A comparative study of the benthic populations in weir ponds draining watersheds of the Fernow Experimental Forest, Parsons, West Virginia.

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Dedicated to my Mom,

Patricia Anne Brittingham

May 2, 1943 to July 22, 1989

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Philippians 4:13; "I can do all things through Christ which strengtheneth me." To God be the glory!

ABSTRACT

A study of the benthos of weir ponds draining watersheds of the Fernow Experimental Forest (FEF) was conducted in 1994-1995. The objectives of this study were: (1) to relate differences in weir pond faunas to watershed treatments on the FEF, and (2) to compare current weir pond faunas to those described in 1973 by Steve Harris. In 1971-1972, there were fewer invertebrates but greater taxa richness than in 1994-1995. Total density varied among weir pond and between studies with numbers in the 1971-1972 study ranging from 26,168 to 79,259 individuals collected, while numbers in the 1994-1995 study ranged from 72,779 to 103,743 individuals collected. Mean density among weir ponds in 1994-1995 was not significantly different. In 1971-1972, the weir ponds differed greatly with most of the differences between weir ponds of forested and deforested watersheds. The family Chironomidae was the most abundant group in all four weir ponds in 1971-1972. In the 1994-1995, study the family Chironomidae was only most abundant in weir ponds 3 and 4. Zooplankton populations were very high in the 1994-1995 study, which accounted for 58 percent and 66 percent of the total density for weir ponds 1 and 6.

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CHAPTER I

INTRODUCTION

Benthic populations in forested stream ecosystems can be important indicators of alteration of the natural environment. Macroinvertebrate communities are frequently used in the evaluation of aquatic ecosystems because they reflect changes in the environment that are not otherwise obvious.

This study will evaluate the effects of watershed alteration on the benthos of weir ponds draining small central Appalachian streams at the Fernow Experimental Forest. These watersheds have been managed differently with regard to forest harvest and the use of pesticides and herbicides. The management of agricultural land can greatly influence the composition and magnitude of contaminants in agricultural runoff (Leonard 1988). Alterations of the forest adjacent to the streams can be considered pollution if the natural fluctuation in nutrients and invertebrates populations are affected. The effects of temperature, chemical and physical variables will also be considered in the influence of these invertebrate populations. Since these weir ponds are located at the base of each watershed, the chemical substances leaving these watersheds can be related to the effect on benthic populations. The productivity of aquatic invertebrates in agricultural watersheds has been shown to be affected directly by the toxicity of contaminants, particularly pesticides and herbicides in surface and groundwater runoff (Thomson 1987). Productivity can also be affected indirectly by changes in food resources and habitat caused by increased concentrations of suspended sediment, nutrients, pesticides and herbicides in aquatic ecosystems (Kettle et al. 1987).

Harris (1973) conducted a study of the fauna of weir ponds at the Fernow Experimental Forest in 1971-1972. His conclusions include:

1. Forest practices on watersheds influenced the water quality of the weir ponds in terms of temperature, oxygen, pH, and specific conductance.
2. Populations of benthic fauna differed greatly between weir ponds of forested and deforested watersheds. The largest population was in weir pond 4 (control watershed), and the lowest was in weir pond 1 (fertilized watershed).
3. Temperature and substrate type were predominately responsible for benthic distribution.
4. Temperature was most influential in seasonal fluctuations of benthos.
5. Amount of detritus played an important role in abundance of benthic populations.

The objectives of this study were: (1) to relate differences in weir pond faunas to watershed treatments on the Fernow Experimental Forest, and (2) to compare current fauna to that described by Harris (1973).

CHAPTER II

LITERATURE REVIEW

The weir ponds under study are unique bodies of water. They are a combination of standing and flowing waters, in that the weirs are a man-made deepening and widening of the stream channel. Within these "pools" invertebrates are a composite of the two situations. Fauna of these ponds are presumed to be sensitive to different forestry practices that are performed on the Fernow Experimental Forest and provide a way to study the effects of watershed management.

Effects of deforestation and associated road building on the aquatic environment include an increase in sediment, increased stream flow, and an increase in stream temperature (Huttunen 1992). Burns (1972) found that benthic populations greatly decreased after extensive logging practices, but the dipteran populations increased. The removal of forest cover near a stream results in increased stream temperature, and as a result influences the entire stream ecosystem. Survival, reproduction, and behavior of aquatic macroinvertebrates are influenced by temperature (Sallenave 1991). Temperature determines those aquatic taxa present, controls spawning and hatching, and acts in combination with other water quality constituents in the aquatic environment.

Experimental ponds have been used to determine the impact of environmental disturbances on aquatic ecosystems. Recently they have been used as a test system for environmental studies on pesticides and herbicides (Christman 1993). Since benthic macroinvertebrates are important components of aquatic ecosystems, they are one of the biological components utilized in these tests. Although these benthic organisms have been studied extensively, information is still lacking about the life history and ecology of many species, including many of the aquatic insects that inhabit these experimental ponds (Christman 1993). As a result, studies have tried various field approaches to determine environmental impacts using whole ecosystems, upstream-downstream comparisons, before-after comparisons, and experimental ponds.

Several abiotic and biotic factors are important in structuring stream macroinvertebrate communities including, at least, organic matter, temperature, water chemistry, and competition (Feldman 1992). However, in a lentic environment, such as these ponds, the factors could be different. In these slow-flowing pools, the amount of detritus is higher than that of a riffle. Recent studies have found that correlations between detritivorous feeding groups and amounts of their presumed food were non-significant in the pool habitats (Boulton and Lake 1992). This lack of correlation between benthic detritivore densities and organic matter in the pools may reflect an over abundance of detritus in the pool habitat. This high level of organic matter in the pools may contribute to deteriorating water quality, which in turn may adversely affect many of the common detritivores (Bolton 1992).

Temperature is a well known factor in determining species presence-absence and community composition. In a study in the Italian Alps, temperature was found as an important factor in determining community structure of Chironomids (Rossaro 1991). It has been suggested that even a small increase in water temperature (1.0 C) may allow insects to grow faster and emerge earlier as adults, thus increasing their productivity (Sallenave 1991).

Among various aspects of water chemistry, pH has been shown to play a role in influencing the composition and abundance of macroinvertebrate taxa. Field studies have indicated that acid deposition in temperate areas has reduced abundance, biomass, and diversity (Feldman 1992). However, the family Chironomidae, as well as other abundant families of Diptera, have been shown to exhibit no significant effects to reduced pH. In a study in Shenandoah National Park, Virginia, Chironomidae exhibited similar abundances between treatment groups of pH of 5.8 and 7.1, and was the most abundant family. It appeared that the majority of the chironomid taxa present were not sensitive to acidic conditions and seemed to be resistant, thus showing an increase in relative density under acidic conditions (Feldman 1992). Another study in Sudbury, Ontario showed that chironomid taxa tolerated the reduction in pH from 7.4 to 5.9. However, exposure to pH of 4.5 lowered taxa richness and composition of the chironomid community. Acidity appeared to directly alter chironomid composition and reduce species richness by eliminating taxa from the community through increased larval mortality (Griffiths 1992).

CHAPTER III

DESCRIPTION OF STUDY AREA

The Fernow Experimental Forest is located in Tucker County in the Allegheny Plateau Near Parsons, West Virginia, which is in the northern part of the Monongahela National Forest. Established in 1934, the 1,902 ha experimental forest includes the entire catchment of Elklick Run, which is a fourth tributary of the Black Fork of the Cheat River (Griffith and Perry 1992). The topography is rugged, with elevations ranging from 533 to 1,112 m, and slopes of 10 to 60 percent. A rainy, cool climate is typical with mean annual precipitation around 147 cm, with a mean annual temperature of 9 C. Vegetation on the Fernow fits into a mixed hardwood forest type, with dominant vegetation including: red oak (*Quercus rubra*), black cherry (*Prunus serotina*), sugar maple (*Acer saccharum*), rhododendron (*Rhodedendron maximum*), tulip popular (*Liriodendron tulipifera*), dogwood (*Cornus florida*), American beech (*Fagus grandifolia)*, and red maple (*Acer rubrum*).

Four weir ponds at the base of experimental watersheds of the Fernow Experimental Forest were selected for study (Table 1). Weirs are steep sided, with depth increasing towards the notch, and with bottoms of bed rock.

Table 1. Description of treatments for the four watersheds

WS	Treatment	Treatment date	Area (ha)	Aspect
1	Installation	5/51	30.1	NE
	Clearcut of merchantable trees	5/57 - 6/58		
	Aerial application of urea (fertilizer)	5/71		
	Aerial application of Dimilin	5/86, 5/92		
3	Installation	5/51	34.3	S
	Intensive selection cut	10/58		
	Light partial cuts	9/63		
	Patch cutting (5.6 acres)	7/68		
	Clearcut, all but buffer strip	7/69		
	Clearcut buffer strip	11/72		
	Aerial application of ammonium sulfate 3 times/year	1/89 to present		
4	Installation	5/51	38.7	ESE
	Control - no treatment			
6	Installation	11/56	22.3	S
	Lower half clearcut	3/64		
	Maintained barren with herbicides	5/65 - 10/69		
	Upper half clearcut	10/67		
	Maintained barren with herbicides	5/68 - 10/69		
	Norway spruce planted	3/73		
	Treatment of hardwood stems with herbicides	8/75, 9/80		

Watershed 1

Installed in 1951, this 30.1 ha watershed was clear-cut of all merchantable trees between 1957 to 1958. This watershed was used to evaluate the effects of carelessly logging a watershed on the quality and quantity of water draining from it. Skidroads were loggers choice, with no care to protect soil and water resources. Soil erosion losses from skidroads were estimated at 40 tons/acre during logging, 4 tons/acre the first year after logging, and 0.1 tons/acre the second year after logging. Much of this eroded soil reached the stream, which greatly increased the sediment concentrations. Annual water yields were increased 5.1 inches in 1958 and returned to normal within 5 years after logging. Average growing season maximum temperatures were temporarily increased 8 F, a result of the removal of the trees from the viparian zone. Rapid revegetation of this watershed resulted in a much faster recovery from this drastic treatment than expected (Kochenderfer 1995). In 1971, the Forest Service used this watershed for a study on the effects of nitrogen fertilization. The Forest Service applied 500 pounds per acre of urea to the watershed. In 1986 and in 1992 this watershed was used for a pesticide study. Dimilin was aerially applied at a concentration of 2 oz. formulation per acre.

Watershed 3

Trees on this watershed (installed in 1951) were first harvested in 1958 by intensive selection of trees larger than 5.0 inches diameter breast height (DBH). The watershed also received light partial cuts in 1963 and 1968. Then in 1969 the entire watershed (34.3 ha) was clear-cut down to 1-inch DBH except for a 7.4 acre buffer strip of uncut trees left along the stream channel. In 1972 the 7.4 acre buffer strip was clear-cut. Logging roads were carefully layed out to provide efficient harvesting of forest products without harming other resources (Adams et al. 1994). The primary purpose of this study was to evaluate the effects of clearcutting on the stream water. This treatment had only minor effects on stream water chemistry. Water yields increased 10 inches the first year, then decreased rapidly as the watershed quickly became revegetated. Beginning in 1989, the watershed has been used for an artificial acidification study. Ammonium sulfate fertilizer is being aerially applied three times a year to the watershed at the rate of 150 pounds/acre/year. This doubles the amount of sulfur and nitrogen that normally deposits on the watershed from atmospheric deposition (Adams et al. 1994).

Watershed 4

Installed in 1951, this 38.7 ha site has been used as an untreated control to compare with other watersheds that have been treated.

Watershed 6

Installed in 1956, this 22.3 ha site was clear-cut of its lower half in 1964 and maintained barren with herbicides until 1969. In 1967, the upper half was clear-cut and maintained barren until 1969 (Adams et al. 1994). The objective of this study was to determine what portion of the watershed yielded the most water and to quantify the amount of water that could be produced when a watershed was maintained completely devoid of vegetation. Maximum annual water yield increases averaged almost 6 inches after the lower half was deforested and rose to over 10 inches after complete deforestation. In 1973, the entire watershed was planted with Norway spruce (*Picea abies*). In both 1975 and 1980, the watershed was aerially applied with 2,4,5-T and Roundup herbicides to release the spruce from competing hardwoods. This part of the study was designed to determine how converting a hardwood covered watershed to a coniferous cover affects the quality and quantity of water draining from it. Streamflow is expected to decrease as the spruce grow, eventually becoming at least 25 percent less than the streamflow measured when the watershed was occupied with a hardwood cover (Kochenderfer 1995).

CHAPTER IV

METHODS AND MATERIALS

Sampling

Monthly collections were made from October 1994 to October 1995. Two quantitative bottom fauna samples were randomly taken from each weir pond using a staff-mounted Ekman dredge (24 x 24 cm). A 10 foot jon-boat was used for sampling the weir ponds in order not to disturb the sites. Weir ponds were marked off in 1 meter squares with each square given a number to be used in a table of random numbers for selecting sampling locations. Samples were washed down in a bucket with a 250 micron mesh bottom, and preserved in alcohol.

In the laboratory, detritus and samples were washed through a nested sieve series (10, 1 and 0.25 mm). The top sieve retaining "very course particulate organic matter" or VPOM, the middle sieve retaining "course particulate organic matter" or CPOM and the bottom sieve retaining "fine particulate organic matter" or FPOM. Organisms found in the VPOM were placed in the CPOM sieve for tabulation. Macroinvertebrates in CPOM were preserved in 100 percent ethanol and identified to genus when possible using a 3X Baush and Lomb dissecting microscope. When keying dipteran larvae, it was necessary to clear the body using a KOH solution, then placing them under a compound microscope for identification of mouth and body parts. Most of the FPOM samples were subsampled due to the large amount of detritus present. FPOM was placed in a partitioned container, agitated, and the contents of 1 section pipetted out and if necessary resubsampled. Subsamples of FPOM ranged from ½ to 1/16, depending on the number of animals and/or amount of sediment in the FPOM. Samples were picked under a dissecting microscope a spoonful at a time. Macroinvertebrates were then preserved in 100 percent ethanol and placed in labeled vials.

The VPOM, CPOM and FPOM sample remaining after removal of macroinvertebrates were dried at 60 C to a constant mass in the drying oven for a minimum of 48 hours. Dried samples were weighed and placed in a muffle furnace at 550 C for a 2-3 hour period. Samples were then reweighed to determine the ash-free dry weight of detritus associated with each sample.

Habitat parameters

At each sample location, depth was measured using a meter stick. Water temperature was continuously recorded by electronic thermographs (HOBO temps) placed in each weir pond. Weekly water samples were collected from the streams immediately upstream of the weir ponds. They were analyzed by the U.S. Forest Service Timber and Watershed Laboratory, Parsons, West Virginia. Water samples were analyzed for pH, conductivity, alkalinity, Ca, Na, K, Mg, Cl, NO_3-N, NH_3-N, and SO_4.

CHAPTER V

RESULTS

HABITAT

Temperature

Daily mean temperatures were calculated from the continuous temperature record for each weir pond. Temperatures were similar among weir ponds during the study with WS 3 having the highest number of annual degree days (ADD) of 3,666, and WS 6 having the lowest ADD of 3,262 (Fig. 1). In the Harris 1971-1972 study, temperature was taken at the substrate surface using the Pallman method of sucrose inversion. A mean temperature was taken for a two week period. Readings were taken from April to October of 1972 (Fig. 2). Temperatures in 1971-1972 for WS 6 had the highest temperature and was similar to WS 3 which was warmer than WS 4 and WS 1. However, in 1994-1995 WS 1, 4 and 6 had similar temperatures but WS 3 had a slightly higher temperature.

Water quality

Water quality parameters varied among the weir ponds during the study. The pH values were greater in WS 1 (6.2) with WS 4 and WS 6 having the same mean pH value of 5.9 (Table 2). WS 3 had the lowest pH value (5.7) which could be due to the fact that the acidification study was started in 1989. WS 1 had the highest levels of pH, conductivity, alkalinity, calcium, magnesium, Na, and SO_4. WS 6 had the lowest levels of

Figure 1. Mean daily temperatures recorded by electronic thermographs (HOBO temps.) at selected sites. (WS 1 = watershed 1, WS 3 = watershed 3, WS 4 = watershed 4 (control), WS 6 = watershed 6). (ADD = annual degree days).

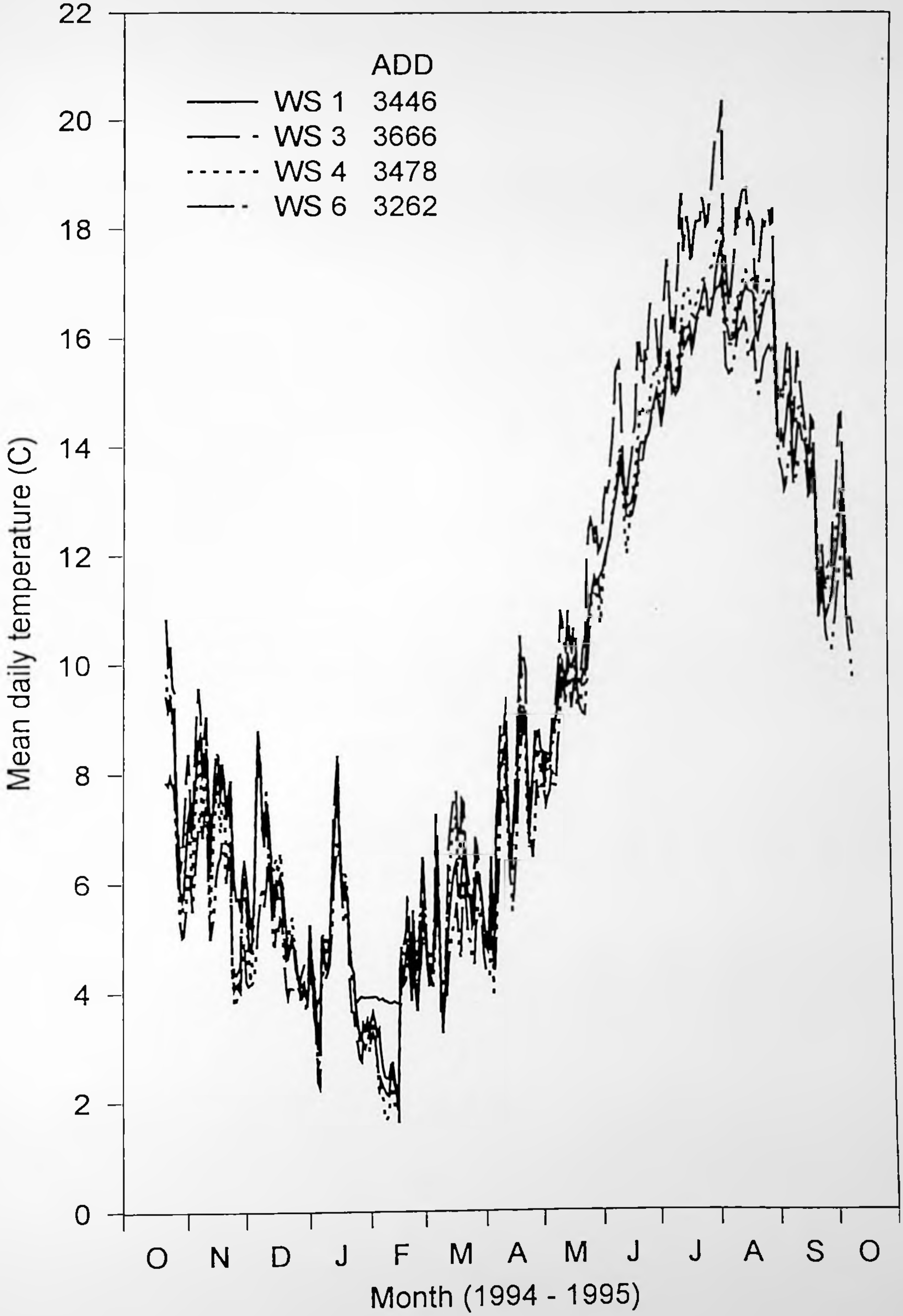
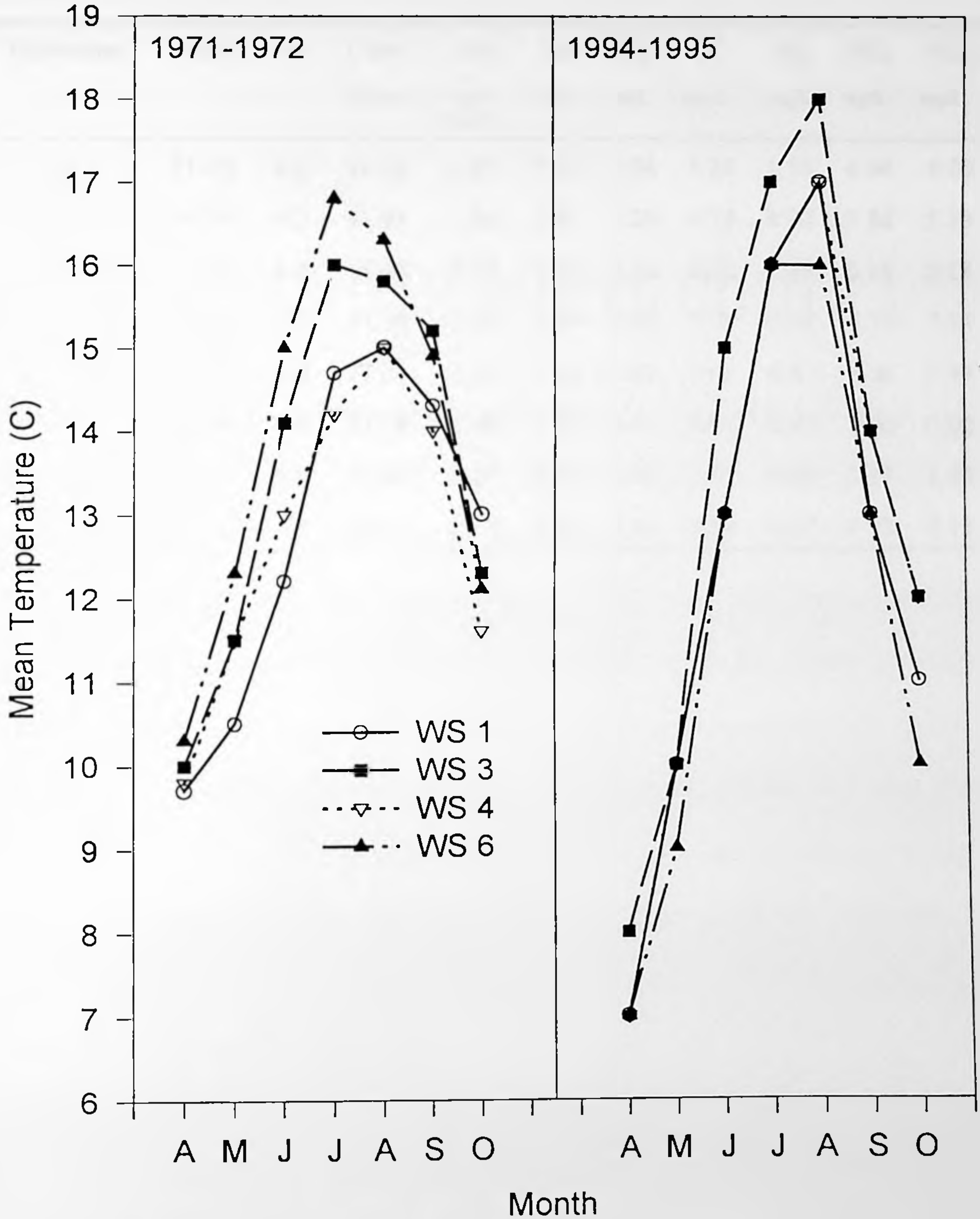

ADD
WS 1 3446
WS 3 3666
WS 4 3478
WS 6 3262
Mean daily temperature (C)
0
2
4
6
8
10
12
14
16
18
20
22
O N D J F M A M J J A S O
Month (1994 - 1995)

Figure 2. Monthly temperature means for common months for the two studies. The 1971-1972 temperatures measured by sucrose method from April 1972 to October 1972. The 1994-1995 temperatures measured by HOBO temps.



1971-1972
1994-1995
Mean Temperature (C)
19
18
17
16
15
14
13
12
11
10
9
8
7
6
WS 1
WS 3
WS 4
WS 6
A M J J A S O
A M J J A S O
Month

Table 2. Mean annual water quality parameters for watersheds on the FEF. Data collected from November 1971 - October 1972, and from November 1994 - October 1995 (NA = not available).

Watershed	Study	pH	Cond	Alk	Ca	Mg	K	Na	SO_4	NO_3	Cl
			uS/ cm	mg/L $CaCO_3$	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg L
WS 1	71-72	6.0	78.36	3.89	7.15	1.94	1.34	1.15	4.64	4.76	NA
	94-95	6.2	41.61	1.82	2.97	1.29	0.72	0.77	9.36	5.39	0.44
WS 3	71-72	6.0	16.63	3.59	1.0	0.42	0.65	0.49	2.38	0.28	NA
	94-95	5.7	31.76	0.39	1.94	1.05	0.78	0.42	4.75	7.38	0.64
WS 4	71-72	6.0	17.29	3.45	1.10	0.43	0.61	0.47	3.26	0.14	NA
	94-95	5.9	23.58	0.68	1.51	0.74	0.54	0.37	4.94	3.02	0.49
WS 6	71-72	5.9	35.67	3.17	2.12	1.06	1.22	0.66	3.17	1.66	NA
	94-95	5.9	20.51	1.17	1.19	0.65	0.58	0.47	6.02	0.11	0.23

conductivity, Ca, Mg, NO_3 and Cl. In the Harris 1971-1972 study, WS 1 had the highest level in all of the nine parameters collected, which in comparison to the 1994-1995 study shows that WS 1 has the highest level in seven of those nine parameters. Among weir ponds, alkalinity values in the 1971-1972 study were higher than those of the 1994-1995 study.

Watershed and weir pond parameters

Physical features of the four watersheds in the study are shown in Table 3. Watershed area (ha) ranged from 22 to 39 ha, with similar elevation and slope. Predominant foliage varied from oaks, yellow popular, maples and white ash except for WS 6 which was completely planted with norway spruce. Stand age of the watersheds ranged from 22 to 37 years old, except for WS 4 (control) which was over 90 years old. The area (m^2) of the weir ponds ranged from 25 to 42 m^2, with WS 6 deeper than the others. Bottom profiles of the four weir ponds show a relationship of depth to distance from the crest of the weir (Fig. 3). The farther from the weir crest, the shallower the depth. Water shed 6 had the greatest minimum depth of about 110 cm with WS 4 having the lowest minimum depth of 10 cm.

PARTICULATE ORGANIC MATTER

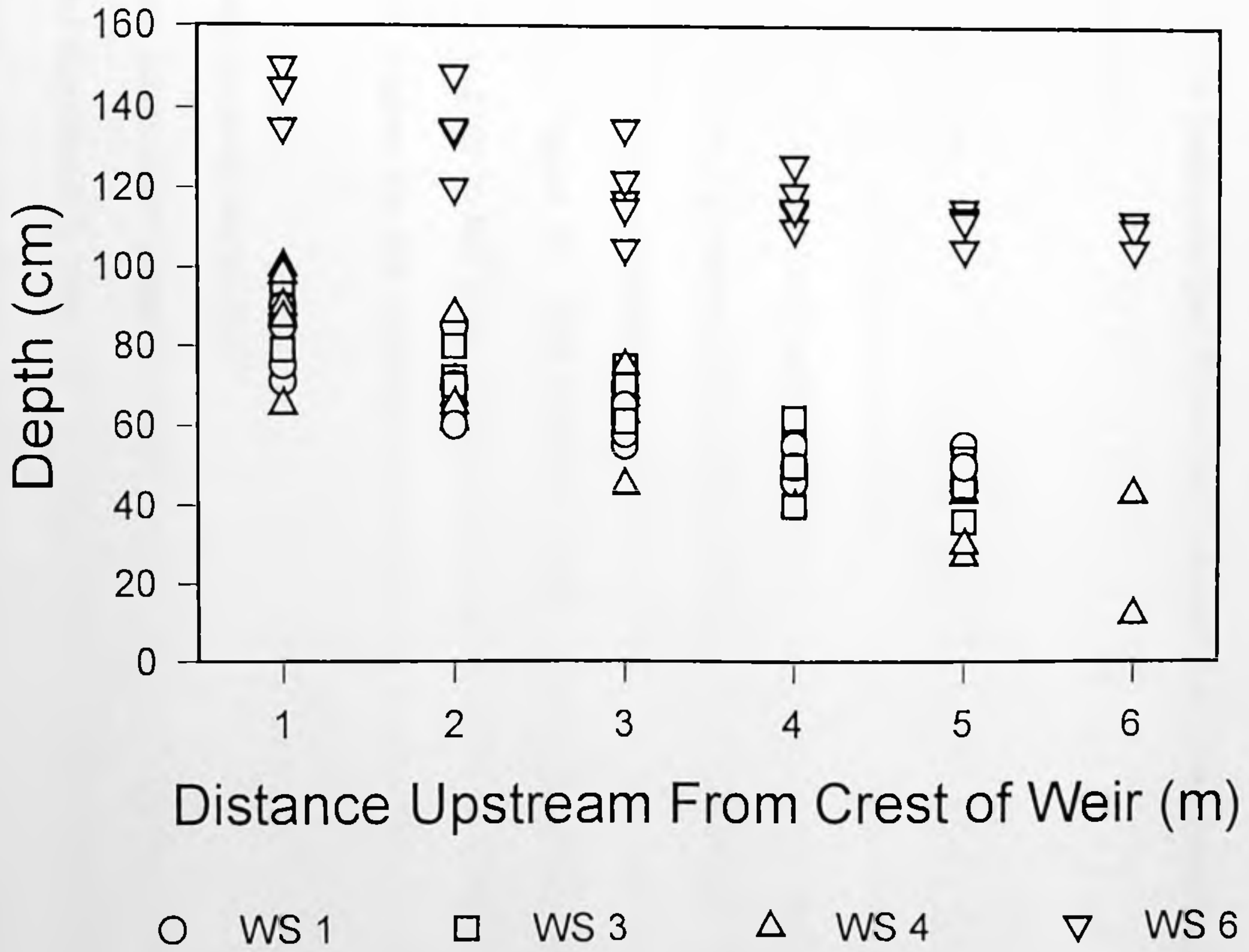
Sample location

Total particulate organic matter (TPOM, AFDM/m^2) varied with depth and distance from the crest of the weir. TPOM increased with depth in all

Table 3. Physical features of the four watersheds on Fernow Experimental Forest.

	Watershed			
	1	3	4	6
Treatments	Urea fertilized Dimilin study	Deforested Ammonium sulfate	Control	Deforested/Herbicided, Norway spruce stand
Area (ha)	30	34	39	22
Elevation (m)	646	738	747	738
Predominant foliage	chestnut oak, yellow popular, Sugar maple	red oak white ash yellow popular	red and chestnut oaks, sugar maple	norway spruce
Average slope	10°	6°	8°	7°
Stream (%)	3	4	2	3
Stand age (yrs.)	37	26	90	22
Weir pond				
Area (m^2)	25	42	30	35
Mean depth (m)	0.8	0.8	0.7	1.3

Figure 3. Bottom profiles of each weir pond for the 1994-1995 study. Points are from individual Ekman sampling locations.


