Ostracode community baseline for water quality monitoring at Steele Creek Park

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for the Friends of Steele Creek Park, Bristol, Tennessee

Introduction

Ostracoda is a group of crustaceans which is defined by a bivalve carapace and small size, often considered meio- or microfauna. Ostracodes are distributed globally and found most bodies of water due to their small size are highly sensitive to water chemistry and hydrology. Previous studies have collected ostracodes from water bodies throughout North America to establish databases for future research and baseline species lists which are used to track changes in water quality and keep record of ostracode tolerances. Despite its various ecosystems and climate regimes, the southeast United States has had very few records of ostracodes. Having so few sampling sites in the region, this project is the first in the northeast of Tennessee and one of only a handful of studies in the state and in the Southeast.

The study presented a large diversity of ostracodes as well as many new occurrences of species never before reported in the region, as well as reshaping the autecology of some species. This report will describe, in detail, each species' valve shape and, if available, the species in-life appearance. Along with a species inventory, water chemistry was recorded at each sampling site in order to establish average conditions for aquatic habitats around the park. This project is a preliminary survey which will allow future park researchers and naturalists to track the changes of aquatic health and biodiversity around the park, while providing informative outreach to park visitors.

Materials & Methodology

Multiple samples were collected from permanent and ephemeral, lotic and lentic aquatic bodies from around the park. Typically, freshwater ostracodes are found on vegetation or in finer substrates along the shoreline (i.e. littoral and benthic zones); very few freshwater species are planktonic and reside in the limnetic zones of lakes. Steele Creek Lake is the largest water body in the park and the recipient of most tributaries around the park, so several shoreline and point source locations as well as open water locations were sampled around the lake in order to have a broader idea of biodiversity and aquatic conditions. Many creeks and streams throughout the park were sampled in both flowing and pooling sections, which may contain different species. During times of high water levels in the park, seasonal springs and flooded areas were sampled to understand the fauna that inhabited ephemeral habitats. Several point sources and pools were sampled from the wetland area which the park management is maintaining as part of a park restoration project. Areas that are heavily trafficked or with detrimental surface conditions such as oil and weedy vegetation were given special notice so that these areas could be monitored closely during restoration projects. In total this study sampled 29 unique sites from nine bodies of water throughout the park, with some sites being sampled multiple times with different collection methods.

Due to the small size of ostracodes, their collection can be very simple but frustrating due to the uncertainty that any were actually collected. Different methods of collection were used in this study determined by the site hydrology, vegetation cover and substrate. Collected samples were kept in tightly sealed plastic containers, which most ostracodes can survive in these containers for several days with sufficient vegetation or algae. Sample sites that had vegetal and algal cover were typically sampled using a suction tool, such as a turkey baster. At each site both water and actual vegetation were suctioned as well as substrate sediment if present. Collection from lentic sites with little to no vegetation utilized a long handled, 150 micron net to agitate sediment or leaf litter. Sites with fast flowing water utilized the 'kick-net' method, in which sediment is agitated upstream and caught downstream in the net. Debris collected in the net was washed out into a container using a squirt bottle.

Ostracodes were identified using a binocular stereo (i.e. dissecting) microscope with 50x zoom. Most individuals were collected alive while others were only collected as valves. The presence of species was noted but due to the abundance and convoluted movements of some species the actual number of individuals was not recorded. Identification of species was based on Smith and Delorme (2009) and Forester et al. (2005)'s NANODe database. Species designations were identified to the best of the author's knowledge and available sources, although cryptic species are prevalent throughout Ostracoda.

In ostracode biodiversity studies it is usually necessary to collect water chemistry data at each sample site. Environmental tolerance ranges, such as salinity and temperature, have been calculated for most species in North America based on the associated water chemistry data collected. Using a combo water tester, three essential environmental factors were collected at each sample site: water temperature (℃), pH, and total dissolved solids (TDS; mg/L). This data along with species presence will be submitted to the NACODe database (1999) which tracks ostracode tolerances and biodiversity in North America.

Results

Of the 29 sites sampled, 25 resulted in the capture of live ostracodes or valves. Although most sites produced numerous individuals, some samples only contained a single individual. A total number of 10 species were identified throughout the park, all of which are new occurrences in the region. Several rare and unexpected species were collected including *Prionocypris canadensis*, *Pseudocandona albicans* and *Paracandona euplectella*.

