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The Abundance and Distribution of Macroinvertebrates in Relation to Macrophyte Communities in Swan Lake, Nicollet County, MN

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ABSTRACT

We compared the macroinvertebrate communities among vegetation types in Swan Lake, a large prairie marsh in south-central Minnesota. Activity traps and sweep nets were used to sample macroinvertebrates during the summer months of 1992 and 1993. Twenty-four sites on the lake were sampled along six established transects. Each site was located in one of four different habitats, including three major macrophyte communities: *Typha angustifolia, Scirpus acutus, Potamogeton* spp., and an open water site having little or no vegetation. The diversity, relative abundance, and biomass of the invertebrates collected from each vegetation type were compared to assess which type of vegetation supported the greatest numbers and most diverse invertebrate fauna. A total of 16 orders, 46 families and 93 genera were identified. Results suggest that the open water sites produced the largest number of organisms, whereas the *Typha* sites produced the largest total biomass of invertebrates. Nine orders showed a significant difference in abundance between vegetation communities, but there was not a significant difference of any order in biomass between vegetation types. There was a significant difference in the mean diversities between vegetation community types. *Typha* sites supported the most diverse populations of macroinvertebrates and the open sites produced the least diverse populations. The abundance of six orders was significantly different between years and may be attributed to fluctuating water levels. Our results suggest that the occurrence and abundance of certain macrophyte communities may enhance the quality of a marsh for consumers of macroinvertebrates.

Key Words: macroinvertebrate communities, macrophyte, distribution, abundance, diversity, Swan Lake

INTRODUCTION

A number of studies have compared the ability of different species of macrophytes to support varying densities of invertebrate communities (Berg 1949; McGaha 1952; Krull 1970; Soszka 1975; Gerrish and Bristow 1979; Chilton 1990). These studies showed that the abundance and distribution of invertebrates varies greatly over time and that some plants support greater numbers, higher diversity, and greater biomass of organisms than others (McGaha 1952; Krull 1970; Chiffon 1990). The surface area of the plant and the leaf morphology may have an important effect on a plant's ability to support macroinvertebrates (McGaha 1952) and chemicals secreted by the plants may also be a factor influencing the total possible number of invertebrates present (Krull 1970). Krull (1970) noted that those communities with higher plant surface area tended to support larger invertebrate populations. Many insects are dependent on the litter deposited as vegetation dies and sinks to the bottom and this may also play a role in determining which plants support the greatest numbers of macroinvertebrates (Nelson et al. 1990). Until recently, studies of plant-invertebrate interactions have concentrated on the invertebrates associated with individual plant species and less attention has been paid to invertebrates supported at the community level. The objectives of this study were to qualitatively survey the macroinvertebrate diversity of Swan Lake and to determine the numbers, biomass, and distribution of invertebrates in relation to vegetative community type. The resulting data from this study allow one to determine which macroinvertebrates are present in Swan Lake and which macrophyte communities support the greatest number and diversity of invertebrates. Extrapolation of this information could be used in the management of the lake for macrophyte, macroinvertebrate, and waterfowl populations.

Historically, studies on waterfowl food availability and the quality of wetlands have concentrated on plant communities (Krull 1970). However, macroinvertebrates have recently been recognized as an important component in the diets of both nesting and juvenile waterfowl (Swanson et al. 1979; Krapu 1979). The availability of invertebrate foods depends on the availability of high quality plant habitat which generally produces an abundant supply of aquatic animals (Swanson et al. 1979). Consequently, proper management of waterfowl must include consideration of plant communities and their ability to produce and support invertebrate populations. Swan Lake has historically been an excellent haven for waterfowl and other wildlife. In a 1917 U.S. Biological Survey report, Swan Lake was referred to as the most important waterfowl lake within the Great Plains Region (Department of Natural Resources, State of Minnesota 1993), and it is this important habitat for wildlife which merits the study of the macroinvertebrates of Swan Lake.

METHODS

Site description

Swan Lake is a major waterfowl lake located in Nicollet county in south central Minnesota. The lake has an average depth of one meter and covers approximately 4,000 hectares, making it the largest prairie pothole marsh in America. The surrounding land is primarily agricultural and is used for pasture, row crop farming, and hay. The lake is fed by five county ditches and three field drainage ditches. The watershed is relatively small (about 8,000 hectares) and until recently, water levels were erratic;. In 1989, a control structure was constructed at the outlet by the Minnesota Department of Natural Resources (MNDNR) to regulate the lake level, allowing important vegetation to become reestablished. Thirty-three species of aquatic plants have been identified in the lake by the MNDNR (MN Division of Game and Fish Section of Research and Planning 1967). The dominant emergent vegetation types of Swan Lake are hardstem bulrush (*Scirpus acutus*) and narrowleaf cattail (*Typha angustifolia).* The sediment varies from soft muck to hard sandy substrate and generally contains a large amount of organic detritus.