Depth (cm)
160
140
120
100
80
60
40
20
0
1
2
3
4
5
6
Distance Upstream From Crest of Weir (m)
WS 1
WS 3
WS 4
WS 6

four weir ponds (Fig. 4). TPOM decreased with distance from the crest of the weir ponds (Fig. 5). One way ANOVA showed that pond 6 was significantly deeper than the other ponds (Table 4). There was no significant effect of pond on sampling distance (distance from crest of weir). There was no effect of the sample date on either depth or distance from the weir crest. This indicates that there was no locational bias among ponds or among samples.

Seasonal variation

Mean TPOM of the four weir ponds over the course of the study did seem to show some seasonal trends (Fig. 6a-d). The combined TPOM for the four weir ponds was greatest in the fall and lowest in the spring. Seasonal variation of the three components of TPOM (VPOM, CPOM and FPOM) are illustrated in Figure 6. The FPOM for the combined weir ponds was significantly higher in fall than in other seasons ($p<0.05$). Seasonal organic particulate matter for the individual weir ponds is illustrated in Figure 7.

Comparison among watershed

Mean particulate organic matter varied among sites (Fig. 8a-d). Weir pond 4 had significantly more CPOM and FPOM than the other weir ponds. A Tukey's Honestly Significant Difference (HSD) was used to determine the pairwise comparisons for the organic matter data. Weir pond 1 had significantly more VPOM than pond 4. TPOM did not differ significantly

Figure 4. Depth of weir pond in relation to total organic matter. (POM = particulate organic matter).

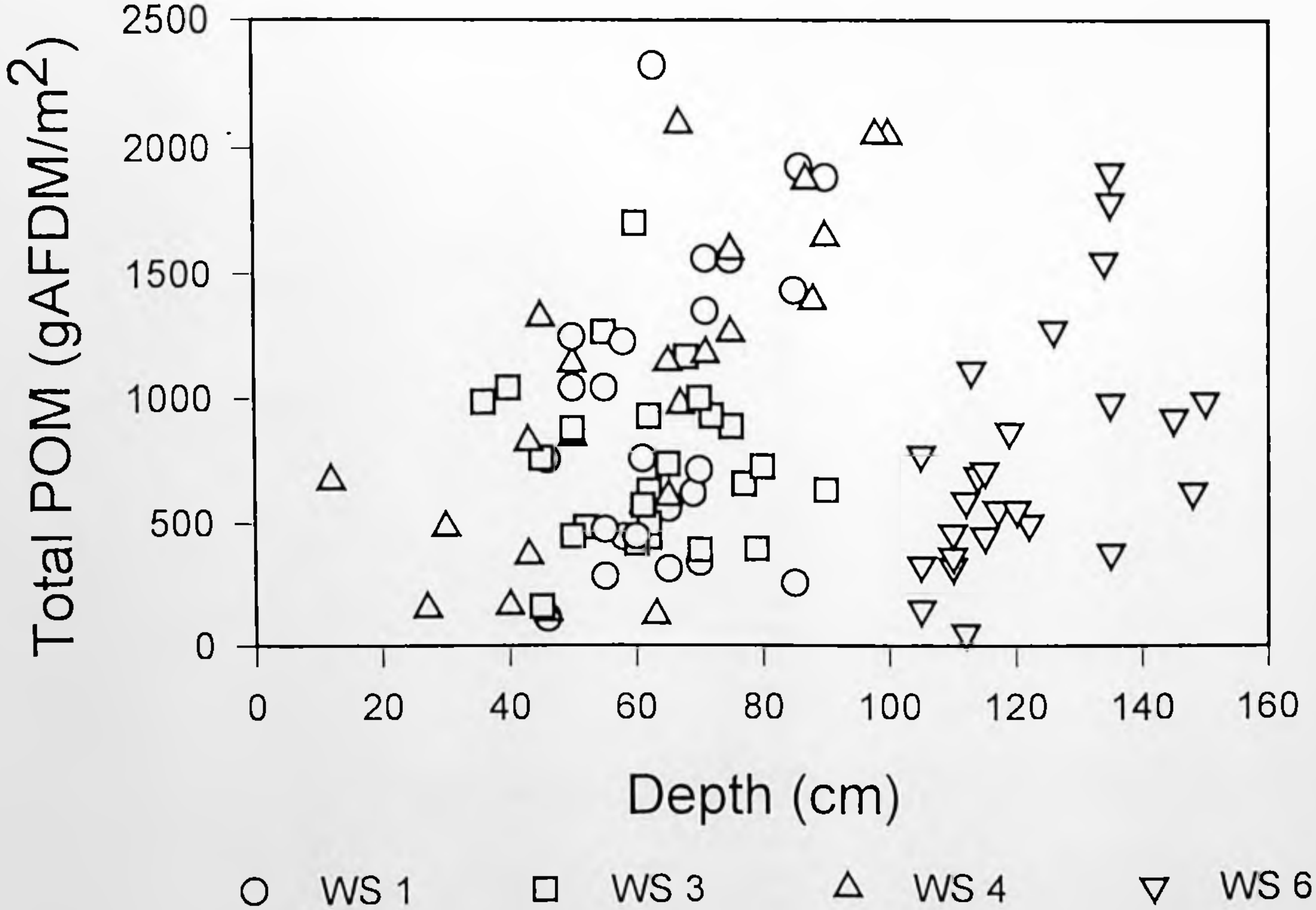

Total POM (gAFDM/m2)
2500
2000
1500
1000
500
0
0
20
40
60
80
100
120
140
160
Depth (cm)
WS 1
WS 3
WS 4
WS 6

Figure 5. Distance from weir crest in relation to total particulate organic matter.

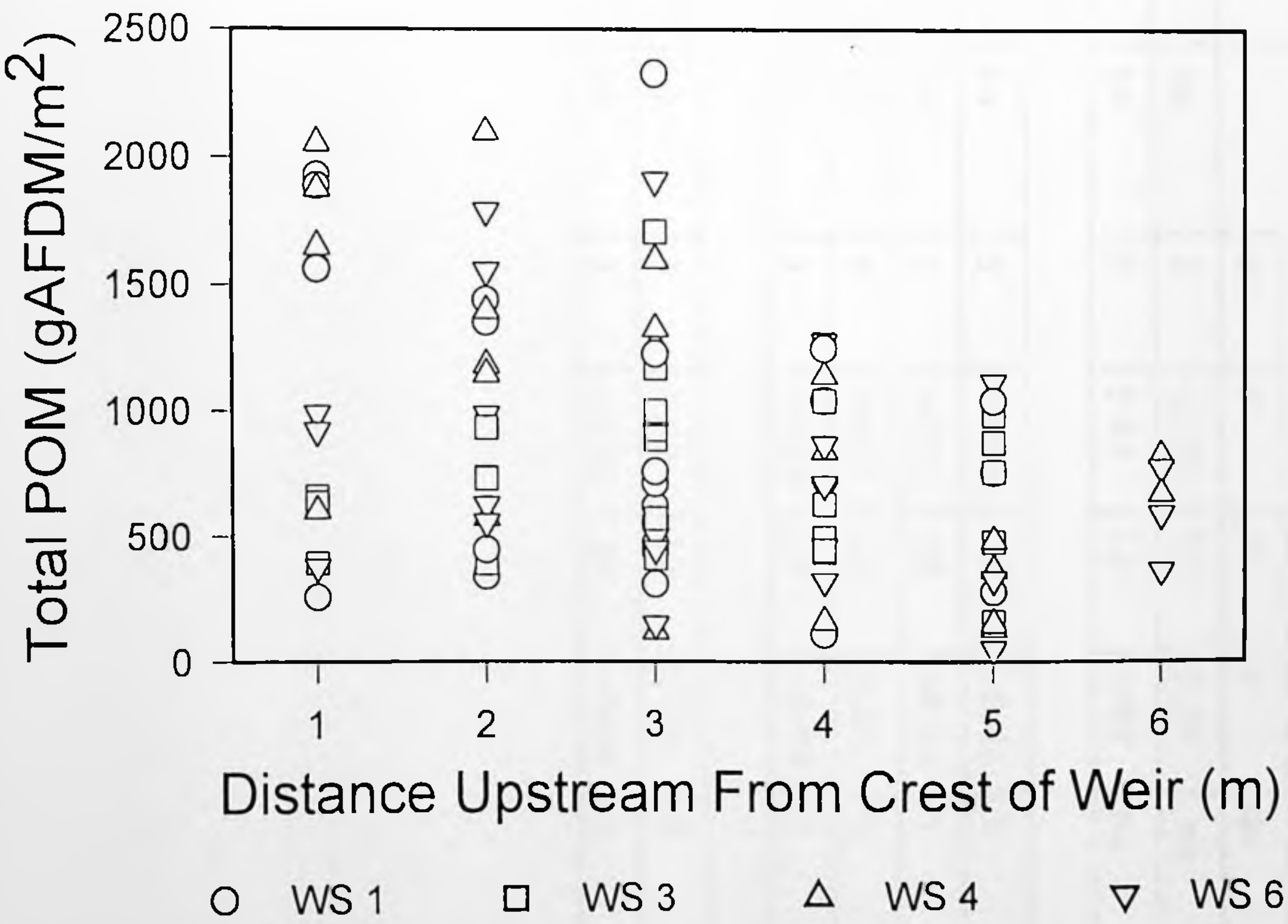

Total POM (gAFDM/m2)
2500
2000
1500
1000
500
0
1
2
3
4
5
6
Distance Upstream From Crest of Weir (m)
WS 1
WS 3
WS 4
WS 6

Table 4. One-way analysis of covariance on the four weir ponds (1994-1995). Depth is a covariate.

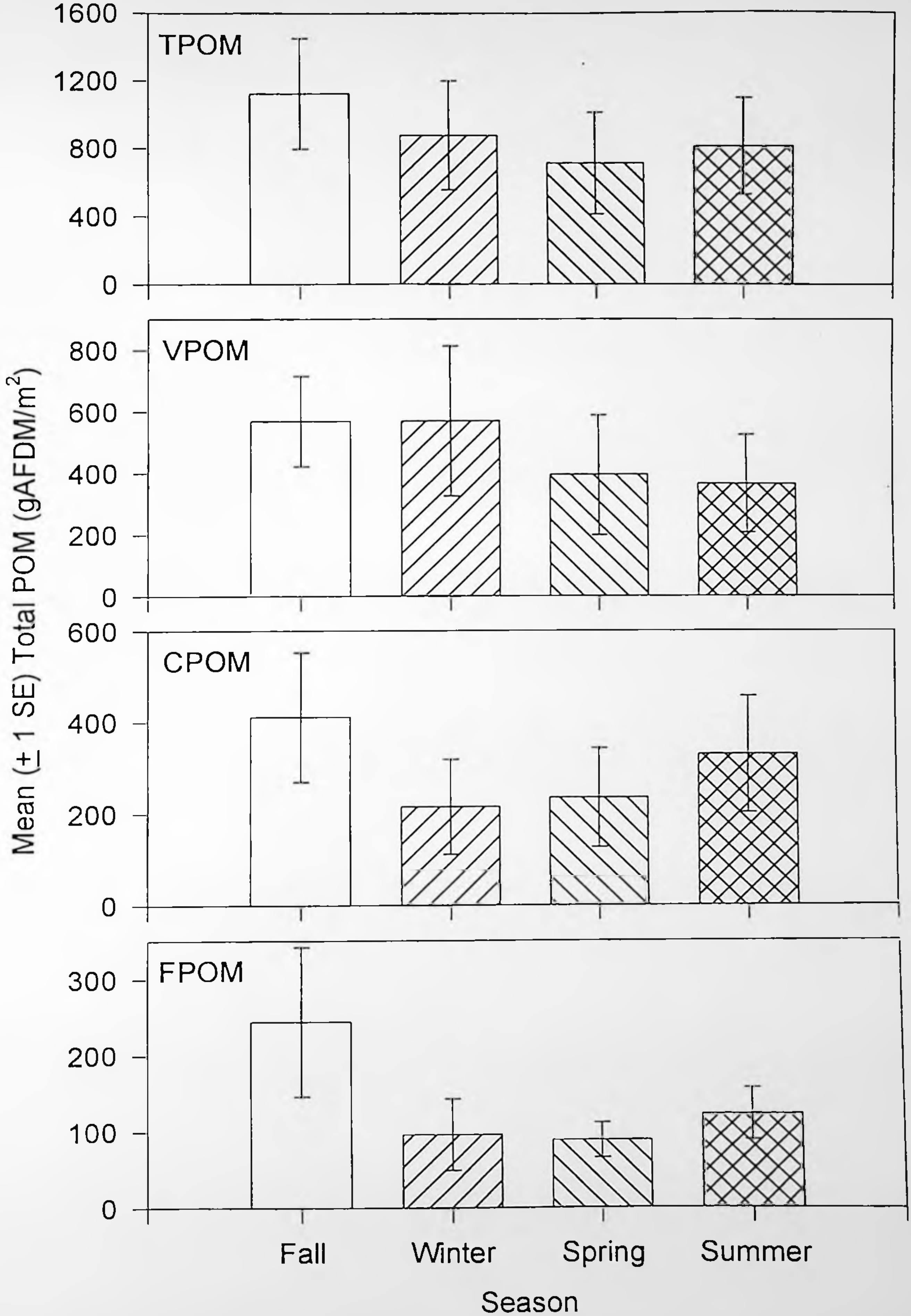
Dependent Variable	Error df	Pond		Date		Depth	
		df	P	df	P	df	P
Depth	88	3	<0.01	12	0.14	na	na
Distance	88	3	0.46	12	0.62	na	na
FPOM	84	3	<0.01	12	<0.01	1	<0.05
CPOM	84	3	<0.01	12	<0.01	1	<0.01
VPOM	87	3	<0.01	12	0.06	1	<0.01
Total POM	81	3	<0.01	12	<0.05	1	<0.01
Density	87	3	0.10	12	0.34	1	<0.01
Richness	87	3	<0.01	12	<0.01	1	<0.01

Figure 6. a. Mean (± 1 SE) seasonal total POM for the combined weir ponds for the 1994-1995 study.

b. Mean (± 1 SE) seasonal VPOM (very course particulate organic matter) for the combined weir ponds for the 1994-1995 study.

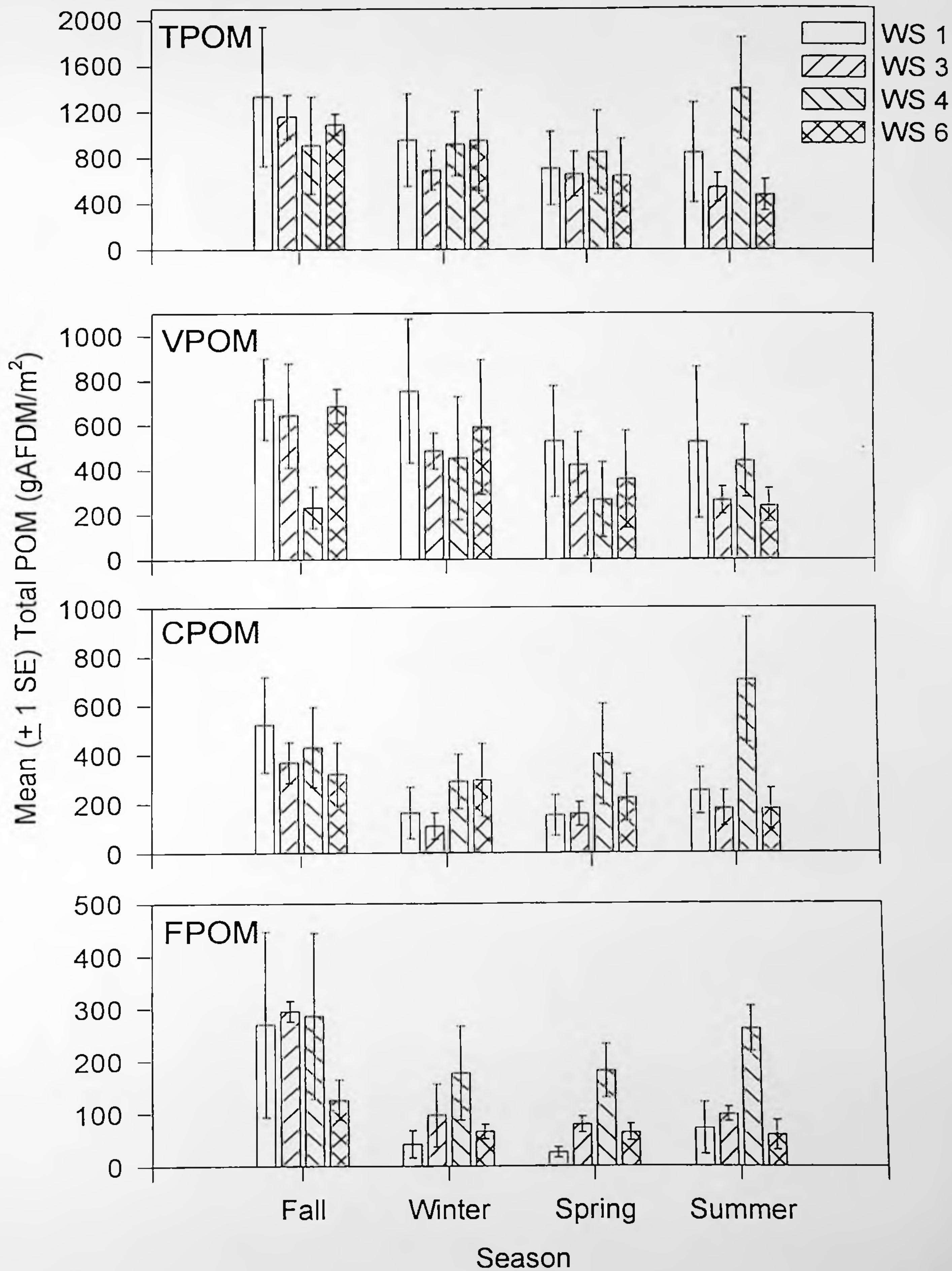
c. Mean (± 1 SE) seasonal CPOM (course particulate organic matter) for the combined weir ponds for the 1994-1995 study.

d. Mean (± 1 SE) seasonal FPOM (fine particulate organic matter) for the combined weir ponds for the 1994-1995 study.



TPOM
VPOM
CPOM
FPOM
Mean (± 1 SE) Total POM (gAFDM/m²)
1600
1200
800
400
0
600
200
300
100
Fall
Winter
Spring
Summer
Season

Figure 7. Mean (± 1 SE) seasonal POM (particulate organic matter) for each weir pond for the 1994-1995 study.



TPOM
VPOM
CPOM
FPOM
WS 1
WS 3
WS 4
WS 6
Mean (+ 1 SE) Total POM (gAFDM/m2)
2000
1600
1200
800
400
0
1000
800
600
400
200
0
1000
800
600
400
200
0
500
400
300
200
100
0
Fall
Winter
Spring
Summer
Season

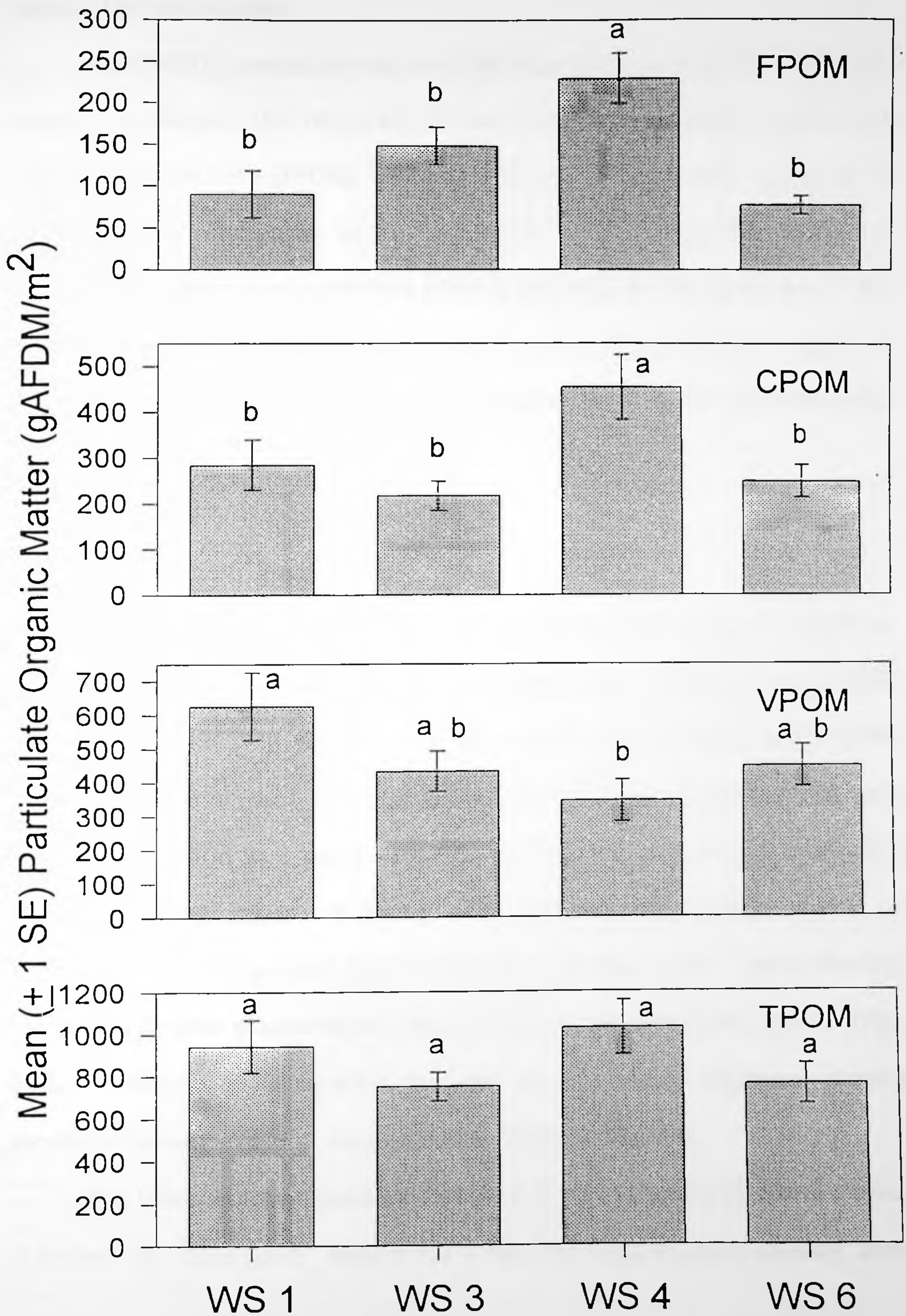
Figure 8. Mean (± 1 SE) POM for each weir pond. A Tukey's Honestly Significant Difference (HSD) was used to determine the pairwise comparisons for the organic matter data.

a. Mean (± 1 SE) FPOM (fine particulate matter) for each weir pond.

b. Mean (± 1 SE) CPOM (course particulate matter) for each weir pond.

c. Mean (± 1 SE) VPOM (very course particulate matter) for each weir pond.

d. Mean (± 1 SE) TPOM (total particulate matter) for each weir pond.



Mean (+ 1 SE) Particulate Organic Matter (gAFDM/m^2)
FPOM
CPOM
VPOM
TPOM
0
50
100
150
200
250
300
400
500
600
700
800
1000
1200
a
b
a b
WS 1
WS 3
WS 4
WS 6

among the weir ponds.

An ANOVA comparison on the POM data for the weir ponds displayed similar findings to the Tukey's HSD test (Table 4). All components of the organic matter data (TPOM, VPOM, CPOM and FPOM) were significantly different when compared by pond ($p < 0.01$). All components except for VPOM were significantly different when compared by date of sample. This implies that the particulate organic matter varied from sample to sample for each weir pond, but overall the total organic matter seemed to be similar.

MACROINVERTEBRATE ABUNDANCE

1994-1995 and 1971-1972 study

The taxonomic composition for the 1994-1995 study is shown in Table 5a-d. Weir pond 3 had the highest mean density with 7,980 individuals, and weir pond 6 had the lowest mean density with 5,598 individuals. Dipterans accounted for most of the invertebrates in weir pond 3 (71%) and weir pond 4 (69%). Ostracods dominated in weir pond 1 (58%) and weir pond 6 (66%), with dipteran populations second in importance with 32 percent and 15 percent in ponds 1 and 6. Mean density for the four weir ponds varied from 1,000 per m^2 to 20,000 per m^2 (Fig. 9a,b). Analysis of covariance revealed no significant difference among ponds or among dates in mean density (Table 4, Fig. 10).

The taxonomic composition for the 1971-1972 study by Steve Harris is shown in Table 6a-d. Weir pond 4 had the highest mean density with

Table 5a. Taxon list of weir pond 1 on the FEF.

Taxon	Date													Total	Percent
	102094	111894	121694	12095	22495	31795	41495	51795	62095	71795	81595	92295	102095		
Collembola	28	0	0	0	0	0	0	0	0	0	0	0	0	28	0.03
Ephemeroptera															
Eurylophella	0	0	0	0	0	0	0	0	0	0	38	0	0	38	0.04
Litobrancha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Heptageniidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Ameletus	0	0	0	0	0	0	9	0	0	0	0	0	0	9	0.01
Odonata															
Aeshna	0	0	0	0	9	0	0	0	0	0	0	0	0	9	0.01
Lanthus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Plecoptera															
Paracapnia	0	0	0	0	38	0	0	0	0	0	0	0	0	38	0.04
Chloroperlidae	0	0	9	0	0	0	0	0	0	0	0	0	0	9	0.01
Sweltsa	0	0	9	0	9	0	0	0	0	0	0	0	0	19	0.02
Leuctra	0	0	9	19	66	9	0	28	0	0	76	9	38	255	0.30
Amphinemura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Soyedina	0	0	0	0	0	38	0	0	0	0	0	0	0	38	0.04
Peltoperla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Isoperla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Hemiptera															
Sigara	0	0	0	0	0	0	0	0	0	19	0	0	0	19	0.02
Trichoptera															
Polycentropus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Lepidostoma	0	0	0	0	0	0	0	19	0	0	0	0	0	19	0.02
Pycnopsyche	0	0	19	47	85	19	19	0	0	0	0	0	0	189	0.22
Coleoptera	0	0	0	0	0	0	0	9	0	0	9	0	0	19	0.02
Megaloptera															
Sialis	0	0	0	9	0	0	0	0	0	0	0	0	0	9	0.01
Diptera															
Culicoides	0	0	0	19	0	0	0	0	0	0	0	0	0	19	0.02
Palpomyia	0	0	0	0	76	38	0	0	0	0	38	0	0	151	0.18
Chaoborus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Dixa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Limnophila	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Molophilus	0	0	9	38	28	9	0	0	0	0	0	0	0	85	0.10
Chironomus	473	955	302	312	38	189	95	312	113	2647	5652	4225	7429	22741	26.57
Dicrotendipes	0	0	0	0	0	0	0	9	66	151	38	0	0	265	0.31
Micropsectra	0	0	0	0	0	9	0	0	0	0	0	0	0	9	0.01
Microtendipes	28	0	57	57	0	113	0	0	0	9	0	0	0	265	0.31
Paratendipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Polypedilum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Tanytarsus	0	0	0	9	47	28	85	38	0	0	47	0	0	255	0.30
Tribelos	0	9	19	57	0	9	0	0	9	9	0	9	0	123	0.14
Orthoclad group	0	0	0	0	0	0	57	113	0	0	0	0	0	170	0.20
Brillia	0	0	0	9	0	0	0	0	0	0	0	0	0	9	0.01
Corynoneura	0	0	0	9	0	0	0	0	0	0	0	0	0	9	0.01
Cricotopus	0	0	0	76	104	0	0	132	0	0	0	0	0	312	0.36
Eukiefferiella	0	0	0	95	0	0	0	0	0	0	38	0	0	132	0.15
Heterotrissocladius	0	0	0	236	1361	766	0	0	0	0	0	38	0	2401	2.81
Orthocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Parachaetocladius	0	0	0	28	0	0	0	0	0	0	0	0	0	28	0.03
Parametriocnemus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Paraphaenocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Psectrocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00

Table 5a. Continued

Taxon	Date													Total	Percent
	102094	111894	121694	12095	22495	31795	41495	51795	62095	71795	81595	92295	102095		
Rheocricotopus	0	0	0	0	0	0	38	0	0	0	0	0	0	38	0.04
Stilocladius	0	0	0	38	0	0	0	0	0	0	0	0	0	38	0.04
Symposiocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Thienemanniella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Prodiamesa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Procladius	170	28	85	38	0	248	0	0	0	38	28	9	47	690	0.81
Thienemannimyia	0	0	0	0	28	0	0	0	0	0	0	0	0	28	0.03
Zavrelimyia	9	9	76	28	19	9	9	28	38	9	0	0	9	248	0.29
Cladocera	0	0	0	0	0	0	38	1096	227	0	756	38	76	2231	2.61
Copepoda	378	860	85	397	76	113	378	76	151	113	227	0	0	2864	3.35
Ostracoda	558	643	586	359	85	491	4991	2977	7713	12401	2571	10813	5775	49972	58.39
Acarian	9	9	0	0	38	0	0	38	0	0	0	151	38	284	0.33
Bivalvia															
Pisidium	9	0	0	0	0	0	0	0	19	0	0	0	0	28	0.03
Oligochaeta	85	690	312	0	0	0	0	0	66	0	0	0	331	1484	1.73
Mean Density	1749	3204	1588	1881	2117	2089	5718	4877	8403	15397	9518	15293	13743	85577	100.00
SE	463	1919	85	369	1059	709	2864	945	1163	6684	3923	6957	132		
Total richness	10	8	13	20	16	15	10	13	9	9	12	8	8		

Table 5b. Taxon list of weir pond 3 on the FEF.