Water chemistry results were taken at each sample site and averaged for sites where multiple samples were taken. The temperature of sampled water ranged from 7.2 to 14.6 ℃, with lower temperatures typically being found around the lake and warmer temperatures found in small streams. The pH range throughout the park was not large with a near neutral value of 7.24 and the most alkaline at 8.66. The TDS or salinity varied substantially around the park, from 300 to 3300 mg/L, but remained relatively fresh to slightly brackish.

Species Guide

Family Darwinulidae
Darwinula stevensoni

Image from NACODe

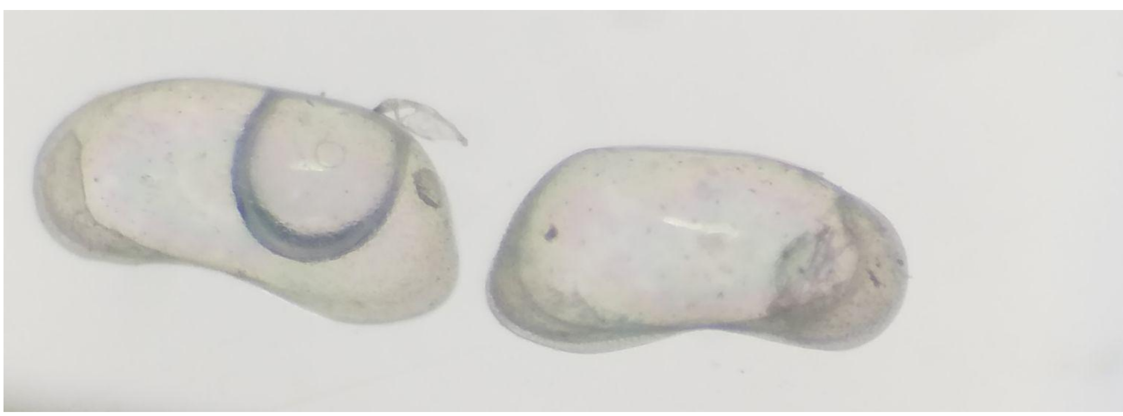
Locations: 7
Size: 0.7mm
Appearance: Valves are smooth, opaque to light brown
Shape: Cigar or wedge shaped in side view and top view
Notes: Has unique rosette muscle scar pattern. Usually a common species, which may appear more during certain seasons.

Family Candonidae

Subfamily Candoninae

Candona sigmoides

50x



40x

Locations: 5, 16, 19, 21

Size: 0.85-1.0mm

Appearance: Valves are smooth, opaque with brown-yellow body.

Shape: Subreniform, mellow arched dorsum and steeply arched posterior.

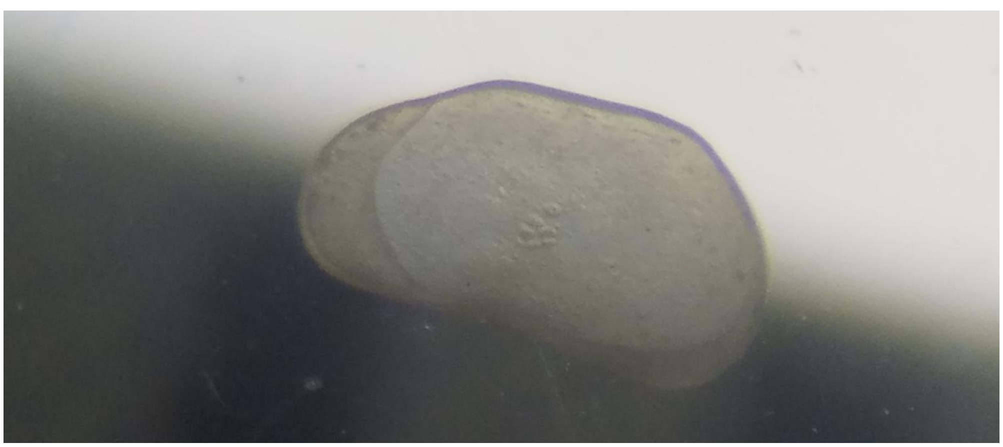
Notes: Can be confused with *Prionocypris canadensis*, which is more ovate, larger and has more of a yellow coloration.

