Macroinvertebrate Community Structure and Physicochemical Conditions of Desperado Spring

David Bass
Department of Biology, University of Central Oklahoma, Edmond, OK 73034 USA

Bobbie Gaskin
Department of Biology, University of Central Oklahoma, Edmond, OK 73034 USA

Kinsey Tedford
Department of Biology, University of Central Oklahoma, Edmond, OK 73034 USA

Abstract: Desperado Spring is a small rheocrene spring located in south-central Oklahoma that emerges from a rocky outcrop and flows into the nearby Blue River. Macroinvertebrate collections and water quality measurements were taken seasonally for an annual period at the springhead and in the springbrook. A total of 16,410 individuals representing 49 taxa were collected in Surber net samples while an additional four species were collected using a dip net. This spring fauna was dominated by insects, especially midges (Chironomidae). Shannon's species diversity values at the springhead differed significantly from those in the springbrook during all four seasonal collections, probably due to increasing levels of oxygen in the springbrook.

Introduction

Springs are described as naturally occurring sources of emerging groundwater that have unique properties unto themselves, such as discrete habitats with relatively constant conditions with respect to temperature, dissolved oxygen concentration, and flow (van der Kamp 1995). Investigations of springs are limited and only a few ecological studies of these unique environments have occurred in Oklahoma. Matthews et al. (1983) attempted to determine whether macroinvertebrate community compositions could be useful indicators of groundwater quality, but low similarities between the springs in the study led to inconclusive results. Varza and Covich (1995) concluded limited food availability and predation by crayfish limited macroinvertebrate abundance in Buckhorn Spring. Bass (2000) reported a combined total of 39 taxa of macroinvertebrates from two springs in the Pontotoc Ridge Nature Preserve sampled only once during 1995. Based on samples of invertebrates from springs along a southeast to northwest gradient across Oklahoma, Gaskin and Bass (2000) concluded a unique spring fauna was generally not present in Oklahoma and the spring inhabitants were associated with populations from other nearby stream habitats. Rudisill and Bass (2005) reported 64 taxa, dominated by dipteran larvae, during a year-long investigation from three adjacent springs in Roman Nose State Park. Graening et al. (2006) compiled a checklist of all amphipods known from Oklahoma, including *Allocrangonyx* sp., from Desperado Spring. In another annual study, Brown and Bass (2014) collected 114 invertebrate taxa, dominated by the species complex *Hyalella azteca* and *Tanytarsus*, from three springs in south-central Oklahoma.

The macroinvertebrate community of Desperado Spring was previously sampled by Gaskin and Bass (2000). Desperado Spring is a rheocrene spring located in the Blue River Wildlife Management Area of south-central Oklahoma in Johnston County (34.3319°N, 96.5993°W) (Fig. 1). The spring emerges from a rocky outcrop and flows approximately 15 meters before draining into the Blue River. The

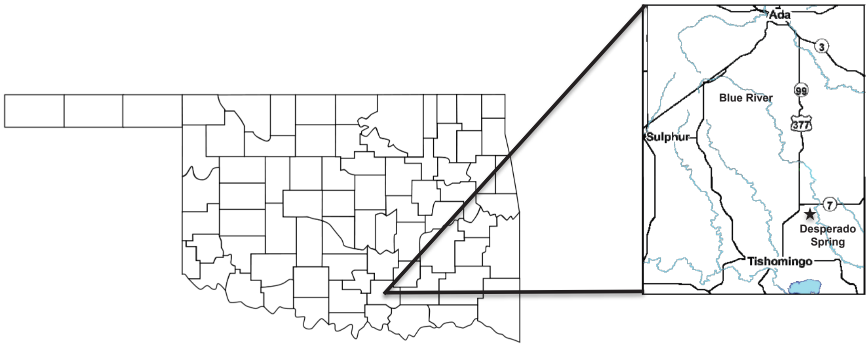

Figure 1. Map showing location of Desperado Spring in Johnston County, Oklahoma.

substrate of this spring is composed primarily of cobble, gravel, and sand with an abundance of aquatic vegetation (Gaskin and Bass 2000).

Purposes of the current investigation were to 1) describe the macroinvertebrate community composition of Desperado Spring over an annual period, 2) compare composition of these communities to previously collected data on this and other springs, and 3) determine selected physicochemical conditions of Desperado Spring.

Methods

Desperado Spring was sampled seasonally (October, January, April, and July) beginning in 2002. Both physicochemical and macroinvertebrate samples were collected during each quarterly visit.

Two sampling sites (springhead and 12 m downstream in springbrook) were established within the springbrook and three Surber net samples were collected from each site. Qualitative samples were also collected, by examining microhabitats, to capture species that may have been missed by the Surber net. All samples were washed in a number 60 (0.250mm) U.S. standard sieve bucket, and preserved with a 10% mixture of formalin and Rose Bengal dye. The preserved macroinvertebrates were returned to the laboratory to be sorted, identified, and counted. Identification of macroinvertebrates was determined primarily using keys by Wiederholm (1983), Epler (1995), Smith (2001), Merritt et al. (2008), and Thorp and Covich (2009). All specimens were deposited in the Invertebrate Section of the University of Central Oklahoma Natural History Museum.

