chironomus riparius (P)	-	-	-	5
Stempellinella (P)	1	-	1	-
Stenochironomus (L)	1	-	-	-
Corynoneura (L)	1	-	-	-
Georthocladius? (L)	-	-	1	-
Muscoidea (L)	-	1	-	-
Tabanidae (L)	-	-	-	1
Colembola [SA]	2	2	-	-
ARACHNIDA				
Araneae [SA]	4	-	2	-
MALACOSTRACA				
Decapoda				
Orconectes	10	1	6	-
Isopoda				
Lirceus	34	-	13	-
Copepoda		-	3	-
ANNELIDA	2	-	1	-
Oligochaeta	144	76	84	831
Hirudinea				
Glossiphoniidae	10	-	3	-
GASTROPODA				
Physidae				
Physa	-	-	-	39
BIVALVIA				
Sphaeriidae				
Pisidium	13	-	1	-
Sphaerium	-	-	8	-
Aquatic Total	**736**	**460**	**492**	**2386**
Total	**742**	**468**	**495**	**2386**

*L = Larvae, P = Pupae, A = Adult and SA = Semiaquatic

Table 4: Proportional similarity values for Alcan and Tyson Branch samples collected on July 22, 1999 and August 5, 1999.

	Alcan July	**Tyson July**	**Alcan August**	**Tyson August**
Alcan July	-	-	-	-
Tyson July	19%	-	-	-
Alcan August	71%	18%	-	-
Tyson August	20%	41%	17%	-

Appendix: Box plot comparisons of Alcan and Tyson Branches for community metrics and the ICI from samples collected July 22, 1999 and August 5, 1999. Data is comprised of two data points for each stream representing values from each of the two collection dates. Top and bottom lines represent high and low values for a site, respectively, and box midlines represent the median value. Box figures represented as a line are comprised of two data points with the same value.

Figure 1: Comparison of Macroinvertebrate Taxa Richness between Alcan and Tyson Branches from samples collected July 22, 1999 and August 5, 1999.

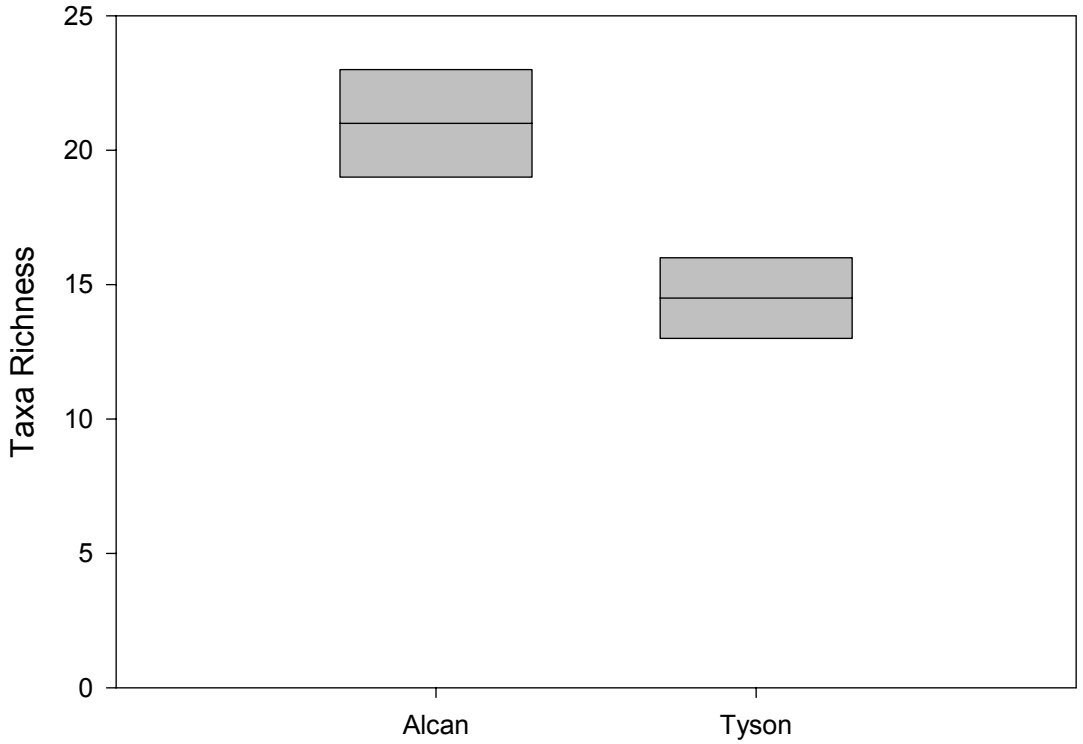

Figure 2: Comparison of Macroinvertebrate NOD Sensitive Taxa Richness between Alcan and Tyson Branches from samples collected July 22, 1999 and August 5, 1999.