Taxon	Date													Total	Percent
	102094	111894	121694	12095	22495	31795	41495	51795	62095	71795	81595	92295	102095		
Collembola	0	0	0	38	38	0	0	0	0	38	0	0	0	113	0.11
Ephemeroptera															
Eurylophella	0	0	0	0	0	9	0	38	0	0	0	0	0	47	0.05
Litobrancha	9	0	0	19	0	9	0	28	0	0	0	0	0	66	0.06
Heptageniidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Ameletus	0	0	0	66	0	38	0	9	0	0	0	0	0	113	0.11
Odonata															
Aeshna	0	0	0	0	0	9	0	0	0	0	0	0	0	9	0.01
Lanthus	0	0	0	9	0	9	0	0	0	0	0	0	0	19	0.02
Plecoptera															
Paracapnia	0	0	0	9	0	9	0	0	0	0	0	0	0	19	0.02
Chloroperlidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Sweltsa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Leuctra	0	0	0	9	595	57	217	38	454	9	0	0	0	1380	1.33
Amphinemura	0	0	0	0	0	0	0	9	0	0	0	0	0	9	0.01
Soyedina	0	0	0	0	0	0	0	9	0	0	0	0	0	9	0.01
Peltoperla	0	0	0	0	170	0	0	0	0	0	0	0	0	170	0.16
Isoperla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Hemiptera															
Sigara	0	0	0	0	0	0	19	0	9	0	0	0	28	57	0.05
Trichoptera															
Polycentropus	0	0	9	9	9	9	19	0	0	0	0	0	0	57	0.05
Lepidostoma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Pycnopsyche	0	0	0	28	38	9	38	9	9	0	0	0	0	132	0.13
Coleoptera	0	0	19	0	0	0	0	38	0	0	0	0	0	57	0.05
Megaloptera															
Sialis	0	0	0	0	0	0	0	9	0	0	9	0	0	19	0.02
Diptera															
Culicoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Palpomyia	57	0	0	208	151	0	19	38	0	0	0	0	19	491	0.47
Chaoborus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Dixa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Limnophila	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Molophilus	0	0	0	0	57	0	0	0	0	0	0	0	0	57	0.05
Chironomus	5293	4792	2722	3308	2023	2013	2344	529	378	1342	1493	3025	1758	31021	29.90
Dicrotendipes	0	0	0	0	0	0	0	132	198	9	302	19	9	671	0.65
Micropsectra	0	0	0	0	0	0	0	38	0	0	0	0	0	38	0.04
Microtendipes	728	151	66	1314	47	180	85	66	151	9	9	0	28	2836	2.73
Paratendipes	0	151	0	0	0	0	0	9	0	0	0	0	0	161	0.15
Polypedilum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Tanytarsus	9	0	0	463	76	681	463	794	9	38	47	0	0	2580	2.49
Tribelos	2108	1758	587	1607	652	3336	1531	983	66	19	2098	2042	6257	23025	22.19
Orthoclad group	0	0	0	0	0	85	208	501	151	0	0	9	0	955	0.92
Brillia	0	0	0	19	0	0	0	0	0	0	0	0	0	19	0.02
Corynoneura	151	0	0	198	0	0	0	38	151	0	0	0	0	539	0.52
Cricotopus	0	0	0	0	9	0	38	0	0	0	0	0	0	47	0.05
Eukiefferiella	0	0	0	76	0	0	0	38	0	0	0	0	0	113	0.11
Heterotrissocladius	0	0	236	2478	1503	1181	0	9	0	0	0	0	0	5406	5.21
Orthocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Parachaetocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Parametriocnemus	0	0	0	38	0	9	9	0	0	0	0	0	0	57	0.05
Paraphaenocladius	0	0	0	0	0	9	0	0	0	0	0	0	0	9	0.01
Psectrocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00

Table 5b.Continued

Taxon	Date													Total	Percent
	102094	111894	121694	12095	22495	31795	41495	51795	82095	71795	81595	92295	102095		
Rheocricotopus	0	0	0	0	0	19	350	0	0	0	0	0	0	369	0.38
Stilocladius	0	0	0	0	0	0	0	38	0	0	0	0	0	38	0.04
Symposiocladius	0	0	0	0	0	19	0	0	0	0	0	0	0	19	0.02
Thienemanniella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Prodiamesa	0	0	0	0	19	9	0	0	0	0	0	0	0	28	0.03
Procladius	1380	539	19	350	113	248	85	350	0	0	151	463	132	3828	3.69
Thienemannimyia	0	0	0	0	9	19	9	0	0	0	0	0	0	38	0.04
Zavrelimyia	19	0	104	397	66	208	208	238	95	28	47	0	0	1408	1.36
Cladocera	0	0	0	0	0	0	0	113	1381	3829	794	1531	482	7911	7.63
Copepoda	3327	1096	208	794	756	491	605	1021	1210	2117	567	605	756	13554	13.07
Ostracoda	302	0	265	38	0	0	302	0	605	302	0	605	151	2571	2.48
Acarian	0	151	0	38	0	38	0	0	0	0	0	0	302	529	0.51
Bivalvia															
Pisidium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Oligochaeta	227	841	28	1096	0	0	132	265	85	0	170	76	227	3147	3.03
Mean Density	13611	9480	4244	12609	6333	8705	6882	5388	4934	7543	5690	8374	10151	103743	100.00
SE	4764	4074	2089	3327	3989	3129	2788	870	2609	1493	1947	2456	7524		
Total richness	11	8	11	24	18	25	19	27	15	11	11	9	12		

Table 5c. Taxon list of weir pond 4 on the FEF.

Taxon	Date													Total	Percent
	102094	111894	121694	12095	22495	31795	41495	51795	62095	71795	81595	92295	102095		
Collembola	9	0	0	0	0	0	0	0	0	0	0	0	0	9	0.01
Ephemeroptera															
Eurylophella	0	0	0	47	0	0	0	9	0	0	0	0	0	57	0.08
Litobrancha	28	0	0	0	28	0	0	0	0	0	0	0	0	57	0.08
Heptageniidae	0	9	0	0	0	0	0	0	0	0	0	0	0	9	0.01
Ameletus	0	0	0	0	9	9	0	0	0	0	0	0	0	19	0.03
Odonata															
Aeshna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Lanthus	0	0	0	0	0	0	9	0	0	0	0	0	0	9	0.01
Plecoptera															
Paracapnia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Chloroperlidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Sweltsa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Leuctra	0	0	0	76	38	236	85	0	0	9	0	0	0	444	0.60
Amphinemura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Soyedina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Peltoperla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Isoperla	0	0	0	9	0	0	0	0	0	0	0	0	0	9	0.01
Hemiptera															
Sigara	0	9	0	9	0	0	0	9	0	0	0	19	19	66	0.09
Trichoptora															
Polycentropus	0	0	0	0	0	0	9	0	0	0	0	0	0	9	0.01
Lepidostoma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Pycnopsyche	0	0	28	19	19	0	95	0	0	0	0	0	0	161	0.22
Coleoptora	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Megaloptera															
Sialis	0	0	9	9	19	0	9	0	0	0	0	19	0	66	0.09
Diptera															
Culicoides	0	0	0	0	0	38	0	0	0	0	0	0	0	38	0.05
Palpomyia	151	28	113	47	57	9	0	47	161	0	0	9	0	624	0.84
Chaoborus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Dixa	38	0	0	0	0	0	0	0	0	0	0	0	0	38	0.05
Limnophila	0	0	0	0	9	0	0	0	0	0	0	0	0	9	0.01
Molophilus	0	0	0	0	0	0	0	9	0	0	0	0	0	9	0.01
Chironomus	841	2420	728	2476	284	926	359	1862	1011	699	501	1200	917	14225	19.10
Dicrotendipes	0	0	0	0	0	9	0	9	38	9	0	0	0	66	0.09
Micropsectra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Microtendipes	66	38	236	66	28	9	57	9	0	0	0	0	19	529	0.71
Paratendipes	0	0	0	0	0	0	0	47	0	0	0	0	0	47	0.06
Polypedilum	0	0	0	0	0	0	19	0	38	0	0	0	0	57	0.08
Tanytarsus	0	0	47	151	454	586	463	312	76	0	151	9	0	2250	3.02
Tribelos	1796	907	1002	539	662	529	312	1474	76	0	321	624	1550	9792	13.15
Orthoclad group	0	0	0	0	0	198	123	19	0	0	0	0	0	340	0.46
Brillia	0	0	9	28	9	9	0	0	0	0	0	0	0	57	0.08
Corynoneura	38	0	0	265	151	0	0	9	0	0	0	0	0	463	0.62
Cricotopus	0	0	0	0	47	0	0	0	0	0	0	0	0	47	0.06
Eukiefferiella	0	0	0	113	0	161	0	19	0	0	0	0	0	293	0.39
Heterotrissocladius	0	0	123	917	841	28	76	9	0	0	0	0	0	1994	2.68
Orthocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Parachaetocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Parametriocnemus	0	0	0	0	0	151	0	0	0	0	0	0	0	151	0.20
Paraphaenocladius	0	0	0	0	0	151	0	0	0	0	0	0	0	151	0.20
Psectrocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00

Table 5c.Continued

Taxon	Date													Total	Percent
	102094	111894	121894	12095	22495	31795	41495	51795	82095	71795	81595	92295	102095		
Rheocricotopus	0	0	0	0	0	265	19	0	0	0	0	0	0	284	0.38
Stilocladius	0	0	9	0	0	0	0	0	0	0	0	0	0	9	0.01
Symposiocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Thienemanniella	0	0	0	0	0	0	0	0	113	0	0	0	0	113	0.15
Prodiamesa	0	0	0	19	0	0	0	0	0	0	0	0	0	19	0.03
Procladius	992	1096	1493	3355	2543	180	284	1692	1191	0	0	2892	4045	19764	26.54
Thienemannimyia	0	0	0	47	0	151	0	9	0	0	0	0	0	208	0.28
Zavrelimyia	9	76	85	198	161	95	47	76	47	19	9	0	0	822	1.10
Cladocera	0	0	0	0	0	0	0	151	0	0	151	1210	0	1512	2.03
Copepoda	189	1448	822	587	794	1739	832	1966	3628	3932	0	1664	1021	18601	24.98
Ostracoda	113	0	132	38	0	38	76	151	38	151	0	0	0	737	0.99
Acarian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Bivalvia															
Pisidium	19	0	0	0	9	0	19	0	9	0	0	9	0	66	0.09
Oligochaeta	95	9	0	132	0	0	0	0	0	0	0	0	0	236	0.32
Mean Density	4386	8040	4839	9130	6163	5520	2892	7892	6427	4820	1134	7656	7571	74471	100.00
SE	1739	1654	151	1115	2552	3081	1172	2713	3346	2930	928	4990	1163		
Total richness	14	10	14	22	19	21	18	20	12	6	5	10	6		

Table 5d. Taxon list of weir pond 6 on the FEF.

Taxon	Date													Total	Percent
	102094	111894	121694	12095	22495	31795	41495	51795	62095	71795	81595	92295	102095		
Collembola	0	0	0	0	0	0	0	38	0	0	0	0	0	38	0.05
Ephemeroptera															
Eurylophella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Litobrancha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Heptageniidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Ameletus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Odonata															
Aeshna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Lanthus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Plecoptera															
Paracapnia	0	0	0	9	9	0	0	0	0	0	0	0	0	19	0.03
Chloroperlidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Sweltsa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Leuctra	0	0	0	0	57	0	57	0	0	38	38	0	0	189	0.26
Amphinemura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Soyedina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Peltoperla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Isoperla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Hemiptera															
Sigara	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Trichoptera															
Polycentropus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Lepidostoma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Pycnopsyche	0	0	0	0	0	0	9	0	0	0	0	0	0	9	0.01
Coleoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Megaloptera															
Sialis	0	9	0	0	0	0	0	0	0	0	0	0	0	9	0.01
Diptera															
Culicoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Palpomyia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Chaoborus	0	0	0	0	0	0	0	0	0	0	0	9	19	28	0.04
Dixa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Limnophila	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Molophilus	0	0	0	0	0	9	0	0	0	0	0	0	0	9	0.01
Chironomus	28	9	9	19	47	9	0	0	0	9	784	198	9	1125	1.55
Dicrotendipes	0	0	0	0	0	0	0	0	0	0	161	0	0	161	0.22
Micropsectra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Microtendipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Paratendipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Polypedilum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Tanytarsus	28	0	0	0	0	0	38	38	9	0	0	9	0	123	0.17
Tribelos	9	9	0	0	9	0	0	0	0	0	0	0	0	28	0.04
Orthoclad group	0	0	0	0	0	47	132	66	0	0	151	0	0	397	0.55
Brillia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Corynoneura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Cricotopus	0	0	0	0	0	0	9	0	0	0	0	0	0	9	0.01
Eukiefferiella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Heterotrissocladius	0	0	0	0	38	0	170	0	38	0	0	28	0	274	0.38
Orthocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Parachaetocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Parametriocnemus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Paraphaenocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Psectrocladius	9	0	0	0	0	0	0	19	28	0	0	0	0	57	0.08

Table 5d.Continued

Taxon	Date													Total	Percent
	102084	111894	121694	12095	22495	31795	41495	51795	82095	71795	81595	92295	102095		
Rheocricotopus	0	0	0	0	0	38	227	47	0	0	0	0	0	312	0.43
Stilocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Symposiocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Thienemanniella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Prodiamesa	0	0	0	0	0	9	0	0	9	0	0	0	0	19	0.03
Procladius	378	852	955	728	189	180	388	227	274	28	682	510	2552	7722	10.81
Thienemannimyia	0	0	0	0	47	0	0	9	0	0	0	0	0	57	0.08
Zavrelimyia	57	38	57	38	38	95	38	57	19	0	38	9	0	482	0.66
Cladocera	775	709	0	0	0	0	0	0	416	2543	78	406	312	5238	7.19
Copepoda	142	236	340	302	0	0	9	189	881	473	1381	1021	1890	6645	9.13
Ostracoda	113	350	4877	4388	1474	454	482	907	3100	1815	15917	2193	11607	47675	65.51
Acarian	0	19	38	0	0	47	0	0	38	0	0	38	151	331	0.45
Bivalvia															
Pisidium	0	0	0	9	0	0	0	0	0	0	0	9	0	19	0.03
Oligochaeta	350	681	350	227	0	0	47	47	0	104	0	0	0	1805	2.48
Mean Density	1890	2713	8828	5718	1909	888	1607	1645	4812	5009	19187	4433	16541	72779	100.00
SE	548	520	3820	1144	151	340	588	435	945	1758	12873	1824	10907		
Total richness	10	10	7	8	9	9	12	11	10	7	9	11	7		

Figure 9. a. Mean (± 1 SE) density for each weir pond for the 1994-1995 study.

b. Mean density for each weir pond for the 1971-1972 study. (No error bars since only one set of densities for each weir pond).

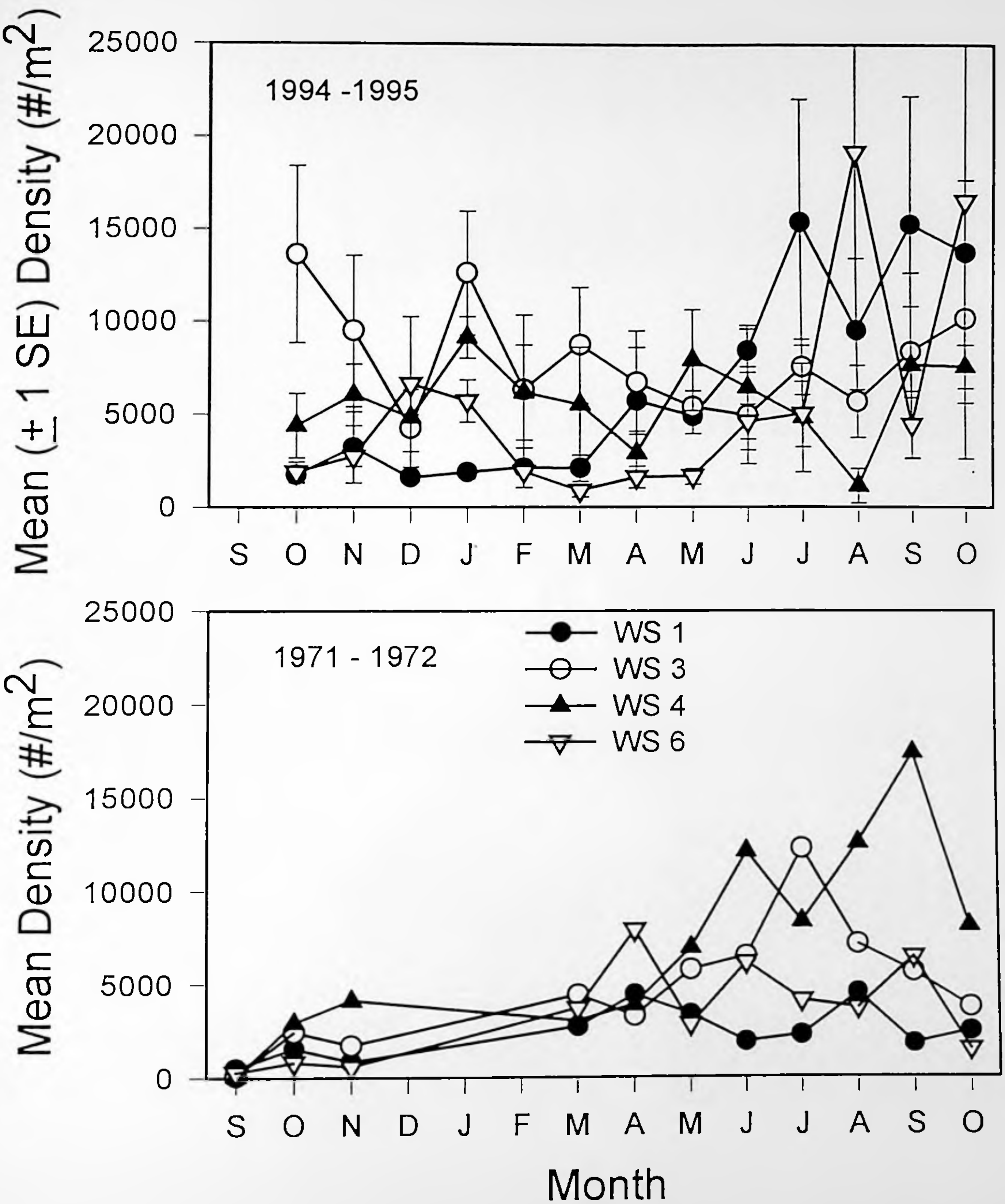

1994 -1995
1971 - 1972
WS 1
WS 3
WS 4
WS 6
Mean (± 1 SE) Density (#/m2)
Mean Density (#/m2)
25000
20000
15000
10000
5000
0
S O N D J F M A M J J A S O
Month

Figure 10. a. Mean (± 1 SE) macroinvertebrate density for each weir pond for the 1994-1995 study. (a HSD was used for the pairwise comparisons).

b. Mean macroinvertebrate density for each weir pond for the 1971-1972 study. (No error bars since only one set of densities for each weir pond).

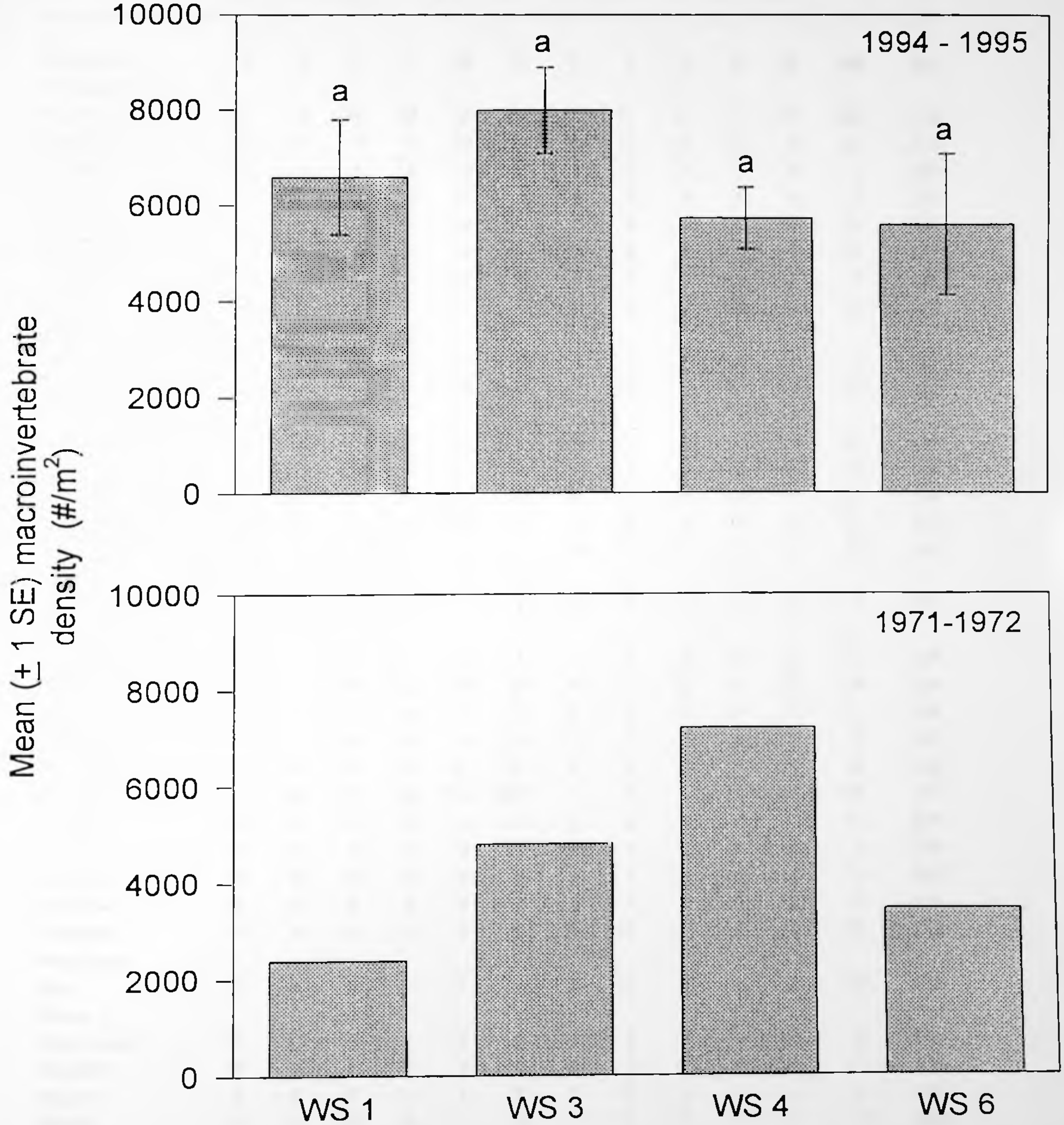

Mean (± 1 SE) macroinvertebrate density (#/m2)
1994 - 1995
a
a
a
a
1971-1972
10000
8000
6000
4000
2000
0
WS 1
WS 3
WS 4
WS 6

Table 6a. Taxon list of weir pond 1 on the FEF

Taxon	Data											Total	Percent
	9/71	10/71	11/71	3/72	4/72	5/72	6/72	7/72	8/72	9/72	10/72		
Collembola	0	0	0	11	43	11	32	0	0	0	11	108	0.41
Ephemeroptera													
Baetidae	0	0	86	86	54	86	0	11	11	0	171	525	2.01
Ephemerella	0	11	0	0	22	0	0	11	0	0	0	44	0.17
Hexagenia	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Epeorus	0	0	0	0	11	0	0	0	0	0	0	11	0.04
Habrophlebia	0	0	0	11	0	0	0	0	0	0	11	22	0.08
Habrophlebiodes	0	0	0	0	289	331	11	0	0	0	0	631	2.41
Lachlania	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Ameletus	0	0	0	0	11	0	0	0	0	0	22	33	0.13
Odonata													
Hagenius	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Lanthus	0	0	11	0	0	0	0	0	0	11	0	22	0.08
Plecoptera													
Alloperla	0	22	0	150	193	11	0	11	0	0	0	387	1.48
Leuctra	0	0	0	0	128	11	0	0	0	0	64	203	0.78
Peltoperla	0	0	0	0	246	22	22	0	0	0	11	301	1.15
Acroneuria	0	0	0	0	86	11	0	0	0	0	0	97	0.37
Isogenus	0	0	0	0	0	0	0	0	0	0	11	11	0.04
Hemiptera													
Corixidae	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Trichoptera													
Diplectrona	0	0	0	0	0	11	0	0	0	0	0	11	0.04
Polycentropus	0	0	0	22	43	0	0	0	0	0	11	76	0.29
Lype	0	0	0	0	0	0	11	0	0	0	0	11	0.04
Psychomyia	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Brachycentrus	0	0	0	11	32	32	0	0	0	0	0	75	0.29
Pycnopsyche	0	22	0	54	310	246	0	0	0	0	107	739	2.82
Ptilostomis	0	0	0	0	0	0	0	0	0	0	11	11	0.04
Ochrotrichia	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Rhyacophila	0	0	0	0	0	0	0	0	0	0	22	22	0.08
Lepidoptera	0	0	0	0	0	11	0	0	0	0	0	11	0.04
Coleoptera	0	0	0	0	0	0	11	11	11	0	0	33	0.13
Megaloptera													
Sialis	0	0	0	0	11	0	0	32	0	0	0	43	0.16
Diptera													
Brachydeutera	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Scatophila	0	0	0	0	0	0	0	0	0	0	22	22	0.08
Muscidae	0	0	0	11	0	0	0	0	0	0	0	11	0.04
Hydrellia	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Syrphidae	0	11	0	0	0	0	0	0	0	0	0	11	0.04
Empididae	0	0	11	0	11	32	54	11	11	0	0	130	0.50
Stratiomyidae	0	0	11	0	0	0	0	0	0	0	0	11	0.04
Eulalia	0	22	0	22	22	11	0	0	22	0	0	99	0.38
Tabanus	64	32	0	32	43	166	54	22	11	0	43	467	1.78
Cecidomyiidae	11	11	11	0	0	0	0	0	0	0	0	33	0.13
Atrichopogon	0	11	0	0	0	11	0	0	0	0	0	22	0.08

Table 6a. Continued

Taxon	Date											Total	Percent
	9/71	10/71	11/71	3/72	4/72	5/72	6/72	7/72	8/72	9/72	10/72		
Culicoides	0	54	0	0	43	43	11	0	0	0	11	162	0.62
Palpomyia	22	299	11	257	181	278	64	54	138	235	75	1595	6.10
Chironomus	128	267	22	0	54	43	385	1101	1866	878	86	4938	18.87
Glyptotendipes	32	118	0	791	737	408	203	22	150	0	587	3028	11.58
Microtendipes	11	0	0	0	107	11	22	64	54	0	43	312	1.19
Paratendipes	0	0	0	0	0	22	0	0	0	0	0	22	0.08
Tanytarsus	0	11	0	398	641	802	54	128	32	0	22	2086	7.97
Cricotopus	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Hydrobaenus	0	0	0	54	0	11	0	0	0	0	0	65	0.25
Metriocnemus	0	0	0	150	0	0	0	0	0	0	0	150	0.57
Trichocladius	11	22	0	0	84	86	22	11	0	0	54	280	1.07
Pentaneura	32	374	577	246	855	321	641	502	481	331	791	5151	19.68
Procladius	0	0	11	11	0	0	0	0	0	0	0	22	0.08
Pericoma	0	22	0	0	0	11	0	0	0	0	0	33	0.13
Psychoda	0	22	22	11	22	86	22	0	22	0	0	207	0.79
Helius	0	0	0	11	11	0	0	0	0	0	0	22	0.08
Hexatoma	11	32	0	22	32	0	11	0	0	0	11	119	0.45
Limonia	0	0	0	11	0	22	0	0	0	0	0	33	0.13
Ormosia	32	64	0	0	0	0	0	0	0	0	64	160	0.61
Pseudolimnophila	75	11	0	22	22	11	22	11	0	0	11	185	0.71
Tipula	0	0	0	11	0	0	0	0	0	0	22	33	0.13
Copepoda	0	22	32	86	43	43	54	22	1464	214	43	2023	7.73
Acarian	0	0	0	0	11	11	11	0	0	0	0	33	0.13
Bivalvia													
Pisidium	0	32	11	0	0	64	22	139	0	0	75	343	1.31
Oligochaeta	54	54	11	214	66	75	107	64	128	86	32	891	3.40
Nematoda	0	0	0	0	0	0	22	11	0	11	0	44	0.17
Total density	483	1546	837	2713	4424	3358	1868	2238	4502	1764	2434	26168	100.00
Total richness	12	23	13	25	32	33	23	19	14	7	28		

Table 6b. Taxon list of weir pond 3 on the FEF

Taxon	Date											Total	Percent
	9/71	10/71	11/71	3/72	4/72	5/72	6/72	7/72	8/72	9/72	10/72		
Collembola	0	0	0	11	22	0	0	0	0	0	0	33	0.06
Ephemeroptera													
Baetidae	0	43	246	11	203	22	0	0	11	0	139	675	1.28
Ephemerella	0	11	0	11	0	0	22	0	22	22	11	99	0.19
Hexagenia	0	0	0	0	0	0	0	0	0	22	0	22	0.04
Epeorus	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Habrophlebia	0	0	0	0	0	32	0	0	0	0	0	32	0.06
Habrophlebiodes	0	0	0	0	11	0	0	0	0	0	11	22	0.04
Lachlania	0	0	22	0	0	0	0	0	0	0	0	22	0.04
Ameletus	0	0	0	0	11	0	0	0	0	0	22	33	0.06
Odonata													
Hagenius	0	0	0	0	0	0	11	0	0	0	0	11	0.02
Lanthus	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Plecoptera													
Alloperla	0	0	0	11	0	0	0	0	0	0	0	11	0.02
Leuctra	0	11	0	22	32	96	0	0	0	0	54	215	0.41
Peltoperla	0	0	0	11	54	11	0	0	0	0	11	87	0.16
Acroneuria	0	0	0	22	22	0	0	0	0	0	0	44	0.08
Isogenus	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Hemiptera													
Corixidae	0	0	0	0	0	0	0	0	22	0	0	22	0.04
Trichoptera													
Diplectrona	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Polycentropus	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Lype	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Psychomyia	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Brachycentrus	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Pycnopsyche	0	0	0	22	32	32	0	0	0	0	11	97	0.18
Ptilostomis	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Ochrotrichia	0	0	0	0	11	0	0	0	0	0	0	11	0.02
Rhyacophila	0	0	0	0	11	0	0	0	0	0	0	11	0.02
Lepidoptera	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Coleoptera	0	11	0	11	0	0	22	0	0	0	0	44	0.08
Megaloptera													
Sialis	0	11	0	0	0	0	22	86	75	64	22	280	0.53
Diptera													
Brachydeutera	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Scatophila	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Muscidae	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Hydrellia	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Syrphidae	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Empididae	0	0	0	0	0	0	0	0	0	0	11	11	0.02
Stratiomyidae	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Eulalia	0	0	0	0	0	0	0	0	11	0	0	11	0.02
Tabanus	0	32	64	32	22	32	43	32	22	139	22	440	0.83
Cecidomyiidae	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Atrichopogon	0	0	0	0	0	0	0	0	0	0	0	0	0.00

Table 6b. Continued

Taxon	Date											Total	Percent
	9/71	10/71	11/71	3/72	4/72	5/72	6/72	7/72	8/72	9/72	10/72		
Culicoides	0	0	22	96	11	54	22	183	0	0	43	431	0.82
Palpomyia	0	75	54	545	32	353	299	844	246	770	64	3282	6.22
Chironomus	32	887	150	128	267	321	1485	1357	1122	1278	267	7294	13.82
Glyptotendipes	0	43	171	740	225	652	75	1517	460	246	214	4343	8.23
Microtendipes	0	0	0	11	0	0	0	0	0	0	0	11	0.02
Paratendipes	0	0	0	64	0	0	0	54	0	0	0	118	0.22
Tanytarsus	0	524	160	791	1336	3319	460	3473	1197	171	1357	12788	24.23
Cricotopus	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Hydrobaenus	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Metriocnemus	0	0	0	54	0	0	0	43	0	0	0	97	0.18
Trichocladius	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Pentaneura	0	64	64	257	214	171	64	235	64	1133	107	2373	4.50
Procladius	11	428	342	588	545	428	994	2479	1881	0	673	8369	15.86
Pericoma	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Psychoda	0	0	0	11	0	0	0	0	0	0	0	11	0.02
Helius	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Hexatoma	0	22	0	0	11	11	11	214	0	0	11	280	0.53
Limonia	0	11	0	11	0	0	0	0	11	0	0	33	0.06
Ormosia	0	11	11	22	0	0	0	0	0	0	0	44	0.08
Pseudolimnophila	0	11	0	22	0	0	0	428	0	0	0	461	0.87
Tipula	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Copepoda	0	64	0	64	75	11	1539	470	0	11	43	2277	4.32
Acarian	0	0	0	0	0	11	0	0	11	11	0	33	0.06
Bivalvia													
Pisidium	32	128	321	107	43	96	225	567	1186	1614	364	4683	8.87
Oligochaeta	0	44	86	738	87	64	1177	214	758	129	246	3543	6.71
Nematoda	0	0	0	0	0	22	0	43	0	0	0	65	0.12
Total density	75	2431	1713	4403	3277	5738	6471	12249	7099	5610	3703	52769	100.00
Total richness	3	19	13	27	22	19	16	17	16	13	21		