Shannon's (1948) diversity index was calculated for springhead samples and the springbrook samples for each spring for each collection period. Sorenson's index of similarity (Brower et al. 1997) was used to make comparisons between the species present at springhead and springbrook sites for each collection. Chi-square contingency analyses were performed to determine if there was a relationship in number of individuals between the springhead and springbrook during the different seasons. Furthermore, a Hutcheson *t*-test was used to compare species diversity between the springhead and springbrook samples. The Hutcheson *t*-test is a median test with a distribution-free procedure that assumes the two populations or samples have the same shape. It is a modified version of the classic *t*-test that provides a way to compare samples using Shannon's diversity index values (Zar 2010).

Water temperature, dissolved oxygen concentration, and pH were measured at both collecting sites within the springbrook, while alkalinity and flow were measured only at the springhead. In addition, a water sample collected from the head of each spring was used to determine turbidity, conductivity, and concentrations of ammonia, nitrites, nitrates,

Table 1. Physicochemical conditions for near the springhead in Desperado Spring, Blue River Wildlife Management Area, Johnston County, Oklahoma. Values in parentheses describe conditions in springbrook.

Parameter/Collection	Oct. 2002	Jan. 2003	Apr. 2003
Water Temp °C	17.9 (17.6)	17.1 (16.7)	16.6 (16.7)
Dissolved Oxygen (mg/l)	4.5 (4.8)	6.6 (9.4)	5.3 (8.2)
DO Percent Saturation (%)	45 (48)	66 (95)	53 (83)
pH	6.5 (6.5)	7.2 (7.2)	7.2 (7.6)
Alkalinity (mg/l)	463	486	380
Turbidity (JTU)	1	1	1
Specific Conductivity (μmhos/cm)	630	486	397
Ammonia (mg/l)	0.62	0.38	0.43
Nitrates (mg/l)	0.11	0.04	0.11
Nitrites (mg/l)	2	2	2
Orthophosphates (mg/l)	0.22	0.1	0.04
Flow (m/sec)	0.4	0.4	0.4

and orthophosphates in the laboratory using a Bausch & Lomb Spectrophotometer 20 (Hach 1987).

Results & Discussion

Results from the analysis of these physicochemical conditions indicated whether the water quality would be sufficient to support aquatic macroinvertebrates (Table 1). Both dissolved oxygen concentration and percent oxygen saturation values increased between the springhead and springbrook sites as atmospheric oxygen diffused into the water below the emergence point (van der Kamp 1995). The values of most other parameters were relatively constant.

A total of 16,410 individuals representing 49 species were collected in the Surber net samples during the four seasonal sampling periods from Desperado Spring (Table 2). Four additional species of hemipterans and coleopterans were collected only in the qualitative samples, so they were not included in the statistical analyses. Hexapods made up 94.4% of the individuals and 34 taxa, while non-hexapods formed 5.6% of the individuals and 15 species. This overwhelming dominance by hexapods is a different finding than what was reported by Brown and Bass (2014) in nearby Pontotoc Ridge springs where non-hexapods were the most abundant group. Although it is well known that many springs often support more non-insects than insects (Webb et al. 1995, Brown and Bass 2014), hexapods were much more abundant in Desperado Spring. This is most likely due to the close proximity of the Blue River, an environment only about 15 meters from the springhead, that supports many aquatic insects. Blue River fauna may also colonize the spring run during periods of flooding. Over half of the insect species found in Desperado Spring were previously reported in an investigation of invertebrate drift occurring in the Blue River by Matzinger and Bass (1995).

Four genera of Chironomidae larvae dominated the Desperado Spring macroinvertebrate community making up 81.8% of the individuals present in the collections. These included *Sublettea* (33.7%), *Eukiefferiella* (24.3%), *Paratendipes* (13.0%), and *Corynoneura* (10.7%). *Sublettea*, *Eukiefferiella*, and *Corynoneura* always occurred in higher numbers at the springhead, while *Paratendipes* was usually more abundant in the springbrook (Table 2). It is possible these distributions reflected preferences for different microhabitats – the springhead substrate was composed primarily of cobble and gravel, while the springbrook substrate contained more sand and leaf debris overlying rock.

Comparisons of the species present at the springhead and those present at the springbrook sites using Sorensen's index of similarity ranged from 0.40 - 0.62 during the four collection periods. Specifically, those values were 0.50 during October, 0.52 during January, 0.62 during April, and 0.40 during July. Although some overlap of species did occur at both sites, other species were limited to either the springhead or

Table 2. Macroinvertebrates collected in Desperado Spring, Blue River Wildlife Management Area, Johnston County, Oklahoma.