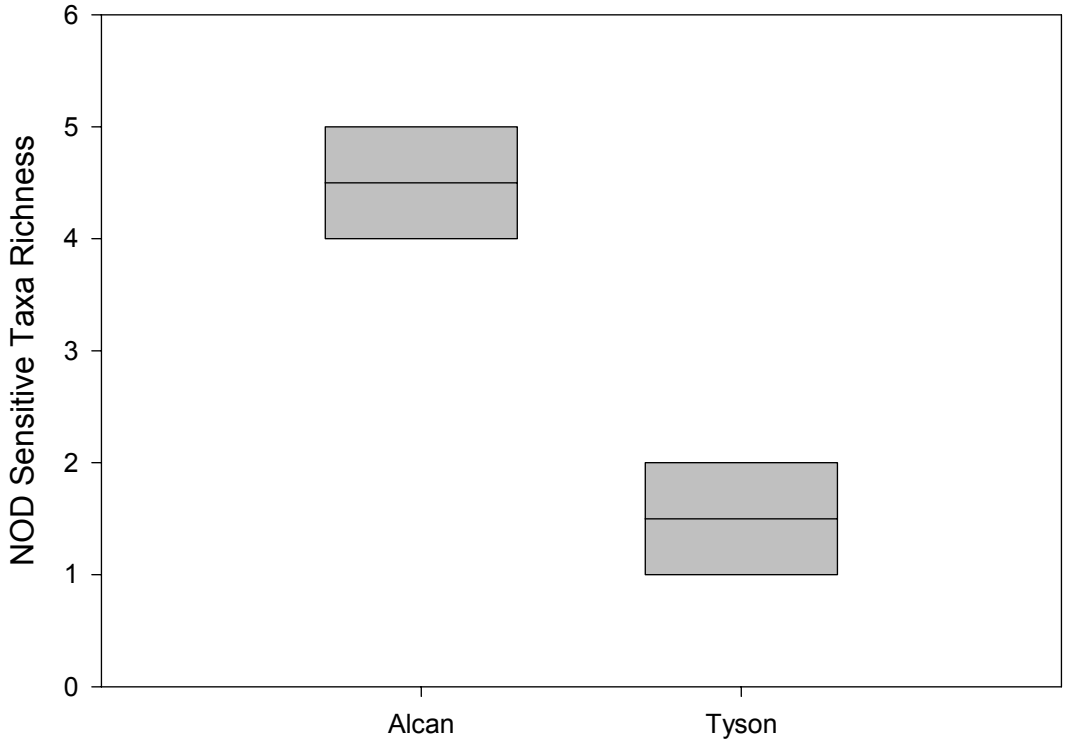

Figure 3: Comparison of Diptera Taxa Richness between Alcan and Tyson Branches from samples collected July 22, 1999 and August 5, 1999.

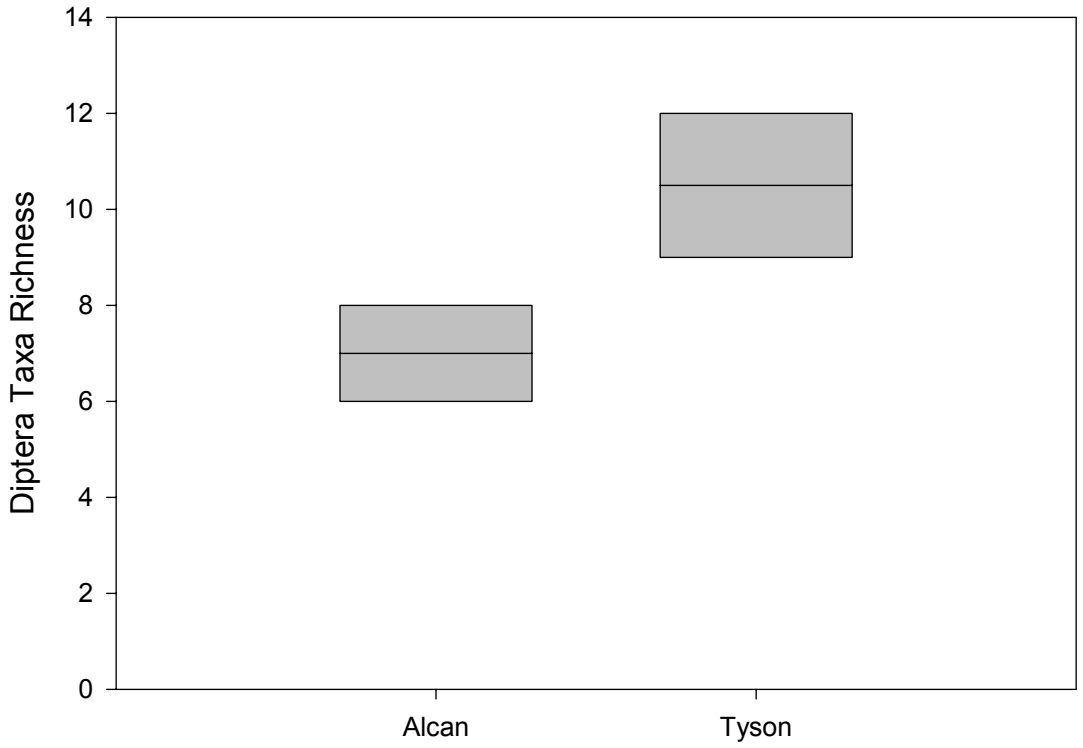

Figure 4: Comparison of Ephemeroptera Richness between Alcan and Tyson Branches from samples collected July 22, 1999 and August 5, 1999.

