Community Structure and Distribution Patterns of Aquatic Macroinvertebrates in a Tall Grass Prairie Stream Ecosystem

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A survey of macroinvertebrates occupying streams in the Tallgrass Prairie Preserve of north-central Oklahoma was conducted from May 1991 to March 1992. Invertebrate collections and water samples were taken from six stations visited bimonthly during that period. The invertebrates were quantitatively sampled for using a Surber net and qualitatively collected by hand examination of microhabitats at each site. The measures of water temperature, dissolved oxygen concentration, pH, and specific conductance fell within ranges expected in Oklahoma and usually capable of supporting a diverse biota. Dominant taxa included the oligochaete *Limnodrilus*, the mayflies *Baetis* and *Caenis*, and the chironomids *Dicrotendipes* and *Orthocladius*. The chironomid *Fittkauimyia* is reported for the first time in North America outside of Florida. Species diversity values were generally high and pollution-intolerant taxa were present at most stations throughout the study period, indicating high quality for the water in the streams.

INTRODUCTION

The Tall Grass Prairie Preserve was established by the Nature Conservancy in 1989. This land is located in Osage County of north-central Oklahoma and currently includes 30,000 acres (12,000 ha). Previously, the land was grazed by cattle, and some oil field activity presently occurs. This study focuses on the aquatic macroinvertebrate community inhabiting the Sand Creek stream ecosystem which drains the area.

Aquatic macroinvertebrate communities are often studied in conjunction with stream investigations. Frequently these studies are conducted to determine species composition of a stream or its drainage basin. Several such investigations have taken place in Oklahoma (*1-13*). However, there have been no such efforts in the Sand Creek drainage basin of the Tall Grass Prairie Preserve.

Benthic macroinvertebrate communities have also served as indicators of water quality in streams (*14-18*). Characteristics of macrobenthic organisms which makes them especially useful for water quality studies include: 1) long life cycles which may reflect conditions for an extended period of time; 2) low motility; 3) various ranges of tolerance to varying environmental conditions; and 4) occupancy of central positions in aquatic food chains (*19*).

Species diversity indices have been used to analyze community structure of benthic macroinvertebrates. Shannon's diversity index (*d*) (*20*) is possibly the most widely accepted as it reflects the eveness of taxa distribution, is dimensionless, and is relatively independent of sample size (*16*). Other studies have shown the usefulness of Shannon's diversity index (*17,18,21*). Sorenson's index of similarity (*22*) has been used to compare faunal similarity between sampling sites (*18*).

The objectives of this investigation were to: 1) determine the taxonomic composition and relative abundance of the macroinvertebrate community; 2) establish seasonal trends occurring in the macroinvertebrate community; and 3) provide baseline water quality data, based on macroinvertebrates and several physicochemical measurements, to better understand and manage the watershed of the Sand Creek drainage basin.

METHODS

Macroinvertebrate communities in the Sand Creek drainage basin were investigated for an annual period. Six sampling sites were established (Figure 1) and visited bimonthly: May, July, September, November, January, and March. Four quantitative samples were collected at each site during each collection using a Surber net. Qualitative