Paracandona euplectella

50x

Locations: 10
Size: 0.6-0.75mm
Appearance: Valve is pitted and bumpy, opaque. No living specimens found.
Shape: Subrectangular with slightly arched dorsum and ventral, rounded ends in side view.
Notes: Only a single valve was recovered from this rare, hyporheic species. This valve was likely carried in by Steele Creek or a spring.

Pseudocandona albicans



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Locations: 16, 26
Size: 0.8mm
Appearance: Valves are slightly pitted with pores, opaque. No living specimens found.
Shape: Trapezoidal with linear dorsum slightly arched venter, rounded ends in side view.
Notes: Only two single valves were recovered, likely belonging to near-adult instars due to their smaller size.

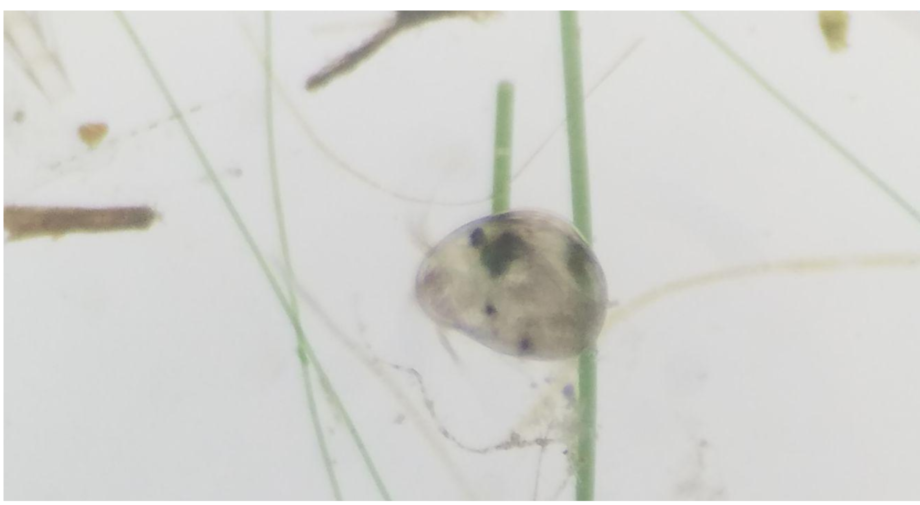
Subfamily Cyclocypridinae

Cypria ophthalmica


50x

Locations: 5, 6, 12, 19, 21, 23, 24, 26
Size: 0.5-0.6mm
Appearance: Valves are smooth, brown with a speckled, scaly-like pattern. Notable single eyespot.
Shape: Oval with linear venter in side view, very compressed in top view.
Notes: Very common and active species usually found amongst vegetation.

Physocypria pustulosa


50x

Locations: 8, 11, 16, 17
Size: 0.5mm
Appearance: Carapace is smooth and has a mottled or blotchy appearance. Has a prominent eyespot but can be obscured by coloration.
Shape:Almost circular in the side view but has a noticeable hump and narrowly compressed top view.
Notes: Common and active species usually found among vegetation.

Family Cyprididae

Subfamily Eucypridinae

Prionocypris canadensis

40x

Locations: 5, 16, 19, 23

Size: 1.5-1.75mm

Appearance: Carapace is smooth except for some small denticles on the lower margin of the valves. Valves are opaque but the animal's vivid yellow body is highly visible.

Shape: Elongate oval in side view and narrowly ovate in top view. Does vaguely resemble *Candona sigmoides* but *P. canadensis* is larger, less angular, and has a yellow appearance.

Notes: Somewhat active species and the largest species found in the park.