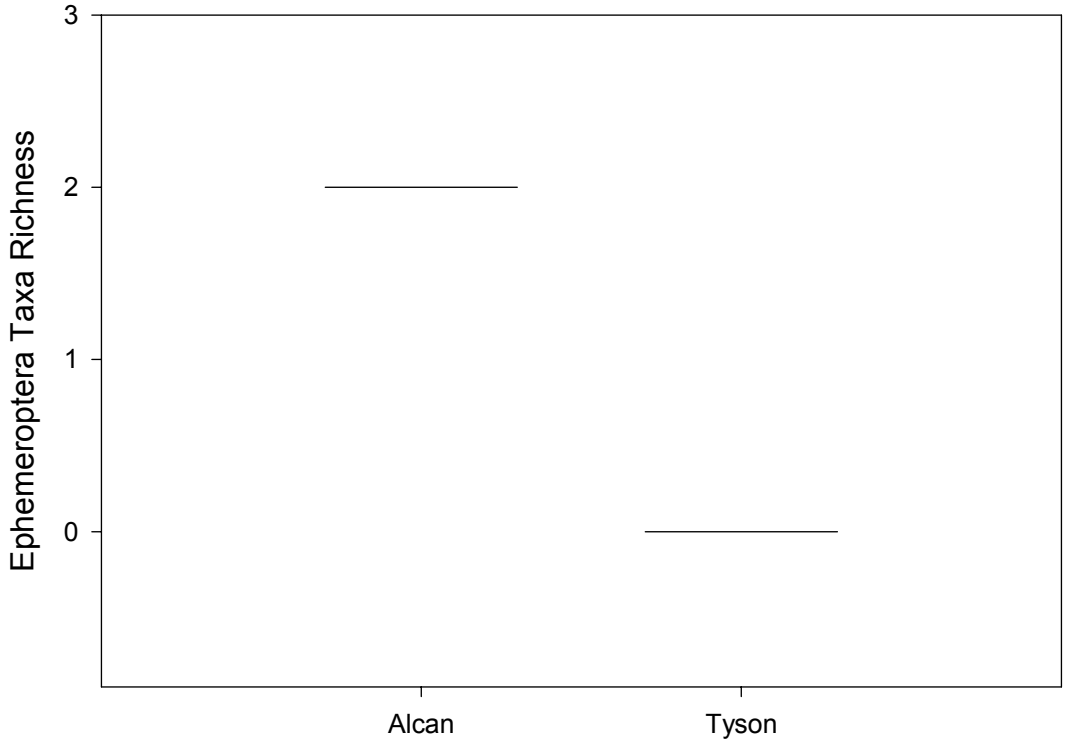

Figure 5: Comparison of Ephemeroptera, Plecoptera and Trichoptera (EPT) Taxa Richness between Alcan and Tyson Branches from samples collected July 22, 1999 and August 5, 1999.

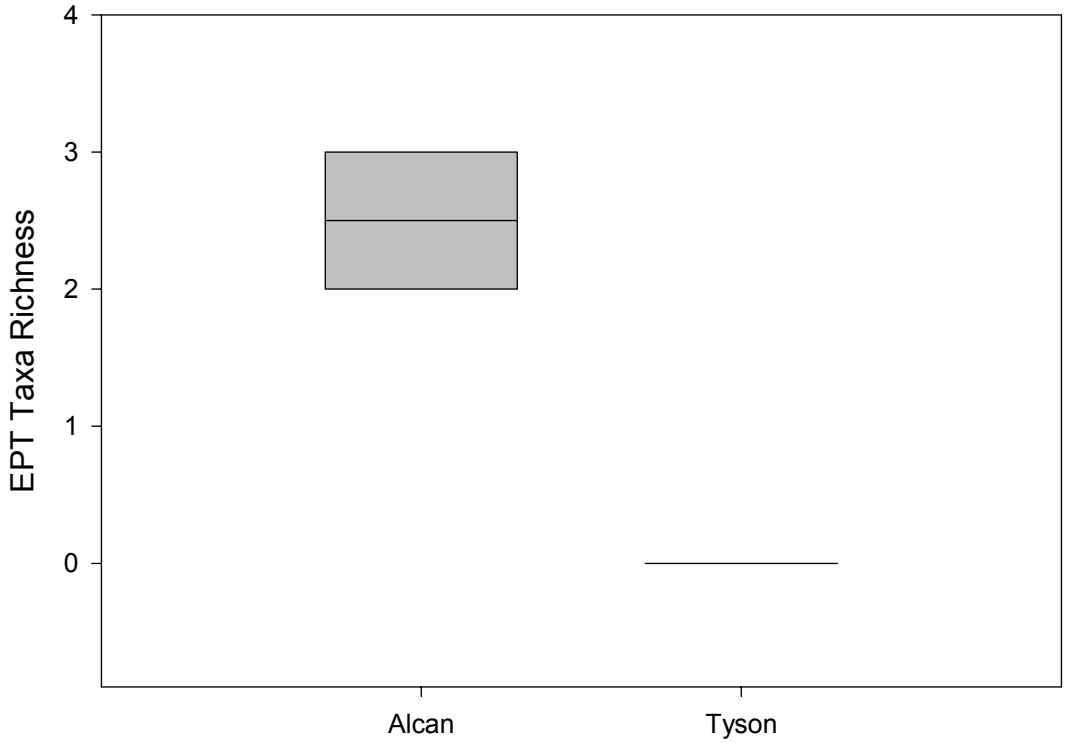

Figure 6: Comparison of Macroinvertebrate Total Abundance between Alcan and Tyson Branches from samples collected July 22, 1999 and August 5, 1999.

