Macroinvertebrate Community Structure and Physicochemical Conditions of a Southeastern Oklahoma Bog

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Abstract: An unusual wetland pond, known as a quaking bog, is located on the Oka' Yanhali Preserve in Johnston County, Oklahoma. There is little known about these ecosystems, and none have been described in published studies from Oklahoma. Physicochemical data and aquatic macroinvertebrates were collected in June and December of 2014. With the exception of low dissolved oxygen concentrations, the water quality was capable of supporting a healthy aquatic ecosystem. A total of 10,917 individuals representing 40 taxa were collected during summer and winter. Oligochaetes, bivalves, and chironomids dominated the collections, with 75% of all individuals categorized as detritivores. The highest species richness values and greatest number of individuals occurred in the center of the pond where water levels were the most stable.

Introduction

A quaking bog is a type of wetland pond that possesses a false bottom composed of a thick layer of vegetation floating beneath the water surface. The pond retains water from precipitation, runoff, and groundwater seepage. Aquatic vascular plants will grow toward the surface from the floating vegetation over time as additional water flows into the basin and covers the false bottom. When this kind of bog is walked upon, the bottom "quakes" and occasionally portions of the pond substrate may break loose and drift (Buell and Buell 1941). Bogs with false bottoms are generally found in cool, northern climates due to glacial activity, poor drainage, and eutrophication (Mitsch and Gosselink 2007).

According to Henley and Harrison (2000), several different types of wetlands are recognized in Oklahoma, but none of these have been described as quaking bogs possessing a false bottom. There is little known about these ecosystems, including the animal communities present or the water quality conditions they possess. The unnamed bog investigated in this project is similar to the nearby larger and younger Boehler Lake studied by Bass and Potts (2001). Passivirta (1988) suggests bogs contain a wide diversity of macroinvertebrates and have much greater productivity than semi-terrestrial sites.

Objectives of this study included determining basic water quality, identifying macroinvertebrates present, estimating population sizes, calculating species diversity, and comparing macroinvertebrate samples from different areas of the bog.

Study Site

The wetland pond investigated during this study is located in Johnston County of southeastern Oklahoma on the Oka' Yanahli Preserve near the Blue River (4°26'46''N, 96°37'51''W), a property owned and managed

by The Nature Conservancy (Fig. 1). This unnamed bog is small and somewhat circular in shape, measuring approximately 12 meters in diameter. A false-bottom is present a few centimeters below the surface of the water, with approximately three meters of open water existing between the false bottom and the actual pond bottom. Common vegetation in this wetland includes mosses, sedges, rushes, and grasses.

Methods

Sampling of this bog occurred in June and December of 2014 to examine conditions occurring during summer and winter, respectfully. Water quality measurements were collected from the center of the pond. Field testing of these samples included measurements of temperature (YSI 550A meter), dissolved oxygen concentration (YSI 550A meter), pH (Hanna pHep meter), and alkalinity (sulfuric acid titration). Additional water samples were transported to the laboratory to determine conductivity levels (Hanna conductivity meter), turbidity (Bausch & Lomb Spectronic 20), and nutrient (ammonia, nitrite, nitrate, and orthophosphate) concentrations (Hach DR 2800 meter). Oxygen saturation (oxygen nomograph) and carbon dioxide levels (Moore's nomograph) were also determined in the lab.

Macroinvertebrate samples were collected using a petite Ponar bottom grab in a transect across the bog. Two samples were collected near the edge (outer), two samples were collected half-way to the center (middle), and two samples were collected from the center of the pond. All samples were preserved in the field with a mixture of 10% formalin and rose-bengal dye, and returned to the laboratory where they were sorted using a 250-µm sieve, identified, and enumerated. Identification of macroinvertebrates was determined primarily using keys by Merritt et al. (2008) and Smith (2001). In addition, D-ring net samples were taken at each of those locations to obtain organisms that may have been missed by the petite Ponar grab. However, only petite Ponar samples were used in the statistical analysis. Voucher specimens of macroinvertebrates were deposited into the University of Central Oklahoma Natural History Museum.

Shannon's index of diversity was used to calculate species diversity and Sorenson's index of similarity was used to compare macroinvertebrate community similarity.

Results & Discussion

Results of the physicochemical analysis are in Table 1. These results generally fall within the normal ranges of aquatic systems in southeastern Oklahoma (Bass and Potts 2001).