Subfamily Cypricercinae

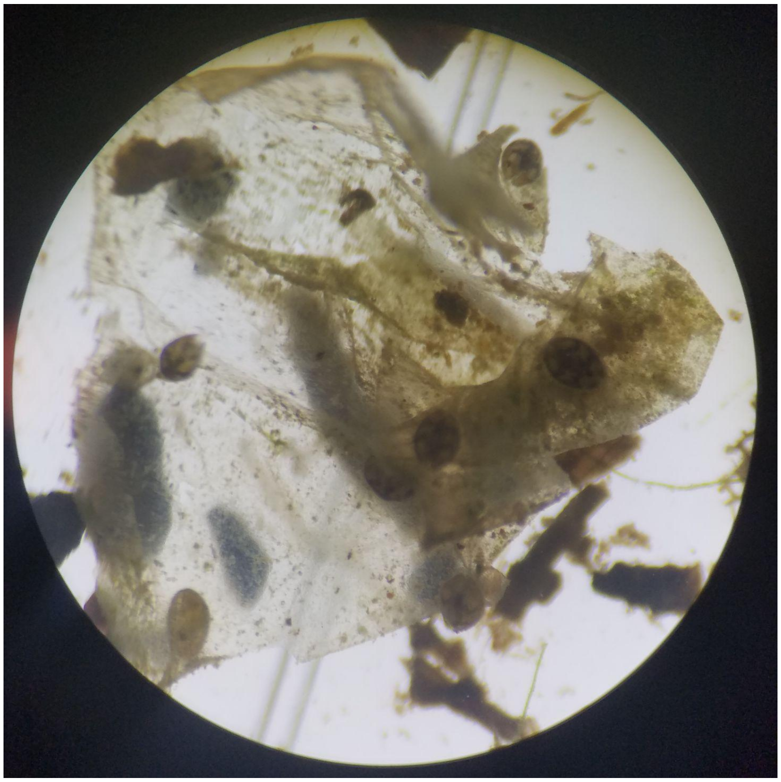
Bradleystrandesia cf. B. reticulata


50x

Locations: 5, 6, 23
Size: 1.0mm
Appearance: The valves of individuals found in the park have pitting but this species has reported being smooth; live individuals are brown in appearance.
Shape: Carapace is subtriangular in side view and ovate in top view; although difficult to see radial pores can be seen on the ventral side of valves.
Notes: Very little information is available about other occurrences of this species in North America. Due to the variable descriptions of this species this identification has been given a *confer* designation.

Subfamily Cypridopsinae

Cypridopsis vidua


A group of *C. vidua*, 25x

Locations: 1, 3, 5-14, 16, 19-21, 23, 24, 26

Size: 0.75-0.8mm

Appearance: The valves are slightly rugose with bumps and pitting, pores seen throughout. Live individuals have a unique striping pattern on carapace.

Shape: The carapace is subtriangular in the side view and ovate in the top view.

Notes: The most common ostracode in the park and cosmopolitan throughout North America. A very active species often seen swimming around samples and walking along vegetation.

Family Ilyocyprididae
Ilyocypris gibba


50x

Locations: 8, 11, 12, 20, 24
Size: 0.75mm
Appearance: Carapace is very rugose with large pitting and folding texture and sometimes hosts lateral projections, opaque to light brown.
Shape: Subrectangular in side view and subovate in top view, juveniles can be wedge shaped.
Notes: Only valves were found during this study. Although this species is typically reported living in lotic habitats, at Steele Creek most valves were recovered from lentic sites, likely carried in from tributaries.

Discussion

This study collected Steele Creek Park's ostracode fauna and tested the aquatic habitats in which they reside (Tables 1 & 2). Of the ten species collected several species including *Cypridopsis vidua*, *Cypria ophthalmica*, and *Physiocypria pustulosa* are cosmopolitan in North America and were more likely to be seen in the study. The only species previously reported nearby is *Candona sigmoides* which was seen in Lake Shenandoah in northern Virginia. New to eastern North America is *Prionocypris canadensis*, which previously was only reported in Alberta and some western states. *Paracandona euplectella* is not necessarily a rare species but due to its unique hyporheic habit makes it difficult to locate without special subterranean sampling techniques, making this sighting unique and unexpected. Although the sites sampled in this study were chosen to reflect the majority of potential ostracode habitats, rare sightings like *P. euplectella*, suggest that there are more rare species throughout the park that require future sampling in unlikely locations such as aquifers, the lake's limnetic zone, and ephemeral pools.

A water chemistry reading was taken alongside each sample at each site, allowing for a baseline signature to be constructed (Table 2). With only a few exceptions, the water temperature around the park had very little variance, residing around 8.5-10℃. The total dissolved solids (in mg/L) varied with the small streams having the lowest amount and pools with high vegetation reading as brackish. The pH at the sites had very little variance but typically was reported at near-neutral or very slightly alkaline. Some sites such as the spillway (e.g. high traffic), the wetland (e.g. presence of surface oil), and the lake (e.g. trash) were given special notice due to anthropogenic pressures but chemistry readings did not find any major difference to aquatic health. The stability of water chemistry throughout the park might suggest that Steele Creek and other water sources likely maintain the positive health of the park's water bodies despite the continued influx of visitors.