Table 6c. Taxon list of weir pond 4 on the FEF

Taxon	Date											Total	Percent
	9/71	10/71	11/71	3/72	4/72	5/72	6/72	7/72	8/72	9/72	10/72		
Collembola	0	0	0	0	0	0	0	0	0	0	22	22	0.03
Ephemeroptera													
Baetidae	0	0	0	11	11	11	0	0	0	0	0	33	0.04
Ephemerella	0	0	22	11	0	11	64	11	11	0	11	141	0.18
Hexagenia	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Epeorus	0	0	0	0	0	0	0	0	0	0	11	11	0.01
Habrophlebia	0	0	0	0	0	11	0	0	0	0	0	11	0.01
Habrophlebiodes	0	0	0	43	0	0	0	0	0	0	11	54	0.07
Lachlania	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Ameletus	0	0	0	0	0	0	0	0	0	0	139	139	0.18
Odonata													
Hagenius	0	0	0	0	0	11	0	0	0	11	0	22	0.03
Lanthus	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Plecoptera													
Alloperla	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Leuctra	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Peltoperla	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Acroneuria	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Isogenus	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Hemiptera													
Corixidae	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Trichoptera													
Diplectrona	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Polycentropus	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Lype	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Psychomyia	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Brachycentrus	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Pycnopsyche	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Ptilostomis	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Ochrotrichia	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Rhyacophila	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Lepidoptera	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Coleoptera	0	0	0	0	11	0	11	0	0	0	0	22	0.03
Megaloptera													
Sialis	0	0	11	0	0	0	0	11	0	0	0	22	0.03
Diptera													
Brachydeutera	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Scatophila	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Muscidae	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Hydrellia	0	0	0	11	0	0	0	0	0	0	22	33	0.04
Syrphidae	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Empididae	0	0	11	11	0	0	32	22	0	0	0	76	0.10
Stratiomyidae	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Eulalia	0	0	0	11	0	0	0	0	0	0	0	11	0.01
Tabanus	0	22	0	0	43	32	54	22	0	0	96	269	0.34
Cecidomyiidae	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Atrichopogon	0	0	0	0	0	0	0	0	0	0	0	0	0.00

Table 6c. Continued

Taxon	Date											Total	Percent
	9/71	10/71	11/71	3/72	4/72	5/72	6/72	7/72	8/72	9/72	10/72		
Culicoides	0	0	0	11	0	11	11	0	22	0	0	55	0.07
Palpomyia	0	11	0	75	54	150	235	43	150	96	118	932	1.18
Chironomus	0	0	43	0	54	171	3740	1475	1240	6304	193	13220	16.68
Glyptotendipes	0	0	64	973	470	737	1945	1699	449	107	2169	8613	10.87
Microtendipes	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Paratendipes	0	0	11	0	0	0	11	11	0	0	0	33	0.04
Tanytarsus	0	321	374	331	107	481	748	342	823	118	737	4382	5.53
Cricotopus	0	0	0	22	0	0	0	0	0	0	0	22	0.03
Hydrobaenus	0	0	0	11	0	0	0	0	0	0	0	11	0.01
Metriocnemus	0	0	0	43	0	0	0	0	0	0	32	75	0.09
Trichocladius	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Pentaneura	54	1186	1603	812	716	386	1635	2511	5503	7693	1827	23936	30.20
Procladius	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Pericoma	0	11	0	0	0	0	0	0	0	0	0	11	0.01
Psychoda	0	0	0	0	22	0	22	0	0	0	0	44	0.06
Helius	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Hexatoma	0	0	0	0	0	0	0	75	0	0	32	107	0.14
Limonia	0	0	0	0	0	0	0	0	0	0	11	11	0.01
Ormosia	0	0	0	11	11	0	43	0	0	0	64	129	0.16
Pseudolimnophila	0	0	0	0	11	0	43	0	0	0	0	54	0.07
Tipula	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Copepoda	0	0	11	11	11	86	182	149	0	75	11	536	0.68
Acarian	0	0	0	0	0	11	11	11	22	0	0	55	0.07
Bivalvia													
Pisidium	0	1304	1924	534	1838	4413	2757	1624	1378	2533	2490	20795	26.24
Oligochaeta	11	86	43	87	502	374	514	278	2918	375	65	5253	6.63
Nematoda	0	0	0	0	11	0	22	32	22	32	0	119	0.15
Total density	65	2941	4117	3019	3872	6906	12080	8316	12538	17344	8061	79259	100.00
Total richness	2	7	11	18	15	15	19	16	11	10	19		

Table 6d. Taxon list of weir pond 8 on the FEF

Taxon	Date											Total	Percent
	9/71	10/71	11/71	3/72	4/72	5/72	6/72	7/72	8/72	9/72	10/72		
Collembola	11	32	0	11	22	11	32	0	0	0	0	119	0.31
Ephemeroptera													
Baetidae	0	0	54	438	108	32	22	0	0	54	193	901	2.38
Ephemerella	0	11	0	193	0	0	11	0	0	0	11	226	0.60
Hexagenia	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Epeorus	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Habrophlebia	0	0	0	0	0	11	0	0	0	0	0	11	0.03
Habrophlebiodes	0	0	0	22	11	0	0	0	0	0	0	33	0.09
Lachlania	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Ameletus	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Odonata													
Hagenius	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Lanthus	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Plecoptera													
Alloperla	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Leuctra	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Peltoperla	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Acroneuria	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Isogenus	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Hemiptera													
Corixidae	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Trichoptera													
Diplectrona	0	11	0	0	0	0	0	0	0	0	0	11	0.03
Polycentropus	0	0	0	11	0	0	0	0	0	0	0	11	0.03
Lype	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Psychomyia	11	0	0	0	0	0	0	0	0	0	0	11	0.03
Brachycentrus	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Pycnopsyche	0	0	0	22	32	32	0	0	0	0	0	86	0.23
Ptilostomis	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Ochrotrichia	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Rhyacophila	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Lepidoptera	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Coleoptera	0	0	0	0	0	0	0	0	0	0	11	11	0.03
Megaloptera													
Sialis	0	0	0	0	0	0	11	11	11	0	0	33	0.09
Diptera													
Brachydeutera	0	0	0	11	0	0	11	0	0	0	0	22	0.06
Scatophila	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Muscidae	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Hydrellia	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Syrphidae	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Empididae	0	0	0	0	0	0	22	0	0	0	0	22	0.06
Stratiomyidae	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Eulalia	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Tabanus	32	32	0	128	11	11	75	0	11	0	54	354	0.94
Cecidomyiidae	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Atrichopogon	0	0	0	0	0	0	0	0	0	0	0	0	0.00

Table 6d. Continued

Taxon	Date											Total	Percent
	9/71	10/71	11/71	3/72	4/72	5/72	6/72	7/72	8/72	9/72	10/72		
Culicoides	0	32	11	138	225	88	22	0	0	0	11	538	1.42
Palpomyia	22	88	11	181	54	0	11	0	0	0	32	387	1.02
Chironomus	11	139	43	22	11	0	2468	1400	2881	5862	342	13379	35.34
Glyptotendipes	43	75	0	705	716	257	171	0	75	11	246	2299	6.07
Microtendipes	0	0	0	43	0	0	0	0	0	0	0	43	0.11
Paratendipes	0	75	75	22	0	22	11	0	0	0	0	205	0.54
Tanytarsus	0	0	0	11	32	22	0	0	0	0	107	172	0.45
Cricotopus	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Hydrobaenus	0	0	0	22	0	0	0	0	0	0	0	22	0.06
Metriocnemus	0	22	0	86	11	11	0	0	0	0	0	130	0.34
Trichocladius	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Pentaneura	54	86	43	235	118	139	235	310	75	299	235	1839	4.86
Procladius	54	32	32	0	0	11	107	428	257	0	160	1081	2.86
Pericoma	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Psychoda	11	0	0	0	0	0	11	0	0	0	0	22	0.06
Helius	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Hexatoma	0	0	0	0	11	0	0	0	0	0	0	11	0.03
Limonia	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Ormosia	11	0	0	11	0	0	32	0	0	0	0	54	0.14
Pseudolimnophila	0	0	11	0	0	0	11	0	0	0	0	22	0.06
Tipula	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Copepoda	0	32	267	791	6390	2094	2661	1859	86	0	11	14191	37.49
Acarian	0	11	22	0	11	22	22	0	0	0	0	88	0.23
Bivalvia													
Pisidium	0	107	22	86	75	0	11	0	0	0	0	311	0.82
Oligochaeta	11	11	0	513	43	43	161	86	203	64	54	1189	3.14
Nematoda	0	0	0	0	0	0	0	11	0	11	0	22	0.06
Total density	271	814	591	3683	7881	2814	6118	4105	3699	6401	1467	37854	100.00
Total richness	11	16	11	22	17	15	21	7	8	6	13		

7,205 individuals, with weir pond 1 having the lowest mean density with 2,379 individuals (Fig. 10a,b). Dipteran populations accounted for the largest group of all four ponds with percentages of 71% (WS 1), 75% (WS 3), 65% (WS 4) and 55% (WS 6). Mean density (#/m^2) for the four weir ponds exhibited an increase from September 1971 to October 1972 (Fig. 9a,b). Weir ponds were cleaned of all sediments in August 1971, which accounts for this increase.

The combined taxonomic composition list for the two studies was made at the family level in order to compare the two studies at a level that was similar taxonomically (Table 7a-d).

Zooplankton (ostracods & cladocerans) populations were very high in the 1994-1995 study. They accounted for 58 percent and 66 percent of the total density for weir ponds 1 and 6. These large populations were not present in the 1971-1972 study, however, it is possible that they were present but not recorded. Densities for the two studies are similar when they are compared without the zooplankton data (ostracods & cladocerans) (Fig. 11). Using this corrected density (without zooplankton), mean density of weir pond 1 and 6 were significantly different (Fig. 12). As stated before, these two weir ponds contained the largest zooplankton populations.

In order to compare the two studies, only the common months were used (October, November, March, April, May, June, July, August, September, October) (Fig. 13a,b). When zooplankton was included, mean density in 1994-1995 was greater than mean density in 1971-1972 in weir

Table 7a. Combined taxon list at the family level for the two studies on weir pond 1.

Date	Sept	Oct		Nov		Dec	Jan	Feb	Mar		Apr		May		Jun		Jul		Aug		Sept		Oct		Total	Percent	Total	Percent
Study	1971	1994	1971	1994	1971	1994	1995	1995	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1994	1994	1971	1971
Collembola	0	28	0	0	0	0	0	0	0	11	0	43	0	11	0	32	0	0	0	0	0	0	0	11	28	0.03	108	0.41
Baetidae	0	0	0	0	96	0	0	0	0	96	0	54	0	86	0	0	0	11	0	11	0	0	0	171	0	0.00	525	2.01
Ephemerellidae	0	0	11	0	0	0	0	0	0	0	0	22	0	0	0	0	0	11	38	0	0	0	0	0	38	0.04	44	0.17
Ephemeridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Heptageniidae	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	11	0.04
Leptophlebiidae	0	0	0	0	0	0	0	0	0	11	0	289	0	331	0	11	0	0	0	0	0	0	0	11	0	0.00	653	2.50
Oligoneuriidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Siphlonuridae	0	0	0	0	0	0	0	0	0	0	9	11	0	0	0	0	0	0	0	0	0	0	0	22	9	0.01	33	0.13
Aeshnidae	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0.01	0	0.00
Gomphidae	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0.00	22	0.08
Capniidae	0	0	0	0	0	0	0	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38	0.04	0	0.00
Chloroperlidae	0	0	22	0	0	19	0	9	0	150	0	193	0	11	0	0	0	11	0	0	0	0	0	0	28	0.03	387	1.48
Leuctridae	0	0	0	0	0	9	19	66	9	0	0	128	28	11	0	0	0	0	76	0	9	0	38	64	255	0.30	203	0.78
Nemouridae	0	0	0	0	0	0	0	0	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38	0.04	0	0.00
Peltoperlidae	0	0	0	0	0	0	0	0	0	0	0	246	0	22	0	22	0	0	0	0	0	0	0	11	0	0.00	301	1.15
Perlidae	0	0	0	0	0	0	0	0	0	0	0	86	0	11	0	0	0	0	0	0	0	0	0	0	0	0.00	97	0.37
Perlodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0.00	11	0.04
Corixidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	19	0.02	0	0.00
Hydropsychidae	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0.00	11	0.04
Polycentropodidae	0	0	0	0	0	0	0	0	0	22	0	43	0	0	0	0	0	0	0	0	0	0	0	11	0	0.00	78	0.29
Psychomyiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0.00	11	0.04
Brachycentridae	0	0	0	0	0	0	0	0	0	11	0	32	0	32	0	0	0	0	0	0	0	0	0	0	0	0.00	75	0.29
Lepidostomatidae	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	19	0.02	0	0.00
Limnephilidae	0	0	22	0	0	19	47	85	19	54	19	310	0	246	0	0	0	0	0	0	0	0	0	107	189	0.22	739	2.82
Phryganeidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0.00	11	0.04
Hydroptilidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Rhyacophilidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0.00	22	0.08
Lepidoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0.00	11	0.04
Coleoptera	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	11	0	11	9	11	0	0	0	0	19	0.02	33	0.13
Sialidae	0	0	0	0	0	0	9	0	0	0	0	11	0	0	0	0	0	32	0	0	0	0	0	0	9	0.01	43	0.16
Ephydridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0.00	22	0.08
Muscidae	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	11	0.04
Cecidomyiidae	11	0	11	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	33	0.13
Hydrelliinae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Syrphidae	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	11	0.04
Empididae	0	0	0	0	11	0	0	0	0	0	0	11	0	32	0	54	0	11	0	11	0	0	0	0	0	0.00	130	0.50
Stratiomyidae	0	0	22	0	11	0	0	0	0	22	0	22	0	11	0	0	0	0	0	22	0	0	0	0	0	0.00	110	0.42
Tabanidae	64	0	32	0	0	0	0	0	0	32	0	43	0	160	0	54	0	22	0	11	0	0	0	43	0	0.00	467	1.78
Ceratopogonidae	22	0	364	0	11	0	19	76	38	257	0	204	0	332	0	75	0	54	38	139	0	235	0	86	170	0.20	1779	6.80
Chaoboridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00

Table 7a. Continued

Date	Sept	Oct		Nov		Dec	Jan	Feb	Mar		Apr		May		Jun		Jul		Aug		Sept		Oct		Total	Percent	Total	Percent
Study	1971	1994	1971	1994	1971	1994	1995	1995	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1994	1994	1971	1971
Dixidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Psychodidae	0	0	44	0	22	0	0	0	0	11	0	22	0	97	0	22	0	0	0	22	0	0	0	0	0	0.00	240	0.92
Tipulidae	118	0	107	0	0	9	38	28	9	77	0	65	0	33	0	33	0	11	0	0	0	0	0	108	85	0.10	552	2.11
Chironomidae	171	501	396	964	22	378	435	85	350	1187	180	1539	359	1284	189	664	2817	1315	5737	2202	4234	876	7429	728	23658	27.65	10384	39.88
Orthocladiinae	11	0	22	0	0	0	491	1465	766	204	95	64	246	107	0	22	0	11	38	0	38	0	0	54	3138	3.67	495	1.89
Prodiamesinae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Tanypodinae	32	180	374	38	588	161	66	47	255	257	9	855	28	321	38	641	47	502	28	481	9	331	57	791	964	1.13	5173	19.77
Cladocera	0	0	0	0	0	0	0	0	0	0	38	0	1096	0	227	0	0	0	756	0	38	0	76	0	2231	2.61	0	0.00
Copepoda	0	378	22	860	32	95	397	76	113	86	378	43	76	43	151	54	113	22	227	1464	0	214	0	43	2864	3.35	2023	7.73
Ostracoda	0	558	0	643	0	586	359	95	491	0	4991	0	2977	0	7713	0	12401	0	2571	0	10813	0	5775	0	49972	58.39	0	0.00
Acarian	0	9	0	9	0	0	0	38	0	0	0	11	38	11	0	11	0	0	0	0	151	0	38	0	284	0.33	33	0.13
Sphaeriidae	0	9	32	0	11	0	0	0	0	0	0	0	0	64	19	22	0	139	0	0	0	0	0	75	28	0.03	343	1.31
Oligochaeta	54	85	54	690	11	312	0	0	0	214	0	66	0	75	86	107	0	64	0	128	0	86	331	32	1484	1.73	891	3.40
Nematoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	11	0	0	0	11	0	0	0	0.00	44	0.17
Density	483	1749	1546	3204	837	1588	1881	2117	2089	2713	5718	4424	4877	3359	8403	1868	15397	2238	9518	4502	15293	1764	13743	2434	85577	100	28188	100

Table 7b. Combined taxon list at the family level for the two studies on weir pond 3.

Date	Sept	Oct		Nov		Dec	Jan	Feb	Mar		Apr		May		Jun		Jul		Aug		Sept		Oct		Total	Percent	Total	Percent
Study	1971	1994	1971	1994	1971	1994	1995	1995	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1994	1994	1971	1971
Collembola	0	0	0	0	0	0	38	38	0	11	0	22	0	0	0	0	38	0	0	0	0	0	0	0	113	0.11	33	0.06
Baetidae	0	0	43	0	246	0	0	0	0	11	0	203	0	22	0	0	0	0	0	11	0	0	0	139	0	0.00	875	1.28
Ephemerellidae	0	0	11	0	0	0	0	0	9	11	0	0	38	0	0	22	0	0	0	22	0	22	0	11	47	0.05	99	0.19
Ephemeridae	0	9	0	0	0	0	19	0	9	0	0	0	28	0	0	0	0	0	0	0	0	22	0	0	66	0.06	22	0.04
Heptageniidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Leptophlebiidae	0	0	0	0	0	0	0	0	0	0	0	11	0	32	0	0	0	0	0	0	0	0	0	11	0	0.00	54	0.10
Oligoneuriidae	0	0	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	22	0.04
Siphlonuridae	0	0	0	0	0	0	66	0	38	0	0	11	9	0	0	0	0	0	0	0	0	0	0	22	113	0.11	33	0.06
Aeshnidae	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0.01	0	0.00
Gomphidae	0	0	0	0	0	0	9	0	9	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	19	0.02	11	0.02
Capniidae	0	0	0	0	0	0	9	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0.02	0	0.00
Chloroperlidae	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	11	0.02
Leuctridae	0	0	11	0	0	0	9	595	57	22	217	32	38	96	454	0	9	0	0	0	0	0	0	54	1380	1.33	215	0.41
Nemouridae	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	19	0.02	0	0.00
Peltoperlidae	0	0	0	0	0	0	0	170	0	11	0	54	0	11	0	0	0	0	0	0	0	0	0	11	170	0.16	87	0.16
Perlidae	0	0	0	0	0	0	0	0	0	22	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	44	0.08
Perlodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Corixidae	0	0	0	0	0	0	0	0	0	0	19	0	0	0	9	0	0	0	0	22	0	0	28	0	57	0.05	22	0.04
Hydropsychidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Polycentropodidae	0	0	0	0	0	9	9	9	9	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	57	0.05	0	0.00
Psychomyiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Brachycentridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Lepidostomatidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Limnephilidae	0	0	0	0	0	0	28	38	9	22	38	32	9	32	9	0	0	0	0	0	0	0	0	11	132	0.13	97	0.18
Phryganeidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Hydroptilidae	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	11	0.02
Rhyacophilidae	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	11	0.02
Lepidoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Coleoptera	0	0	11	0	0	19	0	0	0	11	0	0	38	0	0	22	0	0	0	0	0	0	0	0	57	0.05	44	0.08
Sialidae	0	0	11	0	0	0	0	0	0	0	0	0	9	0	0	22	0	86	9	75	0	64	0	22	19	0.02	280	0.53
Ephydridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Muscidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Cecidomyiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Hydrelliinae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Syrphidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Empididae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0.00	11	0.02
Stratiomyidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0.00	11	0.02
Tabanidae	0	0	32	0	64	0	0	0	0	32	0	22	0	32	0	43	0	32	0	22	0	139	0	22	0	0.00	440	0.83
Ceratopogonidae	0	57	75	0	76	0	208	151	0	631	19	43	38	407	0	321	0	1037	0	246	0	770	19	107	491	0.47	3713	7.04
Chaoboridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00

Table 7b. Continued

Date	Sept	Oct		Nov		Dec	Jan	Feb	Mar		Apr		May		Jun		Jul		Aug		Sept		Oct		Total	Percent	Total	Percent
Study	1971	1994	1971	1994	1971	1994	1995	1995	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1994	1994	1971	1971
Dixidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Psychodidae	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	11	0.02
Tipulidae	0	0	55	0	11	0	0	57	0	55	0	11	0	11	0	11	0	642	0	11	0	0	0	11	57	0.05	818	1.55
Chironomidae	32	8138	1454	6853	481	3355	6692	2798	6210	1734	4423	1828	2552	4292	803	2020	1418	6401	3951	2779	5085	1695	8053	1838	60331	58.15	24554	46.53
Orthocladiinae	0	151	0	0	0	236	2807	1512	1323	54	605	0	624	0	302	0	0	43	0	0	8	0	0	0	7571	7.30	97	0.18
Prodiamesinae	0	0	0	0	0	0	0	19	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0.03	0	0.00
Tanypodinae	11	1399	492	539	406	123	747	189	473	845	302	759	586	599	95	1058	28	2714	198	1945	463	1133	132	780	5274	5.08	10742	20.36
Cladocera	0	0	0	0	0	0	0	0	0	0	0	0	113	0	1361	0	3629	0	794	0	1531	0	482	0	7911	7.63	0	0.00
Copepoda	0	3327	64	1096	0	208	794	756	491	64	605	75	1021	11	1210	1539	2117	470	567	0	605	11	756	43	13554	13.06	2277	4.32
Ostracoda	0	302	0	0	0	265	38	0	0	0	302	0	0	0	605	0	302	0	0	0	605	0	151	0	2571	2.48	0	0.00
Acarian	0	0	0	151	0	0	38	0	38	0	0	0	0	11	0	0	0	0	0	11	0	11	302	0	529	0.51	33	0.06
Sphaeriidae	32	0	128	0	321	0	0	0	0	107	0	43	0	96	0	225	0	567	0	1186	0	1614	0	384	0	0.00	4683	8.87
Oligochaeta	0	227	44	841	86	28	1096	0	0	738	132	87	265	64	85	1177	0	214	170	758	76	129	227	246	3147	3.03	3543	6.71
Nematoda	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0	0	43	0	0	0	0	0	0	0	0.00	65	0.12
Density	75	13611	2431	9480	1713	4244	12609	6333	8705	4403	6682	3722	5388	5738	4934	6471	7543	12249	5690	7099	8374	5610	10151	3703	103743	100.00	52769	100.00

Table 7c. Combined taxon list at the family level for the two studies on weir pond 4.

Date	Sept	Oct		Nov		Dec	Jan	Feb	Mar		Apr		May		Jun		Jul		Aug		Sept		Oct		Total	Percent	Total	Percent
Study	1971	1994	1971	1994	1971	1994	1995	1995	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1994	1994	1971	1971
Collembola	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	9	0.01	22	0.03
Baetidae	0	0	0	0	0	0	0	0	0	11	0	11	0	11	0	0	0	0	0	0	0	0	0	0	0	0.00	33	0.04
Ephemerellidae	0	0	0	0	22	0	47	0	0	11	0	0	9	11	0	64	0	11	0	11	0	0	0	11	57	0.08	141	0.18
Ephemeridae	0	28	0	0	0	0	0	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	57	0.08	0	0.00
Heptageniidae	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	9	0.01	11	0.01
Leptophlebiidae	0	0	0	0	0	0	0	0	0	43	0	0	0	11	0	0	0	0	0	0	0	0	0	11	0	0.00	65	0.08
Oligoneuriidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Siphlonuridae	0	0	0	0	0	0	0	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	139	19	0.03	139	0.18
Aeshnidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Gomphidae	0	0	0	0	0	0	0	0	0	0	9	0	0	11	0	0	0	0	0	0	0	11	0	0	9	0.01	22	0.03
Capniidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Chloroperlidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Leuctridae	0	0	0	0	0	0	76	38	236	0	85	0	0	0	0	0	9	0	0	0	0	0	0	0	444	0.60	0	0.00
Nemouridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Peltoperlidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Perlidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Perlodidae	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0.01	0	0.00
Corixidae	0	0	0	9	0	0	9	0	0	0	0	0	9	0	0	0	0	0	0	0	19	0	19	0	66	0.09	0	0.00
Hydropsychidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Polycentropodidae	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0.01	0	0.00
Psychomyiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Brachycentridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Lepidostomatidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Limnephilidae	0	0	0	0	0	28	19	19	0	0	95	0	0	0	0	0	0	0	0	0	0	0	0	0	161	0.22	0	0.00
Phryganeidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Hydroptilidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Rhyacophilidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Lepidoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Coleoptera	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	11	0	0	0	0	0	0	0	0	0	0.00	22	0.03
Sialidae	0	0	0	0	11	9	9	19	0	0	9	0	0	0	0	0	0	11	0	0	19	0	0	0	66	0.09	22	0.03
Ephydridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Muscidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Cecidomyiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0.00	33	0.04
Hydrellinae	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Syrphidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Empididae	0	0	0	0	11	0	0	0	0	11	0	0	0	0	0	32	0	22	0	0	0	0	0	0	0	0.00	76	0.10
Stratiomyidae	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	11	0.01
Tabanidae	0	0	22	0	0	0	0	0	0	0	0	43	0	32	0	54	0	22	0	0	0	0	0	96	0	0.00	289	0.34
Ceratopogonidae	0	151	11	28	0	113	47	57	47	86	0	54	47	161	161	246	0	43	0	172	9	96	0	118	662	0.89	987	1.25
Chaoboridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00

Table 7c. Continued

Date	Sept	Oct		Nov		Dec	Jan	Feb	Mar		Apr		May		Jun		Jul		Aug		Sept		Oct		Total	Percent	Total	Percent
Study	1971	1994	1971	1994	1971	1994	1995	1995	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1994	1994	1971	1971
Dixidae	0	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38	0.05	0	0.00
Psychodidae	0	0	11	0	0	0	0	0	0	0	0	22	0	0	0	22	0	0	0	0	0	0	0	0	0	0.00	55	0.07
Tipulidae	0	0	0	0	0	0	0	9	0	11	0	22	9	0	0	86	0	75	0	0	0	0	0	107	19	0.03	301	0.38
Chironomidae	0	2703	321	3365	492	2013	3233	1427	2060	1304	1210	631	3715	1389	1238	6444	709	3527	974	2512	1834	6529	2486	3099	26988	36.21	26248	33.12
Orthocladiinae	0	38	0	0	0	142	1323	1049	964	76	217	0	57	0	113	0	0	0	0	0	0	0	0	32	3904	5.24	108	0.14
Prodiamesinae	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0.03	0	0.00
Tanypodinae	54	1002	1186	1172	1603	1578	3601	2703	425	812	331	716	1777	396	1238	1635	19	2511	9	5503	2892	7693	4045	1827	20794	27.92	23936	30.20
Cladocera	0	0	0	0	0	0	0	0	0	0	0	0	151	0	0	0	0	0	151	0	1210	0	0	0	1512	2.03	0	0.00
Copepoda	0	189	0	1446	11	822	567	794	1739	11	832	11	1966	86	3629	182	3932	149	0	0	1664	75	1021	11	18801	24.98	538	0.68
Ostracoda	0	113	0	0	0	132	38	0	38	0	76	0	151	0	38	0	151	0	0	0	0	0	0	0	737	0.99	0	0.00
Acarian	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	11	0	11	0	22	0	0	0	0	0	0.00	55	0.07
Sphaeriidae	0	19	1304	0	1924	0	0	9	0	534	19	1838	0	4413	9	2757	0	1624	0	1378	9	2533	0	2490	66	0.09	20785	26.24
Oligochaeta	11	95	86	9	43	0	132	0	0	87	0	502	0	374	0	514	0	278	0	2918	0	375	0	65	236	0.32	5253	6.83
Nematoda	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	22	0	32	0	22	0	32	0	0	0	0.00	119	0.15
Density	65	4386	2941	6040	4117	4839	9130	6163	5520	3019	2892	3872	7892	6906	6427	12080	4820	8316	1134	12538	7656	17344	7571	8061	74471	100	79259	100

Table 7d. Combined taxon list at the family level for the two studies on weir pond 6.

