Macroinvertebrate Community Structure and Physicochemical Conditions of the Roman Nose Spring System

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Roman Nose State Park is located approximately 12 km north of Watonga, Oklahoma, in Blaine County in the Gypsum Hills of the Central High Plains ecoregion. Aquatic macroinvertebrate samples were collected and physical-chemical conditions were measured from the park's freshwater spring system during alternate months from January 2002 through November 2002. Water quality parameters measured included water temperature, dissolved oxygen, pH, alkalinity, turbidity, conductivity, nitrogen ammonia, nitrite nitrogen, nitrate nitrogen, and phosphate. Water quality was always within acceptable parameters to support aquatic life during this period. However, possible contamination from agricultural activities and increasing human usage negatively impacted water quality. A total of 21,268 individuals from 64 taxa were collected and identified from three springs. Little Spring was the most populated both in the overall number of taxa (47) and the number of individuals (10,689). Middle Spring had significant differences in the number of individuals in the upper and lower sites. The month of November had both the highest number of individuals and taxa. Species diversity values were generally low: the values were always under 2.00 and usually increased at the lower sites. Significant differences in species diversity values were found over time in Little Spring and Middle Spring. Species similarity values were over 0.60 between springs for the combined collection times and over 0.45 between upper and lower sites of each spring for the collection times. Total species richness ranged from 37 to 47. Aquatic insects were the dominant group of invertebrates encountered throughout the study and included dipterans, ephemeropterans, odonates, coloeopterans, hemipterans, trichopterans, and collembolas. Continued work on this spring system is important to further inventory the invertebrates present and to determine if any patterns exist throughout the years, as well as to monitor the water quality trends of the springs. *© 2005 Oklahoma Academy of Science.*

INTRODUCTION

Springs can be described as naturally occurring points where groundwater emerges (van der Kamp 1995). The ecology of springs is unique among all other aquatic environments. In general, the temperatures are fairly uniform throughout the year, dissolved oxygen concentrations are lower at the springhead and increase further downstream, and flow is constant except during periods of heavy rainfall and extended drought. Springs are also indicative of the groundwater from which they emerge (Matthews et al 1983). Despite their uniqueness, the springs of the United States have been largely overlooked when studies of environments are undertaken.

In Oklahoma, only a few investigations of springs have been conducted and these are limited in scope. Varza and Covich (1995) studied a spring in the Arbuckle Mountains of Oklahoma and found that population changes of aquatic herbivores

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might be due to changes in food availability as well as being modified by predation from crayfish. Matthews et al (1983) surveyed 49 Oklahoma springs during two consecutive summers (1981-1982) and determined that the invertebrate communities were too variable to be useful for biomonitoring of groundwater quality. Bass (2000) collected baseline data regarding physical and chemical conditions and collected 39 species of macroinvertebrates from two springs in the Pontotoc Ridge Nature Preserve in Oklahoma. Gaskin and Bass (2000) studied the 54 species of macroinvertebrates from seven springs across Oklahoma and found the number of organisms collected from each site was directly related to the available microhabitat present at the springs. Their findings also indicated there was probably not a unique "spring fauna" present, but that inhabitants of these springs also occur in other nearby aquatic habitats.

The purpose of our study was to identify the taxa of aquatic macroinvertebrates present and to document the water chemistry of three springs at Roman Nose State Park, Blaine County, Oklahoma. The objectives were to 1) establish parameters of seasonal water chemistry of the three springs, 2) determine the numbers and types of macroinvertebrates present seasonally and year round, and 3) compare and contrast the findings among the three springs.

Roman Nose State Park is located approximately 12 km north of Watonga, Oklahoma, in Blaine County (Figure 1). It has an average annual air temperature of 15°C, and the average annual precipitation ranges from 68.6 to 83.8 cm (Oklahoma Climatological Survey 2004). A three-spring system is located in Roman Nose Canyon on the eastern slope of the Blaine Escarpment in the Gypsum Hills of the Central High Plains ecoregion in northwestern Oklahoma. The gypsum rock present throughout the area allows springs to form and results in the spring water being extremely hard. Because gypsum is a very soft rock and is easily dissolved, cracks, crevices and underground storages result from water that seeps into the ground. These cracks extend to Roman Nose Canyon resulting in the springs. The water emerging from the springs is believed to be both from rains that fall on sandy highland to the south and west and by siphoning water from the North Canadian River. This siphoning is due to the difference in elevation between the river and the springs (Weber 1994).