Ostracodes are great indicators of aquatic health and can be used to monitor the changing conditions of a site. Each species has a specific tolerance range for a certain condition, which are calculated by the lowest and highest collected values for that condition. For example, based on all the sites that *Cypridopsis vidua* has been recorded at, its tolerance for pH ranges from 5.2 to 12. Unfortunately, the most populous and common species, such as *C. vidua*, are not great indicators due to their high tolerance ranges and cosmopolitan ecology. Oftentimes, biomonitoring requires rare or specialized species to monitor a site's health. *Candona sigmoides* would act as a great indicator species that has a very narrow tolerance for most conditions and is semi-common throughout the park. If monitored regularly, a decrease in *C. sigmoides* populations may represent a shift in aquatic health around the park, particularly TDS and pH.

This study is one of few to take place in the Southeast and will have a significant impact on known ostracode ecology. This study will provide new data for each species and may adjust the autecology for some. This study at Steele Creek Park marks the lowest latitude that *Paracandona euplectella* and *Pseudocandona albicans* have ever been reported and both have previously been deemed a cold species and will dramatically increase the tolerance ranges of both species in regards to water and annual climatic temperatures. Repeated sampling will benefit the park by providing new insights to the biodiversity and health of the park, as well as a flagship site for the Southeast.

Conclusion

The goal of this study was to survey Steele Creek Park's aquatic habitats for ostracodes and record the water chemistry at each site. The survey created a baseline faunal inventory for future monitoring of the park's aquatic ecosystem. Multiple samples were taken from 29 unique sites that were likely to be habitats for ostracodes and other microfauna. Most samples had ostracodes, sometimes with living individuals or just valves. A total of 10 species of ostracodes were reported from this study. The park's most abundant species such as *Cypridopsis vidua* and *Cypria ophthalmica* are common for North American ecosystems. Unexpected species such as *Paracandona euplectella* and *Pseudocandona albicans* offer insight into the biodiversity of the mostly unstudied southeast United States. The semi-common species *Candona sigmoides*, has a very narrow tolerance range and populations can offer park naturalists with a useful bioindicator of the park's aquatic health. Averaged chemistry readings showed that pH was generally neutral to slightly alkaline, the water is mostly fresh and brackish, with some expected variance in water temperature. Overall, the park's aquatic ecosystem seems to be well maintained and responds well to visitors and other anthropogenic pressures. Repeat surveys can potentially uncover new species and provide the park a simple method of monitoring aquatic health. This study has offered a much needed insight into the ostracode fauna of Steele Creek Park and the Southeast as a whole. Although this study is preliminary, it is hopeful that it will give the park and its community a sense of connection to their environment on a microscopic scale.

