2011

Factors structuring zooplankton density and composition within a Louisiana river and floodplain tributaries with emphasis on hydrologic processes

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FACTORS STRUCTURING ZOOPLANKTON DENSITY AND COMPOSITION WITHIN A LOUISIANA RIVER AND FLOODPLAIN TRIBUTARIES WITH EMPHASIS ON HYDROLOGIC PROCESSES

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Science

in

The School of Renewable Natural Resources

by
William L. Sheftall IV
B.A., Rhodes College, 2007
August 2011

ACKNOWLEDGEMENTS

I have to start by saying thank you to my committee members, Dr. Mike Kaller, Dr. William Kelso, and Dr. Glenn Thomas. They overlooked my thin resume when I applied for grad school, and gave me the opportunity to gain experience in their fields and further my education. I feel that they took a real shot in the dark with me, and I hope they're pleased with the outcome.

Next, I have to thank my officemates, and friends, Thorpe Halloran and Chris Bonvillain. Because I started LSU when I did, I had to move in to the "office" with Thorpe and Chris. My lack of space and privacy was worth the lessons that I would learn from two people who had already established themselves in the system and had learned what to do (and probably more importantly, what not to do). Two to three years is a long time to share a small space with, but I think it worked out pretty well.

My fieldwork would not have been possible without the assistance of many people. Thorpe, Chris, Peter Markos, Melissa Fries, Jonathan West, Zach Harrington and Devon Oliver all volunteered their time (most of them on more than one occasion) to help me collect my samples. Also, a huge thanks to Ben Hartman who enthusiastically helped me with some of my zooplankter enumeration so that I could have a chance at finishing. As well, I am very grateful to Mrs. Deb Kelly for her expertise and help with my water chemistry samples.

Lastly, and most importantly, I must thank my parents, and Allison, for their steadfast support throughout this chapter of my life.

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ABSTRACT

Zooplankters are important members of freshwater communities, facilitating the transfer of energy from primary production to higher trophic levels. Lentic floodplain systems are important in providing zooplankters with adequate habitat for growth and reproduction. Recently, The Nature Conservancy has been interested in cataloguing the aquatic taxa that inhabit the Ouachita River and floodplain in northern Louisiana, concurrent with an attempt to reestablish a river-floodplain connection with the river and eastern floodplain (the Mollicy Farms Unit, part of the Upper Ouachita National Wildlife Refuge). Sampling was conducted at seven sites along the Ouachita River and western floodplain monthly for one year to investigate zooplankton density and composition in relation to environmental variables and hydrology. Principal component analysis was used to illustrate relationships among zooplankton groups with environmental variables and sampling sites, and cladoceran taxa were found to be correlated to specific environmental variables by multivariate analysis of variance. Results indicated that highest densities were exhibited by rotifers, followed by copepods and cladocerans. Abundances of the zooplankton groups were correlated primarily with specific conductance, PO_4, temperature, chlorophyll *a*, Secchi depth, and dissolved oxygen. Additionally, average densities of zooplankton groups were greater at floodplain sites than at sites near or within the river mainstem. During the low water phase, copepods and certain cladoceran taxa were found in greater densities than during the high water phase, indicating a potential concentration effect. These findings will contribute to our understanding of the interactions between environmental parameters and zooplankters within the Ouachita River and floodplain, as well as an overall understanding of zooplankton dynamics in river-floodplain systems.

INTRODUCTION

Zooplankton has a global distribution, occupying habitats that range from oceans to stagnant lakes to flowing rivers. In freshwater systems, most common zooplankters are members of the Phyla Arthropoda and Rotifera, and communities are usually dominated by cladocerans, copepods and rotifers. Freshwater zooplankters are primary consumers, feeding on an array of items, typically bacteria, detritus, phytoplankton, and other small zooplankters, and are in turn consumed by predaceous zooplankton, other invertebrates, ichthyoplankton and adult zooplanktivorous fishes (Wetzel 2001). Zooplankters represent an important link in freshwater trophic webs, facilitating the movement of nutrients and energy from allochthonous and autochthonous primary production to higher level consumers.

Within a river-floodplain system, zooplankton is dispersed along a gradient of lotic to lentic habitats, and local environmental conditions likely influence the spatial and temporal dynamics of the resident zooplankton community. Research has been conducted on riverine zooplankton (potamoplankton) to measure abundance (Kim et al. 2001; King 2004), diversity, and environmental relationships (Sluss et al. 2008), with most studies restricted to low-current areas. Rotifers are the zooplankton group most associated with lotic environments (Kim et al. 2001) because of their short life history and ability to propagate quickly (Bennett and Boraas 1989; Thorp et al. 1994). However, most zooplankters are most abundant in lentic environments such as backwaters, lakes, land-water interfaces, side channels, and floodplains (Saunders and Lewis 1989; Casper and Thorp 2007) because of their weak ability to swim against currents (Winner 1975). These slow-moving or stagnant aquatic habitats within riverine systems can provide zooplankton with a stable food source, as well as conditions that favor reproduction (Walks 2007) and population growth. Both copepods and cladocerans can take advantage of

these low-flow habitats and have been found to be abundant in slower, shallower, lotic habitats (Thorp et al. 1994; Casper and Thorp 2007).

