MACROINVERTEBRATE DIVERSITY AND FUNCTIONAL GROUP COMPOSITION IN THE EMERGENT PLANT ZONE OF PRENTISS BAY MARSH, MICHIGAN

By

K. D. Levy and R. W. Merritt
Department of Entomology
Michigan State University
East Lansing, MI 48824

Abstract

We investigated the spatial and temporal distribution of macroinvertebrates in a freshwater marsh in Les Chenaux Island Northern Bioreserve, Prentiss Bay, Michigan. The pristine marsh was divided into transects at two distinct sites. Macroinvertebrates were sampled along both transects over a four month period using a D-frame aquatic dip net. We performed a functional feeding group analysis of macroinvertebrates to evaluate trophic dynamics in relation to food resources. The depositional site gradually increased in depth with distance from shore and supported a diverse plant community dominated by*Typha angustafolia, Sagittaria latifolia, Potamegton natans* and *Scirpus subterminalis* . This site also supported a great diversity of benthic and epiphytic macroinvertebrates, predominantly consisting of collectors (gatherers and filterers) and shredders. The erosional site consisted of a small rock embankment that had a sharper gradient slope than the depositional area with significant wave action. *Scirpus acutus* dominated the plant community. The macroinvertebrate community of the erosional site was mainly dominated more by collectors, due to decreased plant diversity and density. Functional group ratios were used to evaluate ecosystem attributes, such as autotrophy/heterotrophy (P/R) ratios, benthic storage, and habitat stability.

Introduction

Freshwater invertebrates in marshes are an important food source for many waterfowl and fish species and play an essential role in the transfer of energy. Macroinvertebrates are used for evaluation of ecological conditions of aquatic habitats because: (1) they are ubiquitous and affected by perturbations in many different aquatic habitats; (2) the large number of species exhibit a range of responses to environmental stress; and (3) their sedentary nature and relative long life cycles allow for analysis of temporal and spatial disturbances (Rosenberg and Resh 1996).

Considering the perturbations that the Great Lakes are exposed to, such as suspended sediments and pollutants (Krieger 1984, 1992), the need for conservation of endemic species of invertebrates and their habitats is imperative. The Great Lakes contain about 200 species of fish; 90% of these are directly or indirectly dependent on wetlands for food and shelter during some portion of their life cycle (Whillans 1990). Despite the apparent importance of macroinvertebrates as a food source for fish, comparatively little is known of the distribution, composition and ecology in these habitats. Additionally, one finds little mention of the contributions of invertebrates to energy and materials flow in wetland food webs (Krieger 1992) and of invertebrate community regulation procedures to evaluate biotic integrity of wetland habitats (Batzer and Wissinger 1996).

The Great Lakes marshes are presently areas of interest for many biologists. Studies have focused on the general structure of pelagic and marsh zooplankton communities and pelagic-littoral mixing zones and its effects on macroinvertebrate distributions (Robertson and Grannon 1981, Balcer et al

1984). Less is known about other invertebrates, particularly insects inhabiting benthic substrates, plant surfaces or the water surface. Brady (1994) found that invertebrate community structure was less diverse in sandy sediments of Sagniaw Bay in contrast to the planktonic zones or on the vegetation. The macrophytes in Brady's system provided a stable substrate for abundant periphyton growth and increased protection from physical factors such as wave action (Brady 1994). Cardinale (1996) working in the same marsh found that the pelagic-littoral mixing was correlated with biotic distributions of algae and epiphytic invertebrate communities. He also found that the pelagic-littoral mixing gradient influenced distributions of epiphytic organisms on a seasonal basis (e.g., the thickening of *Scirpus* stands ultimately inhibited water circulation).

The goal of this study was to add information to the growing data base of macroinvertebrates in freshwater coastal wetlands. Specific objectives included: 1) determining the diversity and relative abundance of aquatic macroinvertebrates present in the marsh community; 2) comparing the distribution of macroinvertebrates among different habitats within the marsh; and 3) examining functional feeding group relationships among marsh macroinvertebrates (Merritt and Cummins 1996; Cummins and Wilzbach 1985).

Materials and Methods

Site Description

Prentiss Bay marsh is on Lake Huron, approximately 100 km north-east of St. Ignace, Michigan (Figure 1). This marsh is approximately 1 km in length by 0.5 km in width. The study area is part of Les Chenaux Island Bioreserve wetland complex. It is protected from extreme wave action from Lake Huron and has a number of diverse microhabitats.