References

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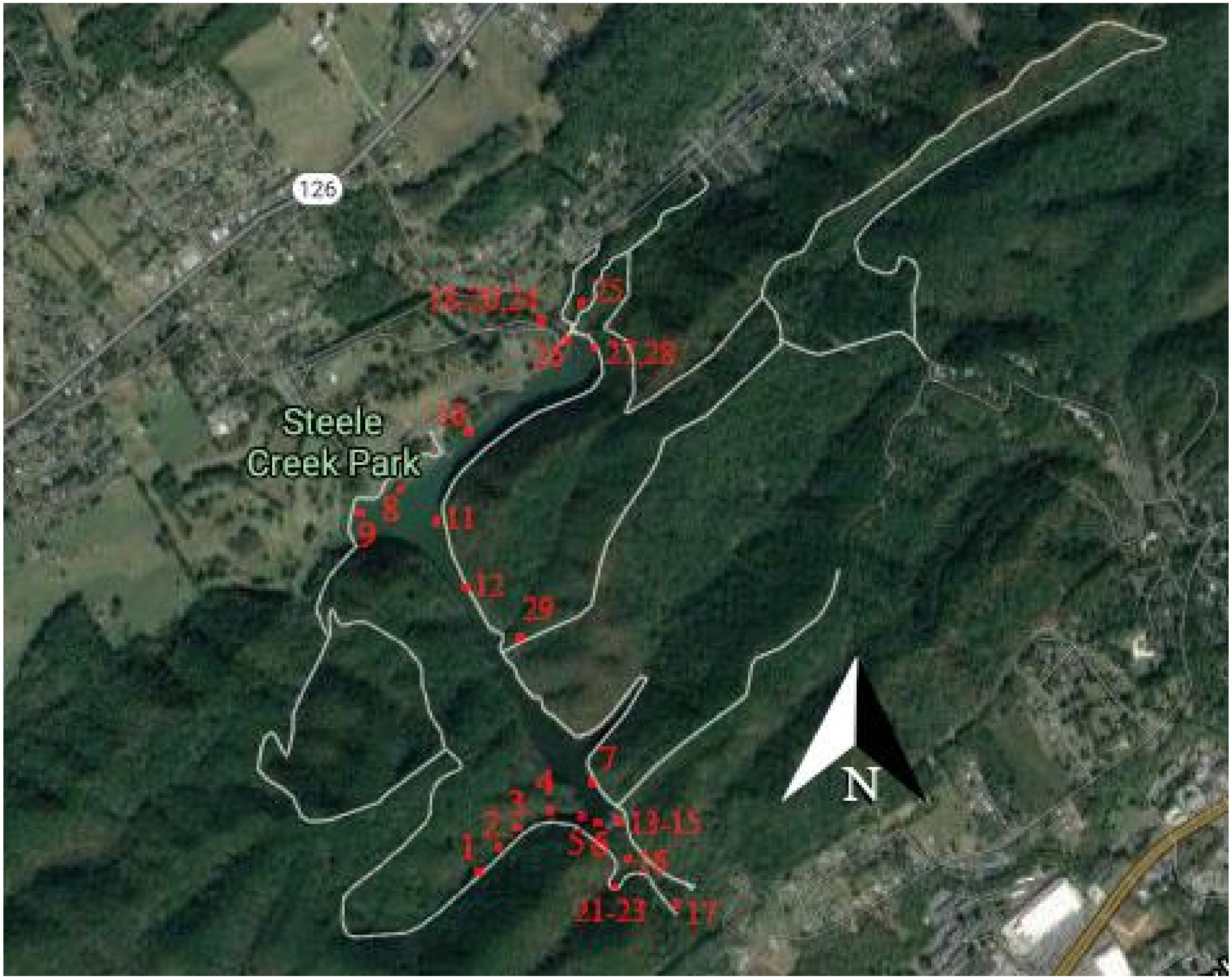
Forester RM, Smith AJ, Palmer DF, Curry BB. 2005. North American Non-Marine Ostracode Database NANODe, Version 1, http://www.kent.edu/nanode, Kent State University, Kent, Ohio, USA

Smith AJ, Delorme LD. 2009. Ostracoda. In Thorp JH, Covich AP. (Eds.). *Ecology and classification of North American freshwater invertebrates* (pp.725-771). Academic press.

Site #	Site Location	Sample Description
1	Slagle Creek- Pool	Shallow pool formed in creek along trail, medium flow, suction and net mixed
2	Slagle Creek- Tree Pool*	Very shallow pool formed in area under roots, suction only
3	Slagle Creek- Rocky Flow	Faster flowing part of creek with medium size stones, suction only
4	Slagle Creek- Trail Pool*	Stagnant pool formed in flooded trail, suction only
5	Slagle Creek- Lake Connection	Shallow inlet formed from inflow of Slagle Creek into Steele Creek Lake, suction and netted collection from submerged log
6	Lake- Log	Large submerged log and benthic leaf litter, net collection
7	Lake- Near Shore Sand	Shallow sediment along shore, suction collection
8	Lake - Visitor Center Dock	Floating and attached algae around dock, suction and net
9	Lake - Visitor Center Log	Partially submerged log in adjacent pond to lake, suction and net
10	Lake- NE Shore	Shoreline east of VC covered in leaf litter with submerged tree roots, netting only
11	Lake- Log 2	Submerged log near shoreline of eastern portion of lake, netting and suction
12	Lake- Algal Shoreline	Nearshore vegetation near submerged branches and gooey algae, suction only
13	Dam- Spillway	Suction from algae growing along edge atop waterfall
14	Dam- Pool Overflow	Organic-rich pool separated from flowing spillway
15	Dam- Falls*	Pooling area alongside falls, suction from algae