Date	Sept	Oct		Nov		Dec	Jan	Feb	Mar		Apr		May		Jun		Jul		Aug		Sept		Oct		Total	Percent	Total	Percent
Study	1971	1994	1971	1994	1971	1994	1995	1995	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1994	1994	1971	1971
Collembola	11	0	32	0	0	0	0	0	0	11	0	22	38	11	0	32	0	0	0	0	0	0	0	0	38	0.05	119	0.31
Baetidae	0	0	0	0	54	0	0	0	0	438	0	108	0	32	0	22	0	0	0	0	0	54	0	193	0	0.00	901	2.38
Ephemerellidae	0	0	11	0	0	0	0	0	0	193	0	0	0	0	0	11	0	0	0	0	0	0	0	11	0	0.00	228	0.60
Ephemeridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Heptageniidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Leptophlebiidae	0	0	0	0	0	0	0	0	0	22	0	11	0	11	0	0	0	0	0	0	0	0	0	0	0	0.00	44	0.12
Oligoneuriidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Siphlonuridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Aeshnidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Gomphidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Capniidae	0	0	0	0	0	0	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0.03	0	0.00
Chloroperlidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Leuctridae	0	0	0	0	0	0	0	57	0	0	57	0	0	0	0	0	38	0	38	0	0	0	0	0	189	0.28	0	0.00
Nemouridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Peltoperlidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Perlidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Perlodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Corixidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Hydropsychidae	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	11	0.03
Polycentropodidae	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	11	0.03
Psychomyiidae	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	11	0.03
Brachycentridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Lepidostomatidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Limnephilidae	0	0	0	0	0	0	0	0	0	22	9	32	0	32	0	0	0	0	0	0	0	0	0	0	9	0.01	86	0.23
Phryganeidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Hydroptilidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Rhyacophilidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Lepidoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Coleoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0.00	11	0.03
Sialidae	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	11	0	11	0	11	0	0	0	0	9	0.01	33	0.09
Ephydridae	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0.00	22	0.06
Muscidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Cecidomyiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Hydrellinae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Syrphidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Empididae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0	0	0	0.00	22	0.06
Stratiomyidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Tabanidae	32	0	32	0	0	0	0	0	0	128	0	11	0	11	0	75	0	0	0	11	0	0	0	54	0	0.00	354	0.94
Ceratopogonidae	22	0	128	0	22	0	0	0	0	300	0	279	0	96	0	33	0	0	0	0	0	0	0	43	0	0.00	923	2.44
Chaoboridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	19	0	28	0.04	0	0.00

Table 7d. Continued

Date	Sept	Oct		Nov		Dec	Jan	Feb	Mar		Apr		May		Jun		Jul		Aug		Sept		Oct		Total	Percent	Total	Percent
Study	1971	1994	1971	1994	1971	1994	1995	1995	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1995	1972	1994	1994	1971	1971
Dixidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
Psychodidae	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0.00	22	0.06
Tipulidae	11	0	0	0	11	0	0	0	9	11	0	11	0	0	0	43	0	0	0	0	0	0	0	0	9	0.01	87	0.23
Chironomidae	54	66	289	19	118	9	19	57	9	603	38	759	38	301	9	2650	9	1400	945	3056	208	5973	9	695	1437	1.97	16098	42.53
Orthocladiinae	0	9	22	0	0	0	0	38	85	108	539	11	132	11	66	0	0	0	151	0	28	0	0	0	1049	1.44	152	0.40
Prodiamesinae	0	0	0	0	0	0	0	0	9	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	19	0.03	0	0.00
Tanypodinae	108	435	128	690	75	1011	766	274	274	235	425	118	293	150	293	342	28	738	699	332	520	299	2552	395	8261	11.35	2920	7.71
Cladocera	0	775	0	709	0	0	0	0	0	0	0	0	0	0	416	0	2543	0	76	0	406	0	312	0	5238	7.19	0	0.00
Copepoda	0	142	32	236	267	340	302	0	0	791	9	6390	189	2094	681	2661	473	1859	1361	88	1021	0	1890	11	6645	9.13	14191	37.49
Ostracoda	0	113	0	350	0	4877	4386	1474	454	0	482	0	907	0	3100	0	1815	0	15917	0	2193	0	11607	0	47675	65.51	0	0.00
Acarian	0	0	11	19	22	38	0	0	47	0	0	11	0	22	38	22	0	0	0	0	38	0	151	0	331	0.45	88	0.23
Sphaeriidae	0	0	107	0	22	0	9	0	0	96	0	75	0	0	0	11	0	0	0	0	9	0	0	0	19	0.03	311	0.82
Oligochaeta	11	350	11	681	0	350	227	0	0	513	47	43	47	43	0	161	104	86	0	203	0	64	0	54	1805	2.48	1189	3.14
Nematoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	11	0	0	0	0.00	22	0.06
Density	271	1890	814	2713	591	6626	5718	1909	888	3693	1607	7881	1645	2814	4612	6118	5009	4105	19187	3699	4433	6401	16541	1467	72779	100	37854	100

Figure 11. Density (#/m^2) for the 1994-1995 and 1971-1972 study with zooplankton (ostracods & cladocerans) included and excluded for each weir pond.

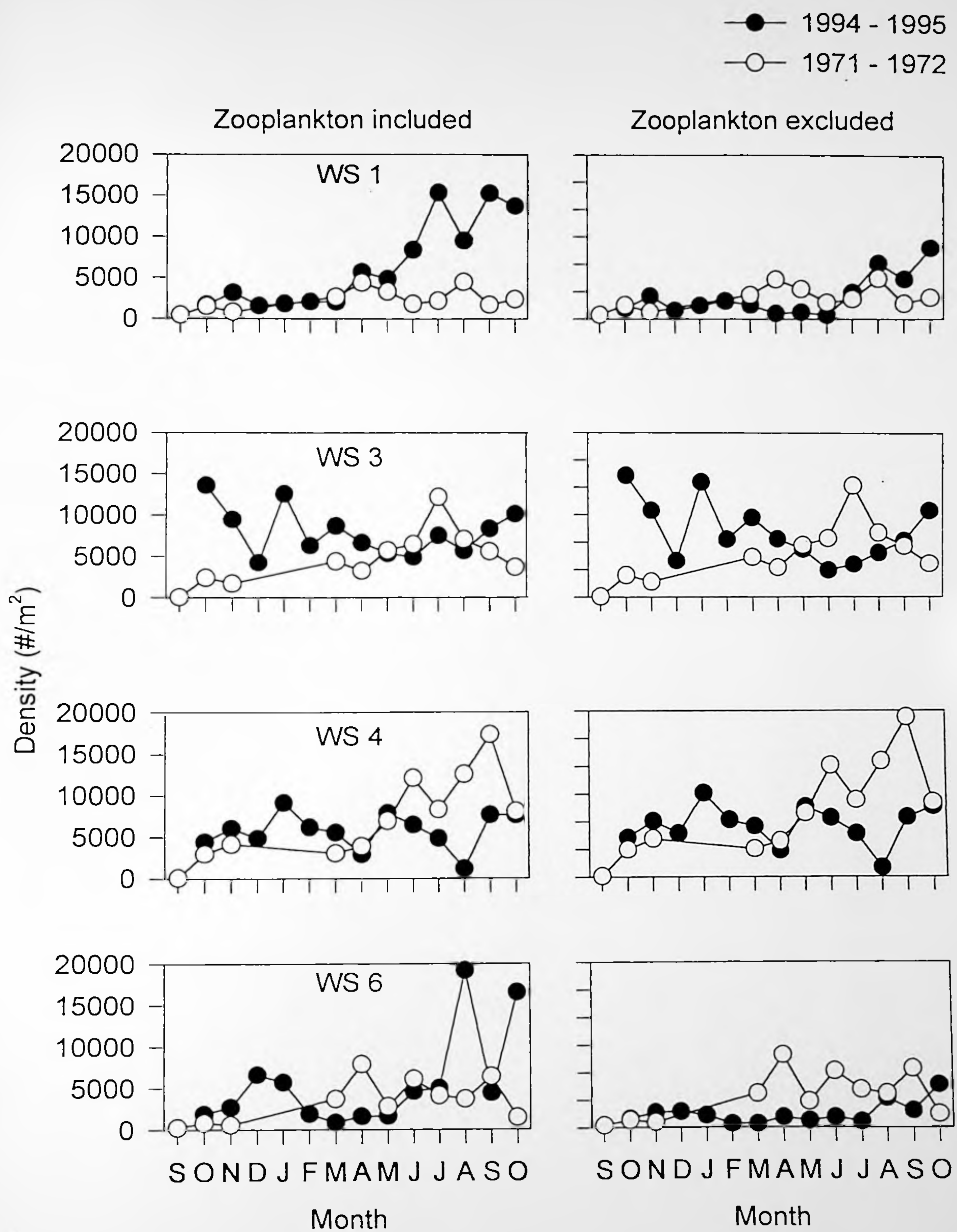

1994 - 1995
1971 - 1972
Zooplankton included
Zooplankton excluded
WS 1
WS 3
WS 4
WS 6
20000
15000
10000
5000
0
Density (#/m2)
S O N D J F M A M J J A S O
Month

Figure 12. Mean (± 1 SE) density for the 1994-1995 study, with and without zooplankton (ostracods & cladocerans) densities for each weir pond. (one-way ANOVA, * = $p<0.01$)

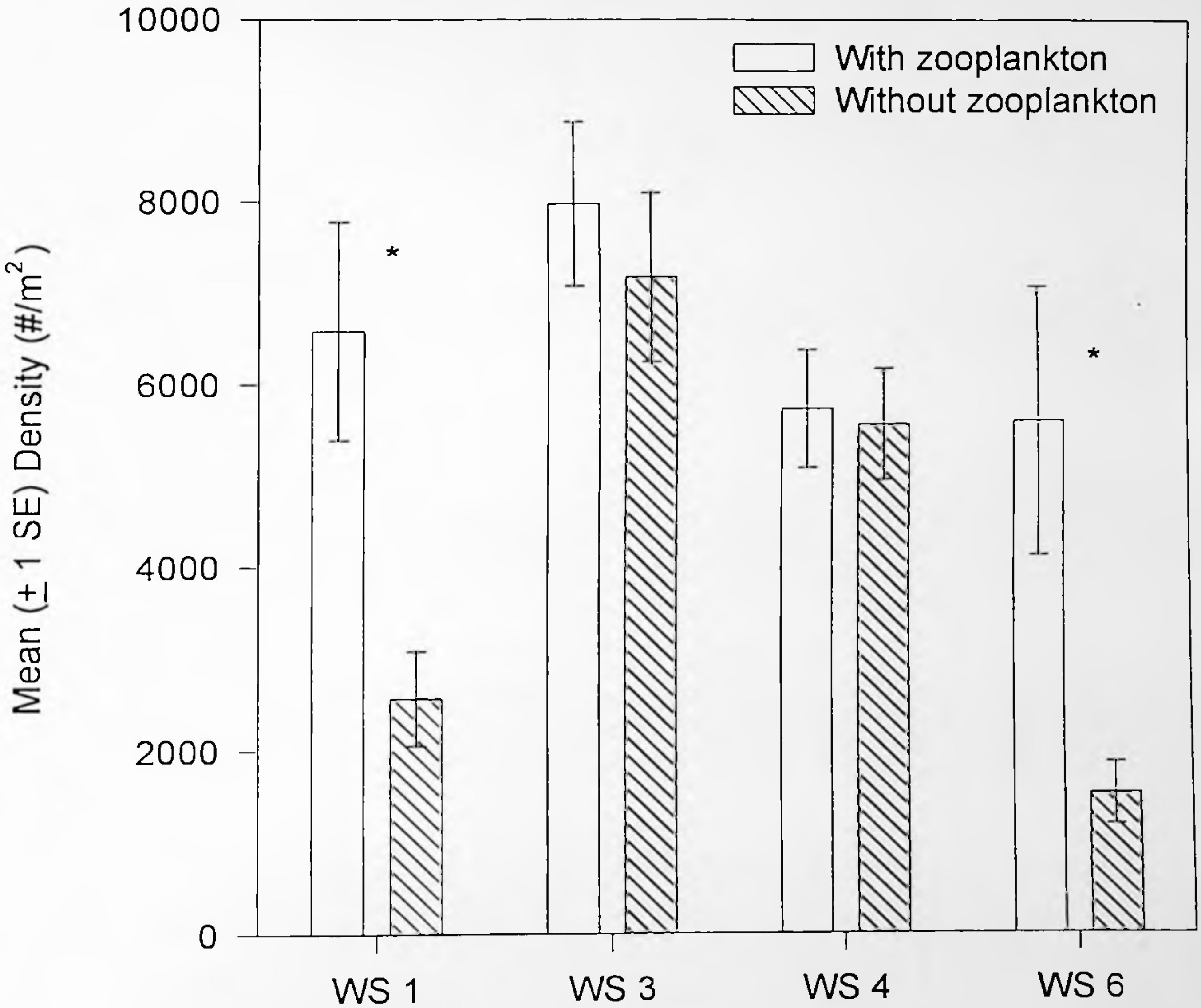
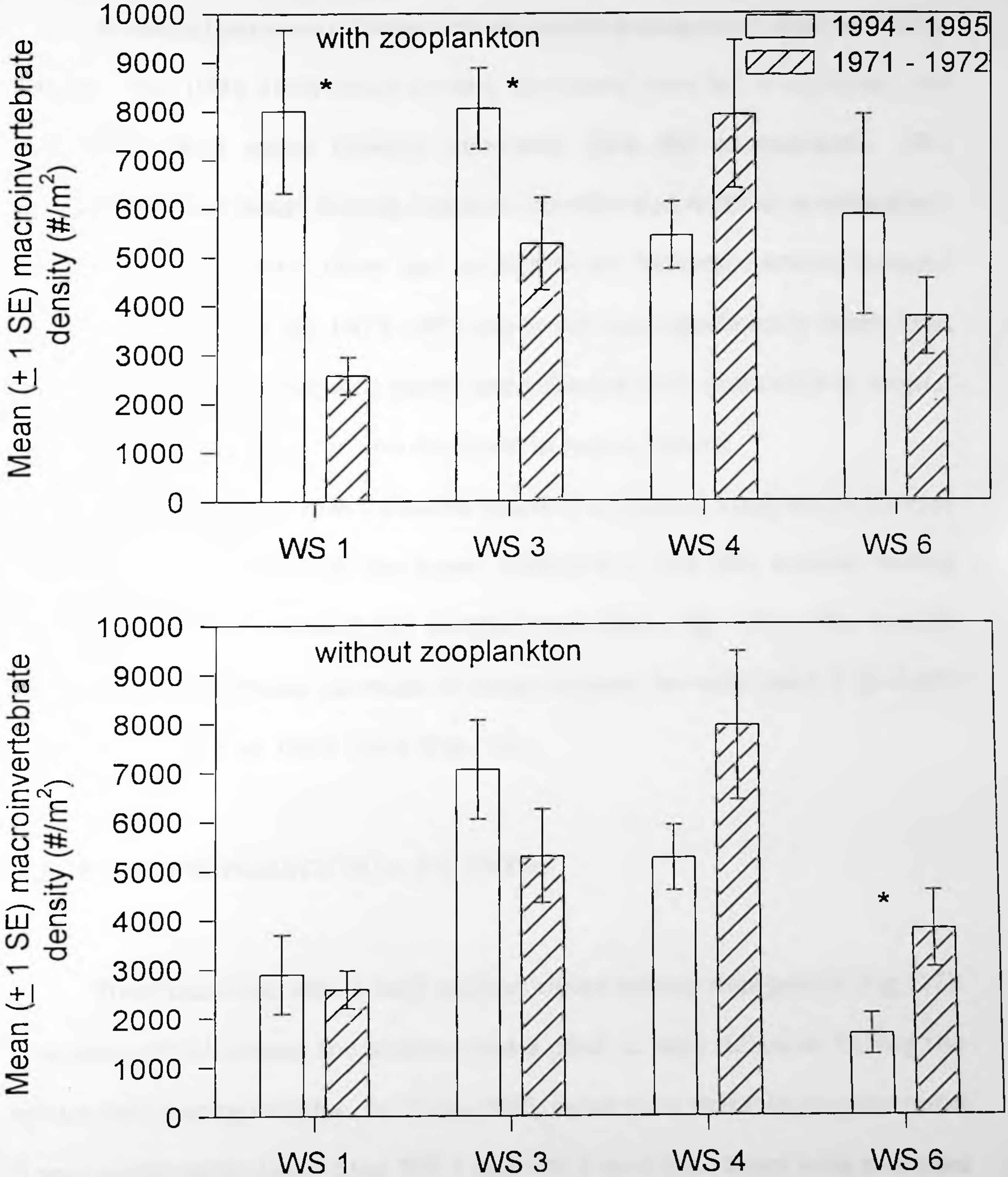

With zooplankton
Without zooplankton
Mean (± 1 SE) Density (#/m2)
10000
8000
6000
4000
2000
0
*
*
WS 1
WS 3
WS 4
WS 6

Figure 13. Mean (± 1 SE) macroinvertebrate density for the 1994-1995 and 1971-1972 study among common months (Oct, Nov, Mar, Apr, May, Jun, Jul, Aug, Sept, Oct) (one-way ANOVA, *=p<0.05)

a. Mean (± 1 SE) density for the two studies with ostracods and cladocerans for each weir pond..

b. Mean (± 1 SE) density for the two studies without ostracods and cladocerans for each weir pond.


with zooplankton
1994 - 1995
1971 - 1972
Mean (± 1 SE) macroinvertebrate density (#/m2)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
*
*
WS 1
WS 3
WS 4
WS 6
without zooplankton
Mean (± 1 SE) macroinvertebrate density (#/m2)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
*
WS 1
WS 3
WS 4
WS 6

ponds 1 and 3. When zooplankton was excluded, mean density in 1994-1995 was less than mean density in 1971-1972 in weir pond 6.

Seasonal patterns of mean density varied among study and pond (Fig. 14a,b). The 1994-1995 mean density decreased from fall to summer, and the 1971-1972 mean density increased from fall to summer. The comparison was made during common months and without zooplankton. In the 1994-1995 study there was no significant difference among seasons ($p=0.7$), however in the 1971-1972 study fall was significantly lower than the others ($p<0.05$). The weir ponds were cleaned of all sediments in August 1971, which accounts for this decrease in mean density.

A BACI (Before-After/Control-Impact) statistical analysis (Schroeter 1993) was performed on the mean densities of the two studies during common months without the zooplankton data (Fig. 15). The results indicated a significant increase in mean density for weir pond 3 ($p<0.05$) from 1971-1972 to 1994-1995 (Fig. 16).

MACROINVERTEBRATE TAXA RICHNESS

Total taxa richness in both studies varied among weir ponds (Fig. 17). A similar trend among the studies was a peak in taxa richness during the winter and spring months. In 1994-1995, mean taxa richness for weir pond 6 was significantly lower than WS 1 and WS 3 ($p<0.05$). Mean taxa richness was higher during the 1971-1972 study with weir pond 1 having a

Figure 14. Mean (± 1 SE) seasonal density for combined weir ponds for common months, without zooplankton (ostracods & cladocerans) (HSD was used for pairwise comparisons).

a. Mean (± 1 SE) seasonal density for 1994-1995 for each weir pond and season.

b. Mean (± 1 SE) seasonal density for 1971-1972 for each weir pond and season.

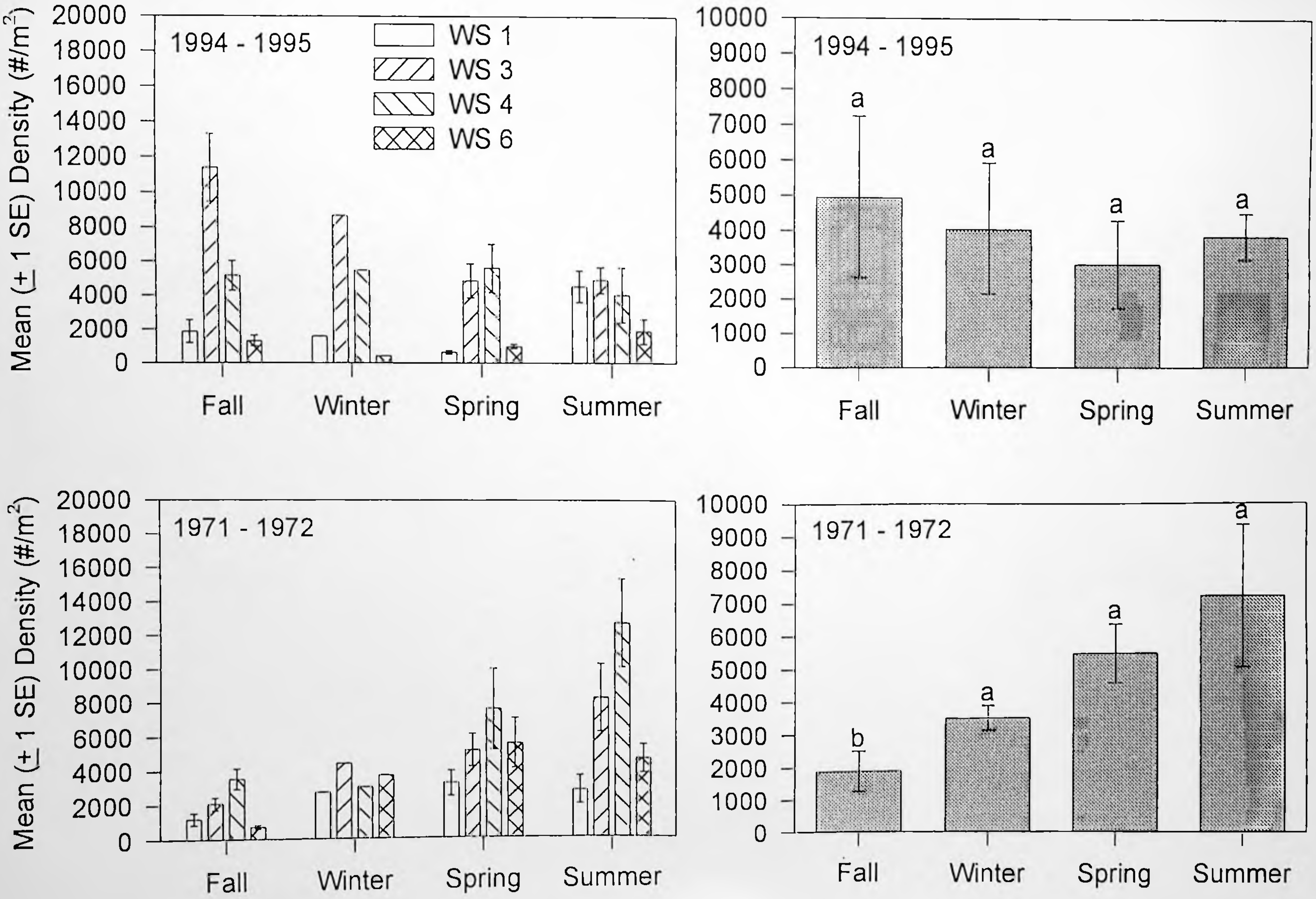

Mean (± 1 SE) Density (#/m^2)
1994 - 1995
WS 1
WS 3
WS 4
WS 6
Fall
Winter
Spring
Summer
1971 - 1972
a
b

Figure 15. A BACI analysis of the two studies using mean density for common months (zooplankton excluded).

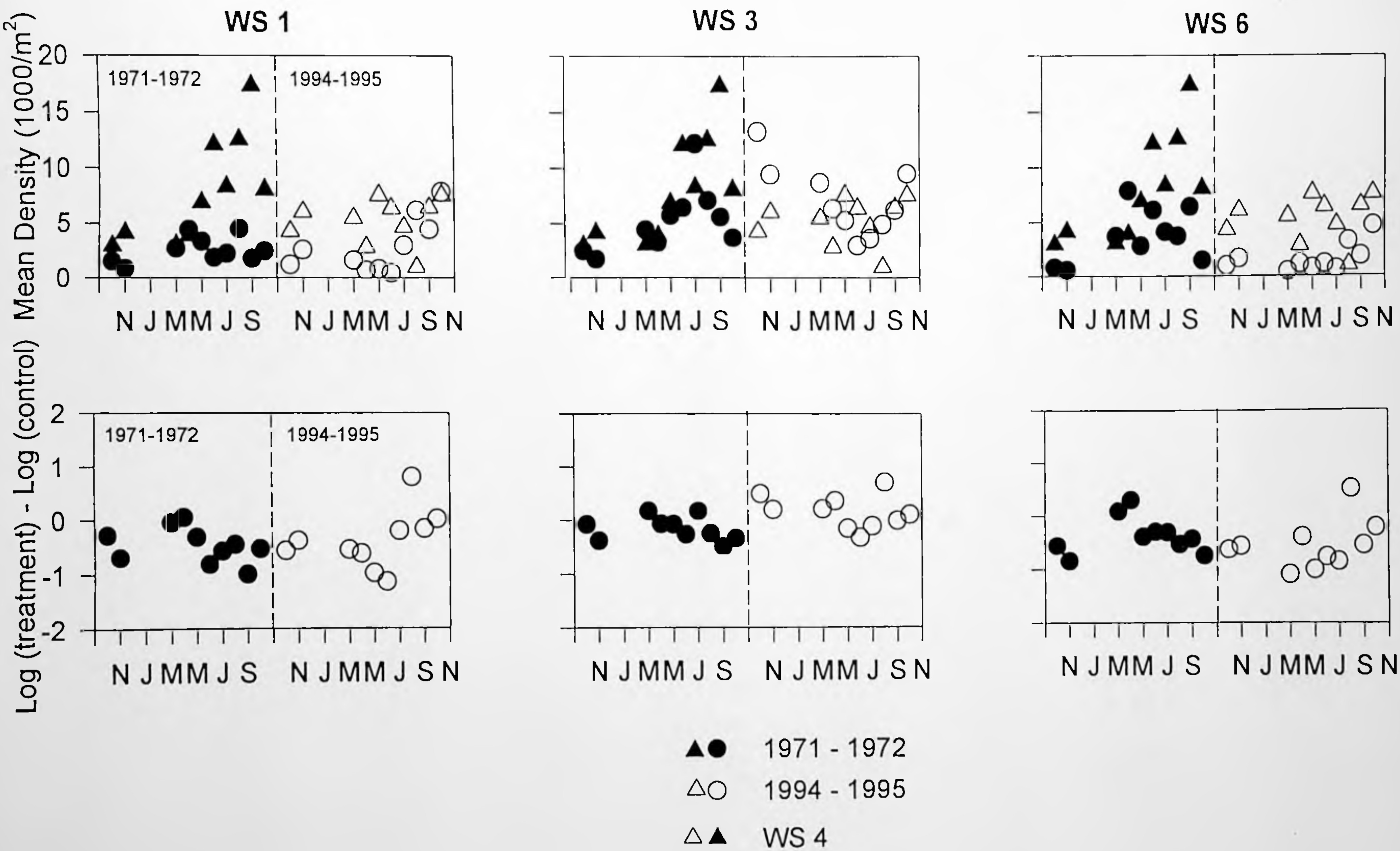

WS 1
WS 3
WS 6
Mean Density (1000/m²)
Log (treatment) - Log (control)
1971-1972
1994-1995
N J M M J S N J M M J S N
1971 - 1972
1994 - 1995
WS 4

Figure 16. A BACI analysis interaction plot for mean density for the two studies among weir ponds.

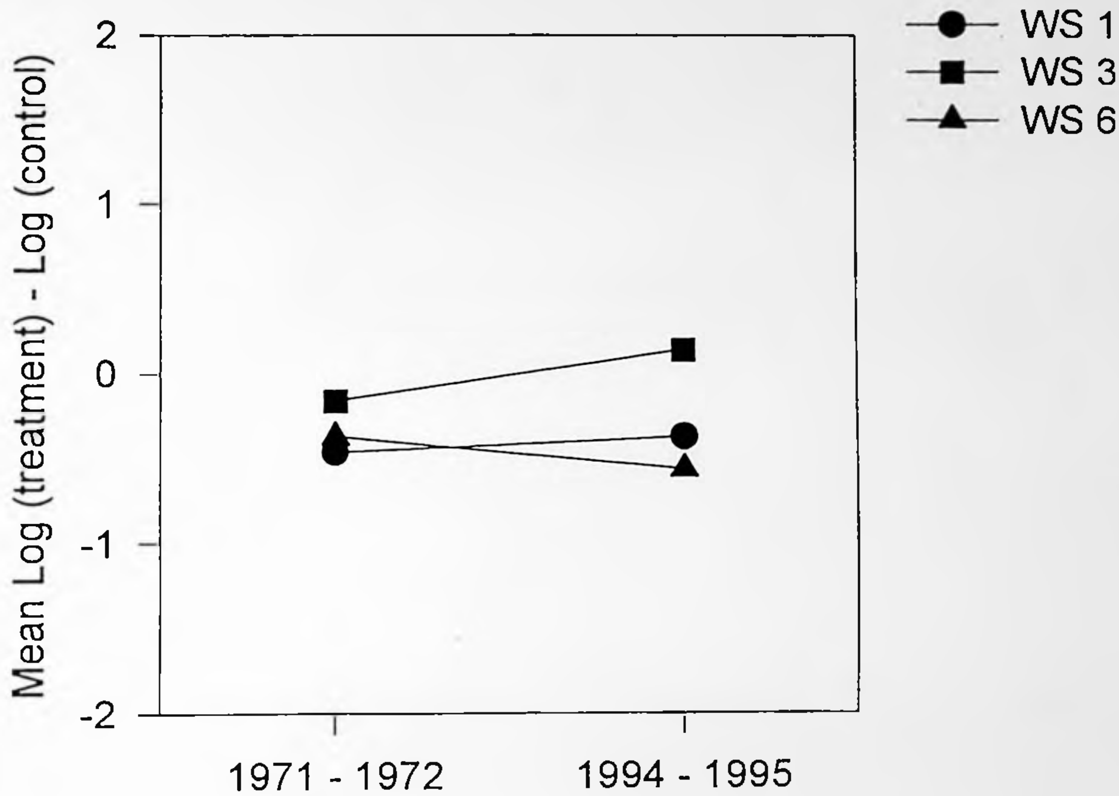
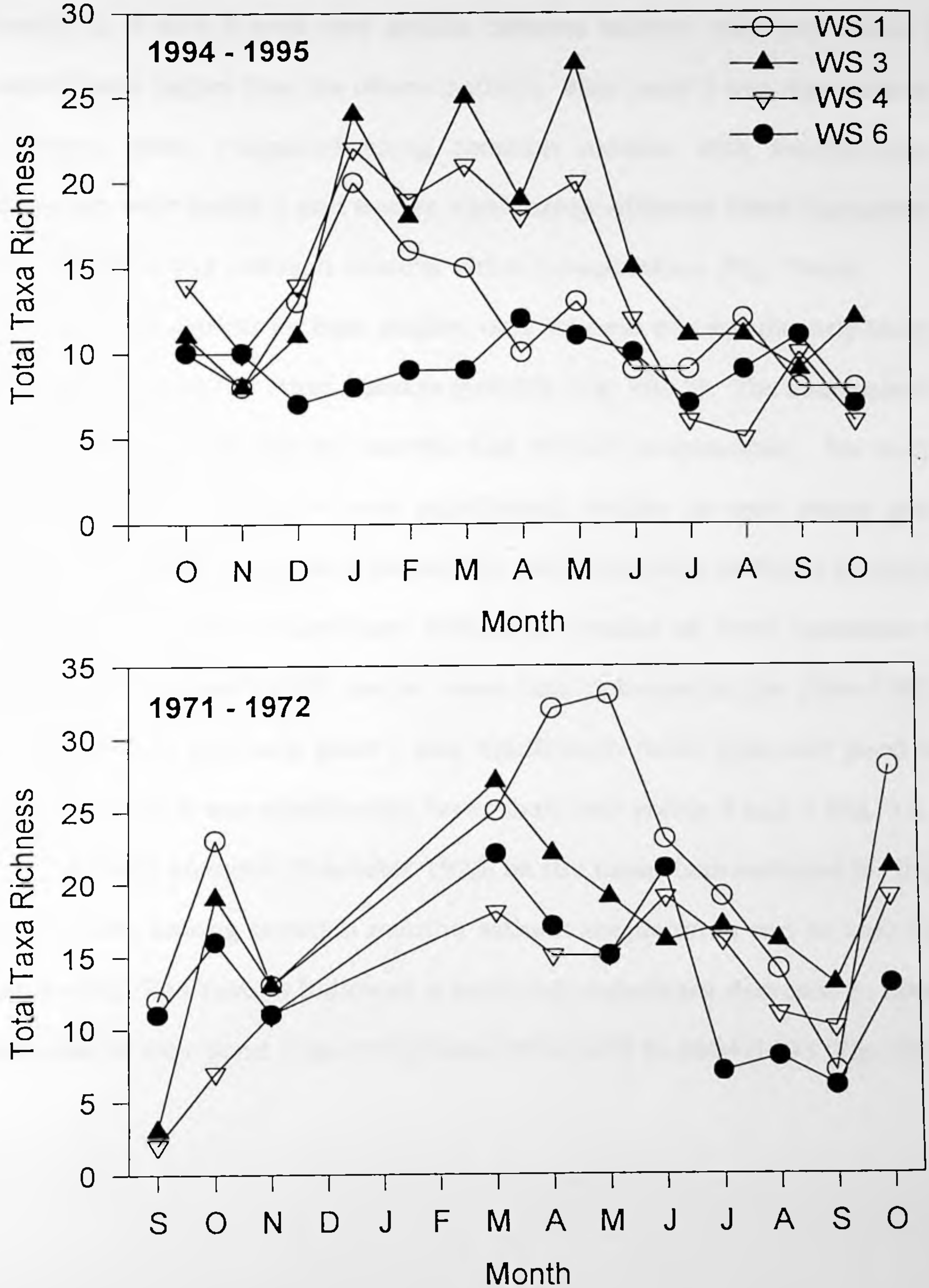

Mean Log (treatment) - Log (control)
2
1
0
-1
-2
1971 - 1972
1994 - 1995
WS 1
WS 3
WS 6

Figure 17. Total taxa richness for the two studies among weir ponds.