Three springs, Little Spring, Middle Spring, and Big Spring, are located in a forested area on the western side of the park. The names are appropriate with regard to flow and size. Little Spring emerges from small cracks in the ground as a slow trickle, and its flow has been reported to be the lowest of the three springs. Middle Spring emerges in a more impressive fashion with higher flows being recorded. Big Spring is the most impressive of the three in terms of flow with water gushing from a cavernous opening. This spring has the largest recorded flow (Weber 1994, Fay 1959). Trails lead to each of the three springs and, because this is a recreational area, visitors often enter the springs.

METHODS

Six sampling sites were established within the spring system (Table 1) and collections were made during January, March, May,

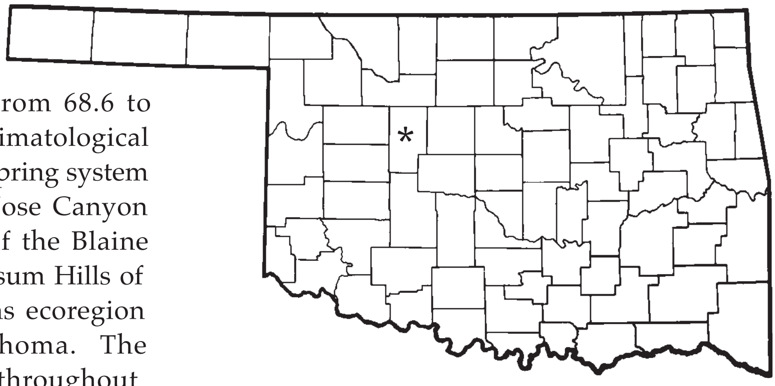

Figure 1. Location of Roman Nose State Park, OK.

July, September, and November of 2002. Macroinvertebrate collections were obtained quantitatively via three replicate Surber net samples at each site, the material was washed through a number 60 (0.250 mm) US standard sieve bucket, transferred to a jar and preserved with a mixture of 10% formalin and rose bengal dye. After being returned to the laboratory, samples were washed through a number 60 (0.250 mm) US standard soil sieve, sorted, and stored in 70% ethanol until the macroinvertebrates were identified and counted. To capture taxa possibly missed in the Surber net sampling, collections of macroinvertebrates were made qualitatively by dip nets and hand collections. Macroinvertebrate identifications were determined primarily by using keys by Smith (2001), Merritt and Cummins (1996), Epler (1995), and Wiederholm (1983). Upon completion of the identifications, collections were deposited in the University of Central Oklahoma Invertebrate Collection.

Sorenson's (1948) index of similarity was calculated to make comparisons between upper and lower sites at each spring, upper sites among springs, lower sites among springs, and combined sites among springs for each collection period. Shannon's (1948) diversity index for each replicate collection was determined and means were calculated for the upper and lower spring sites, for individual springs, and for sample months. t-tests were performed to determine if species diversity values and number of individuals differed significantly between the upper and lower sites of each spring (StatView 512t Statistical Software, Brainpower Inc., Calabasas CA, and SAS 8.2 Statistical Software, SAS Institute Inc., Cary, NC). One-way analyses of variance were conducted to make comparisons of species diversity and number of individuals among the collections by using SAS Statistical Software.

Physical-chemical conditions were measured in each spring during alternate months from January 2002 through November 2002. Water temperature, dissolved oxygen, pH, and alkalinity were measured in the field at the upper spring head and lower reach sites of each spring. Water samples to determine turbidity, conductivity, nitrogen ammonia, nitrite nitrogen, nitrate nitrogen, and phosphate were collected only at the head of each spring and transported to the laboratory for analysis using a Baush and Lombe Spectrophotometer 20 (Hach Chemical Company 1987).