The temperature of the bog reflected the

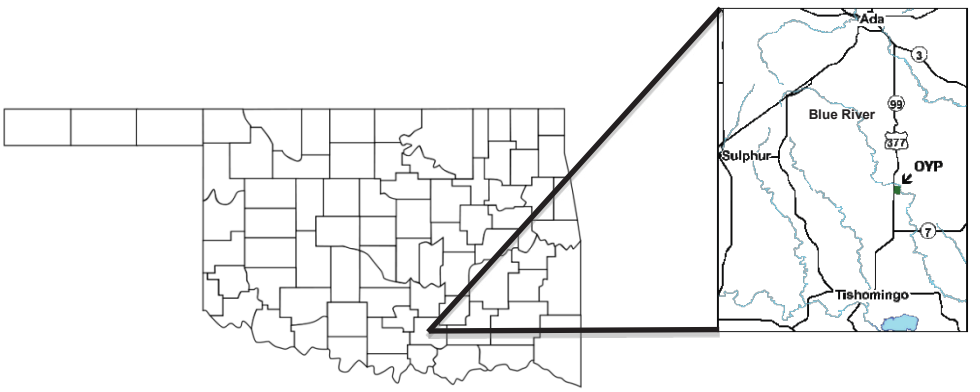

Figure 1. Map of the field site located in Johnston County, Oklahoma.

Table 1. Physicochemical conditions for a quaking bog located in the Oka' Yanahli Preserve, Johnston County, Oklahoma.

Parameter	June 2014	December 2014
Water temperature (°C)	23.8	15.6
Dissolved oxygen (mg/L)	2.0	2.2
Oxygen saturation (%)	11	23
pH	7.3	8
Alkalinity (mg/L)	319	320
Carbon dioxide (mg/L)	0	0
Turbidity (JTU)	10	32
Specific conductance (μmohs/cm)	495	545
Ammonia (mg/L)	0.13	0.08
Nitrites (mg/L)	0.26	0.06
Nitrates (mg/L)	0.56	1.71
Orthophosphates (mg/L)	0.01	7.23

seasonal changes of the local area, ranging from 23.8°C in June to 15.6°C in December. Dissolved oxygen concentration only varied by 0.2 mg/L, with June having a lower value of 2.0 mg/L. This is most likely associated with the large amount of decomposing plant debris present during the summer.

Values for pH ranged from 7.3 in June to 8.0 in December. Alkalinity measurements were relatively stable and ranged from 319 mg/L in June to 320 in mg/L in December. These values were expected for Oklahoma and well buffered against the pH changes. There was no free carbon dioxide in the pond, which is supported by the pH and alkalinity readings.

Turbidity measurements varied from 10 JTUs (Jackson Turbidity Units) in June to 32 JTUs in December. These changes may be associated with the amount of seasonal rainfall. Jona Tucker, TNC Oka' Yanahli Preserve Director (pers. comm), reported that water is usually present in the pond. The drought immediately prior to the June sampling resulted in less than 25 cm of water covering the vegetation, leading to a low turbidity value. Rainfall in an excess of 1.5 inches occurred within a few days prior to the December collection (Oklahoma Climatological Survey, 2015). It was observed there was a greater amount of water present during this time of the year as compared to the summer. The higher turbidity value in December was due to increased rainfall and runoff. Conductivity readings fell within expected ranges for Oklahoma, 495 μmohs/cm in June, and 545 μmohs/cm in December.

Nutrient values were generally low. Ammonia concentrations ranged from 0.13 mg/L in June to 0.08 in December mg/L. Nitrite values were 0.26 mg/L in June, while only 0.06 mg/L in December. Nitrates ranged from 0.56 mg/L in June to 1.71 mg/L in December. Orthophosphate concentrations were 0.01 mg/L in June, and greatly increased to 7.23 mg/L in December. High orthophosphate levels may have been due to rainfall prior to the sampling period during the winter.

During the course of this study, 10,917 individual macroinvertebrates representing 38 taxa were collected with the petite Ponar grab and identified. Of these, 6,103 (56%) were insects and 2,838 (26%) were oligochaetes. The remaining individuals were turbellarians, nematodes, mollusks, collembolans, hydrachnids, and crustaceans (Table 2). Two additional taxa were collected only in the D-ring net samples.