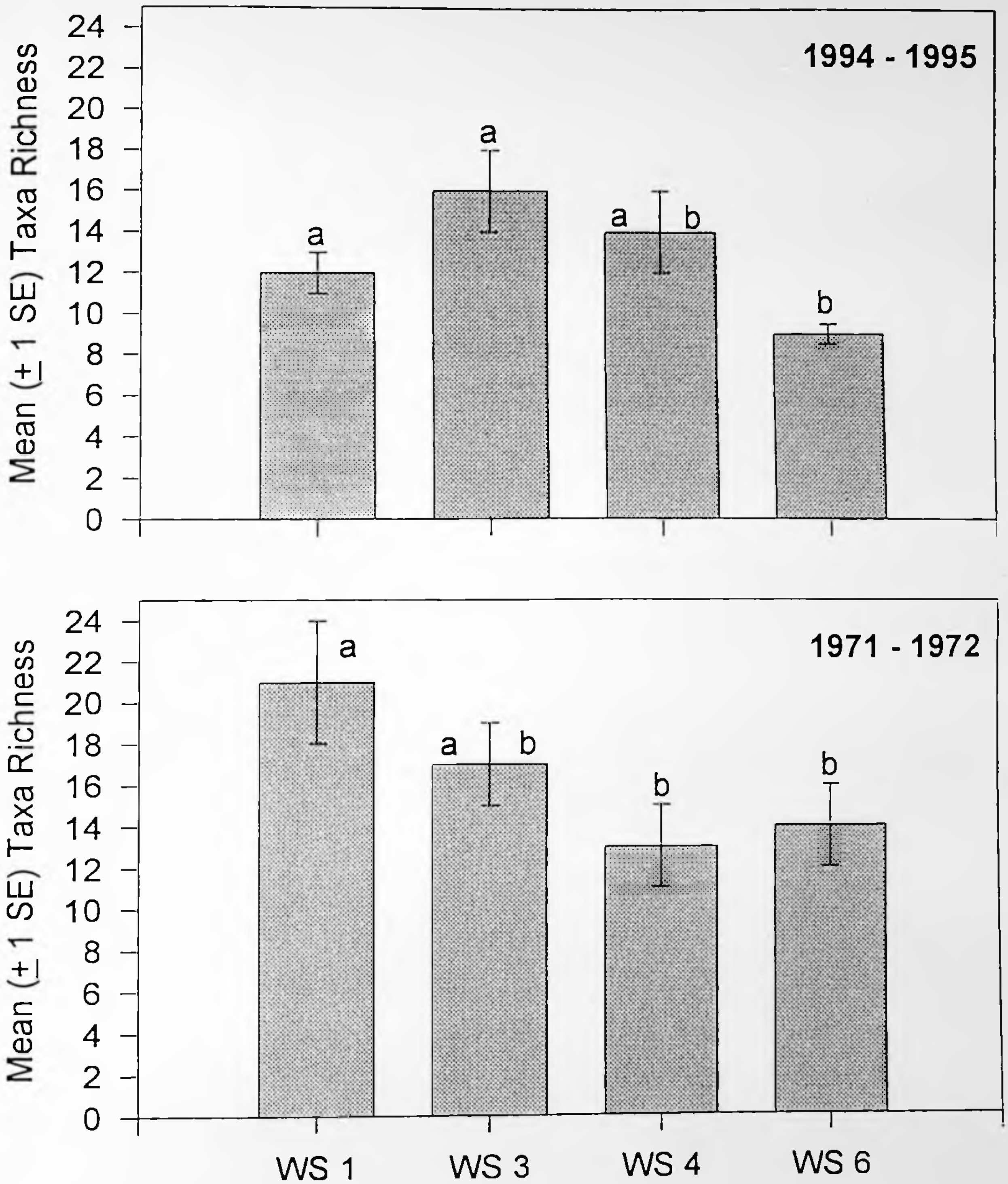
1994 - 1995
WS 1
WS 3
WS 4
WS 6
Total Taxa Richness
30
25
20
15
10
5
0
O N D J F M A M J J A S O
Month
1971 - 1972
Total Taxa Richness
35
30
25
20
15
10
5
0
S O N D J F M A M J J A S O
Month

significantly higher diversity ($p<0.05$) than WS 4 or WS 6 (Fig. 18). Weir ponds 3, 4 and 6 were very similar between studies, with weir pond 1 significantly higher than the others ($p<0.01$). Weir pond 1 was significantly different when compared along common months with zooplankton. However, weir ponds 1 and 6 were significantly different when comparing the studies along common months without zooplankton (Fig. 19a,b).

Across seasons for both studies, taxa richness was significantly lower in summer than the other seasons ($p<0.05$) (Fig. 20a,b). The comparison was made during common months and without zooplankton. For both studies, fall and summer were significantly similar as were winter and spring. A one-way analysis of covariance comparing taxa richness by pond and date resulted in significant differences among all three parameters (Table 4). A Tukey's HSD test on mean taxa richness for the 1994-1995 study revealed that weir pond 1 was significantly lower than weir pond 3 and weir pond 6 was significantly lower than weir ponds 3 and 4 (Fig. 21).

A BACI analysis (Schroeter 1993) on the mean taxa richness for the two studies among common months without zooplankton can be seen in Figure 22. The results indicated a small but significant decrease in taxa richness for weir pond 1 ($p< 0.01$) from 1971-1972 to 1994-1995 (Fig. 23).

Figure 18. Mean ($\pm$ 1 SE) taxa richness for the two studies among weir ponds (HSD was used for pairwise comparisons).



Mean (± 1 SE) Taxa Richness
1994 - 1995
a
a
a
b
b
0
2
4
6
8
10
12
14
16
18
20
22
24
Mean (± 1 SE) Taxa Richness
1971 - 1972
a
a
b
b
b
WS 1
WS 3
WS 4
WS 6

Figure 19. Mean (± 1 SE) taxa richness for the two studies among common months (one-way ANOVA, *=$p<0.01$).

a. Mean (± 1 SE) taxa richness for the two studies among common months with zooplankton (ostracods & cladocerans).

b. Mean (± 1 SE) taxa richness for the two studies among common months without zooplankton (ostracods & cladocerans).

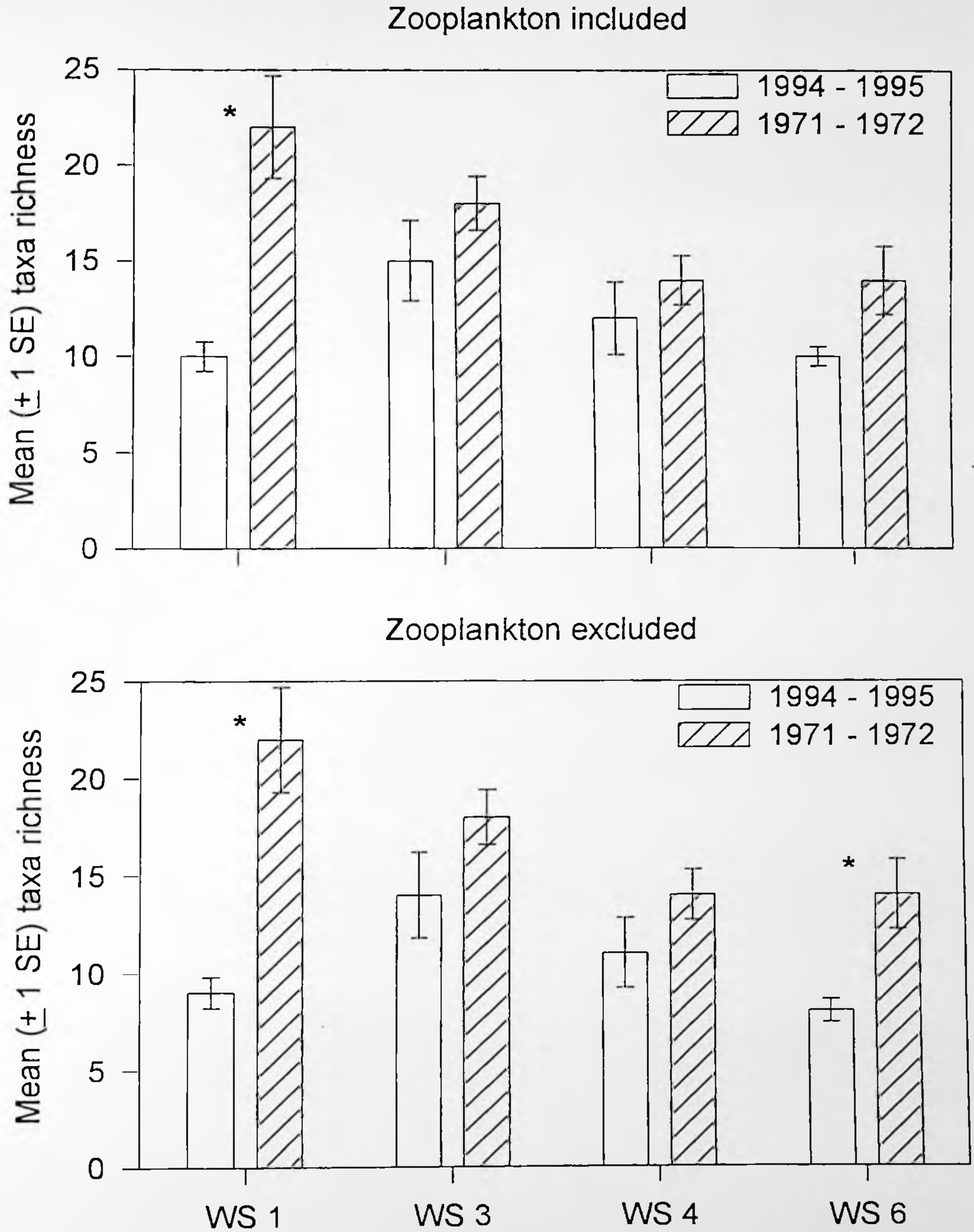
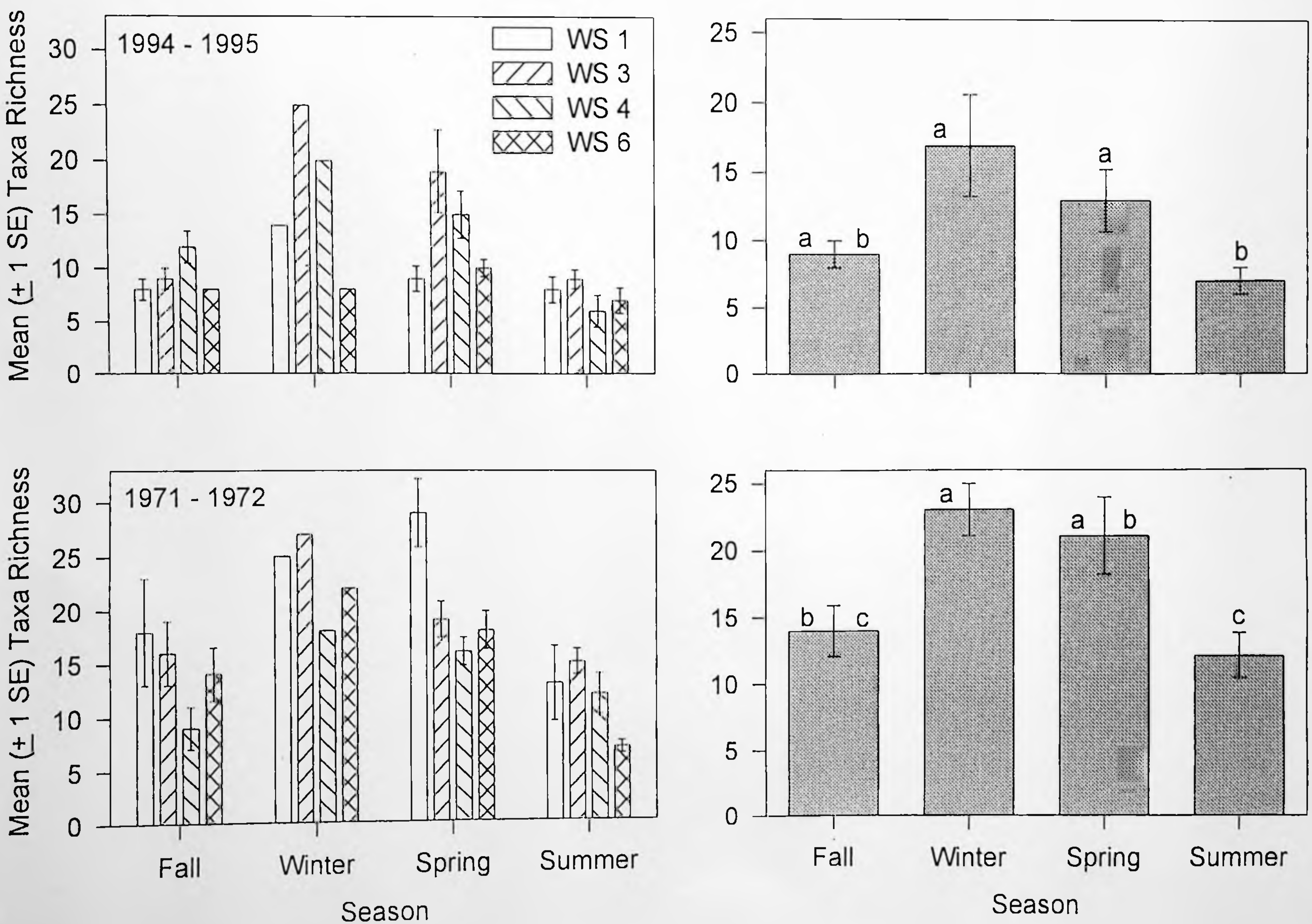

Zooplankton included
Mean (± 1 SE) taxa richness
25
20
15
10
5
0
1994 - 1995
1971 - 1972
*
Zooplankton excluded
Mean (± 1 SE) taxa richness
25
20
15
10
5
0
1994 - 1995
1971 - 1972
*
*
WS 1
WS 3
WS 4
WS 6

Figure 20. Mean (± 1 SE) seasonal taxa richness for the two studies for common months among the four weir ponds (without zooplankton) (HSD was used for pairwise comparisons).

a. Mean (± 1 SE) seasonal taxa richness for 1994-1995 study for each weir pond and season.

b. Mean (± 1 SE) seasonal taxa richness for 1971-1972 study for each weir pond and season.



1994 - 1995
1971 - 1972
WS 1
WS 3
WS 4
WS 6
Mean (± 1 SE) Taxa Richness
Fall
Winter
Spring
Summer
Season

Figure 21. Mean (± 1 SE) taxa richness for the 1994-1995 study among weir ponds (HSD was used for pairwise comparisons).

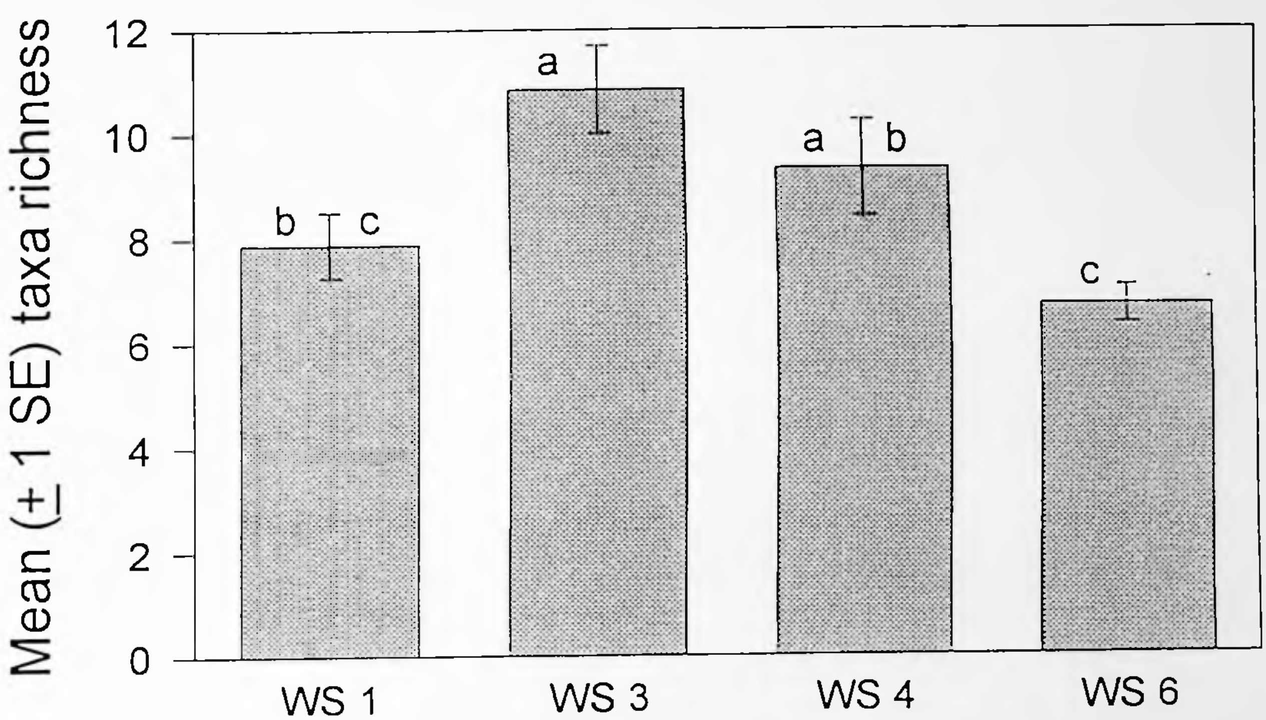

Mean (± 1 SE) taxa richness
12
10
8
6
4
2
0
a
a b
b c
c
WS 1
WS 3
WS 4
WS 6

Figure 22. A BACI analysis of the two studies using taxa richness for the common months (zooplankton excluded).

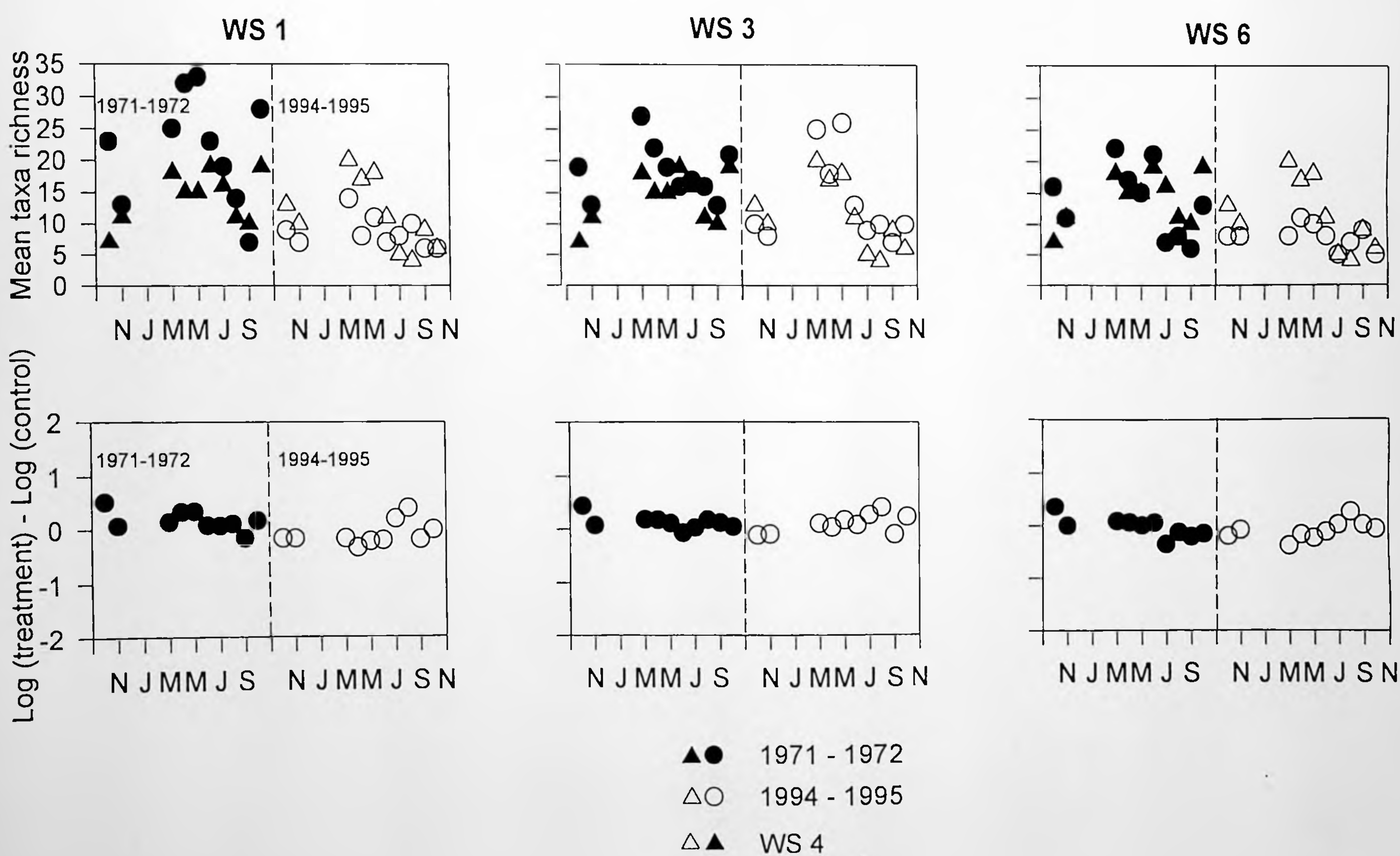
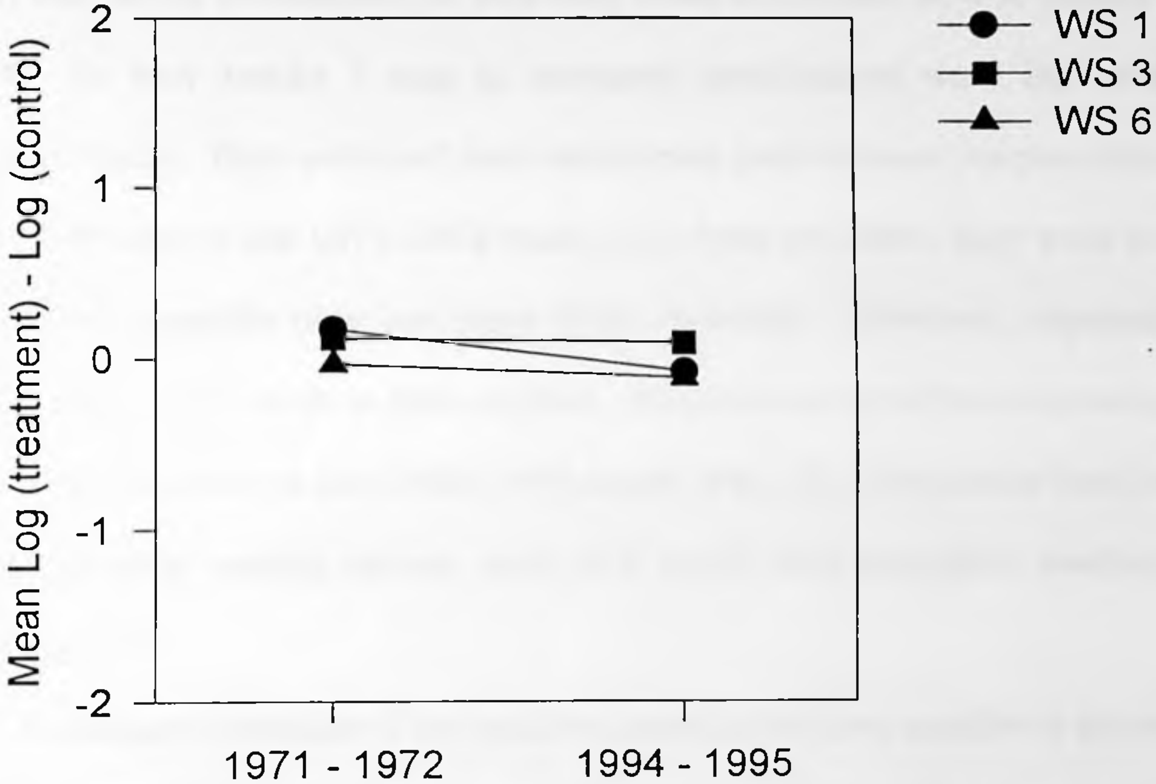

WS 1
WS 3
WS 6
Mean taxa richness
35
30
25
20
15
10
5
0
1971-1972
1994-1995
N J MMM J S N J MMM J S N
Log (treatment) - Log (control)
2
1
0
-1
-2
1971 - 1972
1994 - 1995
WS 4

Figure 23. A BACI analysis interaction plot for taxa richness for the two studies among weir ponds.



Mean Log (treatment) - Log (control)
2
1
0
-1
-2
1971 - 1972
1994 - 1995
WS 1
WS 3
WS 6

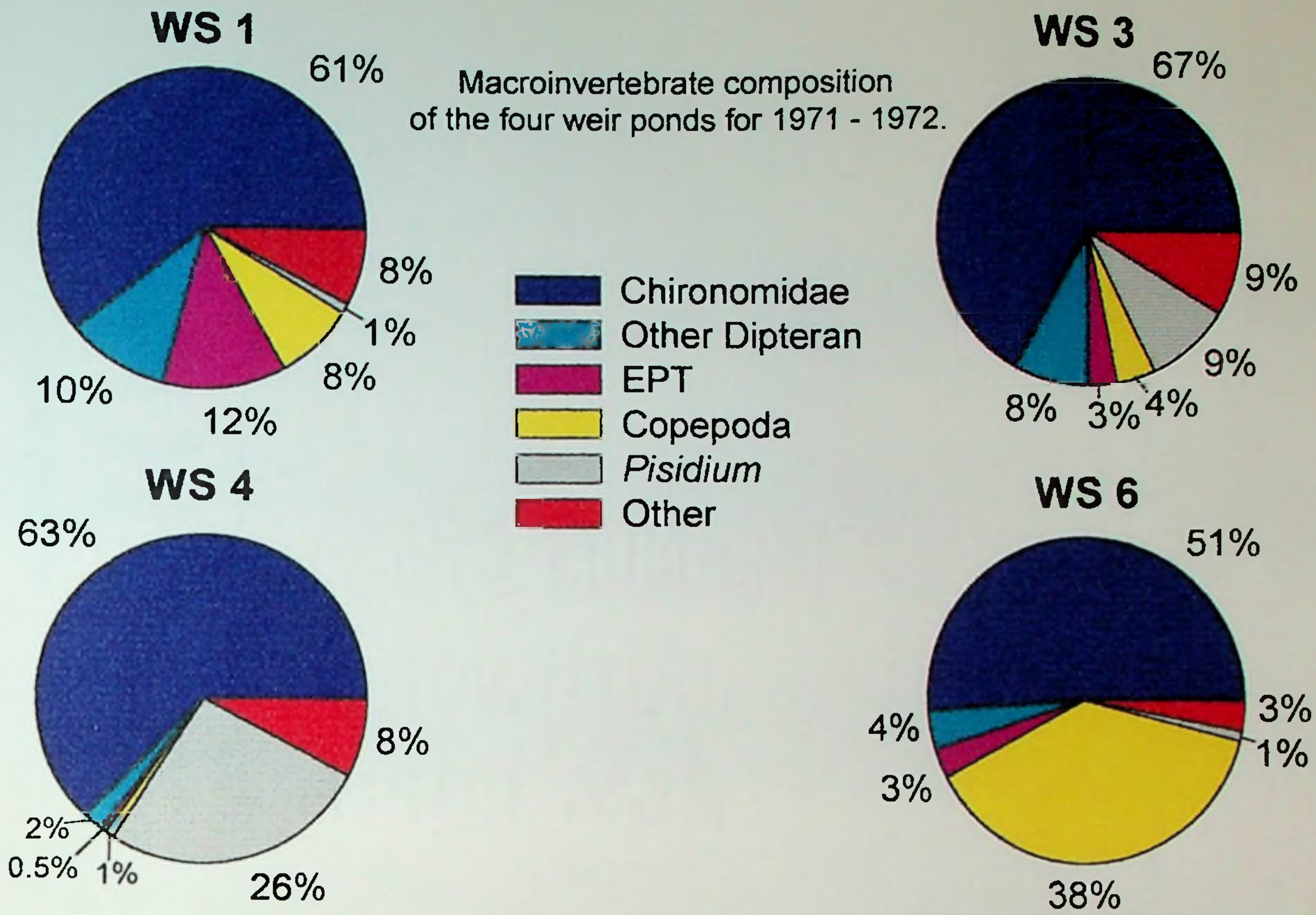
MACROINVERTEBRATE COMPOSITION

In the 1971-1972 study, the family Chironomidae was the most abundant group in all four weir ponds (Fig. 24). However, in the 1994-1995 study, the family Chironomidae was only most abundant in weir ponds 3 and 4. In weir ponds 1 and 6, ostracod populations were the most abundant taxon. Both ostracod and cladoceran populations (zooplankton) were not present in the 1971-1972 study, but does not mean they were not found, they possibly may not have been recorded. However, copepoda populations were present in both studies. Zooplankton densities increasing from fall to summer in the 1994-1995 study (Fig. 25). Ostracods had the highest density among season and weir pond with numbers reaching 50,000 per m^2.

A complete checklist of the taxa recorded in the two studies is shown in Table 8. Three phyla, five classes, twelve orders, forty-one families and 86 genera were represented in the two studies (Table 8).

In the 1971-1972 study 66 taxa were collected, in comparison to 60 taxa collected in the 1994-1995 study (Table 9). Forty-one taxa were unique to the 1971-1972 study, and 34 taxa were unique to the 1994-1995 study. The group with the greatest diversity was the order Diptera with 33 taxa in 1994-1995, and 32 in 1971-1972. The family Chironomidae had 27 taxa in 1994-1995 and 11 in 1971-1972, with 21 taxon unique to the 1994-1995 study.

Figure 24. Macroinvertebrate composition of the four weir ponds for the two studies (EPT = Ephemeroptera, Plecoptera, Trichoptera).