Sampling Methods

Six transects were established 60 degrees apart that originated from the approximate center of the lake and continued to shore. We identified four major vegetation zones along each transect: (1) narrowleaf cattail *(Typha angustifolia),* (2) hardstem bulrush (*Scirpus acutus),* (3) submerged vegetation dominated by *(Potamogeton* spp.), and (4) open water with the bottom usually dominated by filamentous algae. A permanent sample station was established within each vegetation community along the six transects resulting in a total of 24 sample stations. Sampling stations consisted of a 1 m crossbar on a vertical 3 m length of electrical conduit, embedded in the bottom substrate.

Samples were collected every two weeks from May through mid-August. We completed three surveys in 1992 and four surveys in 1993. Quantitative data were collected by two methods; the first procedure used activity traps as modified from Riley and Bookhout (1990). Three activity traps were hung vertically from each sampling station at a depth of approximately 25 cm below the waters surface; traps were retrieved after seven days. Formaldehyde-saturated foam inside of the traps preserved the organisms until the traps were collected. The second procedure used semiquantitative sweep net samples taken with a standard A-frame net. Two sweep net samples, each one meter in length were taken at each site. One sample was taken at surface level and the second sample was taken at the bottom. Samples were poured through a 0.4 mm sieve and invertebrates retained on the sieve were preserved in 10% Formalin and returned to the lab for processing.

Laboratory Procedures

Using a light table and stereo dissecting microscope, each sample was hand sorted from the substrate and identified to the lowest possible taxa, usually genus. Chironomids were identified only to family. Samples that contained large numbers of individuals of one taxonomic group, such as chironomidae, hyalellidae, and corixidae were subsampled. Subsamples were taken by thoroughly mixing the sample in a glass tray which was delineated into quarters and then randomly choosing one-fourth of the total organisms. Sorted invertebrates were grouped by order and by vegetation type from which they were collected. Organisms were oven-dried at 140° C for 24 h, cooled in a desiccator, and weighed to the nearest 0.0001 g to determine dry weight biomass. The organisms were dried in a consistent fashion to confirm that all of the samples had dried to a constant weight. Voucher specimens were retained, and organisms of uncertain taxonomy were confirmed by personnel at the National Fisheries Research Center, Lacrosse, WI.

Data Analysis

Data from the activity traps and the sweep nets were combined to quantitatively determine the number of organisms and grams biomass per catch effort at each site. The data were not normally distributed and could not be transformed to fit a normal distribution; therefore, a non-parametric Kruskal-Wallis test of significance was used to compare total numbers of organisms collected between years, and the mean abundance and biomass for each vegetation type within each year. An overall family-wise significance level of 0.05 was determined by the Bonferroni method (Sokal and Rohlf 1969). A Shannon-Weiner index of diversity was also calculated for each vegetation community (Chiffon 1990).

RESULTS

We collected macroinvertebrates from four classes, representing 16 orders, 46 families and 93 genera (Table 1). Many taxa were rare; eight taxa were collected only once and many others were found in low numbers. Twenty-eight taxa were common to all communities, whereas 20 were found in only one vegetation type (Table 4). Six orders showed a significant difference in abundance between the two years (Acari, Conchostraca, Diptera, Ephemeroptera, Hirudinea, and Trichoptera). The three most abundant orders found were Amphipoda (Hyallela), Hemiptera *(Corixidae, Pleidae, Natonectidae),* and Mollusca (*Basommatophora*, which will be referred to as Mollusca). The total number of organisms was highest in the open sites [29,190] and lowest in the *Typha* sites [21,999] (Fig. 1). Total biomass was greatest in the *Typha* vegetation areas [111.7g], and lowest in the open sites [30.4g] (Fig. 2).

The mean number of organisms was compared among vegetation type (Fig. 3). Nine orders (Atari, Amphipoda, Diptera, Hemiptera, Hirudinea, Isopoda, Mollusca, Odonata, and Trichoptera) showed a significant difference in abundance between the plant communities. Four orders were most abundant in *Typha* (Hirudinea, Isopoda, Mollusca, and Odonata). Otherwise, there was no significant difference in abundance between communities. The total of all the orders combined did not show a significant difference in abundance among habitats (P>.05,K-W test statistic <12.84). The mean biomass of each order was also compared (Fig. 4). None of the orders showed a significant difference in biomass between vegetation types.