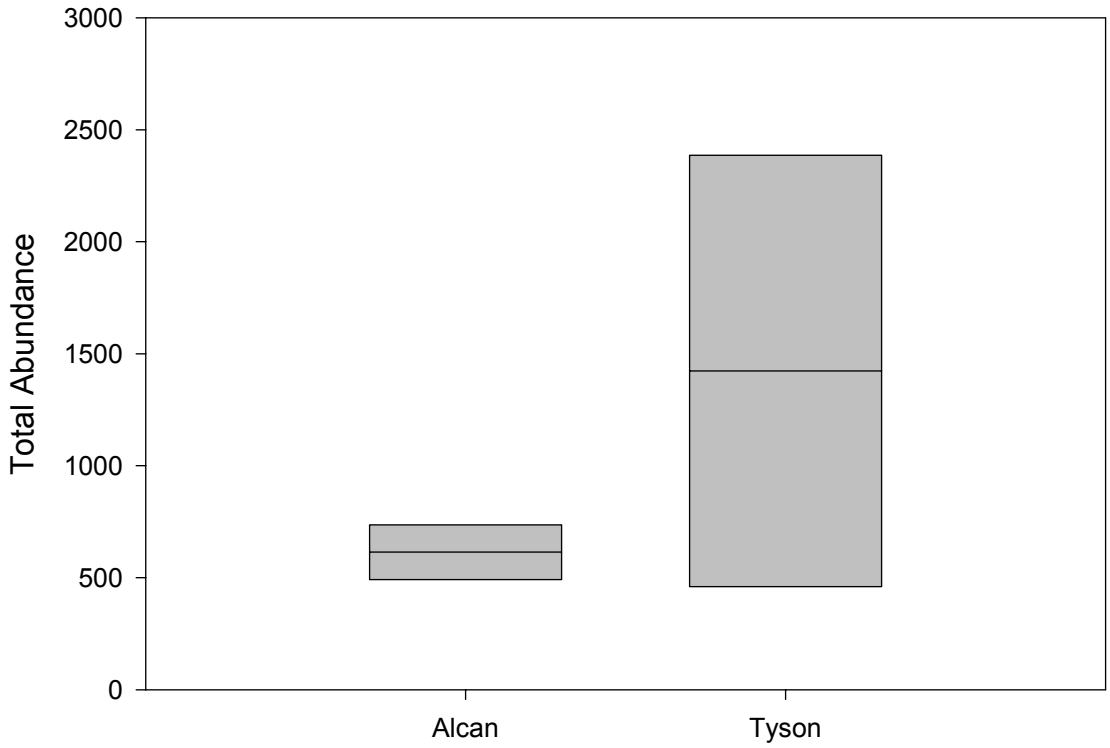

Figure 7: Comparison of Total Ephemeroptera, Plecoptera and Trichoptera (EPT) Abundance between Alcan and Tyson Branches from samples collected July 22, 1999 and August 5, 1999.

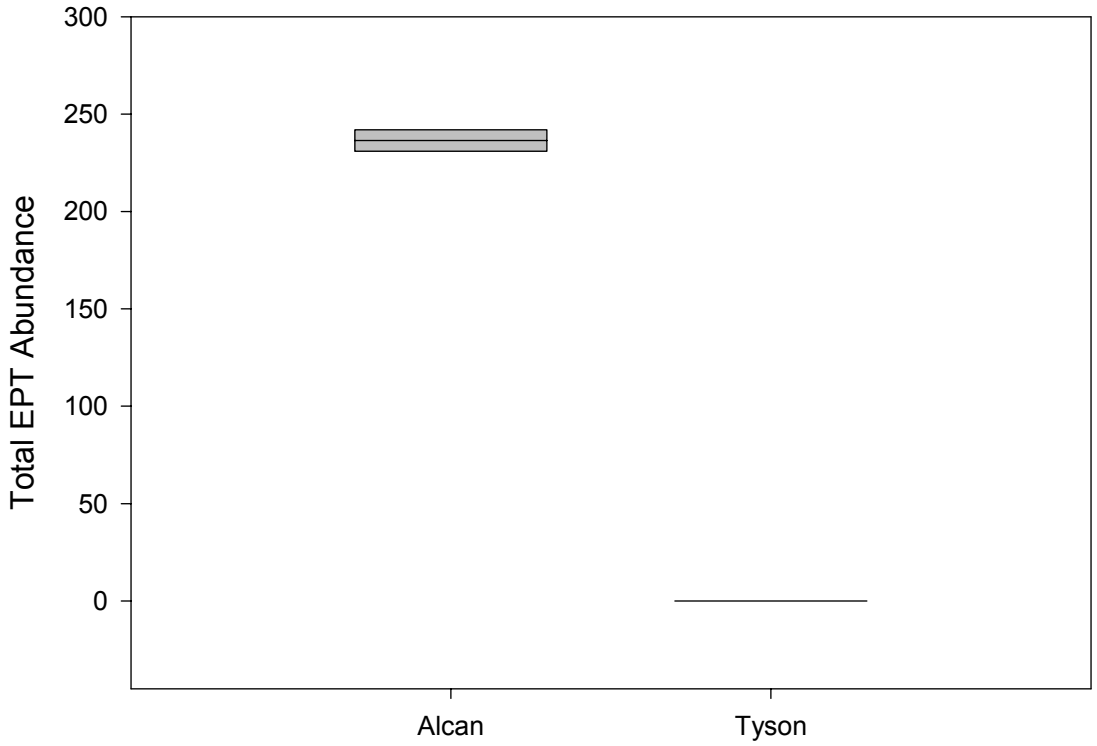

Figure 8: Comparison of Margelef's Diversity Index between Alcan and Tyson Branches from samples collected July 22, 1999 and August 5, 1999.