WS 1
61%
8%
1%
8%
12%
10%
WS 3
67%
9%
9%
4%
3%
8%
Macroinvertebrate composition
of the four weir ponds for 1971 - 1972.
Chironomidae
Other Dipteran
EPT
Copepoda
Pisidium
Other
WS 4
63%
8%
26%
2%
0.5%
1%
WS 6
51%
3%
1%
38%
3%
4%

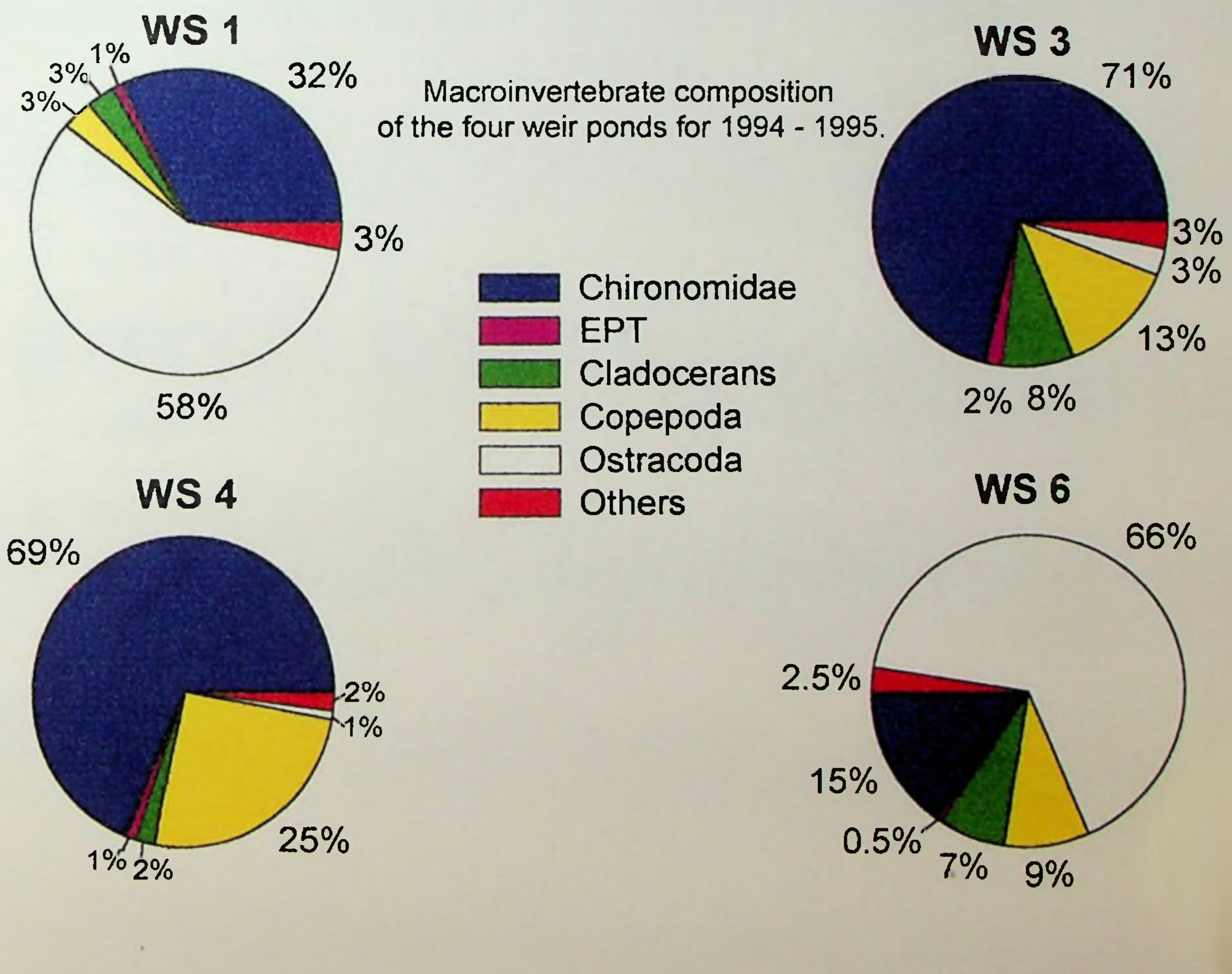
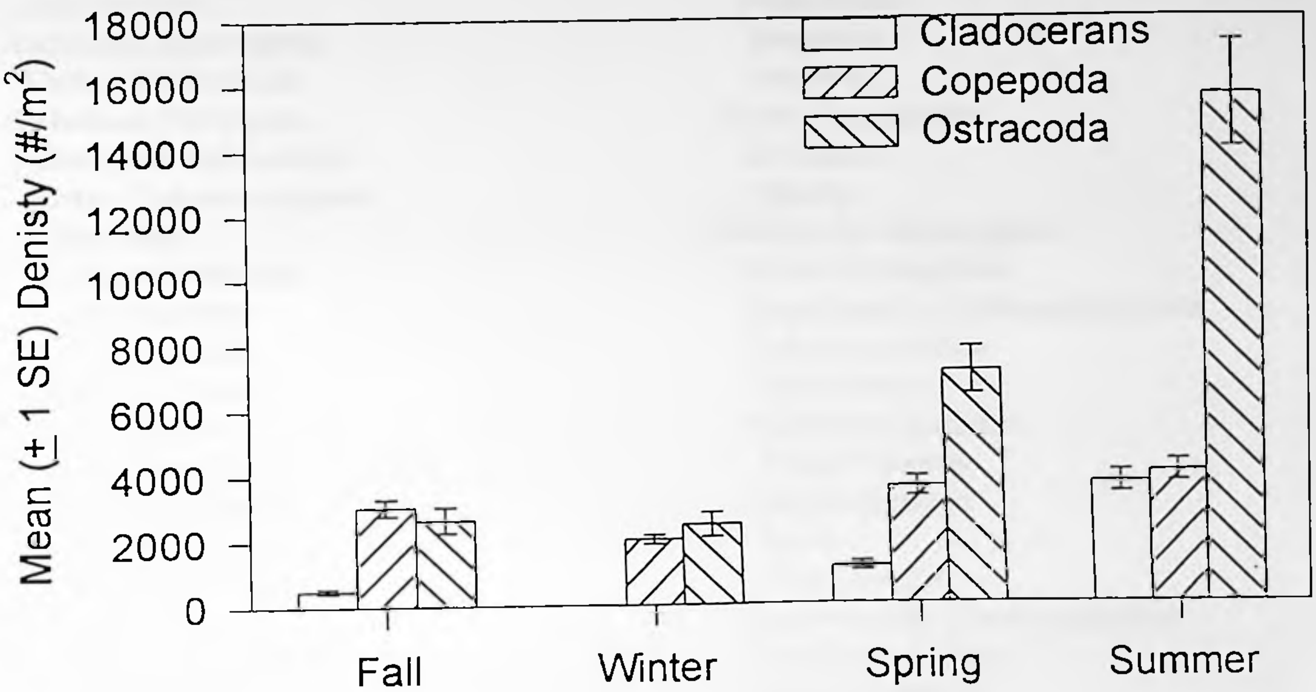

WS 1
32%
3%
58%
3%
3%
1%
WS 3
71%
3%
3%
13%
8%
2%
Macroinvertebrate composition
of the four weir ponds for 1994 - 1995.
Chironomidae
EPT
Cladocerans
Copepoda
Ostracoda
Others
WS 4
69%
2%
1%
25%
2%
1%
WS 6
66%
2.5%
15%
0.5%
7%
9%

Figure 25. Mean (± 1 SE) zooplankton density by season and weir pond for the 1994-1995 study.


Mean (± 1 SE) Denisty (#/m²)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Cladocerans
Copepoda
Ostracoda
Fall
Winter
Spring
Summer

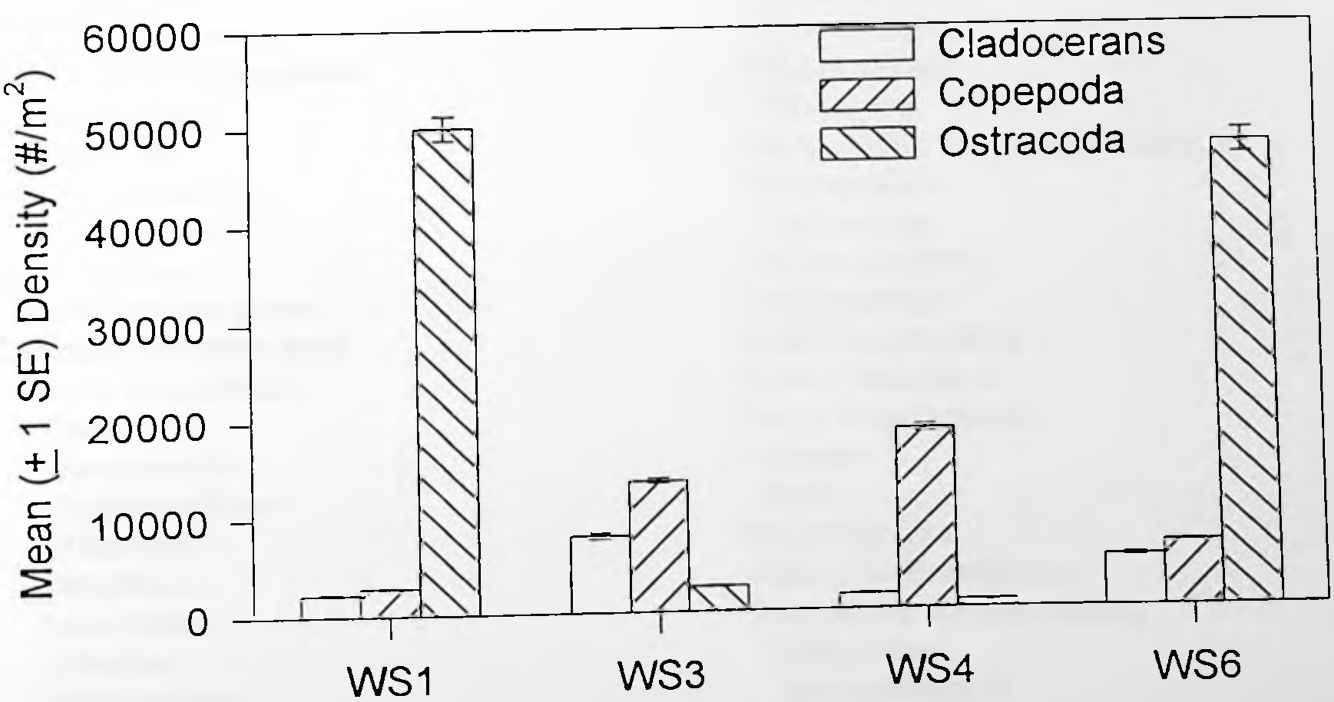

Mean (± 1 SE) Density (#/m²)
60000
50000
40000
30000
20000
10000
0
Cladocerans
Copepoda
Ostracoda
WS1
WS3
WS4
WS6

Table 8. Taxonomic list for the two studies.

Class Insecta
Subclass Apterygota
Order Collembola
Subclass Pterygota
Infraclass Paleoptera
Order Ephemeroptera
Baetidae
Ephemerellidae
Ephemerella
Eurylophella
Ephemeridae
Hexagenia
Litobrancha
Heptageniidae
Epeorus
Leptophlebiidae
Habrophlebia
Habrophlebiodes
Oligoneuriidae
Lachlania
Siphlonuridae
Ameletus
Order Odonata
Suborder Anisoptera
Aeshnidae
Aeshna
Gomphidae
Hagenius
Lanthus
Infraclass Neoptera
Division Exopterygota
Order Plecoptera
Capniidae
Paracapnia
Chloroperlidae
Alloperla
Sweltsa
Leuctridae
Leuctra
Nemouridae
Amphinemura
Soyedina
Peltoperlidae
Peltoperla
Perlidae
Acroneuria
Perlodidae
Isogenus
Isoperla
Order Hemiptera
Corixidae
Sigara
Division Endopterygota
Order Trichoptera
Superfamily Hydropsychoidea
Hydropsychidae
Diplectrona
Polycentropodidae
Polycentropus
Psychomyiidae
Lype
Psychomyia
Superfamily Limnephiloidea
Brachycentridae
Brachycentrus
Lepidostomatidae
Lepidostoma
Limnephilidae
Pycnopsyche
Phryganeidae
Ptilostomis
Superfamily Rhyacophiloidea
Hydroptilidae
Ochrotrichia
Rhyacophilidae
Rhyacophila
Order Lepidoptera
Order Coleoptera
Order Megaloptera
Sialidae
Sialis
Order Diptera
Suborder Brachycera
Infraorder Cyclorrhapha
Ephydridae
Brachydeutera
Scatophila
Muscidae
Subfamily Hydrelliinae
Hydrellia
Syrphidae

Infraorder Orthorrhapha
- Empididae
- Stratiomyidae
  - *Eulalia*
- Tabanidae
  - *Tabanus*

Suborder Nematocera
- Cecidomyiidae
- Ceratopogonidae
  - *Atrichopogon*
  - *Culicoides*
  - *Palpomyia*
- Chaoboridae
  - *Chaoborus*
- Chironomidae
  - Subfamily Chironominae
    - *Chironomus*
    - *Dicrotendipes*
    - *Glyptotendipes*
    - *Micropsectra*
    - *Microtendipes*
    - *Paratendipes*
    - *Polypedilum*
    - *Tanytarsus*
    - *Tribelos*
  - Subfamily Orthocladiinae
    - *Brillia*
    - *Corynoneura*
    - *Cricotopus*
    - *Eukiefferiella*
    - *Heterotrissocladius*
    - *Hydrobaenus*
    - *Metriocnemus*
    - *Orthocladius*
    - *Parachaetocladius*
    - *Parametriocnemus*
    - *Paraphaenocladius*
    - *Psectrocladius*
    - *Rheocricotopus*
    - *Stilocladius*
    - *Symposiocladius*
    - *Thienemanniella*
    - *Trichocladius*
  - Subfamily Prodiamesinae
    - *Prodiamesa*
  - Subfamily Tanypodinae
    - *Pentaneura*
    - *Procladius*
    - *Thienemannimyia*
    - *Zavrelimyia*
- Dixidae
  - *Dixa*
- Psychodidae
  - *Pericoma*
  - *Psychoda*
- Tipulidae
  - *Helius*
  - *Hexatoma*
  - *Limnophila*
  - *Limonia*
  - *Molophilus*
  - *Ormosia*
  - *Pseudolimnophila*
  - *Tipula*

Class Crustacea
- Subclass Branchiopoda
  - Order Cladocera
- Subclass Copepoda
  - Order Cyclopoida
- Subclass Ostracoda

Class Arachnida
- Subclass Acari

Class Bivalvia
- Superfamily Sphaeracea
  - Sphaeriidae
    - *Pisidium*

Phylum Annelida
- Class Oligochaeta

Phylum Nematoda

Table 9. Number of taxa and unique taxa collected for each study.

Taxa	1994-1995		1971-1972	
	Total	Unique	Total	Unique
Ephemeroptera	4	2	8	6
Odonata	2	1	2	1
Plecoptera	8	5	5	2
Trichoptera	3	1	9	7
Diptera	33	23	32	23
Chironomidae	*27*	*21*	*11*	*5*
Zooplankton	4	2	2	0
Other	6	0	8	2
TOTAL	60	34	66	41

The family Chironomidae with 31 genera represented overall some of the highest densities for both studies with mean densities up to 2,388 per m^2 (Table 10). In 1971-1972, the genus *Pentaneura* had the highest density among chironomids with 2,388 per m^2, compared to *Chironomus* with 2,297 per m^2 in 1994-1995. The genus *Chironomus* also represented the highest percent total for both studies with 70 percent to 90 percent of the total collected. Four subfamilies of Chironomidae were present in the two studies. However, the subfamily Prodiamesinae was only present in the 1994-1995 study (Table 11). The largest subfamily for both studies was Chironominae with densities ranging from 135 per m^2 to 4,749 per m^2. However, in 1994-1995, weir pond 6 had Tanypodinae with 621 per m^2 which was 76 percent of the total collected. These four subfamilies represent 49 percent to 78 percent of the total collection for both the 1971-1972 and 1994-1995 study (Fig. 26). Seasonal patterns for chironomid show an increase in the winter and summer collections for the 1994-1995 study (Fig. 27). In 1971-1972, chironomid density increased from fall to summer, which might be an effect of sediment cleaning in the weir ponds during August 1971.

The top six taxa for the two studies revealed that *Chironomus* was always in the top three except for weir pond 6 in 1994-1995 where ostracod densities were 66 percent of total (Table 12). However, when comparing the two studies, only common months should be used. When common months are used, and zooplankton (ostracods & cladocerans) densities omitted, the

Table 10. Mean density per m² of the family Chironomidae for common months (Oct, Nov, Mar, Aprl, May, Jun, July, Aug, Sept, Oct) with percentage of total.

Taxon	Pond 1		3		4		6	
	1971-72	1994-95	1971-72	1994-95	1971-72	1994-95	1971-72	1994-95
Chironomus	481 (30)	2209 (90)	726 (21)	2297 (43)	1322 (26)	1074 (31)	1337 (70)	105 (13)
Dicrotendipes	0	27 (1)	0	67 (1)	0	7 (<1)	0	16 (2)
Glyptotendipes	299 (19)	0	434 (12)	0	861 (17)	0	226 (12)	0
Micropsectra	0	1 (<1)	0	4 (<1)	0	0	0	0
Microtendipes	30 (2)	15 (1)	1 (<1)	141 (3)	0	20 (1)	4 (<1)	0
Paratendipes	2 (<1)	0	12 (<1)	16 (<1)	3 (<1)	5 (<1)	21 (1)	0
Polypedilum	0	0	0	0	0	6 (<1)	0	0
Tanytarsus	209 (13)	20 (1)	1279 (36)	204 (4)	438 (9)	160 (5)	17 (1)	12 (2)
Tribelos	0	5 (<1)	0	2020 (38)	0	759 (22)	0	2 (<1)
Brillia	0	0	0	0	0	1 (<1)	0	0
Corynoneura	0	0	0	34 (1)	0	5 (<1)	0	0
Cricotopus	0	13 (1)	0	4 (<1)	2 (<1)	0	0	1 (<1)
Eukiefferiella	0	4 (<1)	0	4 (<1)	0	18 (1)	0	0
Heterotrissocladius	0	80 (3)	0	119 (2)	0	11 (<1)	0	24 (3)
Hydrobaenus	7 (<1)	0	0	0	1 (<1)	0	2 (<1)	0
Metriocnemus	15 (1)	0	10 (<1)	0	8 (<1)	0	13 (1)	0
Orthocladius	0	0	0	0	0	0	0	0
Parachaetocladius	0	0	0	0	0	0	0	0
Parametriocnemus	0	0	0	2 (<1)	0	15 (<1)	0	0
Paraphaenocladius	0	0	0	1 (<1)	0	15 (<1)	0	0
Psectrocladius	0	0	0	0	0	0	0	6 (1)
Rheocricotopus	0	4 (<1)	0	37 (1)	0	28 (1)	0	31 (4)
Stilocladius	0	0	0	4 (<1)	0	0	0	0
Symposiocladius	0	0	0	2 (<1)	0	0	0	0
Thienemanniella	0	0	0	0	0	11 (<1)	0	0
Trichocladius	27 (2)	0	0	0	0	0	0	0
Prodiamesa	0	0	0	1 (<1)	0	0	0	1 (<1)

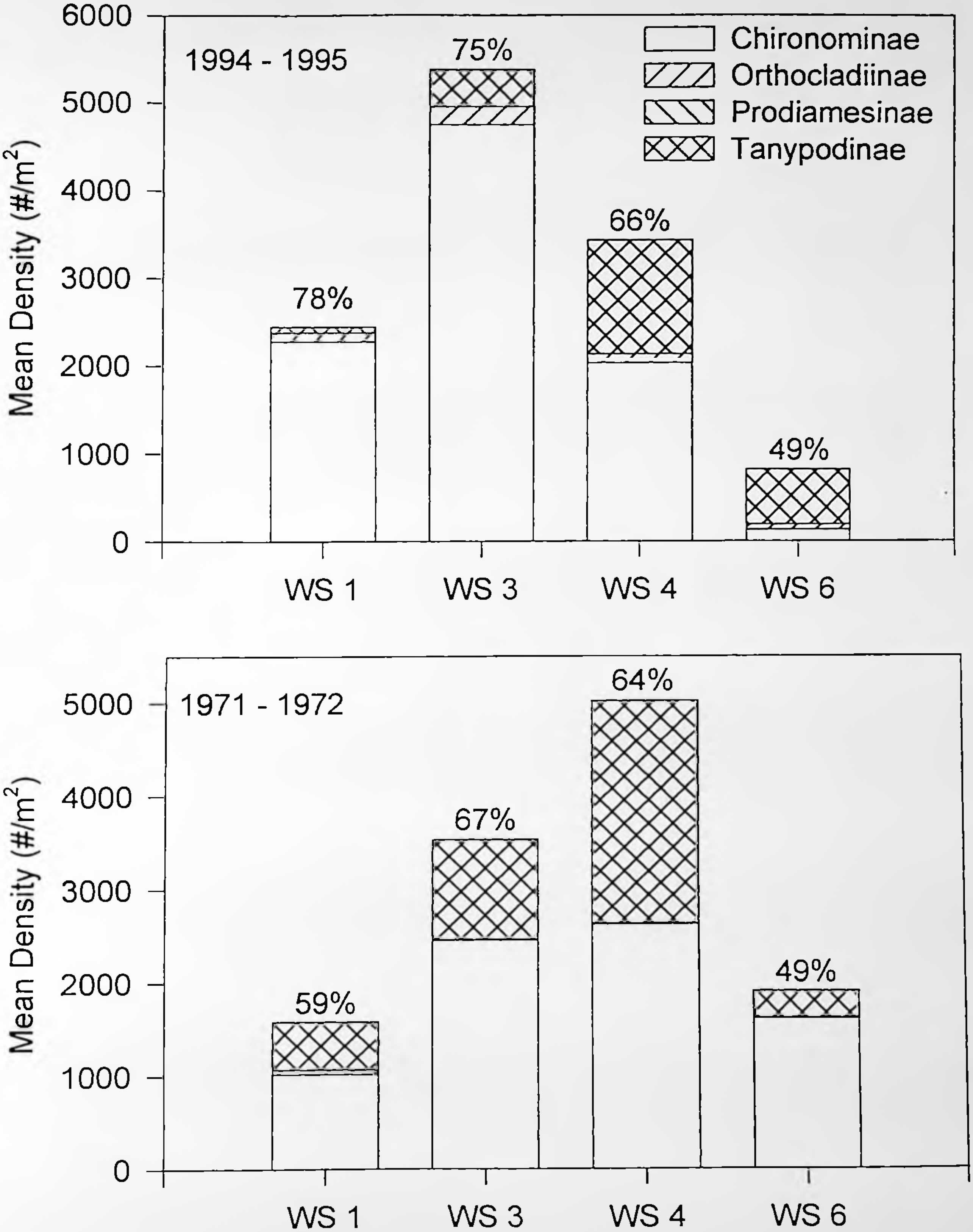
Table 10. Cont.

Taxon	Pond 1		3		4		6	
	1971-72	1994-95	1971-72	1994-95	1971-72	1994-95	1971-72	1994-95
Pentaneura	512 (32)	0	237 (7)	0	2388 (48)	0	179 (9)	0
Procladius	2 (<1)	57 (2)	836 (24)	335 (6)	0	1237 (36)	103 (5)	585 (72)
Thienemannimyia	0	0	0	3 (<1)	0	16 (1)	0	1 (<1)
Zavrelimyia	0	12 (1)	0	84 (2)	0	38 (1)	0	35 (4)
Total	1584	2447	3535	5378	5023	3427	1902	818

Table 11. Mean density per m² of subfamilies in the family Chironomidae for common months (Oct, Nov, Mar, Aprl, May, Jun, July, Aug, Sept, Oct) with percentage of total.

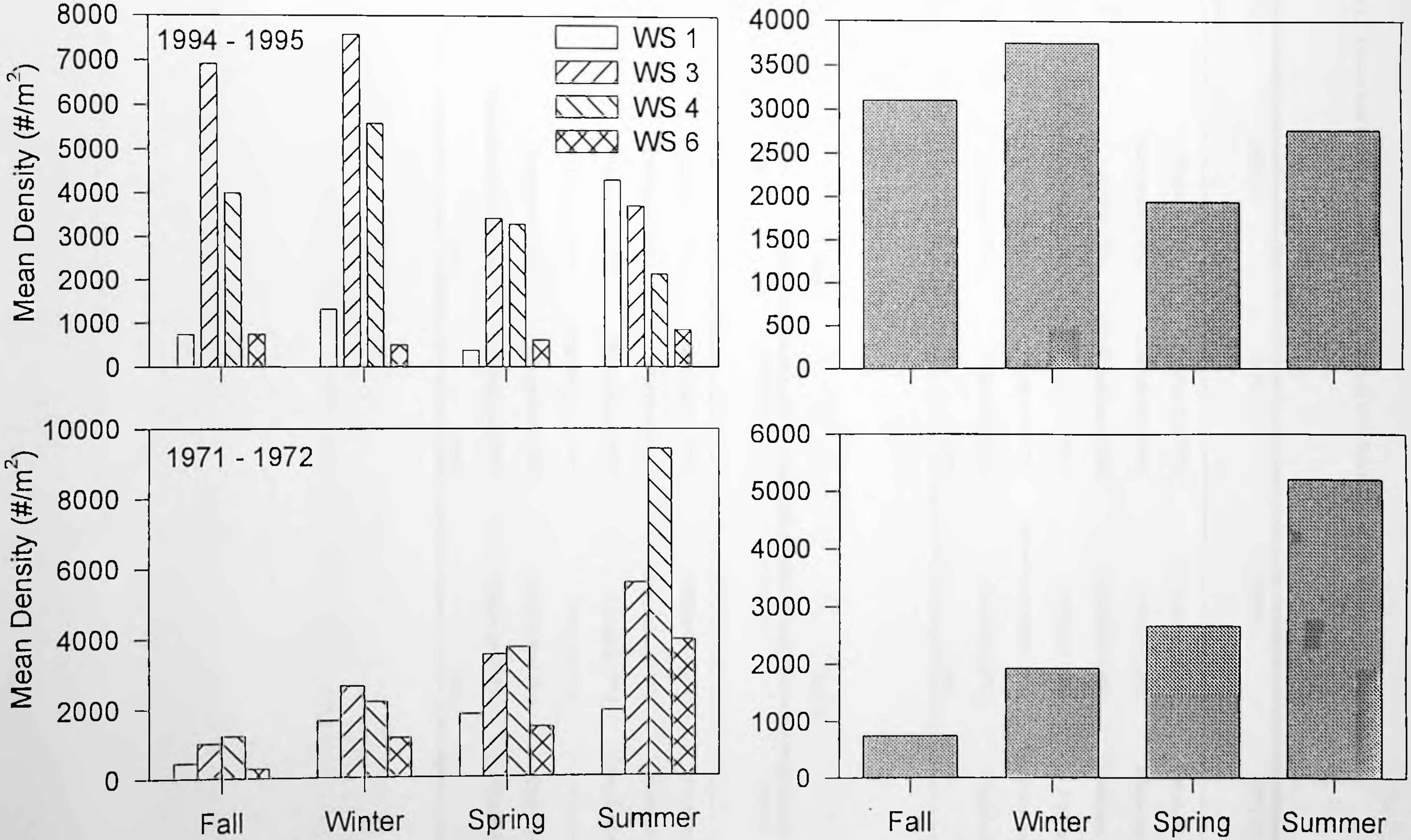
	Pond							
Subfamily	1		3		4		6	
	1971-72	1994-95	1971-72	1994-95	1971-72	1994-95	1971-72	1994-95
Chironominae	1021 (65)	2277 (93)	2452 (69)	4749 (88)	2624 (52)	2032 (59)	1605 (84)	135 (17)
Orthocladiinae	49 (3)	101 (4)	10 (<1)	207 (4)	11 (<1)	104 (3)	15 (1)	61 (8)
Prodiamesinae	0	0	0	1 (<1)	0	0	0	1 (<1)
Tanypodinae	514 (32)	69 (3)	1073 (30)	422 (8)	2388 (48)	1291 (38)	282 (15)	621 (76)
Total	1584	2447	3535	5378	5023	3427	1902	818

Figure 26. Mean chironomid density for the 1994-1995 and 1971-1972 study for each weir pond (with percent of total).



1994 - 1995
Chironominae
Orthocladiinae
Prodiamesinae
Tanypodinae
78%
75%
66%
49%
Mean Density (#/m^2)
0
1000
2000
3000
4000
5000
6000
WS 1
WS 3
WS 4
WS 6
1971 - 1972
59%
67%
64%
49%
Mean Density (#/m^2)
0
1000
2000
3000
4000
5000
WS 1
WS 3
WS 4
WS 6

Figure 27. Mean chironomid density for the two studies for common months among weir pond and season.



Mean Density (#/m^2)
1994 - 1995
WS 1
WS 3
WS 4
WS 6
1971 - 1972
8000
7000
6000
5000
4000
3000
2000
1000
0
10000
8000
6000
4000
2000
0
4000
3500
3000
2500
2000
1500
1000
500
0
6000
5000
4000
3000
2000
1000
0
Fall
Winter
Spring
Summer

Table 12. Top six taxa for the two studies in 1994-95 and 1971-72. Percentage of total sample is given for each.

	Weir 1		Weir 3	
Study Rank	1994-95	1971-72	1994-95	1971-72
1	Ostracoda (58%)	*Pentanura* (20%)	*Chironomus* (30%)	*Tanytarsus* (24%)
2	*Chironomus* (27%)	*Chironomus* (19%)	*Tribelos* (22%)	*Procladius* (16%)
3	Copepoda (3%)	*Glyptotendipes* (12%)	Copepoda (13%)	*Chironomus* (14%)
4	*Heterotrissocladius* (3%)	*Tanytarsus* (8%)	Cladocera (8%)	*Pisidium* (9%)
5	Cladocera (3%)	Copepoda (8%)	*Heterotrissocladius* (5%)	*Glyptotendipes* (8%)
6	Oligochaeta (2%)	*Palpomyia* (6%)	*Procladius* (4%)	Oligochaeta (7%)
TOTAL	96%	73%	82%	78%

	Weir 4		Weir 6	
Study Rank	1994-95	1971-72	1994-95	1971-72
1	*Procladius* (27%)	*Pentanura* (30%)	Ostracoda (66%)	Copepoda (38%)
2	Copepoda (25%)	*Pisidium* (26%)	*Procladius* (11%)	*Chironomus* (35%)
3	*Chironomus* (19%)	*Chironomus* (17%)	Copepoda (9%)	*Glyptotendipes* (6%)
4	*Tribelos* (13%)	*Glyptotendipes* (10%)	Cladocera (7%)	*Pentanura* (5%)
5	*Tanytarsus* (3%)	Oligochaeta (7%)	Oligochaeta (3%)	Oligochaeta (3%)
6	*Heterotrissocladius* (3%)	*Tanytarsus* (6%)	*Chironomus* (2%)	*Procladius* (3%)
TOTAL	90%	96%	98%	90%

top six taxa change (Table 13). The genus *Chironomus* was still in the top three for each weir pond and study, but in weir pond 6 Copepoda was the most abundant, comprising 37 percent of the total collected.