There was no significant difference in mean diversities between the two years (Table 2). However, there was an overall significant difference in mean diversity between vegetation types (Table 3). *Typha* vegetation generally supported the most diverse populations and open sites supported the least diverse populations.

DISCUSSION

This study suggests that there are qualitative and quantitative differences in invertebrate communities between vegetation types, but that the distribution in wetland systems is not as strongly influenced by surface morphology as one would predict based on previous research (Krecker 1939; Rosine 1955; Downing 1981; Dvorak and Best 1982). Six orders differed significantly in abundance between the two years. Factors responsible for these differences are difficult to identify, but one conspicuous variable between years was water level. The summer of 1993 had exceptionally high precipitation and the increased lake depth resulted in fewer submerged vegetation areas throughout the lake. One of the six transects never developed any submerged sites in the summer of 1993 and this was adjusted for in the statistical tests. This lack of submerged sites could cause the submerged sites to appear less productive in terms of total numbers and total biomass of invertebrates than they actually are. Even so, this study implies that open sites tended to support larger populations relative to the other three vegetation types containing more surface area and available substrate. Previous studies (Krecker 1939; Dvorak and Best 1982; Cyr and Downing 1988; Beckett et al. 1991) have generally suggested that a relationship exists between large surface area of a macrophyte community and the high number of macroinvertebrates supported.

Nine orders showed a significant difference in distribution between vegetation types, but none of the orders showed a significant difference in biomass between vegetation types. Submerged sites which contained plants with dissected leaves rarely produced higher numbers or biomass of invertebrates than communities containing plant types with less surface area. The high number of Diptera found in open water sweep net samples can be explained by the large number of chironomid larvae found in the filamentous algae which dominated the bottom of open sites. Hemipterans were also quite prevalent in open water trap samples and this is because they live close to the surface of open water areas; diving to feed and surfacing for air. The open water sites had the lowest total biomass, whereas the *Typha* sites produced the greatest biomass due to the large number of molluscs associated with these sites. Factors other than plant type and surface area may also affect the patterns of macroinvertebrate abundance. Chilton (1990) suggested that the close proximity of differing plant communities could allow for emigration and immigration of invertebrates between macrophytes. Although our sample stations were positioned in such a manner that they were located in relatively pure stands of macrophyte communities, it is possible that the distances between adjacent plant communities allowed for the migration of macroinvertebrates. In habitats other than wetland marshes, the plant species composition tends to play a larger role in the distribution of invertebrates as documented by Krecker (1939) and Gerrish and Bristow (1979).

Mean diversity was significantly different between vegetation types. The Typhasites supported the most diverse populations of macroinvertebrates and the open sites produced the least diverse populations. We attribute this difference to the greater surface area provided by the vegetation types (McGaha 1952; Krull 1970; Downing 1981). Increased surface area of vegetation may provide protection from predators (Krecker 1939; Harrod 1964) and more substrate for growth of periphytic algae, which is an important food source of many invertebrates (Dvorak and Best, 1982). Invertebrates utilize plants as a direct food source, sites for oviposition, and sources of respiratory oxygen (Rooke 1984).

In this study, invertebrate populations displayed seasonal trends similar to those previously reported (Gregg and Rose 1985; Chilton 1990). Most populations were greatest at the beginning of the summer and declined as the summer progressed with the exception of those organisms with a longer development period such as Lepidoptera and Trichoptera.

Sampling of macroinvertebrates in heavily vegetated areas can be difficult to do because of the close association of the invertebrates to the vegetation. Activity traps have been used in past studies (Hanson and Swanson 1989) as a convenient way to collect invertebrates with a minimum amount of work in separating the organisms from the substrate. The traps also have the added feature of only collecting those organisms which are moving at the depth of the trap and effectively isolate the organisms from any plants which may be present. The sweep net samples were used to supplement the trap samples in an attempt to lessen the bias associated with any one technique.

Our data suggest a high variability of numbers within the populations of macroinvertebrates. This high variability of invertebrate populations has been noted before by Rosine (1955) and Krull (1970), and can be explained by a number of causes including normal die off, hatching of eggs, pupation, emergence, and patterns of predation, local movements and uneven distribution.