We sampled this marsh based on two different habitats, an erosional and depositional zone. The first site, a depositional zone, gradually increased in depth to approximately 1 m with distance from shore and had less wave action than the erosional zone. A southwest transect through this zone intersected a diverse vegetation community dominated by*Typha angustifolia, Sagittaria latifolia, Potamogeton natans, Potamogeton richardsonii, Scirpus subterminalis, Nuphar variegata* and a significant amount of detritus buildup from these plants. The second site, an erosional zone, had a sharper gradient slope than the depositional zone, greater wave action, lower detritus accumulation, and a small rock jetty. This eastern transect intersected less diverse vegetation, and included *Scirpus acutus* and*Utricularis gibba.* The maximum depth of water sampled was 1 meter (Fig. 1).

Sampling Methods

All macroinvertebrates sampled were collected from fixed transects laid throughout the marsh (Fig. 1). The transects were chosen to intersect typical vegetation types and depths within the marsh. Samples were taken once a month from June to September 1996.

The benthic samples consisted of randomly selected, timed 30-second sweeps using a D-frame dip net (0.3 m wide with a 500 μm mesh) along the transects. Three locations on each transect were sampled. For the depositional zone transect, the locations were 40 m apart with an average minimum depth of 30 cm and an average maximum depth of 1 m. For the erosional zone transect, the locations were 15 m apart with an average minimum depth of 30 cm and an average maximum depth of 1 m. Each sweep was conducted in a 0.5 m area, therefore the total approximate area of each sweep was 0.15 m^2. At each transect, three samples (replicates) were taken, sieved with a 250 μm mesh standard sieve and preserved in 95 % ethanol in the field.

In the laboratory, the preserved samples were sorted under 10x magnification using Rose Bengal dye, which stained the protein in the samples a neon pink, speeding and increasing the accuracy of the identification process (Mason and Yevich 1967). All invertebrates were keyed down to the lowest taxonomic level possible using Merritt and Cummins (1996) and when required, sent to specialists for species confirmation.

Data Analysis

The data we collected were semi-quantitative, therefore, we compared relative macroinvertebrate abundance and diversity between habitats. The total number of macroinvertebrates in the depositional zone, Site 1, and the erosional zone, Site 2, were analyzed using a three-factor (site, date, location on transect) ANOVA. The macroinvertebrates counts were Log10(x+1) transformed prior to analysis to equalize variances (deSzalay et al. 1996, SYSTAT 1995).

The simplest measurement of species diversity is a count of the number of species present (Margalef 1957). The Shannon-Weaver method, however, is based upon the degree of community organization and relies on the premise that the information content of a community can be expressed as a probability with which the species of the next individual randomly sampled from the community can be correctly predicted (Cameron 1972). Diversity was determined between sites and among trophic categories using Shannon's diversity index. The formula used to express diversity was:

$$H' = -\sum_{i=1}^{s} p_i \log p_i$$

where $p_i = n_i/N$, N = total number of individuals, and n_i = the number of individuals in each of *s* species, where i= 1, 2. . . . ,*s*.

We examined the trophic structure of the macroinvertebrates by grouping taxa into functional feeding group categories based on Merritt and Cummins (1996). Functional feeding group analysis is based on the association between a limited set of feeding adaptations found in freshwater invertebrtates and their basic nutritional resource categories. This approach is based on readily discernible morphological, behavioral and life history attributes of invertebrate taxa rather than on species identity. Invertebrate taxa are differentiated into <u>shredders</u>, that feed on coarse particulate organic matter (CPOM), <u>scrapers</u> that harvest periphtyon and associated material from substrate surfaces, <u>collectors</u> of fine particulate organic matter (FPOM), and <u>predators</u> that capture live prey (Merritt and Cummins 1996). The value of such an approach is that these attributes relate more directly to the system ecology and ecosystem integrity than does taxonomy *per se* (Merritt et al. 1996).

We examined five different macroinvetebrate functional feeding group and other process oriented ratios (e.g., life history, food web) as indicators of marsh ecosystem attributes (Table 1)(Merritt et al. 1996). An example of an ecosystem level prediction based on invertebrate functional group analysis would be the use of the ratio: scrapers plus live vascular hydrophyte shredders as a proportion of CPOM (detrital vascular plant) shredders plus total collectors. This ratio can serve as an analog to P/R, that is, the ratio of gross primary production to community respiration, or, more generally the ratio of autotrophy to heterotrophy (Table 1). Because P/R provides an evaluation of the balance between autotrophy and heterotrophy, it is an excellent indicator of overall ecosystem organization and function. Habitat stability, or scrapers + filtering collectors as a proportion of total shredders + gathering collectors, is based on the habit of macroinvertebrates (sprawlers, burrowers, clingers, climbers, etc.). This ratio measures the available surfaces for stable attachment, indicating that in specific habitats, rigid plant stems and large woody debris provide potential attachment sites. The life cycle ratio (i.e., generations per year >1 as a proportion of generations per <1) uses voltinism as an indicator of recolonization cycles of the invertebrates in the system. This ratio measures the relative dominance of more rapidly colonizing species. Coarse particulate organic matter to fine particulate organic matter (CPOM/FPOM) uses the total number of shredders as a proportion of total number of collectors to indicate the storage in and on the sediments (benthic) of organic matter on a seasonal basis. The ratio of 'top down control' (predators as a proportion of total of all other functional groups) measures how many predators, which normally constitute about 15% or less of the total fauna, are present in the system (Merritt and Cummins 1996).