Table 2. Macroinvertebrates collected throughout different regions of the bog on the Oka' Yanahli Preserve, Johnston County, Oklahoma.

	June 2014			December 2014			Total
Taxa	Center	Middle	Outer	Center	Middle	Outer	
Platyhelminthes							
Dugesiidae*	19	2	1	42	10		74
Unknown Turbellaria	2			9			11
Nematoda							
Unknown Nematoda	46		1	336		4	387
Oligochaeta							
Amphichaeta sp.	5			10		7	22
Dero sp.*	495	6	17	421	12	20	971
Limnodrilus sp.*	1101	5	10	672		2	1790
Unknown Tubificidae	6			46		3	55
Gastropoda							
Physa sp.*	66	1	20	40	6		133
Stagnicola sp.		1	2	1			4
Bivalvia							
Sphaerium sp.*	587	1	48	536	109	40	1321
Crustacea							
Cambaridae				1			1
Cyclopoida				2	9	8	19
Hyalella azteca	3	1	1	1			6
Acarina							
Hydrachnida	2	3	1				6
Collembola							
Isotomidae*		1	3	1	3	6	14
Sminthuridae*							
Odonata							
Amphiagrion sp.				17	1		18
Argia sp.*	54	3	8	54			119
Coenagrion sp.*				25		1	26
Trichoptera							
Helicopsyche sp.				1			1

Continued	June 2014			December 2014			Total
Taxa	Center	Middle	Outer	Center	Middle	Outer	
Coleoptera							
Celina sp.*			1				1
Hydrochus sp.			1				1
Laccobius sp.*	7	1					8
Laccophilus sp.*	17		4	10	2		33
Paracymus sp.*	44	1	2	8			55
Sphaerius sp.*	31		2				33
Tropisternus sp.*	4	2	2	8	3	1	20
Diptera							
Anopheles sp.*							
Chironomus sp.	1	1					2
Chrysops sp.			2	11			13
Corynoneura sp.					2	3	5
Culicoides sp.	2			40		10	52
Dixella sp.	1						1
Larsia sp.*	32	1	2	149	43	72	299
Paratendipes sp.				17		2	19
Polypedilum sp.				3859	46	892	4797
Stratiomys sp.*	53	8		37		3	101
Tanytarsus sp.				468	10	17	495
Tipula sp.				3			3
Unknown Diptera						1	1
Total Individuals	2578	38	128	6825	256	1092	10917
Total Species	22	16	19	29	13	18	38
Species Diversity	1.673	2.459	2.112	1.646	1.776	0.8551	

* indicates taxon collected in qualitative dip net sample

Dominant taxa (>10%) in the pond included oligochaetes, bivalves, and chironomids. Both seasons had a large amount of oligochaetes, but June had more bivalves, while December contained mostly dipterans. The difference in dominant taxa for each season is likely due to seasonal life cycle changes and water availability.

A non-dominant taxa of particular interest was *Sphaerius* sp. of the family Sphaeriusidae, also referred to as the minute bog beetles. This insect has been previously collected from Arizona, California, Texas, and Washington, but this is the first report of that family in Oklahoma (Merritt et al. 2008).

Table 2 shows that collectively, Shannon's species diversity value for the June collection (1.757) was slightly higher than that of December (1.618). However, this was a reflection of the lack of evenness in the winter collection. Species richness was actually less in June (27) than in

December (31), but the winter sample had a much greater number of individuals (8,173) than the summer collection (2,744). Diversity values increased from the center toward the middle and outer portions of the bog in the June collection, while the opposite was observed during December. Although the overall diversity values would indicate this aquatic system is stressed, that may not necessarily be the case in this pond.

When comparing the regions of the pond during the two different seasons, it was observed that the center of the pond did not vary in the amount of diversity. In contrast, the middle and outer portions of the bog for the June collection had greater diversity than the December collection. These observations are most likely due to the reduced amount of water concentrating microhabitats in the center of the pond during the summer. In addition, the June collection contained higher species richness in those areas of the pond (Table 2).