In conclusion, it is important to recognize the role that plant communities play in supporting macroinvertebrate populations with possible implications for wetland management practices. The present study suggests that there are qualitative and quantitative differences in macroinvertebrate abundance and diversity among different vegetation communities. It also implies that changing water levels play a large role in the abundance of certain organisms in a wetland ecosystem. In order to optimally manage a wetland marsh, such as Swan Lake, one must take the plant communities as well as the macroinvertebrate populations into account. For example, to provide maximum protein biomass for young foraging birds, managing the lake to enhance Typha growth should result in large macroinvertebrate populations which could in turn increase chick survival.

ACKNOWLEDGMENTS

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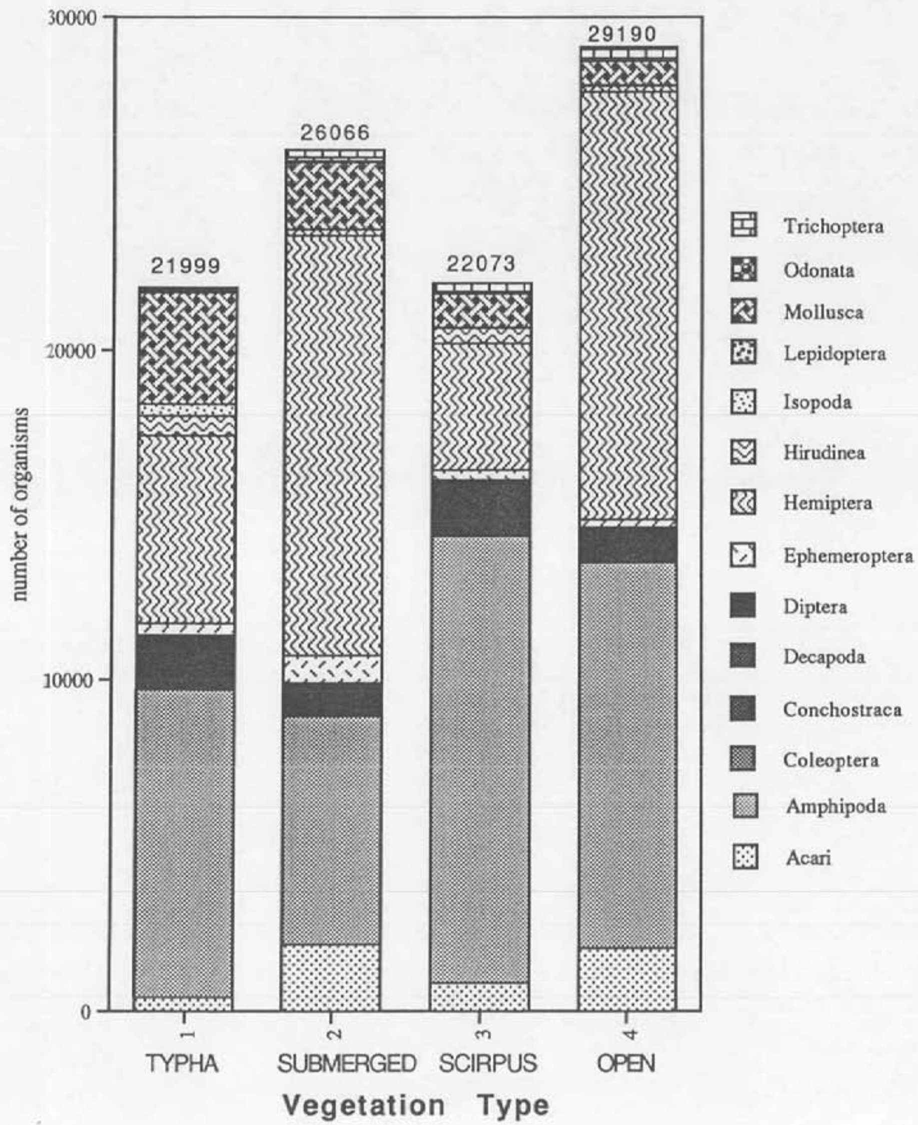
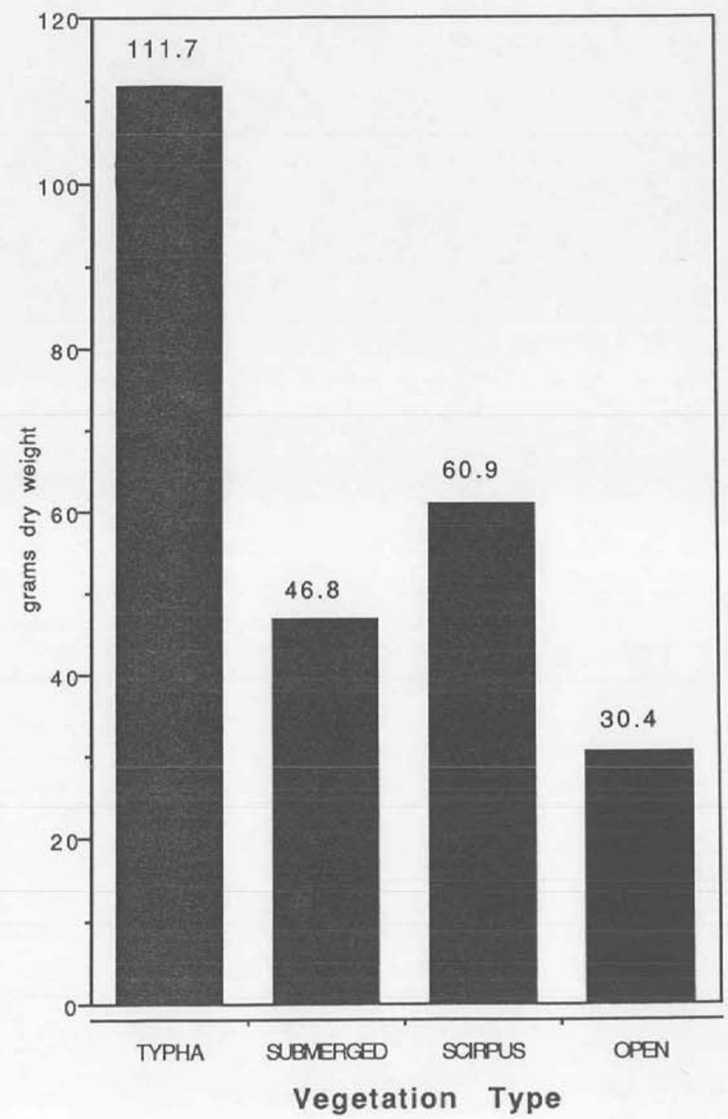
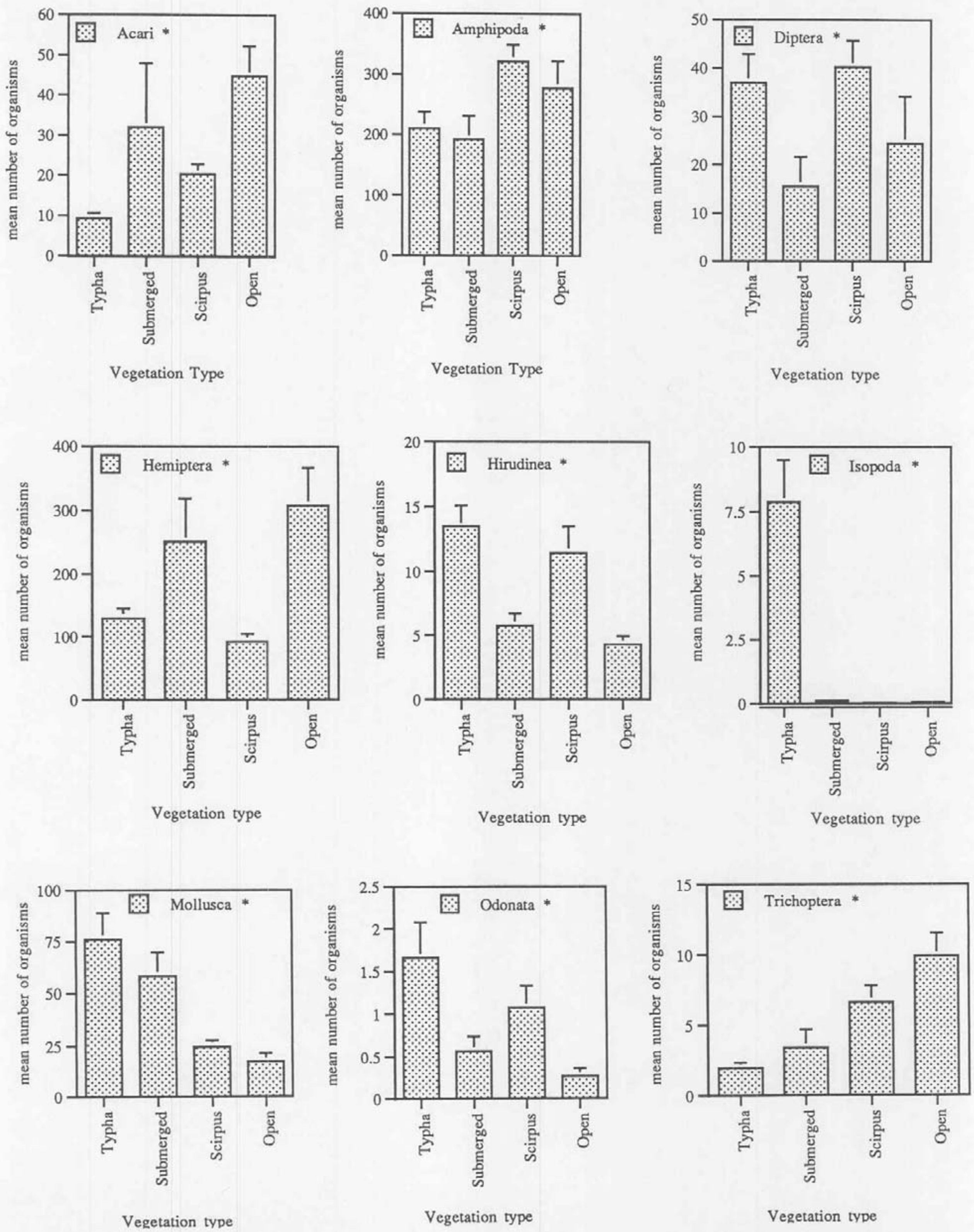
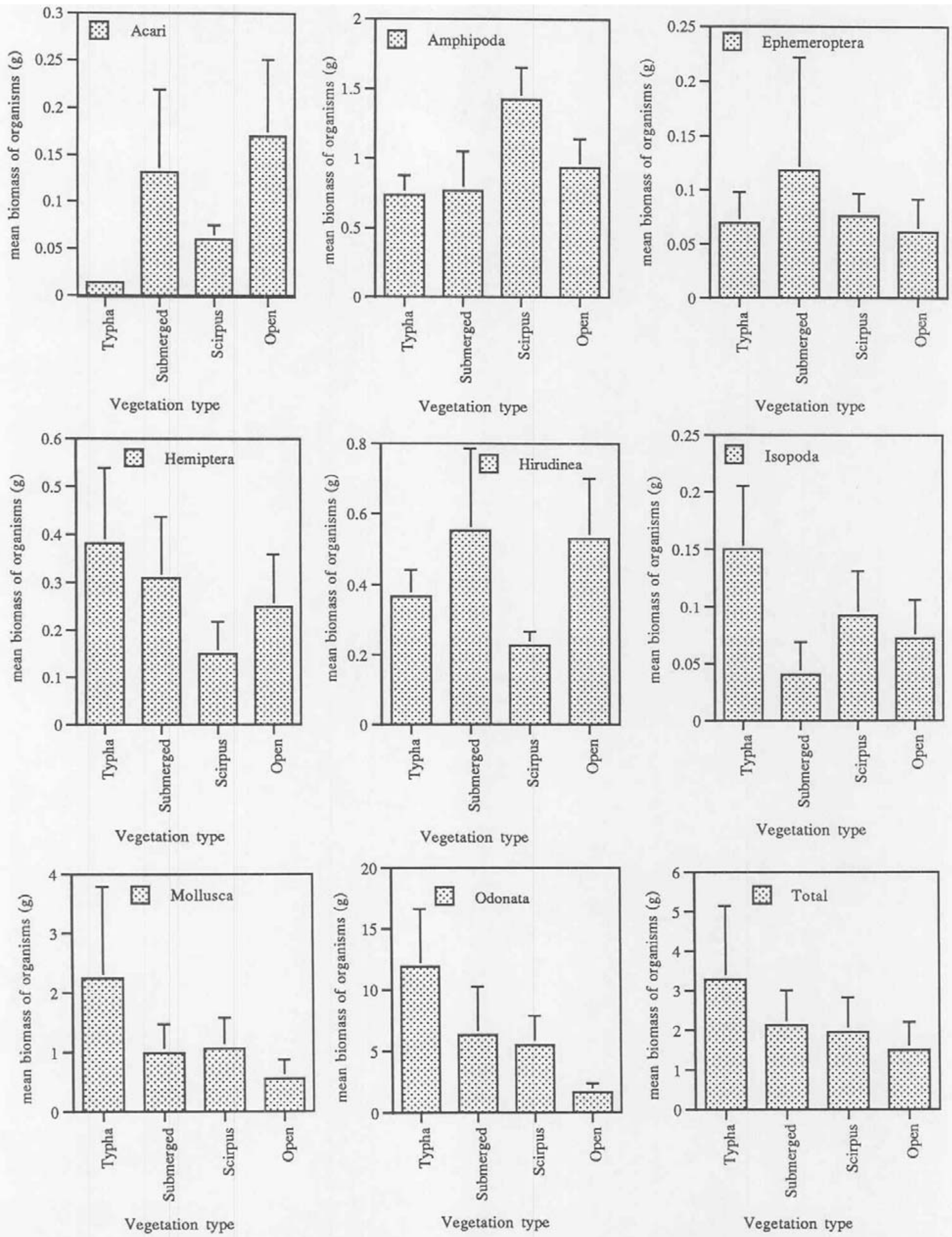