Results and Discussion

Taxonomic Composition, Trophic Relationships and Species Diversity

The macroinvertebrates collected from samples were identified and assigned to functional feeding groups (Table 2) based on the ecological tables from Merritt and Cummins (1996) . The taxonomic composition of the macroinvertebrate fauna of both the depositional and erosional sites were similar. A total of 66 genera of macroinvertebrates were collected; 12 orders represented by 41 families and 56 genera were collected from the depositional site, while 10 orders represented by 29 families and 48 genera were collected from the erosional site (Table 2). There were 37 genera common to both communities. The most numerous orders in both communities, on the basis of specimens collected, were Ephemeroptera, Diptera, Amphipoda and Isopoda. These orders constituted 86% of the total community in the depositional site and 72% in the erosional site.

In the depositional site, the collector community consisted of 5 genera (*Ephemera, Hexagenia, Tricorythodes, Psidium* and*Dressena*) and the entire family Chironomidae ; 15 genera of predators; 6 genera of scrapers; and 17 genera of shredders. In the erosional site, the collector community consisted of 7 genera (*Ephemera, Hexagenia,Tricorythodes, Stenonema, Stenacron,Psidium* and*Dressena*) and the Chironomidae; 14 genera of predators; 5 genera of scrapers; and 9 genera of shredders (Table 2).

The depositional site community consisted of 61% collectors, 15% predators, 18% scrapers and 6% shredders while the erosional site community consisted of 79% collectors, 10% predators, 8% scrapers, and 3% shredders (this excluded all non-insect taxa). Cameron (1972) found similar results when he compared a*Spartina* community to a *Salicornia* community in a salt marsh in California in that the percentage representations of each trophic levels were similar.

Fluctuations in species diversity within each functional feeding catagory for both the depositional and the erosional community had similar trends (Fig. 2). Cameron (1972) found that distribution patterns of the species among the trophic levels differed somewhat when considering all taxonomic groups. In the collector community for the erosional site, species diversity was higher (Fig. 2a). The most abundant collectors were the families Chironomidae (Diptera) and Ephemeridae (Ephemeroptera) for both the depositional and the erosional site. In July, a numerical decrease corresponded to an emergence event of ephemerid mayflies, ultimately decreasing the diversity of both collector communities. This coincided to a numerical increase in the chironomids sampled during this month. In August and September, early instars of ephemerids were collected along with lower numbers of Chironomids. Cameron (1972) determined that the fluctuations in his system may have largely been due to microenvironmental physical factors that probably cued larval maturation, linking the adult emergence to periods of increasing production or litter accumulation. This allowed insects to take advantage of these seasonal pulses of energy for maturation or egg deposition and to ultimately optimize reproductive efforts by insuring food for their larvae.

The diversity of predators in Prentiss Bay is among highest for all of the functional feeding groups investigated. The top macroinvertebrate predators, such as the odonate families Aeschnidae and Libellulidae often are generalists that will prey on nearly all other invertebrates, including each other (Batzer and Resh 1991, Wiggins et al. 1980.) These top predators can be cannibalistic and share common prey, which may play an important role in regulating their populations and increasing diversity (Johnson 1991, Batzer and Wissinger 1996). Predator communities in both sites were dominated by hemipterans of the family Corixidae (Fig. 2b). In July, a numerical peak in corixids in the erosional site was followed by a decrease in numbers in August and September. This numerical shift corresponds to peak numbers in the depositional site, followed a subsequent numerical decrease in September. The pattern of the predator invertebrate diversity may be due to either changes in richness or to changes in number of individuals per species (Cameron, 1972). Such changes were caused by the fluctuations in the abundance of odonates for both the depositional and the erosional sites, which ultimately influenced the predator diversity values.