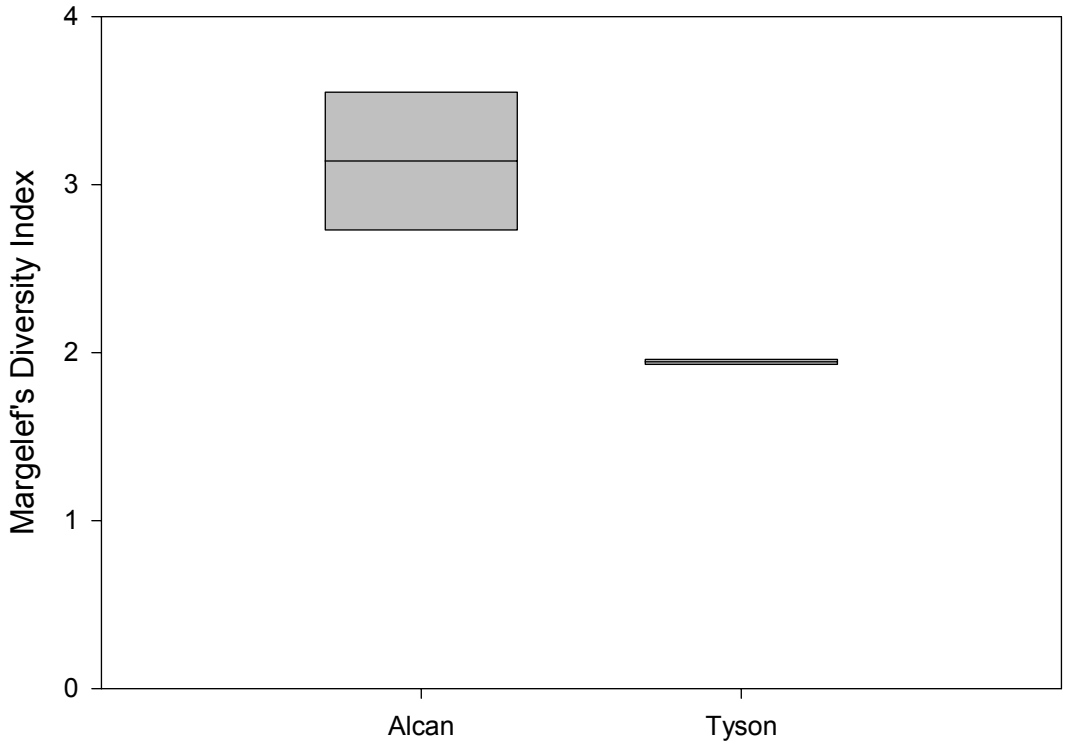

Figure 9: Comparison of Shannon's Diversity Index between Alcan and Tyson Branches from samples collected July 22, 1999 and August 5, 1999.

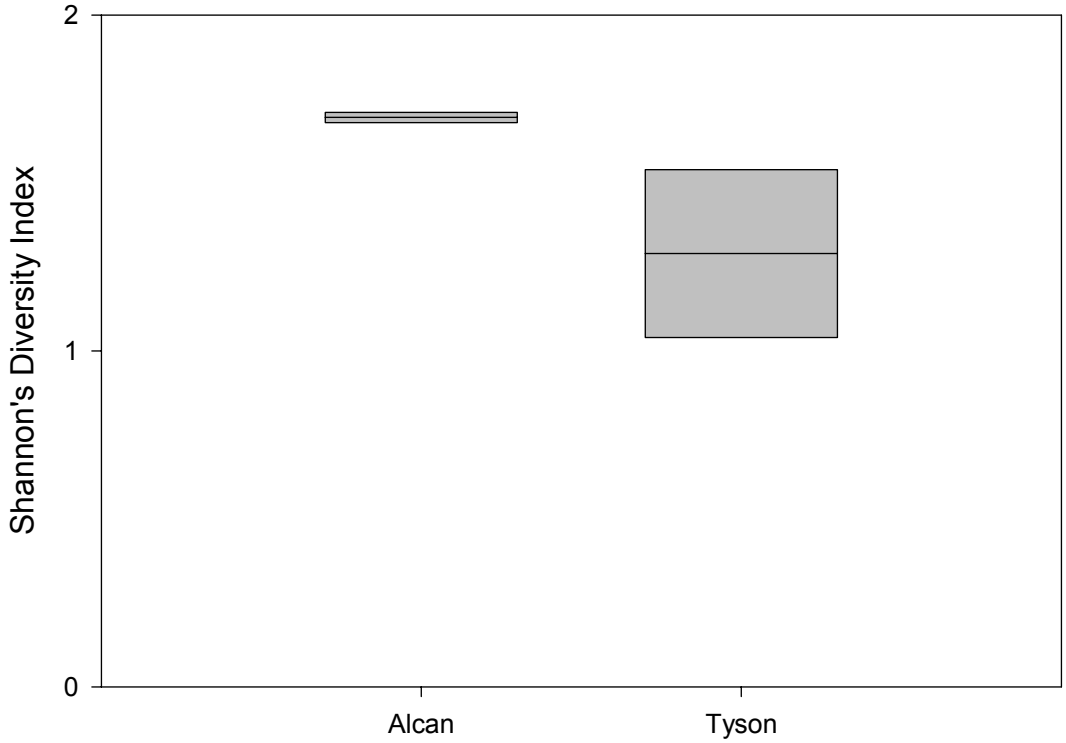

Figure 10: Comparison of the Invertebrate Community Index (ICI) between Alcan and Tyson Branches from samples collected July 22, 1999 and August 5, 1999.