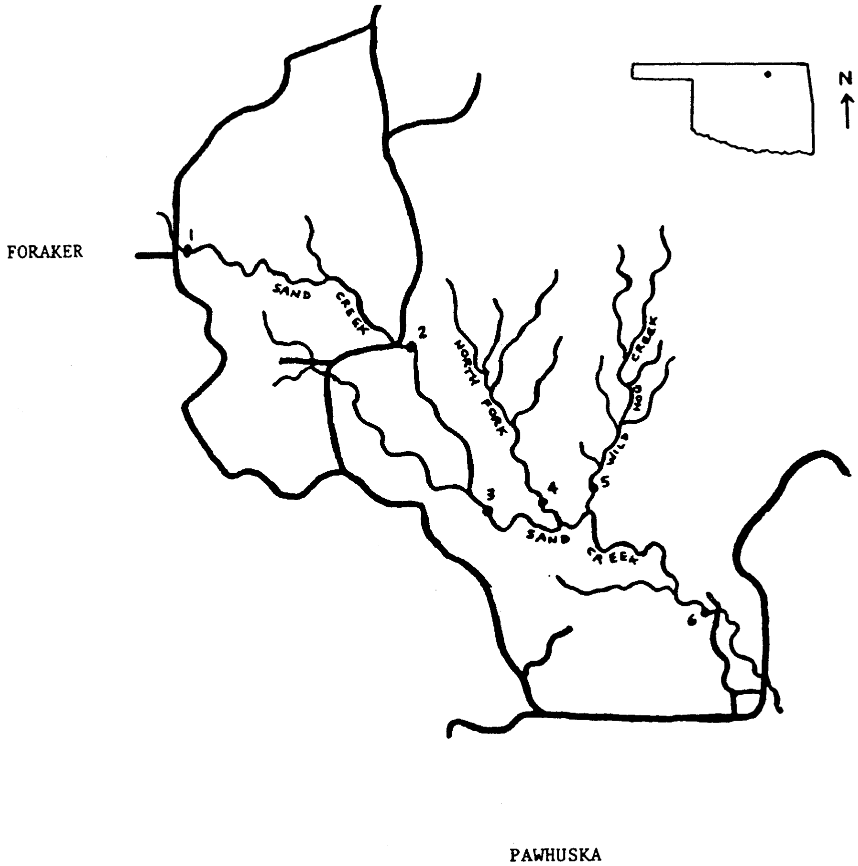

Figure 1. Location of sampling sites.

collections were also made by examining rocks, wood debris, leaf debris, and other microhabitats by hand in the stream for 45 minutes at each sampling site during May and December. This has been demonstrated to be an effective sampling method in combination with traditional sampling equipment (*23*), especially in streams such as these which contain a diversity of microhabitats.

All invertebrate collections were preserved in the field and returned to the laboratory for sorting, identification, and enumeration. Statistical analysis, including a modification of Shannon's diversity index (*16*,*24*) and community similarity (*22*) were determined.

Physicochemical conditions at each station were also monitored during each collection period. These parameters included water temperature (Celsius thermometer), dissolved oxygen concentration (Winkler method), pH (pocket pH meter), and conductivity (conductivity meter).

RESULTS and DISCUSSION

Ranges of the physicochemical parameters are listed in Table 1. The minimum water temperature recorded, 2 ºC, occurred during January at site 6 while the maximum water temperature observed, 35 ºC, occurred during July at site 3. Minimum dissolved oxygen concentration, 5.0 mg/l, was recorded from site 5 during July and maximum dissolved oxygen concentration, 9.9 mg/1, occurred at site 3 during January. The pH ranged from 7.0 at site 3 in January to 8.3 at site 1 in March. Conductivity varied from a low of 285 μS/cm at site 2 in September to a high of 520 μS/cm at site 2 in January. These results, especially water temperature and dissolved oxygen concentration, seem more related to differences between seasons than to differences between sites. Usually the variation among sites sampled at a given time was less than that for a given site sampled at different times. Generally, these values were within ranges expected in this

TABLE 1. Ranges of water quality parameters during each collection, May 1991→March 1992.

Parameter	May	Jul	Sep	Nov	Jan	Mar
Water Temperature (°C)	23–26	26–35	14–24	8–10	2–5	12–14
Dissolved Oxygen (mg/l)	7.2–7.6	5.0–6.1	5.9–6.9	5.6–7.6	8.6–9.9	7.3–8.5
pH	7.8–8.3	7.6–8.1	7.4–7.9	7.4–7.8	7.0–7.5	7.4–8.3
Conductivity (μS/cm)	350–480	360–480	285–510	280–410	410–520	400–500

TABLE 3. Species diversity values for each collection at each site.

Site	May	Jul	Sep	Nov	Jan	Mar
1	3.72	3.28	—	—	1.93	3.85
2	4.40	3.75	3.90	2.11	3.37	3.45
3	3.37	1.19	2.37	3.05	3.34	3.86
4	3.81	2.57	3.67	3.47	2.61	3.12
5	4.13	1.91	3.62	3.33	2.33	4.46
6	—	—	—	3.30	2.66	3.50

TABLE 4. Coefficients of similarity for all pairs of sites annually.

Sites	1	2	3	4	5	6
1	—	—	—	—	—	—
2	0.72	—	—	—	—	—
3	0.66	0.81	—	—	—	—
4	0.63	0.69	0.64	—	—	—
5	0.61	0.74	0.70	0.74	—	—
6	0.66	0.68	0.72	0.64	0.67	—

region of Oklahoma (*25*) and indicate conditions capable of supporting a diverse biota (*26*).

A total of 9010 individuals representing 134 taxa were encountered during this study (Table 2, page 7). In terms of both number of individuals and number of taxa, insects were dominant.

More individuals were collected annually from sites 3 and 4 than at other sites (Table 2). However, this may be misleading since more collections actually occurred at sites 3 and 4. A more accurate view may be to observe the number of individuals collected per sample annually. When viewed in this manner site 6 contained the highest number of individuals, probably because it was further downstream where more nutrients may have been present and conditions were generally more stable (*27*). The fewest individuals collected per sample was at site 4. This was expected since this site experienced stressful conditions (higher conductivity values (Table 1) and reduced flow) during part of the study period. Regarding the number of taxa collected over the annual period, sites 2 and 5 showed the highest numbers. This may be due to the presence of larger amounts of microhabitat in confined areas at the sampling sites (*23,28*).