An important role of macrophytes to marsh invertebrates may be in providing substrates for growth of perphytic algae(Campeau et al. 1994). Scraper diversity patterns were influenced by the amount of algal biomass present, which was dependent upon the amount of macrophytes present. In the depositional site, the abundance of vegetation shaded potential algal growth, leading to subsequent lower diversity of this trophic group in this site. The erosional site, however, may have had a greater diversity of scrapers due to less shading by vegetation, and by the rock embankment, which provided increased substrate for both scrapers and periphyton. The scraper community was dominated by ephemeropterans of the family Caenidae (Fig. 2c). For both communities, similar patterns occurred, though the erosional site seemed to consistently have greater values. A numerical decrease of Caenidae collected in July, followed by collection of early instars in August for both sites, suggest that an emergence occurred. Brady (1992) also found similar results judging from the nymphal size of many small, early instars in similar marsh systems. Heptageniid mayflies were found exclusively in our erosional site, which increased the diversity values.

The shredder community was dominated by Crustaceans of the orders Amphipoda and Isopoda, for both the depositional and the erosional sites (Fig. 2d). Their numbers remained relatively constant throughout the study period. Trichoptera of various genera did affect the diversity patterns slightly. As aquatic macrophytes or leaves decompose, aquatic invertebrate numbers on this detrital material tend to increase (Campeau et al 1994). Trichopterans species numbers were lowest or absent in July and August in the depositional site and during June and September in the erosional site. Cameron (1972) found similar results where changes in diversity were not due to changes in abundance of individuals per species, but to an addition (or subtraction) of species in response to resource availability. Also, in certain cases, low oxygen conditions created by decomposing plant matter may have reduced rather than increased invertebrate numbers at least temporarily (Batzer and Wissinger 1996, Garbor et al. 1994).

Functional Feeding Group Analysis

The calculated ratios of invertebrate functional feeding groups, habit types and voltinism characteristics that are proposed as analogs for ecosystem attributes are summarized in Table 1. The P/R ratio measured gross primary production by examining the macroinvertebrates that fed on live vascular material (shredders and scrapers) as a proportion of invertebrates that fed on dead organic material (shredders and collectors). Based on the criteria established by Merritt et al (1996) for the Kissimmee River-Floodplain ecosystem in Florida, the P/R ratio for the depositional site indicated it was autotrophic. This could be attributed to the large number shredders that consumed live vascular plants, such as caddisflies and noctuid moths. The erosional site was heterotrophic, which was attributed to fewer vascular plant shredders and the predominance of chironomid collector-gatherers that live in the sediments.

Habitat suitability, the availability of stable substrates, indicates if specific habitats, such as rigid plant stems and rooted vascular hydrophytes, rocks and other debris provide adequate attachment sites for macroinvertebrates in the marsh (Merritt et al. 1996). In contrast to the Kissimmee River floodplain, that revealed high ratio values due to the dominance of rigid plant stems and large woody debris for adequate attachment sites for macroinvertebrate climbers, Prentiss Bay marsh had lower ratios. Climbers and clingers, such as the mayflies, *Callibaetis spp., Caenis youngi* and *Caenis latipennis,*, and caddisflies,*Agrypnia improba, Oecetis cinerascens* and*Oecetis immoblis*,were present in this marsh system, but were in lower abundance than burrowers and sprawlers in the sediments. In both the depositional and the erosional site, a low availability of stable substrates exists, and this could possibly be due to the constant wave action that the invertebrates are subjected to in a coastal marsh environment.

. The ratio that indicated if invertebrate predation caused a disproportionate ~~pressure on the invertebrate community~~ was the top down ratio. In the depositional site, the ratio for top down exceeded the specified criteria (Table 1). This may be due to a large number of odonates, which is characteristic of wetland systems (Benke 1976). On the other hand, in the erosional site, the top down ratio constituted approximately 10% of the total macroinvertebrate community which was within the range of normal levels according the given criteria (Merritt et al. 1996), indicating that invertebrate predators were not exhibiting pressure on the invertebrate community.

. The ratio for life cycle measured the relative dominance of more rapidly colonizing species. Multivoltine species that produce population peaks followed by mass emergence may cause temporary deviations in species richness and overall density of invertebrate communities (Lake et al. 1989, Layton and House 1990). The dominance of multivoltine invertebrate populations indicate species that readily colonize new and different habitats. Similar to the Kissimmee River Floodplain ecosystem, as new habitats in Prentiss Bay become available as a result of tidal action or water level fluctuations, the area can be rapidly colonized by significant diverse and abundant macroinvertebrate fauna (Merritt et al. 1996). The depositional and the erosional site were below the criteria and univoltine species dominated this site, indicating relatively rapidly colonizing species and early stages of succession or species could readily colonize new and different habitats (Merritt et al 1996).