RESULTS AND DISCUSSION

Macroinvertebrates

During the investigation a total of 21,268 individuals were collected with a Surber net (Table 2). A total of 64 taxa were collected via the quantitative and qualitative methods, of which nine were collected through qualitative hand collections only. Of the 64

Table 1. General description of sites in the Roman Nose spring system.

Site	Little Spring		Middle Spring		Big Spring	
	Upper	Lower	Upper	Lower	Upper	Lower
Average Depth (cm)	2.1	3.3	14.2	9.4	7.4	11.1
Maximum Depth (cm)	7	7	25	16	12	22
Width (cm)	160	73	170	130	400	300
Distance From Springhead (m)	1	65	8	45	12	30
Substrate	Sand, rock, wood, detritus, and *Rorippa nasturium-aquaticum*	Sand, rock, wood, detritus	Sand, boulder, rock, wood, detritus	Sand, rocks, wood, detritus	Sand	Sand, rocks, wood, detritus

Table 2. List of taxa, including total number of individuals collected and percent composition, for springs at Roman Nose State Park, January 2002-November 2002.

Taxon	Little Spring		Middle Spring		Big Spring		All Springs	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Nematoda	451	4.219	14	0.172	8	0.329	473	2.220
Oligochaeta								
Enchytraeidae			7	0.086	5	0.206	12	0.056
Limnodrilus sp.	3011	28.170	67	0.822	34	1.399	3112	14.630
Lumbriculus sp.	1	0.009					1	0.005
Nais sp.	17	0.159					17	0.080
Pristina sp.			1	0.012			1	0.005
Specaria sp.	3	0.028					3	0.014
Tubificidae	1	0.009			1	0.411	105	0.494
Gastropoda								
Physa sp.	1	0.009					1	0.005
Amphipoda								
Hyalella azteca	1555	14.550	785	9.634	194	7.980	2534	11.915
Decapoda								
Procambarus simulans	1	0.009					1	0.005
Collembola								
Isotomurus palustris	2	0.019	3	0.037			5	0.024
Ephemeroptera								
Baetis sp.	1946	18.210	3247	39.850	209	8.597	5402	25.400
Odonata								
Argia sp.	1417	13.260	765	9.389	217	8.926	2399	11.300
Calopteryx sp.	3	0.029					3	0.001
Gomphidae			15	0.184	7	0.288	22	0.103
Hetaerina sp.	8	0.075	4	0.049	1	0.041	13	0.061
Libellulidae	1	0.009	1	0.012			2	0.009
Hemiptera								
Trepobates sp.			1	0.012			1	0.005
Trichoptera								
Cheumatopsyche sp.	1	0.009	1	0.012	1	0.041	3	0.014
Ochrotrichia sp.	37	0.346	58	0.712	10	0.411	105	0.494
Diptera								
Atherix sp.			7	0.086	7	0.288	14	0.100
Brachycera			1	0.012			1	0.005
Caloparyphus sp.	1	0.009					1	0.005
Chironomidae pupa	42	0.393	14	0.172	15	0.617	71	0.334
Cladotanytarsus sp.			1	0.012			1	0.005
Corynoneura sp.	87	0.814			3	0.123	90	0.423
Cricotopus sp. 1	28	0.262	196	2.405	218	8.968	442	2.078
Cricotopus sp. 2	1	0.009	2	0.025	6	0.247	9	0.042
Cryptochironomus sp.	112	1.048	1	0.012			113	0.531
Culicoides sp.	1	0.009	2	0.025			3	0.014
Dolichopodidae					1	0.041	1	0.005
Empididae	1	0.009					1	0.005
Erioptera sp.	13	0.122	1	0.012	7	0.288	21	0.099
Eukiefferiella devonica group			5	0.061	7	0.288	12	0.056

Table 2. (continued)