Annual species diversity values (Table 3) were high at all sampling sites. This usually indicates that good water quality and a healthy aquatic environment exist in the streams (*16*). A general pattern emerges when the species diversity at each site for each collection is observed. These values were lowest in July and mostly increased following the summer months through the autumn, winter, and spring. The depressed diversity values in July may have been due to emergence of adults or the occurrence of higher temperatures limiting some species (*28*).

Similarity analysis (Table 4) revealed that the greatest similarity occurred between sites 2 and 3 and the least similarity between sites 1 and 5. Sites 2 and 3 were located near each other and possessed similar substrates, an important factor to aquatic invertebrates. Sites 1 and 5 were far apart and had very different physical conditions; the presence of different taxa is not surprising.

A great diversity of aquatic macroinvertebrates was present in these streams. Dominant taxa included the oligochaete *Limnodrilus*, the mayflies *Baetis* and *Caenis*, and the chironomids *Dicrotendipes* and *Orthocladius.* These taxa were present at all stations during most collections. Other common taxa included *Nais, Physa, Stenonema, Enallagma, Sialis, Stenelmis, Bezzia, Cladotanytarsus, Cricotopus bicinctus, Endochironomus, Microtendipes pedellus, Polypedilum halterale, Procladius, and Tanytarsus.* Aquatic insects, especially the dipterans, were the most abundant major group (Table 2).

The chironomid *Fittkauimyia* is reported for the first time in North America outside of Florida. Ninety-three larvae of this genus were collected among decaying leaves in pools at sites 5 and 6 during November.

Overall, the water quality of these streams was generally high. This may be illustrated by the high species diversity, the presence of many pollution-intolerant macroinvertebrates, and the fact that aquatic insects were so much more prevalent than oligochaetes.

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TABLE 2. Taxonomic composition, number of individuals, and species diversity of macroinvertebrates collected from streams: May 1991→March 1992.

Taxa	Sites 1	2	3	4	5	6	Total
Cnidaria							
Hydra sp.		1					1
Platyhelminthes							
Dugesia sp.	1	*		1	7	1	10
Nematoda			1		1	2	4
Nematomorpha							
Gordius sp.				1		1	2
Annelida							
Branchiura sowerbyi						2	2
Dero sp.		15	10		20	18	73
Erpodella sp.	5			24	4		28
Helobdella sp.				1	1		2
Limnodrilus sp.	108	125	66	45	139	135	618
Lumbriculus sp.					1		1
Nais sp.	6	5	8	25	14	9	67
Placobdella sp.	3	1	1		3	2	10
Pristina longiseta	3	2	6		13	3	27
Stylaria lacustris	3						3
Gastropoda							
Gyraulus sp.	1						1
Helisoma antrosa	3						3
Physa sp. 1	5	*	3	*	2	13	23
Physa sp. 2	1						1
Pseudosuccinea columella	2						2
Viviparus sp.					1		1
Pelycepoda							
Corbicula fluminea				*			*
Ligumia subrostrata		3	2			1	6
Sphaerium sp.		35	2	4	1		42
Villosa iris			1	2			3
Crustacea							
Lirceus germani				1	10		11
Procambarus sp.	9	1	11	2			23
Gammarus sp.					3		3
Hyalella azteca	2	15		*	1	11	29
Arachnida							
Hydracarina	1						1
Collembola							
Isotomurus tricolor				1			1
Ephemeroptera							
Baetis sp.	1	*	1	12	19	17	50
Caenis sp.	134	50	169	44	225	45	667
Habrophlebia vibrans			9	3			12
Hexagenia sp.		15	8	8	2	1	34
Leptophlebia sp.		*	9	1	1		11
Stenocron sp.	2		1		4		7
Stenonema sp.	149	157	686	339	314	56	1701
Odonata							
Argia sp.	7	*	43	20	54		124
Arigomphus pallidus	*	1					1
Coengrion sp.	*	1	1		12	1	15
Cordulia sp.			*			*	*
Enallagma sp.	*	1	8	1	14	*	24
Erpetogomphus sp.						*	*
Helocordulia uhleri		*					*
Miathyria sp.	*	*					*
Pseudoleon sp.		1					1