The final ratio, CPOM/FPOM, measured the amount of benthic storage or transport of CPOM to FPOM (Merritt et al 1996). In the depositional site, the ratio is very high, indicating a high amount of benthic storage of CPOM. However, in the erosional site, the ratio is quite a bit lower. Though both sites exceed the criteria, clearly the depositional site had an increased quantity of CPOM detritus than FPOM (41.50 for the depositional site and 0.77 for the erosional site, Table 1). This indicated that the erosional site stored less detritus than the depositional site, most likely due to constant wave action and substrate differences.

Literature Cited

Balcer, M.D., N.L. Korda and S. I. Dobson. 1984. Zooplankton of the Great Lakes, a guide to the identification and ecology of the common crustacean species. Madison, Wisconsin: Univ. Wisconsin Press.

Barbour, M.T., J. Gerritsen, G. E. Griffith, R. Frydenborg, E. McCarron, J.S. White, M.L. Bastian. 1996. A framework for biological criteria for Florida streams using benthic macroinvertebrates. J. N. Am. Benthol. Soc. 15(2):185-211.

Benke, A. C. 1976. Dragonfly production and prey turnover. Ecology 57:915-27.

Brady, Valerie. 1992. The invertebrates of a Great Lakes Coastal Marsh. Master of Science. Michigan State University, Thesis.

Batzer, D.P. and S.A. Wissinger. 1996. Ecology of Insect Communities in Nontidal Wetlands. Annu. Rev. Entomolo. 41:75-100.

Batzer D.P. and V.H. Resh. 1991. Trophic interactions among a beetle predator, a chironomid grazer, and periphyton in a seasonal wetland. Oikos 60:251-57.

Campeau S., H.R. Murkin and R.D. Titman. 1994. Relative importance of algae and ermergent plant litter to freshwater marsh invertebrates. Can. J. Fish. Aquat. Sci. 51:681-92.

Cardinale, B. J. 1996. Ecology of the pelagic-littoral transistion: Some insights from an epiphytic invertebrate community. Master of ScienceThesis. Michigan State University, East Lansing, MI.

Cummins, K.W. and M.A. Wilzbach. 1985b. Field procedures for analysis of functional feeding groups of stream macroinvertebrates. Pymatuning Lab. Ecol., Univ. Pittsburgh. 18p.

De Szalay and V.H. Resh. 1996. Spatial and temporal variability of trophic relationships among aquatic macroinvertebrates in a seasonal marsh. Wetlands. 16(4):458-466.

Garbor T.S., H.R. Murkin, M.P. Stanton, J.A. Boughen and R. D. Titman. 1994. Nutrient additions to wetlands in the Interlake region of Manitoba, Canada: effects of a single pulse addition in spring. Hydrobiologia 270/280:497-510.

Johnson, D.M. 1991. Behavioral ecology of larval dragonflies and damselflies. Trends Ecol. Evol. 6:8-13.

Kreiger, K.A. 1984. Benthic macroinvertebrates as indicators of environmentl degradation in the southern nearshore zone of the central basin of Lake Erie. J. Great Lakes Res. 10:197-209.

Kreiger, K.A. 1992. The Ecology of invertebrates in Great Lakes Coastal Wetlands: Current Knowledge and Research Needs. J. Great Lakes Res. 18:634-650.

Lake, P.S., I.A.E. Bayley and D.W. Morton. 1989. The phenology of a temporary pond in Western Victoria, Australia, with a special reference to invertebrate succession. Arch. Hydrobiol. 115:171-202.

Layton R.J. and J.R. Voshell. 1991. Colonization of new experimental ponds by benthic macroinvertebrates. Environ. Entomol. 20:110-17.

Margalef, D. R. 1957. Information theory in ecology. Gen Syst. 3:36-71.

Mason, W.T., and P.P. Yevich. 1967. The use of phloxine B and rose bengal stains to facilitate sorting benthic samples. Trans. Amer. Microsc. Soc. 86(2): 221-3.

Merritt, R.W. and K.W. Cummins. (eds.). 1996. An introduction tot he aquatic insects of North America. (3rd. edition) Kendall Hunt Publishing Co., Dubuque, IA 862p.

Merritt, R.W., J. R. Wallace, M.J. Higgins, M.K. Alexander, M.B. Berg, W.T. Morgan, K.W. Cummins, and B. VandenEeden. 1996. Procedures for the functional analysis of invertebrate communities of the Kissimmee River-Flood plain Ecosystem. Florida Scientist 59:216-273.