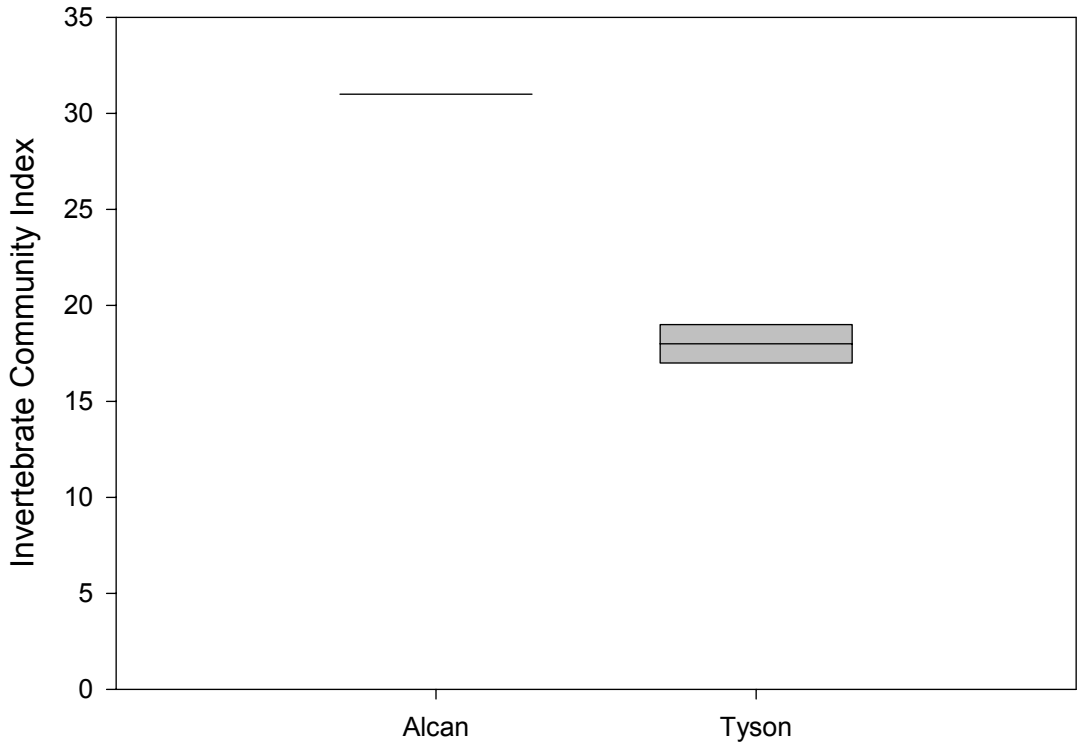

Figure 11: Comparison of Chironomidae Taxa Richness between Alcan and Tyson Branches from samples collected July 22, 1999 and August 5, 1999.

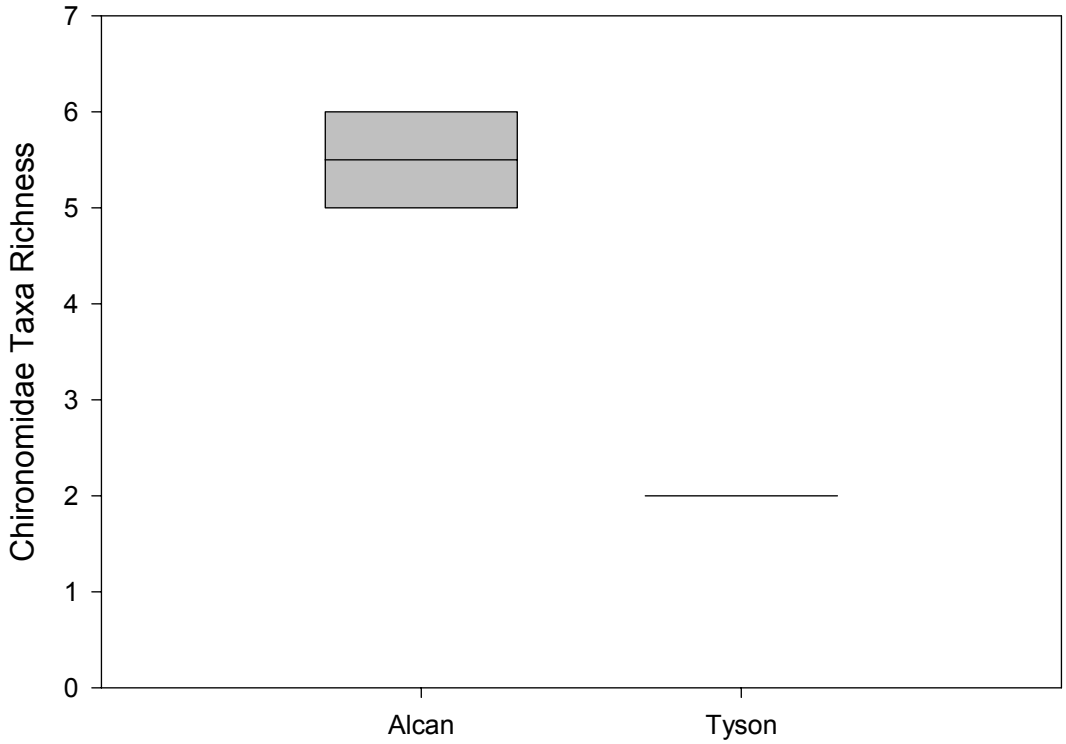

Figure 12: Comparison of Chironomidae NOD Sensitive Taxa Richness between Alcan and Tyson Branches from samples collected July 22, 1999 and August 5, 1999.