Sorenson's index of similarity between the two seasons was 0.689, indicating many of the same taxa were present during both seasons (Table 3). This is not unexpected because the pond is a relatively small habitat. It was observed that the presence of water influenced similarity throughout the different regions of the bog. Collectively, similarity values for the two seasons decreased moving from the center towards the outer edges of the pond. The amount of water present during June fluctuated more in comparison to December. The center of the bog in June was more similar than the middle or outer regions because of the shallow, yet stable amount of water in the center. In contrast, December's similarity values varied because water had risen immediately prior to that collection due to rainfall, providing more opportunities for organisms to disperse throughout the pond.

When examining trophic structure in the pond, it was observed that 75% of the individuals were detritivores in both collections (Fig. 2). This trophic category included organisms such as oligochaetes, nematodes, and *Polypedilum* sp. Collectors such as the bivalve, *Sphaerium* sp., and many of the dipterans constituted 19% of the individuals. The high numbers in these two groups were attributed to the large amount of detritus present in the pond. Predators, herbivores, and scrapers comprised the remaining 6% of the total individuals collected in both seasons.

Table 3. Sorenson's similarity values for macroinvertebrates collected from a quaking bog on the Oka' Yanahli Preserve, Johnston County, Oklahoma.

Collection Date	Center	Middle	Outer
June 2014			
Center	—	0.842	0.683
Middle	—	—	0.743
Outer	—	—	—
December 2014			
Center	—	0.572	0.681
Middle	—	—	0.581
Outer	—	—	—
June vs. December 2014			
Center	0.667	—	—
Middle	—	0.552	—
Outer	—	—	0.378

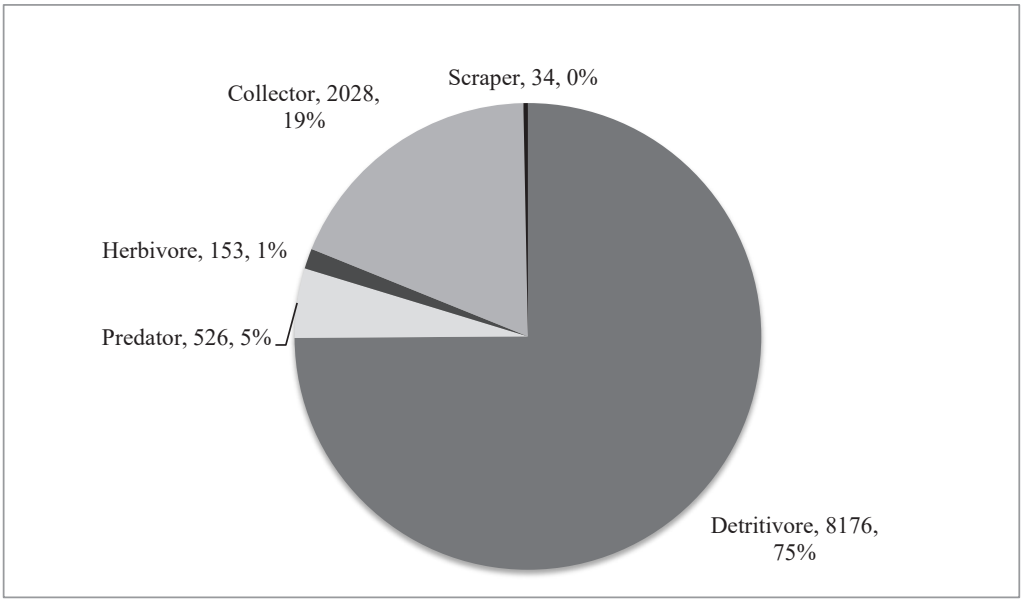

Figure 2. Macroinvertebrate trophic categories, including number of individuals and percent composition for June and December collections.

Summary & Conclusion

Generally high water quality exists within the wetland, except for the low dissolved oxygen concentrations, and these values suggest oxygen is a limiting factor for some aquatic macroinvertebrates. The oligochaetes and chironomids, which dominated most of the collections, are tolerant of reduced oxygen levels. Altogether, a total of 40 taxa and 10,917 individuals of macroinvertebrates were documented from this pond.

Quaking bogs are not only unique ecosystems in Oklahoma, but uncommon in the state. The fragile, unnamed bog on the Oka' Yanahli Preserve showed high water quality and supported a diverse macroinvertebrate community. This research provided a better understanding and additional information regarding freshwater quaking bogs, and this may be used to strengthen measures for their conservation.

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