Taxa	Sites						Total
	1	2	3	4	5	6	
Tetragoneura sp.		*					*
Plecoptera							
Allocapnia vivipara	6	13		47	10	7	83
Isoperla sp.				42			42
Neoperla sp.		1	2				3
Perlesta placida		2	*	18	3		23
Perlinella sp.	3	5	4		10	42	64
Hemiptera							
Corixidae	*			*			*
Gelasticoris sp.		*	*				*
Gerris sp.		*		*	*		*
Microvelia sp.					*		*
Ranatra sp.	*						*
Trepobates sp.	*	1		3	1		5
Megaloptera							
Sialis sp.	17	12	9	22	5	1	66
Trichoptera							
Ceraclea sp.			*				*
Cheumatopsyche sp.		1	*	6	1		8
Nectopsyche sp.		1					1
Oecetis sp.	1	1					2
Polycentropus sp.		16	1		1	1	19
Pycnopsyche sp.		3		2	2		7
Lepidoptera							
Prionoxystus sp.		1					1
Coleoptera							
Ancilius sp.					1		1
Berosus sp.	*		2	2			4
Brachyvatus sp.			10				10
Dineutus sp.		*		14			14
Dubiraphia sp.		2	1				3
Dytiscus sp.			2				2
Ectopria nervosa		6	2	19	1	6	34
Elmis sp.					1		1
Haliplus sp.					*		*
Helichus sp.		1		*			1
Liodessus sp.	2						2
Optioservus sp.	1						1
Ordobrevia sp.				3	1		4
Oreodytes sp.	4	1	24		2		31
Peltodytes sp.	4		6			8	18
Phytobius sp.		*					*
Psephenus herricki		1					1
Stenelmis sp.	23	5	4	17	24	2	75
Tropisternus sp.			2		*	4	6
Uvarus sp.	*	1	*	*		1	2
Diptera							
Ablabesmyia aspera		*					*
A. cinctipes					8	4	12
A. mallochi		1	3	12	3		19
A. ornata		12	41		19		72
A. parajanta	1	3					4
A. tarella	3	5	6		1		15
Axarus sp.				*	*		*
Bezzia sp.	20	29	16	6	30	16	117
Cardiocladius sp.			1				1
Chaoborus punctipennis		1			1		2
Chironomus sp.		17	1	29	14	153	214
Chrysops sp.		10			2		12
Cladotanytarsus sp.	78	66	50	51	35	22	302

Taxa	Sites						Total
	1	2	3	4	5	6	
Conchapelopia sp.	3	14	1				18
Cricotopus bicinctus	11	2	2	15	22	19	71
Cryptochironomus blarina	3			1		4	8
C. fulvus	15	16	24		3	6	64
Cryptotendipes sp.		2	10				12
Dicrotendipes leucoscelis					9		9
D. sp. 1	60	146	189	61	34	163	653
Endochironomus sp.	1	7	20	14	3	3	48
Eukiefferiella sp. 1	4	38	13	18	13		86
E. sp. 2	1			1			2
Fittkauimyia sp.					92	1	93
Glyptotendipes sp.			1				1
Hemerodromia sp.					2		2
Hydrobaenus sp.	114						114
Limnophila sp.					1		1
Larsia sp.		10	21	7	15	10	63
Microtendipes pedellus gr.	2	52	88	27	148	7	324
Micropsectra sp.		186	36	2	20	58	302
Nilotanypus sp.			*	1			1
Orthocladius sp.	25	77	27	120	210	394	853
Parachironomus sp.		2					2
Paracladopelma doris	3	3		4			10
Parakiefferiella sp.	17	1		31	9	66	124
Paramerina sp.	2		4	1	5	6	18
Parametriocnemus sp.	3	94	51		1	19	168
Paraphaenocladius sp.	25	154	13		13	51	256
Paratanytarsus sp.		24	7			4	35
Paratendipes sp.		2			2		4
Pentaneura sp.	1	8			6		15
Phaenocladius sp.				3			3
Phaenopsectra sp.		16					16
Polypedilum convictum		3	1	5	9	4	22
P. halterale	42	11	8	8	4	8	81
P. illinoense	1			9		2	12
Procladius sp.	2	3	12	1	20	41	79
Psectrocladius sp.		5	5	4		4	18
Psectrotanypus sp.				1	1		2
Pseudochironomus sp.	75	33	19	15	6		148
Rheocricotopus sp.		1	4				5
Rheotanytarsus sp.	2	6	2	8	6	1	25
Robackia sp.				1			1
Sciomyzidae	*						*
Silvius sp.					5	1	6
Simulium sp.		1		16		17	34
Stempellina sp.					1		1
Stenochironomus sp.					1		1
Stictochironomus sp.	16	7	3	7	23	4	60
Tabanus sp.		1		12	3		16
Tanypus sp.					49		49
Tanytarsus sp.	10	41	14	15	19	4	103
Thienemanniella sp.	4	3	1	1	3		12
Tipula sp.	1	3			1		5
Number of collections at site	4	6	6	6	6	3	31
Number of species	60	78	67	64	82	55	134
Number of individuals	1062	1619	1809	1237	1801	1482	9010
Ave. no. of individuals/sample	66	67	75	52	75	124	73
Species diversity	4.35	4.72	3.83	4.52	4.52	4.04	4.93

* indicates taxa collected only in nonquantitative samples and not considered in statistical analysis.