Rosenberg, D.M. and V. H. Resh (eds.). 1993. Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman and Hall, New York, NY.

Shannon, C. E., and W. Weaver. 1949. The mathematical theory of communication. Univ. Illinois Press, Urbana. 125 p.

Systat. 1992. Statistics. Version 5.2 Edition. Systat Inc., Evanston, IL. USA.

Wiggins G.B., R.J. Mackay and I.M. Smith. 1980. Evolutionary and ecological strategies on animals in annula temporary pools. Arch. Hydrobiol. Suppl. 58:97-206.

Willans, T.H. 1990. assessing threats to fishery values of Great Lakes wetlands. in J. Kusler and R. Smarton (eds.). Proceedings of an International Symposium: Wetlands of the Great Lakes, Association of State; Wetlands Managers, Inc., New York., pp. 68-71.

Table 1. Calculated functional group (feeding and habit) and voltinism ratios for each ecosystem attribute for ea

Ecosystem Attributes	Depositional Site	Erosional Site	Criteria of Ratios for Evaluation of Ecosystem Parameters
P/R	0.75	0.24	Autrophic system >0.75
HABITAT STABILITY	0.36	0.10	Stable Substrates Not Limiting Wetlands >0.60
TOP DOWN	0.16	0.07	Normal Top Down Predator Control <0.15
LIFE CYCLE	1.32	0.11	Pioneer, Early Succesional (less stable) Community >0.75
CPOM/FPOM	41.50	0.77	Normal Shredder System by Season (Spring and Summer) >0.25

Table 2. Determination of functional feeding groups for each taxa in the depositional site (*) and the erosional site (~) and both sites of Prentiss Bay, MI, 1996.

Functional Feeding Group	Class	Order	Family	Genus
Collectors	Insecta	Ephemeroptera	Baetidae	*Callibaetis spp.*
				Procleon virodocularis
				Procleon pennulatum
			Ephemerellidae	*Eurylophella bicolor*
				Eurylophella funeralis
			Ephemeridae	*Hexagenia limbata*
				Ephemera spp.
			Tricorythidae	*Tricorythodes spp.*
		Diptera	Chironomidae	
			Ephydridae	
			Psychodidae	~*Telmatoscopus spp.*
			Tipulidae	~*Antocha spp.*
	Bivalvia		Dreissenidae	*Dreissena polymorpha*
			Sphaeridae	*Psidium spp.*
Predators	Insecta	Odonata	Aeshnidae	*Aeschna spp.*
				Basiaeschna janata
				Basiaeschna spp.
			Corduliidae	*Epitheca spp.*
				Somatochlora williamsoni
			Gomphidae	*Angomphus spp.*
			Libellulidae	**Libellula quadrimaculata*
				**Sympetrum vicinum*
			Coenagrionidae	**Engallagma ebrium*
				**Engallagma hageni*
				**Engallagma spp.*
				Isnura

Functional Feeding Group	Class	Order	Family	Genus
Predators (con't)				
			Mesovelidae	**Mesovelia vertiucalis*
				Nehalennia irene
			Lestidae	*Lestes spp.*
		Hemiptera	Belostomatidae	**Belostoma spp.*
			Corixidae	*Palmacorixa spp.*
				Trichocorixa spp.
mulsanti				
			Nepidae	**Ranatra spp.*
		Trichoptera	Polycentropidae	*Polycentropus spp.*
		Coleoptera	Dytiscidae	**Agabus spp.*
				Ilybius biguttulus
				Hygrotus spp
				Neoporus spp.
			Haliplidae	*Haliplus immaculicollis*
				Haliplus spp.
			Gyrinidae	*Gyrinus fraternus*
				Grylnus pectorales
				Gyrinus ventralis
		Diptera	Ceratopogonidae	~*Bezzia spp.*
				~*Palpomyia spp.*
			Dolichopodidae	
			Empididae	~*Hemerodroma spp.*
			Tabanidae	*Silvius spp.*
			Tipulidae	**Pedecia spp.*
			*Sciomyzidae	
	Acari			
Scrapers	Insecta	Ephemeroptera	Caenidae	*Caenis youngi*
		Trichoptera	Helicopsychidae	*Helicopsyche spp.*
			Hepatgeniidae	~*Stenacron interpunctatum*
				~*Stenonema*