Taxa	Oct. 2002 Springhead	Oct. 2002 Springbrook	Jan. 2003 Springhead	Jan. 2003 Springbrook	Apr. 2003 Springhead	Apr. 2003 Springbrook	Jul. 2003 Springhead	Jul. 2003 Springbrook	Totals
Platyhelminthes									
Unknown Turbellaria	1		8		14	2	112	3	140
Nematoda									
Unknown Nematoda		1		1		7			9
Oligochaeta									
Branchiura sowerbyi		1	1	3		13			18
Dero sp.				1		2		2	5
Limnodrilus sp.	30	28	9	25	17	166	1	52	328
Lumbriculus sp.	4								4
Pristina sp.						1		1	2
Bivalvia									
Sphaerium sp.						1		1	2
Crustacea									
Caecidotea sp.	6		107		33		5	1	152
Cladocera				2					2
Harpacticoida	1	4		7		5	16	44	77
Hyalella azteca complex					1				1
Ostracoda			4		38	2	25		69
Procambarus sp.		1		6		3		13	23
Acarina									
Hydrachnidae	2		3	16	14		17		52
Collembola									
Isotomidae	2			1	2	3	96		104
Semicerura sp.								1	1
Ephemeroptera									
Baetidae	1			2					3
Odonata									
Argia sp.	25	8	85	19	16	7	265	2	427
Brechmorhoga sp.			1						1
Unknown Zygoptera			1				6		7
Trichoptera									
Hydroptila sp.			2						2
Metrichia sp.	7		30	2	2	1	5		47
Hemiptera									
Aquarius sp.								1	1
Neocorixa sp.*									*
Rhagovelia sp.								1	1
Trepobates sp.*									*
Trichocorixa sp.								8	8
Trichoptera									
Hydroptila sp.			2						2
Metrichia sp.	7		30	2	2	1	5		47
Coleoptera									
Dineutus sp.*									*
Laccophilus sp.*									*
Diptera									
Atrichopogon sp.			1						1
Chironomus sp.						3		34	37
Conchapelopia sp.				2					2
Corynoneura sp.	67	24	1147	161	74	57	126	116	1772
Cricotopus sp.	21		38	22	48	26			155
Dasyhelea sp.	14		92	2				1	109
Dixa sp.							9		9
Ephydridae							1		1
Eukiefferiella sp.	31	2	688	22	3090	131	54		4018
Georthocladius sp.	18	8	15		181	13	563		798
Hemerodromia sp.			1						1
Larsia sp.						23	35	13	71
Limnophila sp.						1			1
Ormosia sp.			1						1
Paratendipes sp.	15	3		96	19	207		1813	2153
Rheotanytarsus sp.					11				11
Simulium sp.				2					2
Stictochironomus sp.	1		9	14		41		17	82
Sublettea sp.	43	2	58	38	368	224	4833		5566
Tanytarsus sp.	3			2				3	8
Tipula sp.		1			2		42	32	77
Number of Individuals	299	83	2333	448	3932	940	6216	2159	16,410
Species Richness	20	12	23	23	18	24	19	21	49 + (4*)
Species Diversity	2.437	1.834	1.516	2.116	0.912	2.102	0.957	0.777	

*** indicates taxa were not present in Surber net samples; found only in quantitative samples.**

the springbrook.

Results from the chi-square analyses indicated there was a statistically significant relationship between the number of individuals in the springhead and springbrook collections for all four seasons (χ^2 contingency test, $p<0.001$). Shannon's diversity values at the springhead ranged from 0.912 - 2.437 while these values in the springbrook were 0.777 - 2.116 (Table 2). Species diversity between the springhead and springbrook was significantly different during each collection month (Hutcheson *t*-test, October t=4.88, $p<0.001$, January t=9.47, $p<0.001$, April t=29.39, $p<0.001$, July t=5.01, $p<0.001$. This was expected because dissolved oxygen concentrations increased, presumably from atmospheric diffusion, as water flowed from the springhead into the springbrook, thus allowing the springbrook to support more species of macroinvertebrates.

Placement of taxa into trophic categories, based on information from Merritt et al. (2008) and Thorp and Covich (2009), revealed collectors dominated at the spring sites. Collectors were composed of 31 taxa, 66% of the species, and made up 94.6% of the individuals present. Predators (14 species, 4.5% of the individuals) and detritivores (two species, 0.9% of the individuals) composed the remaining trophic groups present. It should be noted that some of these species have different trophic roles as they grow and mature, so these proportions may change through time.

A large fraction of insect nymphs and larvae were found in the samples (Table 2). Gaskin and Bass (2000) also observed many immature insects were present in Desperado Spring and suggested that much reproduction must have been occurring there. This may be the case, but there is another possibility to be considered. Individuals making up the spring populations may have originated in the river and later moved into the springbrook, using it as a refuge from predators, such as larger fishes that would have difficulty existing in the spring's shallow water. It is unknown which, if either, of these hypotheses correctly explains the high number of immature individuals in Desperado Spring, but they are both possibilities.

Conclusion

Springs are unique and often over-looked aquatic environments. While many springs are reported to contain fauna found nowhere else, the Desperado Spring invertebrate community is mostly composed of species also found in the nearby Blue River. Non-insects are the dominant groups in many springs, but insects are the prevalent group in Desperado Spring, most likely due to its close proximity to the Blue River. Results of the physicochemical conditions in Desperado Spring indicate the water quality is capable of supporting a diverse biota, and this was confirmed by the intolerant taxa present in the samples.

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