Using common months with zooplankton densities omitted, a top six families/subfamilies list was made for the two studies (Table 14). Chironominae was the top subfamily for all weir ponds in both studies except for weir pond 6 in the 1994-1995 study. In weir pond 6 for 1994-1995, Tanypodinae had 38 percent and Copepoda had 37 percent of the total collected, with subfamily Chironominae with 8 percent. All top six family/subfamily taxon for the four weir ponds in 1994-1995 represented 99 percent of the total collected, compared to the 1971-1972 study where they represented 79 percent to 99 percent of the total collected. Orthocladiinae represented 3 percent to 6 percent of the total collected in 1994-1995, but was not present in the 1971-1972 taxon list.

Densities of ephemeropteran, plecopteran and trichopteran individuals accounted for less than 2 percent of the total collected in 1994-1995 (Fig. 28). The genus *Leuctra* had the highest density with 1,380 per m^2 in weir pond 3. Some other genera found in the 1994-1995 study include *Pycnopsyche, Paracapnia, Litobrancha, Peltoperla* and *Ameletus*. In the 1971-1972 study, ephemeropteran, plecopteran and trichopteran densities accounted for less than 12 percent of the total collected. Weir pond 1 had the highest densities with Baetidae, *Habrophlebiodes, Alloperla, Leuctra, Peltoperla* and *Pycnopsyche* represented.

Table 13. Top six taxa for the two studies in 1994-1995 and 1971-1972 with zooplankton omitted for common months. Percentage of total sample is given for each.

	Weir 1		Weir 3	
Study Rank	1994-95	1971-72	1994-95	1971-72
1	*Chironomus* (77%)	*Pentanura* (20%)	*Chironomus* (33%)	*Tanytarsus* (24%)
2	Copepoda (8%)	*Chironomus* (19%)	*Tribelos* (29%)	*Procladius* (16%)
3	Oligochaeta (4%)	*Glyptotendipes* (12%)	Copepoda (17%)	*Chironomus* (14%)
4	*Heterotrissocladius* (3%)	*Tanytarsus* (8%)	*Procladius* (5%)	*Pisidium* (9%)
5	*Procladius* (2%)	Copepoda (8%)	*Tanytarsus* (3%)	*Glyptotendipes* (8%)
6	*Dicrotendipes* (1%)	*Palpomyia* (6%)	Oligochaeta (3%)	Oligochaeta (7%)
TOTAL	95%	73%	90%	78%

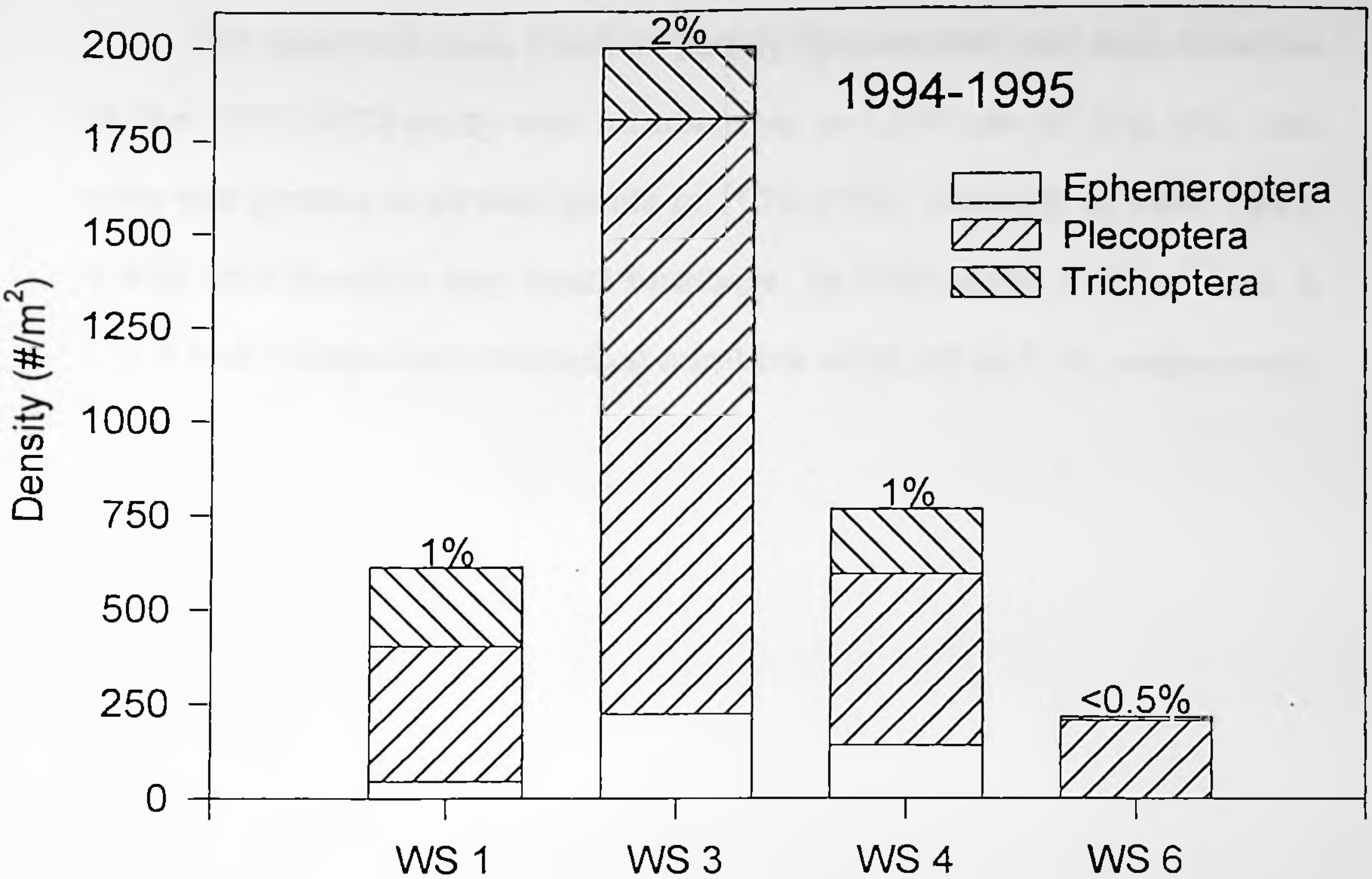
	Weir 4		Weir 6	
Study Rank	1994-95	1971-72	1994-95	1971-72
1	Copepoda (31%)	*Pentanura* (30%)	Copepoda (37%)	Copepoda (38%)
2	*Procladius* (24%)	*Pisidium* (26%)	*Procladius* (36%)	*Chironomus* (36%)
3	*Chironomus* (21%)	*Chironomus* (17%)	Oligochaeta (8%)	*Glyptotendipes* (6%)
4	*Tribelos* (15%)	*Glyptotendipes* (11%)	*Chironomus* (7%)	*Pentanura* (5%)
5	*Tanytarsus* (3%)	Oligochaeta (7%)	Orthoclad group (3%)	Oligochaeta (3%)
6	*Palpomyia* (1%)	*Tanytarsus* (6%)	*Zavrelimyia* (2%)	*Procladius* (3%)
TOTAL	95%	97%	93%	91%

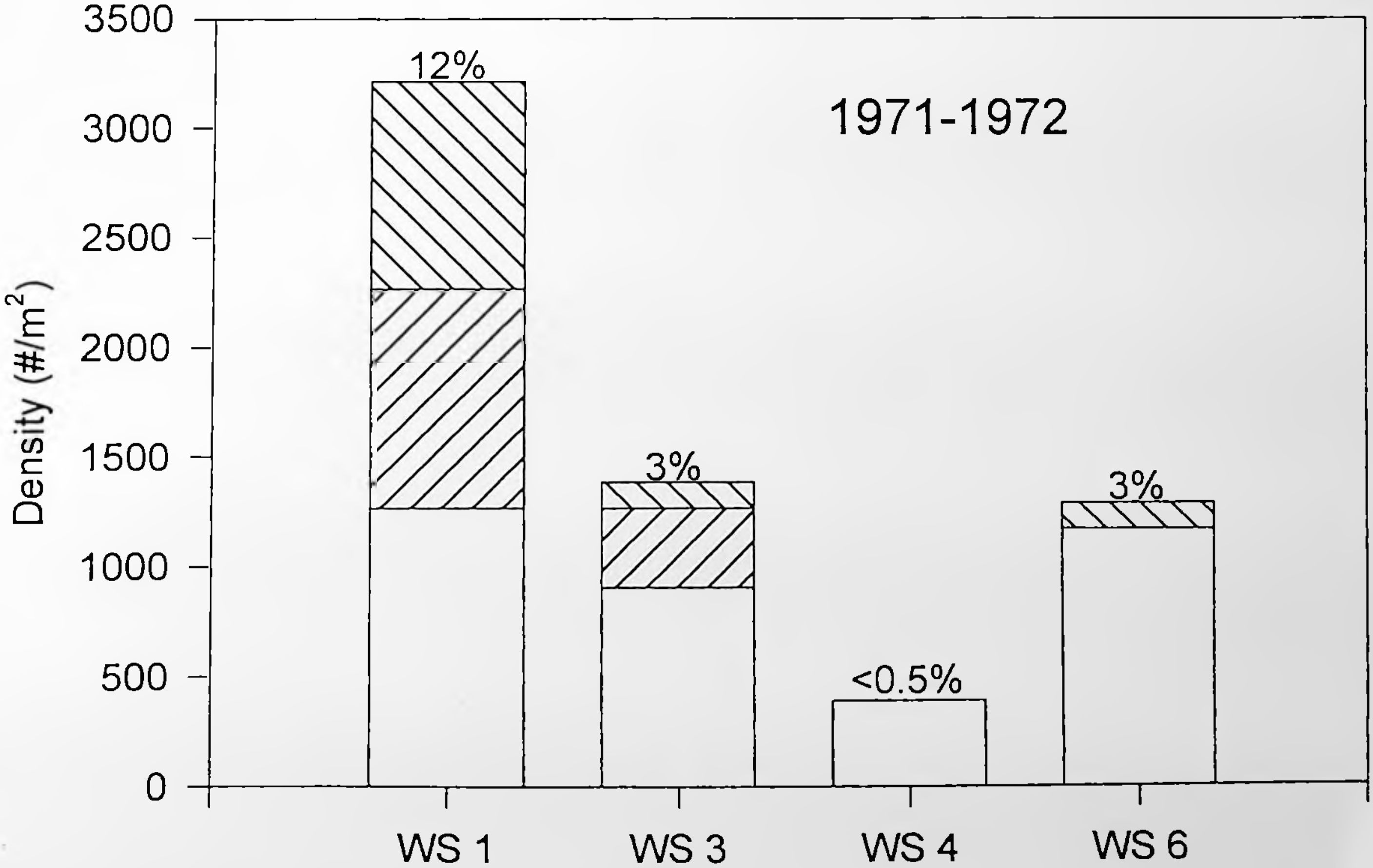
Table 14. Top six class/subclass, family/subfamily for the two studies in 1994-1995 and 1971-1972 with zooplankton omitted for common months. Percentage of total sample is given for each.

	Weir 1		Weir 3	
Study Rank	1994-95	1971-72	1994-95	1971-72
1	Chironominae (79%)	Chironominae (39%)	Chironominae (68%)	Chironominae (46%)
2	Copepoda (8%)	Tanypodinae (20%)	Copepoda (17%)	Tanypodinae (21%)
3	Orthocladiinae (4%)	Copepoda (8%)	Tanypodinae (6%)	Sphaeriidae (9%)
4	Oligochaeta (4%)	Ceratopogonidae (6%)	Orthocladiinae (4%)	Oligochaeta (7%)
5	Tanypodinae (3%)	Oligochaeta (3%)	Oligochaeta (3%)	Ceratopogonidae (6%)
6	Acarian (1%)	Limnephilidae (3%)	Leuctridae (1%)	Copepoda (4%)
TOTAL	99%	79%	99%	93%

	Weir 4		Weir 6	
Study Rank	1994-95	1971-72	1994-95	1971-72
1	Chironominae (39%)	Chironominae (34%)	Tanypodinae (38%)	Chironominae (41%)
2	Copepoda (31%)	Tanypodinae (30%)	Copepoda (37%)	Copepoda (38%)
3	Tanypodinae (25%)	Sphaeriidae (26%)	Chironominae (8%)	Tanypodinae (8%)
4	Orthocladiinae (3%)	Oligochaeta (7%)	Oligochaeta (8%)	Oligochaeta (3%)
5	Ceratopogonidae (<1%)	Ceratopogonidae (1%)	Orthocladiinae (6%)	Baetidae (2%)
6	Leuctridae (<1%)	Copepoda (1%)	Acarian (2%)	Ceratopogonidae (1%)
TOTAL	99%	99%	99%	93%

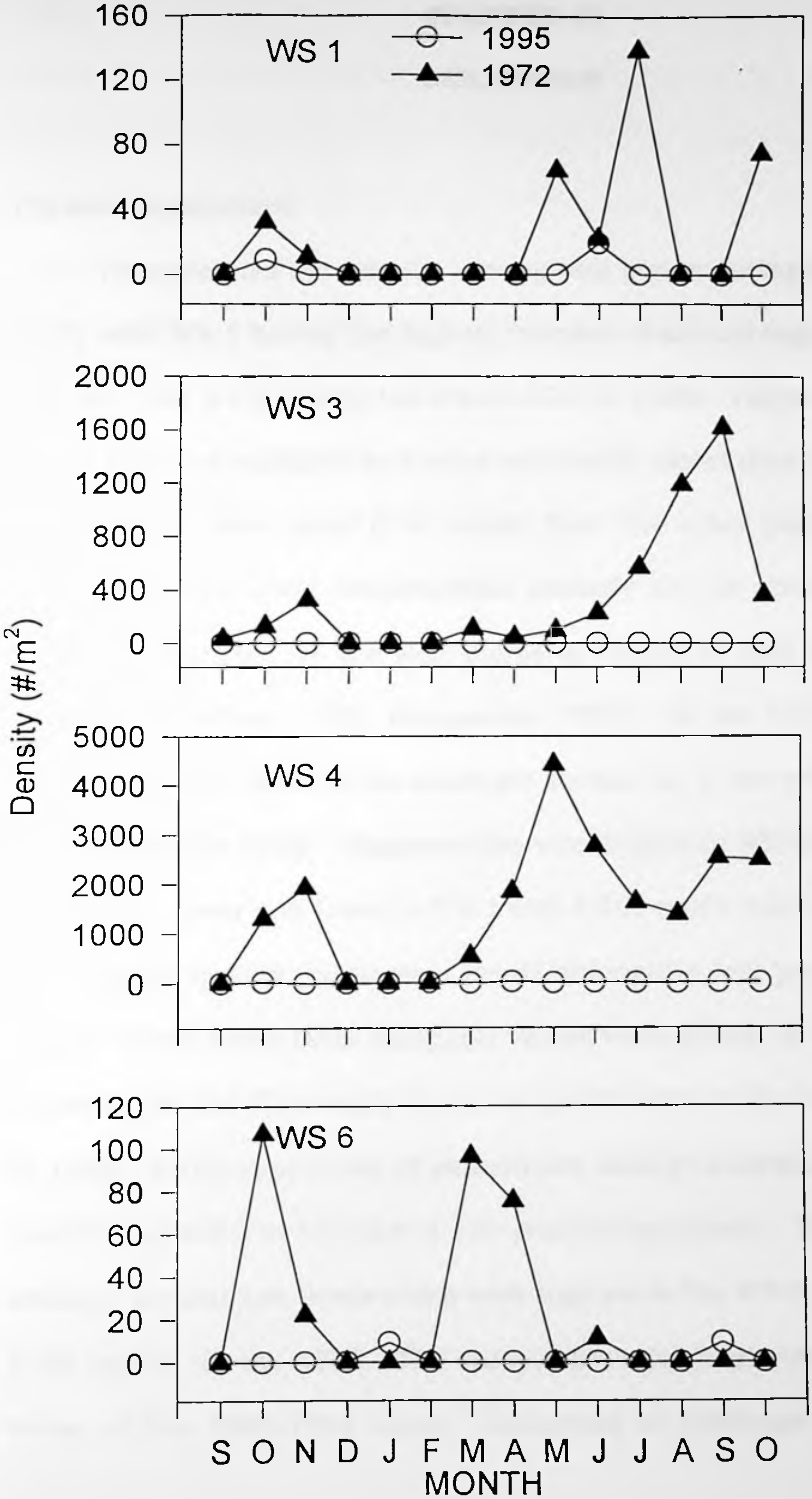
Figure 28. EPT density for the two studies among the four weir ponds (with percent of total).


1994-1995
Ephemeroptera
Plecoptera
Trichoptera
Density (#/m2)
2000
1750
1500
1250
1000
750
500
250
0
2%
1%
1%
<0.5%
WS 1
WS 3
WS 4
WS 6


1971-1972
Density (#/m2)
3500
3000
2500
2000
1500
1000
500
0
12%
3%
<0.5%
3%
WS 1
WS 3
WS 4
WS 6

The fingernail clam *Pisidium* (family Sphaeriidae) had high densities in the 1971-1972 study with numbers up to 4,500 per m^2 (Fig. 29). The clam was present in all weir ponds in 1971-1972. However in 1994-1995, it was only found in very small numbers. In 1994-1995, weir ponds 1, 4 and 6 had *Pisidium* with individual numbers of 28, 66 and 19, respectively.

Figure 29. *Pisidium* density for the two studies among the four weir ponds.



WS 1
1995
1972
WS 3
WS 4
WS 6
Density (#/m2)
160
120
80
40
0
2000
1600
1200
800
400
0
5000
4000
3000
2000
1000
0
120
100
80
60
40
20
0
S O N D J F M A M J J A S O
MONTH

CHAPTER VI

DISCUSSION

Physical parameters

Temperatures were similar among weir ponds during the 1994-1995 study with WS 3 having the highest number of annual degree days (ADD) of 3,666, and WS 6 having the fewest ADD of 3,262. Higher temperatures in WS 3 may be explained by a more southernly aspect than the other three weir ponds. Weir pond 6 is deeper than the other ponds which may account for the lower temperatures possibly due to stratification. The temperature range for the weir ponds is similar to that found in other studies (Christman 1993; Holopainen 1992). In the 1971-1972 study, temperature was taken at the substrate surface for a two week period from April to October 1972. Temperatures were higher in WS 6 because of the lack of tree cover and lower in WS 1 and 4 due to the tree canopy.

Water quality parameters varied among the weir ponds during the study. In the 1994-1995 study, pH values were greater in WS 1 (6.2) and lowest in WS 3 (5.7) probably due to an acidification study that was started in 1989. Aerial application of ammonium sulfate is applied three times a year to the WS 3 at the rate of 150 pounds/acre/year. This also has an effect on the nitrogen levels which were highest in the WS 3 weir pond with 7.38 mg/L. In the 1971-1972 study, alkalinity levels were higher than those of the 1994-1995 study. According to Feldman (1992), stream alkalinity is projected to continue to decrease with continued acid deposition. Decline in stream pH as a result of acid deposition is partially a function of stream alkalinity. Alkalinity will continue to decline if acid deposition continues at its present level or increases (Feldman 1992). Alkalinity levels in the FEF weir ponds were well below the levels found in other ponds in the Northeastern United States (Christman 1993). In his study, pond alkalinity was recorded in the range of 20 to 61 mg/L, in comparison to the FEF weir ponds ranging from 0.39 to 1.8 mg/L. Nitrate levels in the 1994-1995 study ranged from 0.1 to 7.4 mg/L, which were much higher than those found in his study, which ranged from 0.03 to 1.8 mg/L.

Particulate organic matter

Total particulate organic matter (TPOM) increased with depth and decreased with distance from the crest of the weir in all four ponds. Mean particulate organic matter for the 1994-1995 study varied among sites. As reported in 1971-1972 by Harris, the deforested watersheds (3 and 6) had the lowest amounts of detritus, and the forested watersheds (1 and 4) had the highest. This is also true for the 1994-1995 study. Weir pond 4 had the highest amount of detritus which could be a result of it being the largest watershed in area and also having the oldest stand. Weir pond 1 had the next highest amount of detritus and is also older in stand age than WS 3 and 6. The smallest watershed, WS 6, is also the youngest which had the lowest amount of POM. Also, this watershed was converted to a Norway spruce stand in 1973, which adds less organic matter to the stream.

Macroinvertebrate abundance and taxa richness

Mean macroinvertebrate density in the 1994-1995 study did not differ among weir ponds. In the 1971-1972 study, mean density was greater in the forested watersheds (1 and 4) and lower in the deforested watersheds (3 and 6). However, in order to compare these two studies, only common months were used (October, November, March, April, May, June, July, August, September, October). In comparing the two studies, mean macroinvertebrate density was significantly higher for both WS 1 and WS 3 in the 1994-1995 study. Seasonal mean density for the 1994-1995 study did not differ among weir ponds. However, seasonal mean density was significantly lower in the fall in the 1971-1972 study. This is due to the fact that the weir ponds were cleaned of all sediments in August of 1971. A recolonization effect seems to have taken place, with pond densities taking longer than a season to recover.

Zooplankton (ostracods & cladocerans) populations were very high in the 1994-1995 study. These large populations were not present in the 1971-1972 study. However, it is possible that they were not recorded. In a recolonization study (Wallace et al. 1991), it was determined that organisms in the zooplankton community took a much longer time to return after a disturbance (cleaning of weir ponds) than did other aquatic invertebrates. The study found that invertebrate populations returned to pre-disturbance levels within a single year, some within two months. This same finding was present in another study by Christman (1993).

The mean density for the 1994-1995 study with zooplankton data omitted (corrected density) showed that WS 1 and WS 6 were significantly different from the other weir ponds. This was due to the fact that WS 1 and 6 had the highest zooplankton densities. When comparing mean densities of the two studies without zooplankton data (ostracods & cladocerans), the weir ponds are similar except for WS 6. In 1994-1995, WS 6 had the highest population of ostracods and the lowest mean density. Cooler pond temperature and deeper water may be the cause of the lower density in WS 6. As stated before, WS 6 was cleared of all vegetation and planted with Norway spruce (*Picea abies*). This change from a hardwood watershed to a coniferous cover might have an affect on the quality and quantity of water draining from it. According to Kochenderfer (1995), streamflow will decrease as the spruce grow, eventually becoming at least 25 percent less than before the change. A study in Canada found a correlation between macroinvertebrate density and type of biome in which the study stream was located (Corkum 1992). Higher densities were present in a deciduous forest biome, and lower densities in a coniferous forest biome. The lower density in the spruce watershed compared to the deciduous watershed may reflect a similar influence of vegetation on pond fauna at a smaller scale.

Results of the BACI (Before-After/Control-Impact) analysis of the two studies using mean density for common months (zooplankton excluded) suggested that there was a significant increase in mean density for weir pond 3 from 1971-1972 to 1994-1995. It is difficult to determine the reason for this increase due to many factors involved. However, WS 3 has the largest weir pond area with a warmer pond temperature. Sallenave (1991) suggested that even a small increase in water temperature may allow insects to grow faster and emerge earlier as adults thus increasing their productivity. In 1994-1995, weir pond 3 also had the highest levels of nitrates. Krueger and Waters (1983) found that nitrates were positively associated with invertebrate production in three Minnesota streams. The presence of increased nitrate levels produced a favorable environment for macroinvertebrates which in turn produced a higher-quality food. A study by Sallenave (1991) on agricultural watersheds in Ontario had the same results.

Taxa richness was higher in the 1971-1972 study than the 1994-1995 study, even though the weir ponds were cleaned of all sediments in August of 1971. Weir ponds in 1971-1972 had lower macroinvertebrate densities, but higher taxa richness. It is possible that the disturbance of cleaning the weir ponds allowed new and old taxa to recolonize the ponds, which resulted in low densities but high taxa richness. In 1971-1972, weir pond 1 had the highest taxa richness and the lowest mean density. Although speculative, the application of fertilizer to WS 1 in 1971 appeared to have created an environment conducive to a high diversity of genera

(Harris 1973). Weir pond 1 also had the highest levels of nitrates. In the 1994-1995 study, WS 3 had the highest level of nitrates, which also had higher taxa richness. Application of ammonium sulfate to WS 3 three times/year could possible be the reason for this nitrate increase.

The comparison of mean taxa richness for the two studies without zooplankton (ostracods & cladocerans) was significantly lower in WS 1 and 6 for the 1994-1995 study. Zooplankton accounted for 58 percent and 66 percent of the total density for weir ponds 1 and 6. Weir ponds 3 and 4 were similar for both studies regardless of the exclusion of the zooplankton data for the 1994-1995 study. The BACI analysis indicated similar findings, with weir ponds 1 and 6 decreasing slightly in taxa richness.

Macroinvertebrate composition

The family Chironomidae was the most abundant group in all four weir ponds in 1971-1972. However, in 1994-1995 study, the family Chironomidae was only most abundant in weir ponds 3 and 4. Ostracod populations were the most abundant taxon in weir ponds 1 and 6. The dominance of the family Chironomidae in the weir ponds is similar to that of other studies (Christman 1993, Wallace et al. 1991, Sallenave 1991, Feldman 1992).

Zooplankton (ostracods & cladocerans) for the 1994-1995 study was dominated by ostracods with numbers up to $50{,}000/m^2$. However, in the 1971-1972 study they were not seen, but it is possible that they were not recorded. Zooplankton densities were highest in weir ponds 1 and 6, and were dominated by ostracods. Ostracods are found in a variety of environments, but the largest numbers are found in permanent still waters with little or no current typical of deeper water (Locke 1992). Weir pond 6 was the deepest of the weir ponds, and also contained the highest density of ostracods with 66 percent of the total density. Weir pond 1 was deeper than weir ponds 3 and 4, and had a high density of ostracods with 58 percent of the total density. Holopainen (1992) found that low zooplankton densities occurred in ponds with low pH (<6.0). In the 1994-1995 study, weir ponds 3 and 4 had the lower pH values and the lowest zooplankton densities. When comparing the two studies with zooplankton densities omitted from the 1994-1995 study, only weir pond 6 had a significantly lower density in 1994-1995. Although zooplankton had high densities in the 1994-1995 study, when omitted the weir pond densities were similar among studies.

In the 1994-1995, study 60 taxa were collected, in comparison to 66 taxa collected in the 1971-1972 study. Thirty-three taxa were unique to the 1994-1995 study, and 41 taxa were unique to the 1971-1972 study. The family Chironomidae had 27 taxa in 1994-1995 and 11 in 1971-1972, with 21 taxa unique to the 1994-1995 study. The 1971-1972 study only had 5 unique taxa. With difficulty in keying chironomids to genus, it is possible that some chironomids could have been improperly named. In the 1971-1972 study, the genus *Pentaneura* had the highest density among chironomids with $2,388/m^2$. However, in the 1994-1995 study this genus was not found, but a similar genus *Zavrelimyia* was identified. These genera are very similar and are found in the same couplet in keys for the subfamily Tanypodinae.

Four subfamilies of Chironomidae were present in the two studies. The largest subfamily for both studies was Chironominae. However, in 1994-1995 weir pond 6 contained the subfamily Tanypodinae which comprised 76 percent of the total collected, and Chironominae comprised 17 percent of the total collected. This shift in subfamily abundance might be explained by the bottom composition of weir pond 6. Sand was found in greater quantity in weir pond 6, and also a high amount of VPOM. Hornbach (1993) found that Tanypodinae and Orthocladiinae densities were significantly related to sediment size, being found more often in areas with greater proportions of sand. With sand and high VPOM, weir pond 6 supported the highest densities of Tanypodinae and Orthocladiinae. The genus *Procladius*, in the subfamily Tanypodinae, was present in weir pond 6 which represents 36 percent of the total collected. This genus is described as a omnivore with predatory tendencies, which feed on first instar larvae of chironomids and ostracods. As noted before, weir pond 6 had the highest density of ostracods. In both studies, when *Procladius* density was above 10 percent of the total all other chironomids were lower in density. This predator-prey relationship may influence microhabitat utilization by larvae.

The Hornbach (1993) study also found that Chironominae are tube-builders and were more prevalent in areas where sediments are finer. In the 1994-1995 study, weir pond 3 had one of the highest amounts of FPOM which also supported the greatest density of Chironominae. The subfamily Orthocladiinae was present in the 1994-1995 study with densities of 3 to 8 percent of the total collected. However, in the 1971-1972 study, Orthocladiinae was only represented in weir pond 1 with 3 percent of the total collected. As seen in the 1994-1995 study, the majority of the Orthocladiinae density was collected in the winter months (December, January, February). In the 1971-1972 study, no collections were made during these months due to bad weather and ice.

Other studies have indicated that there is a great deal of temporal and spatial variability in chironomid assemblages. Variation in temperature resulted in differences in life cycle patterns and changes in depth preference varied with age. Hornbach (1993) found that sediment size was the most important factor in the structure of midge assemblages in a stream. A study in Austria found that differences in microdistribution have been observed among successive instars of a given chironomid species, and between different species in interstitial sediments (Schmid 1992). Physical factors such as substrate heterogeneity, and particle size composition may influence microhabitat utilization and patch formation by larvae (Schmid 1992). Larval patches not only fluctuated seasonally but with depth, indicating resource segregation between and among species (Schmid 1992).

This diversity of relationships implies that there are complex interactions at the population level, and in turn they may affect both spatial and temporal aspects of community structure.

CHAPTER VII

SUMMARY AND CONCLUSIONS

(1) Benthic fauna of weir ponds draining watersheds of the Fernow Experimental Forest was collected from October 1994 to October 1995.

(2) The objectives of this study were: (a) to relate differences in weir pond faunas to watershed treatments on the FEF, and (b) to compare current weir pond faunas to those described in 1973 by Steve Harris.

(3) Two quantitative bottom fauna samples were randomly taken from each weir pond using a staff-mounted Ekman dredge measuring 24x24 cm.

(4) Various physical and chemical parameters were also measured including, depth, temperature, water chemistry, and particulate organic matter.

(5) Sixty taxa were identified in the 1994-1995 study, and sixty-six taxa were identified in the 1971-1972 study. Mean density for the 1994-1995 study varied from $1,000/m^2$ to $20,000/m^2$. Mean density for the 1971-1972 study varied from $500/m^2$ to $17,000/m^2$.

(6) Taxa richness was higher during the 1971-1972 study, even though weir ponds were cleaned of all sediments in August 1971.

(7) The family Chironomidae was the most abundant group in all four weir ponds in the 1971-1972 study. In the 1994-1995 study, Chironomidae was only most abundant in weir ponds 3 and 4. In weir ponds 1 and 6, ostracod populations were the most abundant taxon.

(8) Zooplankton (ostracods & cladocerans) populations were very high in the 1994-1995 study. They accounted for 58 percent and 66 percent of the total density for weir ponds 1 and 6. These large populations were not present in the 1971-1972 study, however it is possible that they were present but not recorded.

(9) In the 1994-1995 study, alkalinity levels were lower and nitrate levels higher than the 1971-1972 study.

(10) Total particulate organic matter increased with depth and decreased with distance from the crest of the weir in all four ponds.

(11) Mean macroinvertebrate density for the 1994-1995 study among weir ponds showed no significant difference. In the 1971-1972 study, mean density was greater in the forested watersheds (1 and 4) and lower in the deforested watersheds (3 and 6).

(12) Variation in temperature, depth, substrate heterogeneity, and particle size composition may influence microhabitat utilization and patch formation of the benthic fauna in the weir ponds of the FEF.

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