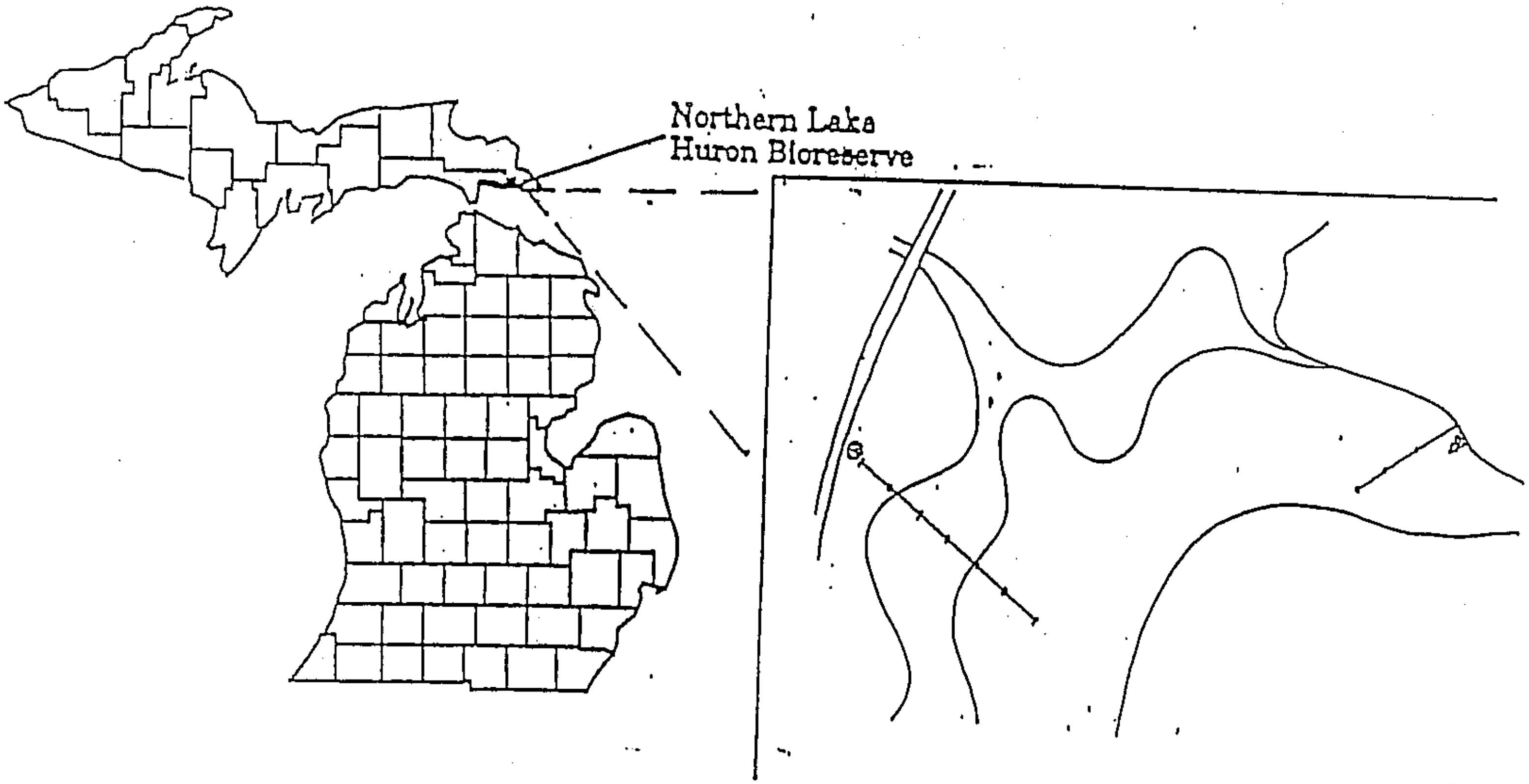
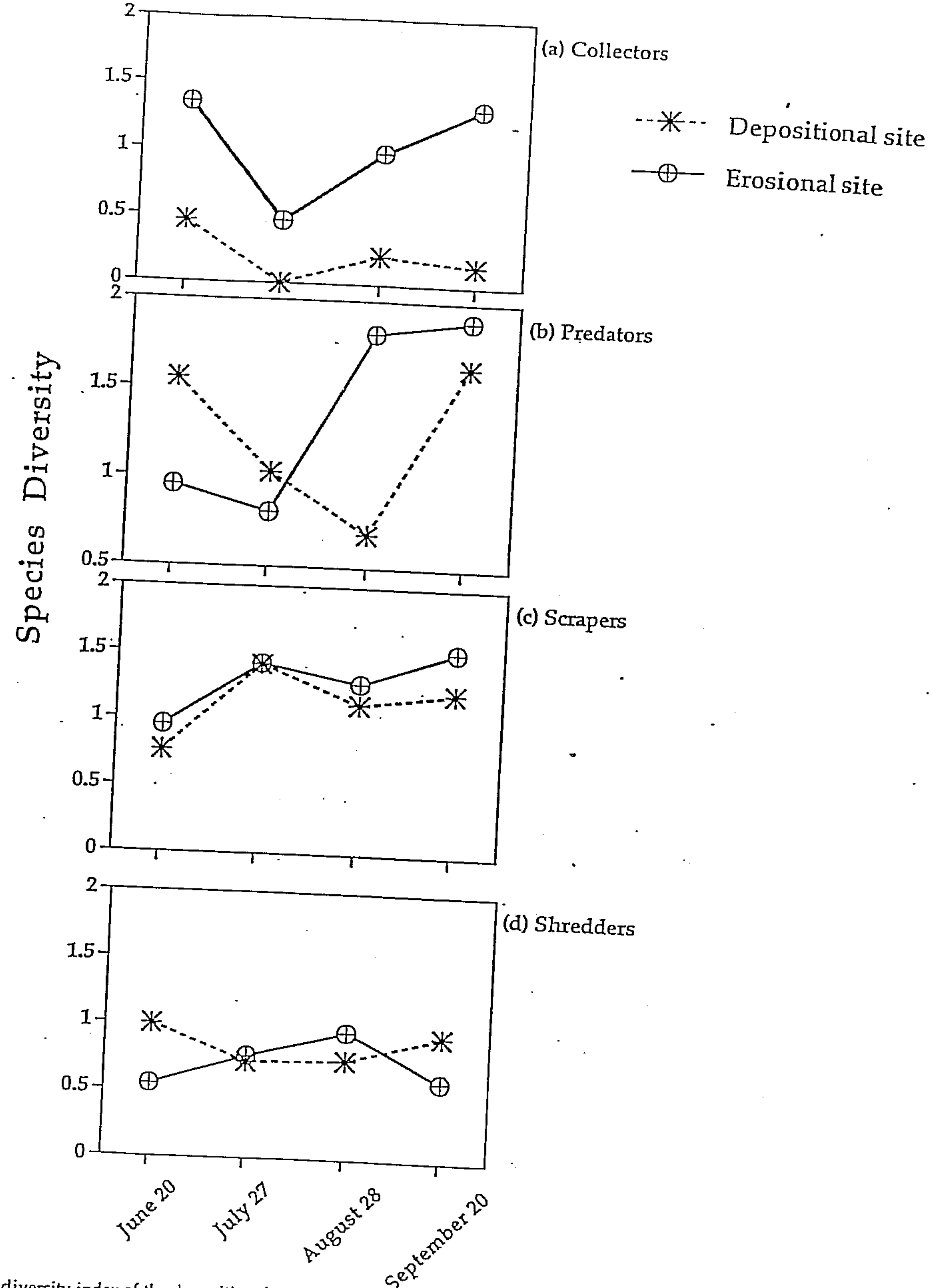