Taxon	Little Spring		Middle Spring		Big Spring		All Springs	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Eukiefferiella sp.	165	1.544	1655	20.312	1328	54.628	3148	14.802
Larsia sp.	2	0.019					2	0.009
Myxosargus sp.	1	0.009					1	0.005
Orthocladiinae sp. 1	1	0.009					1	0.005
Orthocladiinae sp. 2	5	0.047	2	0.025			7	0.033
Orthocladius sp. 1	1	0.009			7	0.288	8	0.038
Orthocladius sp. 2	4	0.037	1	0.012	0	0.000	5	0.024
Parametriocnemus sp.	1398	13.079	227	2.786	88	3.620	1713	8.054
Pilaria sp.	24	0.025			1	0.041	3	0.014
Polypedilum sp.	3	0.028					25	0.118
Probezzia sp.	141	1.319	45	0.552	6	0.247	192	0.903
Stictochironomus sp.	168	1.572	1004	12.322	46	1.892	1218	5.730
Stratiomyidae	1	0.009					1	0.005
Tanytarsus sp.	7	0.066	3	0.037	0	0.000	10	0.047
Thienemanniella sp.	9	0.084	1	0.012	1	0.041	11	0.052
Tipulidae	2	0.029					2	0.009
Tabanidae	1	0.009					1	0.005
Tabanus sp.	1	0.009					1	0.005
Tipula sp.	11	0.103	11	0.135	3	0.123	25	0.118
Zabrachia sp.	2	0.029					2	0.009
Totals of individuals	10689		8148		2431		21268	
Totals of taxa	47		39		37		64	

total taxa collected, 17 of these were found during all six collection times, and only *Hyalella azteca* was present at every site every collection time.

Insects dominated, comprising 15,111 (71%) of the individuals in the quantitative collections. Fifty-three taxa of insects were collected via both quantitative and qualitative techniques. Of the insect taxa the dipterans were the most prevalent group, and within these, chironomids were the most abundant. These findings are similar to other spring studies in Oklahoma, which also found that insects, primarily chironomids, dominated other springs (Bass 2000, Gaskin and Bass 2000, Matthews et al 1983). Other insects collected included ephemeropterans, odonates, trichopterans, collembolans, hemipterans, and coleopterans.

The non-insect individuals in the quantitative collections totaled 6,157 (29%). Eleven taxa were collected using quantitative and qualitative techniques. Of the non-insects collected oligochaetes, amphipods, and nematodes were most prevalent. Also collected were decapods and gastropods.

Numbers of Individuals

Over the course of the study, Little Spring had the highest numbers of individuals (10,689) and taxa (47) (Table 2). Insects dominated this spring composing 5,648 (52.8%) of the individuals. It is interesting to note that non-insects dominated the upper site (3312 individuals, 69.1%), the only site within the spring system having this greater abundance of non-insect fauna. The non-insects that dominated this site were primarily oligochaetes and amphipods, taxa that often thrive where large amounts of vegetation and decaying organic debris are present. The mean number of individuals in the upper site was compared between collecting periods by using a one-way ANOVA, and no difference was found ($F = 0.465$, df = 5, $P = 0.7953$). The lower site of Little Spring was always dominated by insects. A one-way ANOVA determined no difference in the mean number of individuals over time at this site as well (*F* = 2.782, df = 5, *P* = 0.0680).

Middle Spring was the second most populated spring with 8,148 individuals (38.3%) and 39 taxa. Insects dominated the spring in both the upper and lower sites (7,274 individuals, 89.3%). A one-way ANOVA indicated significant difference in the mean number of individuals over time for the upper site (*F* = 6.888, df=5, *P* = 0.0030) and for the lower site (*F* = 8.591, df = 5, *P* = 0.0012). Although the emergence of the insects was not monitored in this study, emergences were probably occurring during early summer, resulting in the lower number of individuals present in the subsequent months after emergences. Later, due to the emergent adults mating and producing new individuals, increases in populations likely occurred. A Tukey comparison found that May was significantly different than January and July in the upper site comparison, and January and July were significantly different in the lower site comparison.

Big Spring was the least populated spring with 2,431 individuals (11.4%) and 37 taxa. The low numbers at this spring were likely due to the increased proportion of bare sand and decreased amount of microhabitat available. Insects dominated in this spring as well. However, a one-way ANOVA indicated no significant differences in the mean number of individuals over time for the upper and lower sites (*F* = 0.967, df=5, *P* = 0.1115). This may be because the emergent patterns were not as striking as in Middle Spring due to the different proportions of insect orders present, thus resulting in different times of emergences.