In addition to zooplankton, inundated floodplains also provide important habitat and food resources for fish. Backwater floodplains habitats are typically characterized by high autochthonous production (Eckblad et al. 1974) and are used by fishes as refuge (Adams et al. 1999), feeding (Sparks 1995; O'Connell 2003), spawning (Kilgore and Baker 1996), and nursery habitats (Turner et al. 1994). Zooplankters in these lentic habitats are often plentiful, supplying a diverse and abundant food source for resident ichthyoplankton (King 2004). In addition to their value as trophic resources on the floodplain, high density zooplankton communities within floodplains are often displaced from lentic backwaters into the river during flood events (Wahl et al. 2008), providing an influx of forage for riverine fishes. These backwater habitats are therefore not only important for fishes that actively use the available floodplain, but also for fishes that benefit from the ecological processes that occur during river-floodplain connections.

The goal of this research project was to assess the zooplankton community within the floodplain tributaries and mainstem of the Ouachita River, and catalog changes in densities and composition over time and space. More specifically, my objectives were to 1) examine trends in zooplankton density as distance increased between individual sites with the Ouachita River, 2) identify correlations among the abundance of several zooplankton groups and environmental characteristics of the river-floodplain habitats, and 3) determine the effects of Ouachita River hydrology on the dynamics of lotic and lentic zooplankton.

METHODS

Study Area

My study occurred in the Ouachita River Basin, which spans approximately 41,000 km^2 between Arkansas and Louisiana (United States Army Corps of Engineers 1998). The Louisiana portion of the basin is part of the South Central Plains, with hardwood bottomlands and terraces dominating the landscape (Daigle et al. 2006). My area of interest was located about 50 km north of Monroe, Louisiana (Figure 1). This section of the Ouachita River is below Felsenthal Lock and Dam and above Columbia Lock and Dam, both of which are used primarily for navigational purposes. Specifically, my study area was the river channel and western floodplain of the Ouachita River (Figure 2), the latter of which is a functional bottomland hardwood forest. Most areas of the floodplain are inundated yearly during the flood pulse, with low-lying regions holding water for most of the year. Tributaries were present within the floodplain and were also inundated throughout my 1-year study.

Both eastern and western floodplains had several visually apparent anthropogenic disturbances, with the most obvious a 25 km-long levee that, until recently, had disconnected the eastern floodplain from the river since 1965. The levee was built by the land owner at that time as a control for crop irrigation, but farming has since ceased. The U.S. Fish and Wildlife Service (USFWS) eventually came into possession of the 65 km^2 tract, named the Mollicy Farms Unit, and added it to the Upper Ouachita National Wildlife Refuge. In 2008, the USFWS collaborated with The Nature Conservancy (TNC) in an effort to reconnect the eastern floodplain to the river and reforest the dormant farmland, with the goal of restoring structure and function to a level similar to the western floodplain. Calculated plans to breach the levee in two locations were postponed by high river stages in spring 2009, and in May 2009, the high water level breached

the levee on its own. Work continues to be done to facilitate the re-connection of the Ouachita River with the Mollicy Farms Unit and restore the ecological function of this degraded system.

Study Sites

My study sites consisted of seven spatially distinct areas within the western floodplain and Ouachita River: two floodplain lake sites, Big Lake (BL), Small Lake (SL); four floodplain tributary sites, Upper Pierre Creek (UPC), Middle Pierre Creek (MPC), Cecil Creek (CC), Lower Pierre Creek (LPC); and one site on the Ouachita River (OR). These locations were chosen in order to obtain a range of distances from the Ouachita River, to encapsulate the varying tributaries and habitat types, and also for accessibility.