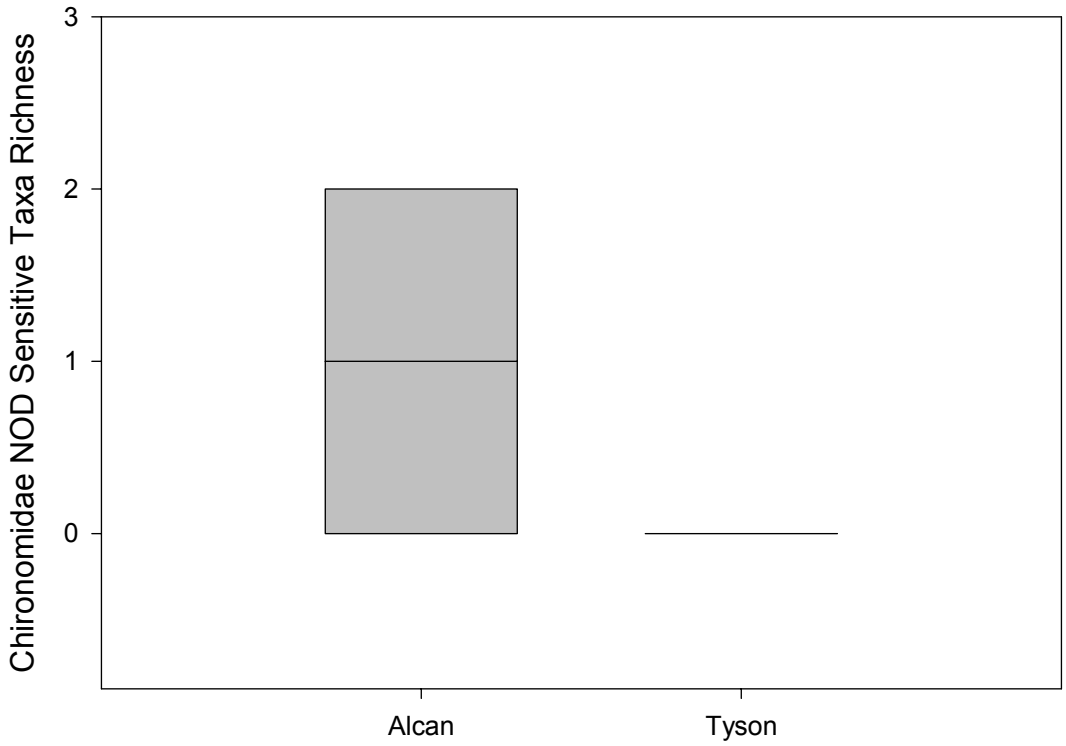

Figure 13: Comparison of Percent Dominant Chironomidae Taxa between Alcan and Tyson Branches from samples collected July 22, 1999 and August 5, 1999.

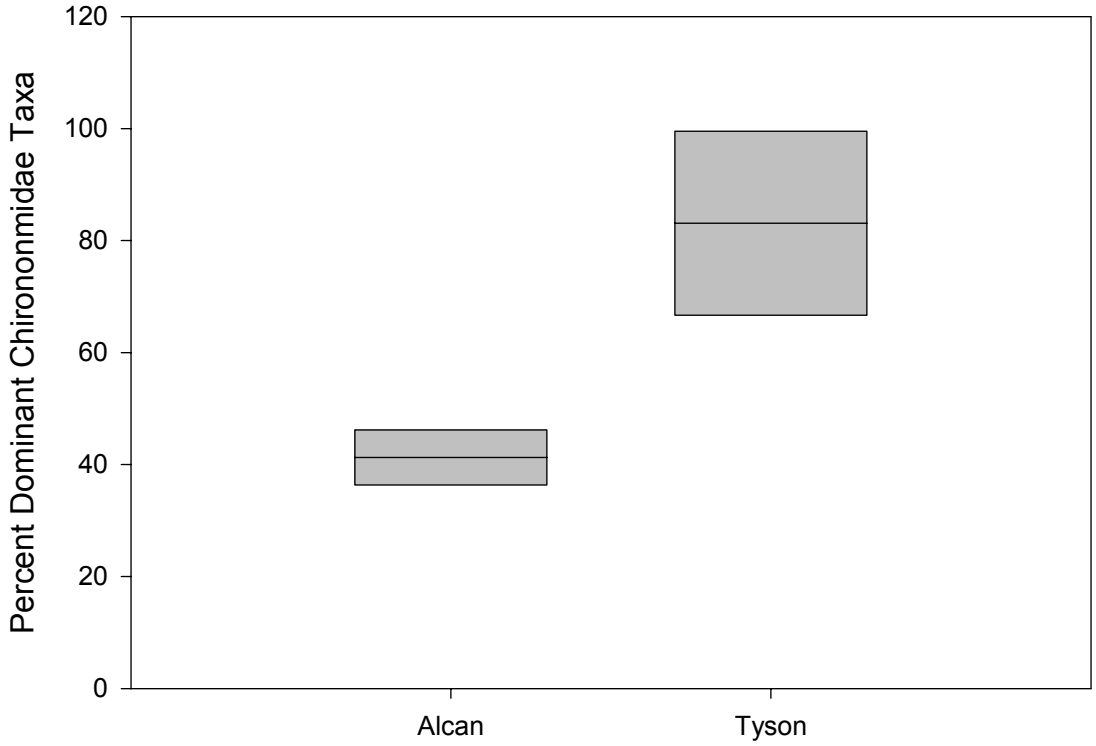

Figure 14: Comparison of Percent *Chironomus riparius* between Alcan and Tyson Branches from samples collected July 22, 1999 and August 5, 1999.