Significant differences were found in the mean number of individuals between the upper and lower sites of the springs during some collection times. Little Spring had significant differences for the May collection (*t* = -4.8798, *P* = 0.0082); Middle Spring in July (*t* = 3.4186, *P* = 0.0268), September (*t* = 6.7966, *P* = 0.0024), and November (*t* = 6.8426, *P* = 0.0024) and Big Spring in January (*t* = -6.9774, *P* = 0.0022), March (*t* = -8.4491, *P* = 0.0011), May (*t* = -11.789, *P* = 0.0003), and July (*t* = -3.1845, *P* = 0.0334).

For the spring system as a whole, the highest numbers of individuals occurred in May, with 4,984 individuals (23.4%), and November with 4,607 individuals (21.7%). The collection period with the lowest number of individuals found was in July, with 1,655 individuals (7.8%). A one-way ANOVA indicated there was a significant difference in the number of individuals over the duration of this study (*F* = 2.95, df = 5, *P* = 0.0159), and a Tukey comparison resulted in differences between July and November and July and May.

Species Richness

Species richness of the spring system was highest in November (40) and lowest in March, May and July (all tied at 22). Little Spring had the highest species richness each time (18-28), most likely because of the increased available microhabitat. Big Spring usually had the fewest species (9-21), probably because much of the substrate consisted of fine sand, a poor microhabitat for many macroinvertebrates.

Species Similarity

Sorenson's species similarity for the combined springs ranged from 0.548 for both the March and November collections and the May and November collections, and 0.780 between the March and July collections. Species similarity for Little Spring was lowest between the March and November collections (0.458) and highest between the May and September collections (0.857). Middle Spring had the lowest similarity between the November and May collections (0.595) and the highest between the May and January collections and the March and July collections (0.759). Big Spring had the lowest similarity between the July and November collections (0.467) and the highest between the March and May collections (0.923).

Species similarity comparisons between springs within the individual months were also examined. Little Spring and Big Spring had the lowest similarities, most likely because the physical aspects of their overall habitats appeared to be slightly more dissimilar to each other. In January, the low value was 0.563 between Little Spring and Big Spring, and the high was 0.741 between Middle Spring and Big Spring. In March, the low was 0.686 between Little Spring and Big Spring, and the high was 0.889 between Middle Spring and Big Spring. In May, the low was 0.744 between Little Spring and Big Spring, and the high was 0.765 between Little Spring and Middle Spring. In July, the low was 0.571 between Little Spring and Big Spring, and the high was 0.765 between Middle Spring and Big Spring. In September, the low was 0.541 between Little Spring and Big Spring, and the high was 0.759 between Middle Spring and Big Spring. In November, the low was 0.417 between Middle Spring and Little Spring, and the high was 0.714 between Middle Spring and Big Spring.

Species similarity was also compared between the upper and lower sites of the springs during each collection time. Generally, the indices showed rather high similarity values with averages over 0.500 for each spring. Higher values consistently occurred at Little and Middle Spring, and the lowest values were at Big Spring. This is likely because of the different substrates between the upper and lower sites of Big Spring. Over the six collection times, March had the highest overall similarities. In January and September there were very low values between the upper and lower sites of Big Spring.

Species similarity of the combined collections at Little, Middle, and Big Springs was also compared between pairs of springs. Overall, the springs were rather similar with close to half or over half of the species shared between pairs of springs. The similarity comparisons of other studies in Oklahoma showed lower species similarity values between pairs of springs. Bass (2000) had a similarity value of 0.47 in his comparison of two springs and Gaskin and Bass (2000) had species similarity values ranging from 0.000 to 0.476. The lower values arose probably because of the distances between the springs in those studies, and thus the differences in substrates and physical-chemical conditions. In this study, the three springs are much closer to one another and their physical-chemical conditions were fairly similar among all three springs.