BL was a floodplain lake formed by a widening and slowing of Cecil Creek, and was located upstream of site CC. The site was shallow with an open canopy and numerous cypress stumps throughout, as well as having gently sloping banks. SL was a narrow, isolated floodplain lake to the east of BL, separated by a strip of hardwood forest during low water periods. Because of the gently sloping banks, water from SL mixed with Cecil Creek and with the middle section of Pierre Creek when waters rose above base flow. Site UPC was furthest north from the mouth of Pierre Creek and the Ouachita River, and was north of MPC. Both of these sites were above a road culvert that reduced flow during low water but did little to inhibit water transfer above base flow. MPC was roughly the same distance from the Ouachita River as sites BL and SL. Site CC was located at the mouth of Cecil Creek, at the Pierre Creek confluence, and was the site closest to the Ouachita River, with the exception of LPC, which was located at the mouth of Pierre Creek, at the Ouachita River confluence. LPC was more channelized than the other sites, and quickly became similar to site OR when river stage increased. All sites were void of aquatic macrophytes, save for very small amounts of *Lemna* spp.

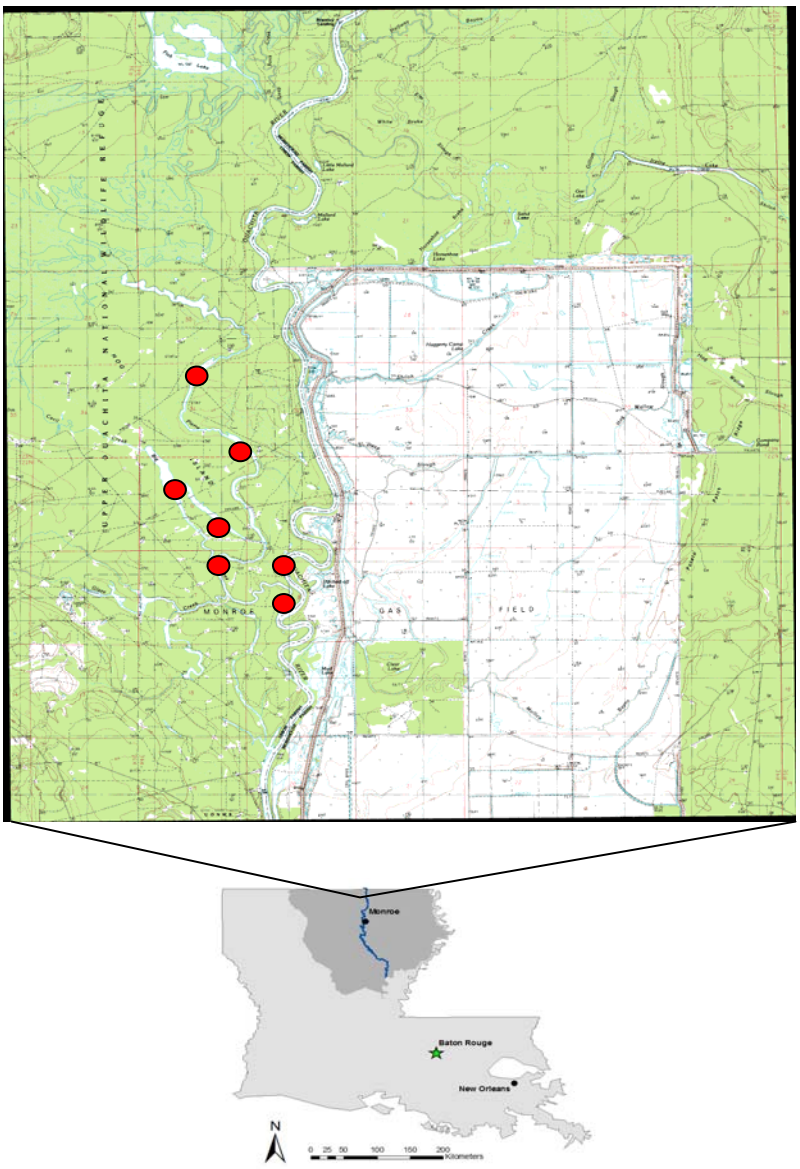

Figure 1. Mollicy Farms Unit (landmass shown in white) within the Ouachita River Basin, Louisiana. Dots indicate study site locations.