16	Steele Creek S- Near Wetland	Fast flowing creek collected through kick-net method, near-shore outlet collected with suction
17	Steele Creek S- Rooster Front	Gravelly sand outlet of fast flowing creek near parking area
18	Steele Creek N- Slow Flow*	Slow flowing portion of creek near walking trail, gravel and sandy substrate, suction and netting at different sites
19	Steele Creek N- Side Pond	Adjacent pond (contained oil) attached to slow flow creek and flooded lawn area (frozen), suction only
20	Steele Creek N- Fast Flow	Faster flowing part of creek, suction used in eddy, kicknet method in middle of stream
21	Wetland- Vegetation	Shallow vegetation collected through suction and netting, near SW Steele Creek source
22	Wetland- Duckweed	Deeper portion of wetland dominated by duckweed, collected through netting
23	Wetland- Motoroil Pond	Isolated pond adjacent to main wetland body, oil on water surface, netted collection
24	Small Stream- Point Source	Small stream feeding into creek from drainage under Steele Creek Dr., suction only
25	Mill Creek- Hole 10*	Bank of creek near Hole 10 with some vegetation, suction only
26	Mill-Steele Creek Confluence	Point where both creeks meet, collected with net from bridge in middle of creeks
27	Hill Stream- Hill Hole*	Small stream on hillside running beneath roots of trees, suction only
28	Hill Stream- Point Source	Point where Hill Stream runs into lake, suction only
29	Hickory Trail Creek*	Small creek running alongside Hickory Trail

Table 1: Site locations and sample methods. * = sites that did not have ostracodes in this study



Site locations at Steele Creek Park. Modified from Google Earth.

Site #	Water Temperature (C)	TDS (mg/L)	pH
1	10.9	500	7.87
2	11	400	7.33
3	9.8	300	7.61
4	9.4	500	7.24
5	8.8	1400	7.78
6	8.2	2600	8.01
7	8.4	2700	8.11
8	8.4	2100	8.22
9	9.2	2600	8.24
10	7.7	3100	8.37
11	9	2500	8.39
12	8.5	2500	8.66
13	8.1	2800	8.13
14	7.9	2700	8.33
15	7.2	2300	8.16
16	7.6	2500	8.28
17	8.5	2700	8.33
18	9.4	2700	8.63
19	12.8	3300	7.46
20	9.4	2700	8.49
21	10.9	3000	7.43
22	9.5	2200	7.76
23	10.6	2500	7.41
24	14.6	3000	7.31
25	10	2900	8.51
26	9.5	2900	8.57
27	11.1	1100	8.25
28	11	1100	8.1
29	11.2	600	8.03

Table 2: Water chemistry values collected at each site.

Site #	***CYPV***	***COPH***	***ILYG***	***PHPU***	***DARS***	***PRIC***	***BRAR***	***PSUA***	***PRCE***	***CANS***	**other**
1	x										Insect larva
2											Copepods
3	x										N/A
4											Cladocerans, copepods
5	x	x				x	x			x	Copepods
6	x	x			x		x				Cladocerans, copepods, "shrimp", water mite, fingernail snail, worms
7	x										Copepods, cladoceran, nematodes, "shrimp"
8	x		x	x							Copepods
9	x										Copepods, nematodes, flatworm
10	x								x		Insect larva, nematodes
11	x		x	x							Flatworms, copepods, *Stentor*, cladocerans
12	x	x	x								Worms
13	x										Cladocerans, copepods, flatworms
14	x										Cladocerans, copepods
15											Cladocerans, copepods
16	x			x		x		x		x	Copepods, rotifers, fingernail snail
17				x							Insect, flatworms
18											Worms, insect larva
19	x	x				x				x	Fingernail snail
20	x		x								Snail, clams, large ciliates
21	x	x								x	Fingernail snail, clams

Site #	***CYPV***	***COPH***	***ILYG***	***PHPU***	***DARS***	***PRIC***	***BRAR***	***PSUA***	***PRCE***	***CANS***	**other**
22		x									N/A
23	x	x				x	x				Fingernail snail
24	x		x								N/A
25											Flatworm, copepods, insect larva, snails, fingernail snail
26	x							x			Worms
27											Insect larva
28		x									Copepods
29											Copepods, insect larva, flatworm

Table 3: Ostracode and microfaunal diversity collected at each site.
CYPV=*Cypridopsis vidua*, COPH=*Cypria ophthalmica*, ILYG=*Ilyocypris gibba*, PHPU=*Physocypria pustulosa*, DARS=*Darwinula stevensoni*, PRIC=*Prionocypris canadensis*, BRAR=*Bradleystrandesia reticulata*, PSUA=*Pseudocandona albicans*, PRCE=*Paracandona euplectella*, CANS=*Candona sigmoides*