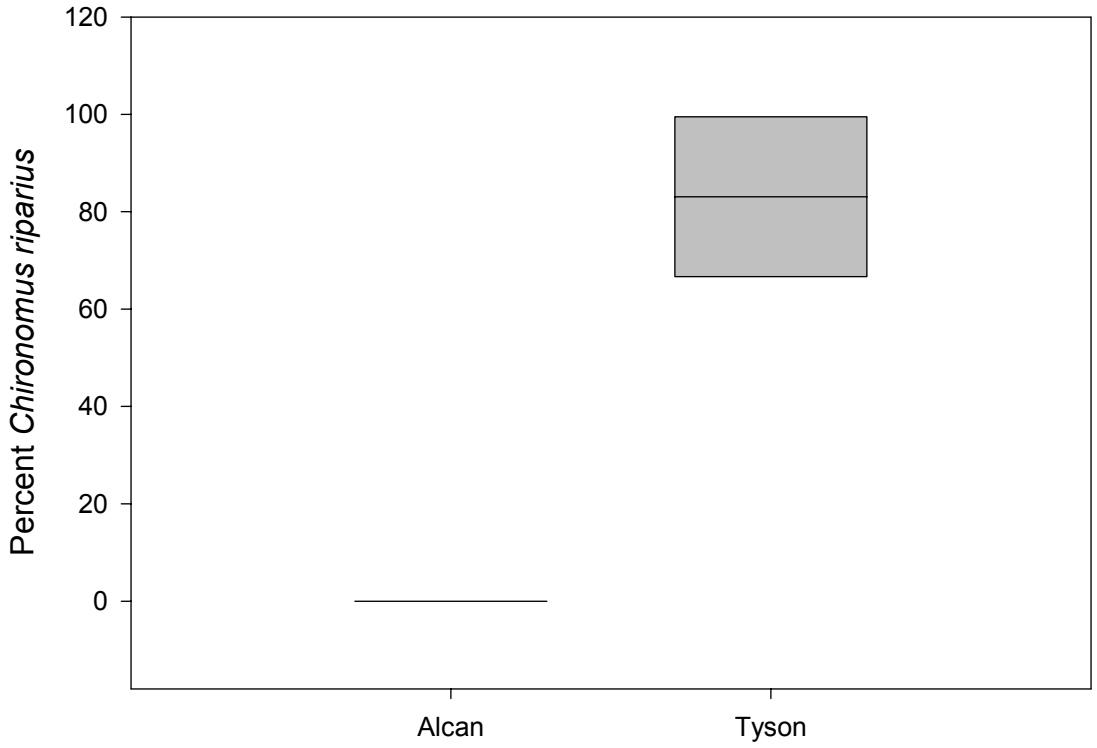

Figure 15: Comparison of Margelef's Chironomidae Diversity Index between Alcan and Tyson Branches from samples collected July 22, 1999 and August 5, 1999.

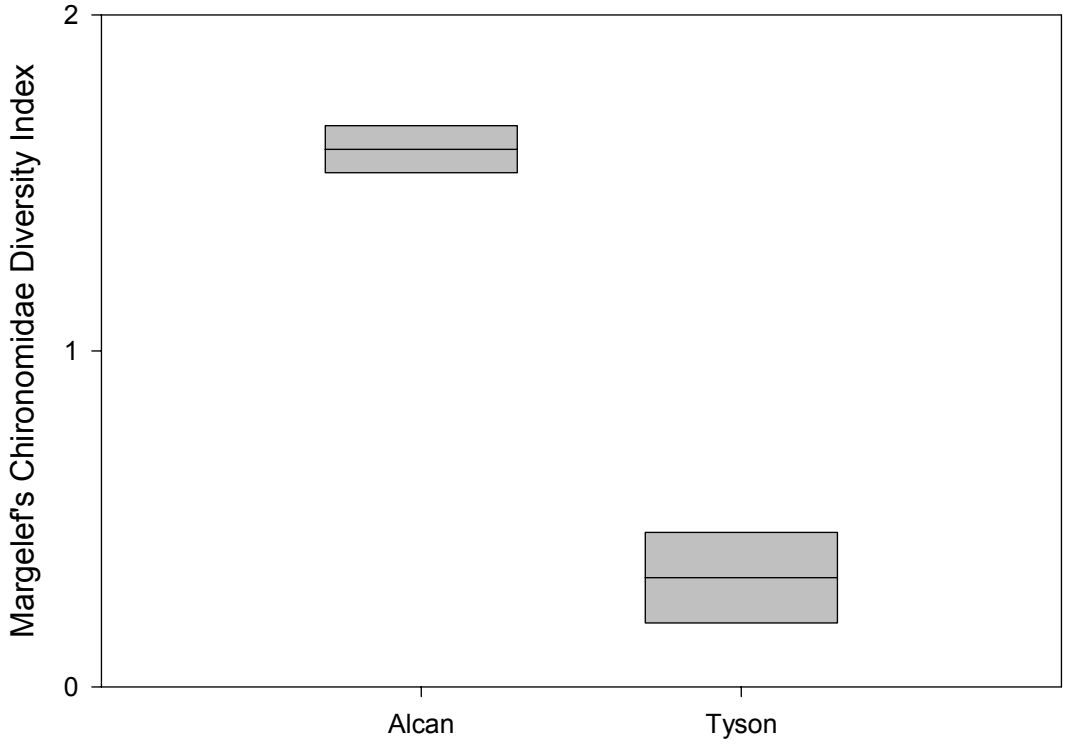

Figure 16: Comparison of Shannon's Chironomidae Diversity Richness between Alcan and Tyson Branches from samples collected July 22, 1999 and August 5, 1999.