Species Diversity

Species diversity values were generally rather low, well under 2.00. The monthly species diversity ranged from 1.119 in May to 1.550 in November. An ANOVA showed significant differences in the mean species diversity of the spring system as a whole over time ($F = 2.34$, df = 5, $P = 0.0469$). A Tukey comparison indicated the differences existed between May and November. These data could be associated with the life cycles of the aquatic insects. In the May collections, the species richness of aquatic insects was much lower as emergences were beginning to occur. In November, the numbers and types of aquatic insects were greater because of previous matings, and the resulting larval stages preparing to overwinter.

Mean species diversities within the months were highest (1.178-1.983) at Little Spring during every collection. This is likely because of the greater amount of available microhabitat present. Within the collection times ANOVAs were performed and significant differences were found among the three springs in July ($F = 8.32$, df = 2, $P = 0.0037$). A Tukey comparison indicated that Big Spring was significantly different from than the other two springs. Significant differences were also found in September ($F = 17.12$, df = 2, $P = 0.0001$). A Tukey comparison indicated the differences were among all three springs.

Significant differences in species diversity between the upstream and the downstream sites of the springs were found during January and November (t = -3.26, P = 0.0311 and t = -3.157, P = 0.0343 respectively) in Little Spring, and in September (t = -9.966, P = 0.0006) in Middle Spring. It was of interest to find no differences in the upper and lower species diversity values at Big Spring. Due to the increased bare sand and lack of available microhabitat, the upper site appeared as if it would support a much lower species diversity value than the lower site. Although the diversities of the upper site were lower than the downstream site, they were not statistically different. The diversity between the upper and lower sites of each spring generally increased at the lower sites (exceptions were Middle Spring in January, May, and November).

Significant differences among the three upstream sites were found for mean species diversity in September only (F = 12.53, df = 2, P = 0.0072). A Tukey comparison showed that the differences were between Little Spring and Big Spring. The downstream sites indicated significant differences for January (F = 6.38, df = 2, P = 0.0327), March (F = 6.81, df = 2, P = 0.0286), July (F = 6.07, df = 2, P = 0.0361), and September (F = 18.68, df = 2, P = 0.0027). Tukey comparisons showed that in January, March, and September the differences were between Little Spring and Middle Spring, whereas in July the differences existed between Little Spring and Big Spring.

Significant differences in mean species diversity among the springs (upper and lower sites combined) were found in July (F = 8.32, df = 2, P = 0.0037) and September (F = 17.12, df = 2, P = 0.0001). Tukey comparisons showed that Big Spring was significantly different from the other two springs in July, and all three springs were different from one another during September.

Little Spring mean diversity values were also compared over the six collection periods. Although the upper site showed no significant differences over time (F = 1.07, df = 5, P = 0.2454), the lower site was significantly different (F = 7.67, df = 5, P = 0.0019). A Tukey comparison revealed May was significantly different from March, September, and November. The total mean diversity for Little Spring (combined upper and lower sites) was also significantly different over time (F = 3.06, df = 5, P = 0.0237), with a Tukey comparison showing the differences lie between May and September.

Middle Spring comparisons of mean diversity values over time were also made. The upper site's mean diversity values were significantly different over time (F = 6.89, df = 5, P = 0.0003). A Tukey comparison showed that November and July were different from January, March, May, and September. An ANOVA showed that the lower sites were also significantly different (F = 6.04, df = 5, P = 0.0051). A Tukey comparison indicated that July was significantly different from the January, March, and May. The total mean diversity for both the upper and lower sites at Middle Spring was also significant (F = 10.02, df = 5, P = <0.0001), with a Tukey test showing that July was different from January, March, May, and September. Big Spring comparisons of mean diversity values over time yielded no significant differences.

Water Quality

Results of the physical-chemical analysis of the spring waters are listed in Table 3. Water temperature, dissolved oxygen saturation, free carbon dioxide content, pH, alkalinity, turbidity, nitrite, and nitrate readings were all within acceptable ranges to support aquatic life. Ammonia, orthophosphate, and conductivity concentrations were high and often exceeded concentrations which are limiting to some aquatic life. The high concentrations of ammonia and orthophosphate recorded in this study could possibly be due to the agricultural activities in the area, because a great deal of land surrounding the park is used for farming. The high conductivity readings are a result of the high mineral content of the region, which is absorbed by the water as it flows underground (Wetzel 1983).