number of organisms
30000
20000
10000
0
21999
26066
22073
29190
1
2
3
4
TYPHA
SUBMERGED
SCIRPUS
OPEN
Vegetation Type
Trichoptera
Odonata
Mollusca
Lepidoptera
Isopoda
Hirudinea
Hemiptera
Ephemeroptera
Diptera
Decapoda
Conchostraca
Coleoptera
Amphipoda
Acari



grams dry weight
120
100
80
60
40
20
0
111.7
46.8
60.9
30.4
TYPHA
SUBMERGED
SCIRPUS
OPEN
Vegetation Type


Acari *
Amphipoda *
Diptera *
Hemiptera *
Hirudinea *
Isopoda *
Mollusca *
Odonata *
Trichoptera *
mean number of organisms
Typha
Submerged
Scirpus
Open
Vegetation Type
Vegetation type



Acari
Amphipoda
Ephemeroptera
Hemiptera
Hirudinea
Isopoda
Mollusca
Odonata
Total
mean biomass of organisms (g)
Typha
Submerged
Scirpus
Open
Vegetation type

Order	Family	Genus	Order	Family	Genus
Acari	Hydrachnidae*	*spp.*			*Psectrotanypus*
Amphipoda	Hyalellidae	*Hyalella*			*Pseudochironomus*
Coleoptera	Chrysomelidae	*Donacia-Larv.*			*Tanypus*
		Neohaemonia		Ephydridae	*spp.*
	Curculionidae*	*spp.*		Sciomyzidae	*Antichaeta*
	Dytiscidae	*Agabus-L*		Stratiomyidae	*Hedriodiscus*
		Agabus-Adult		**Pupae	
		Dytiscus-L	**Ephemeroptera**	Baetidae	*Baetis*
		Graphederus-A			*Callibaetis*
		Hydrovatus		Caenidae	*Caenis*
		Hygrotus	**Hemiptera**	Belostomatidae	*Belostoma*
		Ilybus		Corixidae*	*spp.*
		Laccophilus-L		Gerridae	*Gerris*
		Laccophilus-A		Hebridae	*Hebrus*
		Liodessus-L			*Merrogata*
	Elmidae	*Narpus-A*		Mesoveliidae	*Mesovelia*
	Haliplidae	*Haliplus*		Nepidae	*Ranatra*
		Peltodytes-L		Notonectidae	*Buenoa*
		Peltodytes-A			*Notonecta*
	Hydrophilidae	*Berosus*		Pleidae	*Plea*
		Enochrus-L		Saldidae	*spp.*
		Hydrochara		Veliidae	*Microvelia*
		Hydrochus-L	**Hirudinea***	-------	*spp.*
		Tropisternus	**Isopoda**	Asellidae	*Caecidotea*
	Staphylinidae	*Stenus*	**Lepidoptera**	Pyralidae	*Acentria*
Conchostraca	Caenestheriidae	*Cyzicus*			*Neocataclysta*
	Lynceidae	*Lynceus*			*Nymphula*
Decapoda	Cambaridae	*Orconectes*	**Mollusca**	Lymnaeidae	*Lymnaea*
Diptera	Ceratopigonidae	*Bezzia*		Physidae	*Physa*
		Serromyia		Planorbidae	*Gyraulus*
		Stilobezzia			*Helisoma*
	Chaoboridae	*Chaoborus*			*Promenetus*
	Chironomidae	*Ablabesmyia*	**Nematoda***	-------	*spp.*
		Chironomus	**Odonata**	Aeshnidae	*Aeshna*
		Cladopelma			*Anax*
		Cladotanytarsus		Coenagrionidae	*Enallagma*
		Cricotopus			*Ischnura*
		Cryptochironomus			*Nehalennia*
		Dicrotendipes		Lestidae	*Lestes*
		Endochironomus		Libellulidae	*Libellula*
		Glyptotendipes			*Sympetram*
		Kiefferulus			*Tramea*
		Parachironomus	**Oligochaeta***	-------	*spp.*
		Paratanytarsus	**Trichoptera**	Hydroptilidae	*Agraylea*
		Phaenopsectra		Leptoceridae	*Leptocerus*
		Polypedilum			*Oecetis*
		Procladius			*Triaenodes*
		Psectrocladius		Phryganeidae	*Agrypnia*