Fig 1. Location Map and Schematic Drawing showing the Northern Lake Huron Bioreserve, in Upper Peninsula of Michigan and the transect locations of Prentiss Bay Marsh.

Functional Feeding Group	Class	Order	Family	Genus
Scrapers (continued)				
femoratum				
			Hydroptilidae	~*Hydroptila spp.*
			Molannidae	*Molanna flavicornis*
	Gastropoda		Hydrobiidae	*Amnicola spp.*
			Valvatidae	*Valvata spp.*
Shredders				
	Insecta	Collembola	Sminthuridae	**Sminthurdes spp.*
		Trichoptera	Leptoceridae	**Cerclea spp.*
				Mystacides interjecta
				Oecetis cinerascens
				**Oecetis immobilis*
				Oecetis spp.
				**Trianodes aba*
			Limnephilidae	**Limnephilus anabolia*
				**Nemotaulis spp.*
			Phryganeidae	*Agrypnia improba*
				Fabria spp.
				Phryganea spp.
				~*Ptilostomis spp.*
		Lepidoptera	Noctuidae	**Bellura gortynoides*
			Pyralidae	~*Acentria ephemerella*
				**Paraponyx allionealis*
				**Paraponyx maculalis*
		Coleoptera	Chrysomelidae	**Donacia spp.*
				**Neohaemonia spp.*
		Diptera	Tipulidae	**Helius spp.*
				**Tipula spp.*
	Crustacea	Amphipoda	Gammaridae	*Gammarus spp.*
		Isopoda	Asellidae	*Caecidotea spp*



ig 2. Shannon's diversity index of the depositional and erosional community arranged by functional feeding groups: (a) ollectors; (b) Predators; (c) Scrapers; and (d) Shredders. All values are based on mean for specified date.