Table 3. Physical-chemical ranges of springs in Roman Nose State Park January 2002-November 2002.

Site	Little Spring		Middle Spring		Big Spring	
	Upper	Lower	Upper	Lower	Upper	Lower
Water Temperature (°C)	16-17	15-18	17-18	17	16-17	16-17
Dissolved Oxygen (mg/l)	6.5-9.2	8.5-10.4	7.0-8.9	8.0-10.0	8.1-9.9	8.3-10.1
Percent Dissolved Oxygen Saturation	64-96	86-103	67-92	81-103	83-101	85-104
Free Carbon Dioxide (mg/l)	16-36	5-16	14-29	12-18	10-13	5-13
pH	6.1-7.3	6.6-7.8	6.2-7.4	6.3-7.5	6.4-7.6	6.4-7.7
Alkalinity (mg/l)	181-291	194-270	191-220	189-230	169-282	159-220
Turbidity (FTU)	<1-3		<1-1		1-3	
Conductivity (micromhos/cm)	1669-3080		2380-2740		1711-3110	
Ammonia (mg/l)	2.93->2.93		>2.93		>2.93	
Nitrite (mg/l)	0.002-0.022		0.002-0.045		<0.002-0.039	
Nitrate (mg/l)	1.32->4.88		1.40-4.68		1.49-4.68	
Orthophosphate (mg/l)	0.13->2.45		0.83->2.45		0.22->2.45	
Total Phosphate (mg/l)	0.043->0.817		0.277->0.817		0.073->0.817	

CONCLUSIONS

A total of 21,268 individuals representing 64 taxa of invertebrates were collected during the study. Aquatic insects were the dominant group of invertebrates present in the springs. They comprised 71.1%, whereas the non-insects comprised 28.9% of the individuals. Of the dipterans, chironomids were the most often encountered, making up 95.9% of the dipteran individuals. Also present were ephemeropterans, odonates, trichopterans, collembolans, hemipterans, and coleopterans. Of the non-insects, oligochaetes, amphipods, and nematodes dominated, with decapods and gastropods also present.

For invertebrate taxa, the most prevalent groups were again the insects, with 81.3% of the taxa. Of the insects, the most abundant taxa were dipterans, (66.0%). Chironomids contained over half (18 taxa, 51.4%) of the dipteran taxa. The other groups of insects each composed less than 10% of the insect taxa. The average numbers of taxa in the springs over the course of the collection are lower than those of the other Oklahoma spring studies, but are not particularly unexpected because of the relative isolation of the spring system, as well as the high conductivity values. Compared to many of the other studies, there does not appear to be any unexpected inhabitants; all of the major groups collected in this study have been encountered in other studies. However, many groups of taxa were collected in other studies in Oklahoma (Matthews et al 1983, Bass 2000, Gaskin and Bass 2000) which were not encountered in this study. These groups included plecopterans, turbellarians, isopods, megalopterans, bivalves, planarians, ostracods, and hirundineans. It is suspected that the very high conductivity values were a factor in preventing many of these organisms from being encountered (APHA 1992), as well as the location of the springs; western Oklahoma is a rather arid area with less water and, in turn, fewer springs and streams from which the organisms may emigrate. The taxa collected throughout this study were not endemics or unique to the springs; all are common in streams in the surrounding area. This corroborates the Gaskin and Bass (2000) study, which indicated that there is not a strictly "spring fauna" in Oklahoma.

The spring system at Roman Nose State Park is important not only as a tourist attraction for its sheer beauty, but also for its biological values. These springs are important habitats for aquatic invertebrates of the park, which are important not simply for diversity's sake, but serve in the food web for many animals. The water quality of the system is also important because spring water is often indicative of groundwater quality. Continued work on this spring system is important to further inventory the invertebrates present and to determine if any patterns exist throughout the years, as well as to monitor the water quality trends of the springs.

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