* specimens were not keyed any further

Mean Shannon-Wiener Diversity Indices		
between years 1992 vs 1993		
	1992	1993
Typha	1.7	2.05
Submerged	1.84	2.14
Scirpus	2.14	1.84
Open	2.05	1.7
P=0.072		
P>0.05 and not significant		
Mean Shannon-Wiener Diversity Indices		
1992 and 1993 combined		
	S-W index	**Standard error**
Typha	2.35	0.086
Submerged	2.075	0.079
Scirpus	1.943	0.069
Open	1.681	0.075
P=0.000		
P<0.05 and significant		
Taxa Found in Only One Macrophyte Community	**Taxa Common to All Veg. Communities**	
Ty: Coleoptera, Curculionidae, spp.	Acari, Hydrachnidae, spp.	
Ty: Coleoptera, Dytiscidae, Agabus-Larvae	Amphipoda, Hyallelidae, Hyallela	
Ty: Coleoptera, Dytiscidae, Agabus-Adult	Coleoptera, Dytiscidae, Dytiscus-Larvae	
Sc: Coleoptera, Dytiscidae, Graphederus-Adult	Coleoptera, Haliplidae, Peltodytes-Adult	
Ty: Coleoptera, Dytiscidae, Hygrotus	Conchostraca, Caenestheriidae, Cyzicus	
Op: Coleoptera, Dytiscidae, Ilybus	Diptera, Ceratopigonidae, Bezzia	
Op: Coleoptera, Dytiscidae, Laccophilus-Larvae	Diptera, Chaoboridae, Chaoborus	
Ty: Coleoptera, Dytiscidae, Liodessus-Larvae	Diptera, Chironomidae, spp.	
Ty: Coleoptera, Hydrophilidae, Enochrus-Larvae	Diptera, Pupae	
Ty: Coleoptera, Hydrophilidae, Hydrochus-Larvae	Ephemeroptera, Baetidae, Callibaetis	
Ty: Diptera, Stratiomyidae, Hedriodiscus	Ephemeroptera, Baetidae, Caenis	
Ty: Hemiptera, Belostomatidae, Belostoma	Hemiptera, Corixidae, spp.	
Op: Hemiptera, Hebridae, Merrogata	Hemiptera, Pleidae, Plea	
Ty: Hemiptera, Saldidae, spp.	Hirudinea, spp.	
Ty: Hemiptera, Veliidae, Microvelia	Isopoda, Asellidae, Caecidotea	
Ty: Lepidoptera, Pyralidae, Nymphula	Mollusca, Lymnaeidae, Lymnaea	
Ty: Odonata, Aeshnidae, Aeshna	Mollusca, Physidae, Physa	
Ty: Odonata, Lestidae, Lestes	Mollusca, Planorbidae, Gyraulus	
Ty: Odonata, Libellulidae, Libellula	Mollusca, Planorbidae, Helisoma	
Sb: Odonata, Libellulidae, Sympetram	Mollusca, Planorbidae, Promenetus	
	Nematoda, spp.	
Ty: =Typha	Odonata, Aeshnidae, Anax	
Sb: =Submerged	Odonata, Coenagrionidae, Enallagma	
Sc: =Scirpus	Oligochaeta, spp.	
Op: =Open	Trichoptera, Hydroptilidae, Agraylea	
	Trichoptera, Leptoceridae, Leptocerus	
	Trichoptera, Leptoceridae, Oecetis	
	Trichoptera, Leptoceridae, Triaenodes	

Table 1. Invertebrate taxa identified from Swan Lake.

Table 2. Invertebrate taxa collected from only one macrophyte community and those taxa collected from all four of the plant communities.

Table 3. The mean Shannon-Wiener Diversity Indices between years (1992 vs. 1993). $P<0.05$ is significant.

Table 4. The mean diversity between vegetation communities for 1992 and 1993 combined (Shannon-Wiener Diversity Index). $P<0.05$ is significant.

Figure 1. The number of total organisms collected in each order for four vegetation communities for 1992 and 1993.

Figure 2. The total biomass of all organisms versus vegetation type for 1992 and 1993.

Figure 3. The mean number of organisms versus vegetation type. The error bars are standard error bars. A " denotes those orders which show significant differences in abundance among habitats, $P\leq.001$ and the Kruskal-Wallis test statistic >12.84.

Figure 4. The mean biomass of organisms (grams) versus vegetation type. The error bars are standard error bars.