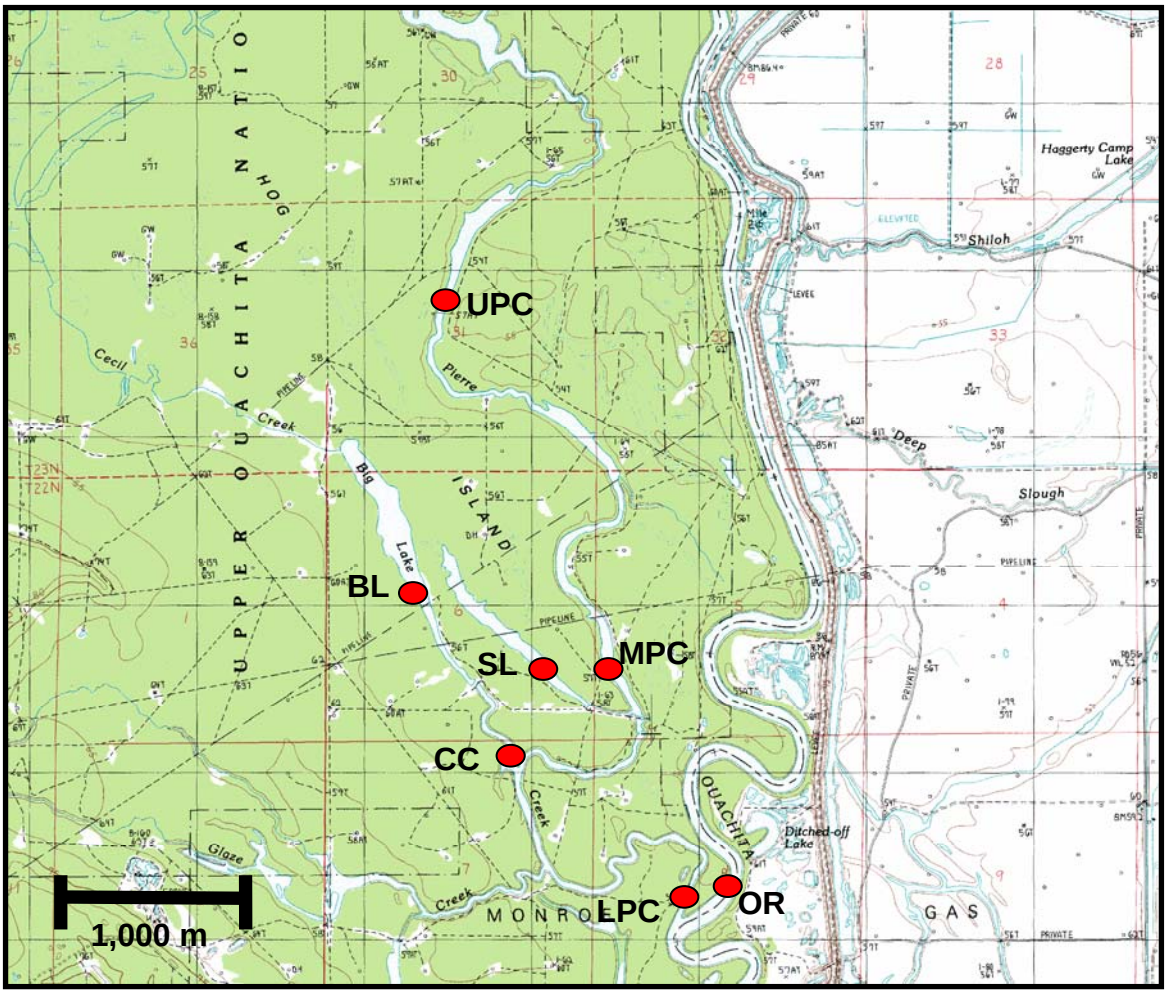

Figure 2. Sampling locations (red dots) within the west floodplain and mainstem of Ouachita River.

Field Methodology

Monthly field sampling took place during daylight hours from 17 August 2009 through 14 July 2010. Two replicate plankton tow samples from each site were taken just below the water surface with a 0.2-m diameter, 0.80-µm mesh push net (Wildlife Supply Company, Yulee, FL), for an overall total of 160 tows (12 months x 7 sites x 2 tows), excluding SL in April and May (lack of access due to flooded roads), and LPC and OR in July (mechanical problems). The net was connected to an aluminum bracket that held the mouth of the net open, and cradled the collection bucket. The aluminum bracket was attached to the side of a ganoe. A flow meter

(General Oceanics, Miami, FL) was attached to the bracket, located to the outside of the mouth of the net, to estimate the volume of water sampled. Tows were pushed for 60-120 seconds with a 3.5 hp motor run at idle, about 1.0 m/ sec. Duration of each tow depended on the tendency of the net to become clogged (Kelso et al. in press). A distance of 100 m was maintained between tows. Net contents were washed into individual collection jars with 90% ethanol and preserved with 90% ethanol. Because 100 m was considered suitable to establish spatial independence (Kelso et al. in press), each tow was treated as one plankton sample.

Funnel traps were deployed each month at BL and SL. Funnel traps consisted of a funnel with a mouth diameter of 0.35 m. The center of a 250-ml plastic bottle cap was drilled out, slid down the neck of the funnel 5 cm (to make organism escape difficult) and held in place with silicone. A 250-ml bottle was screwed into the cap to collect organisms. An aluminum bar, installed for rigidity, was attached to the inside of the funnel mouth with eye bolts. Twenty cm of monofilament was tied from each eye bolt and connected to two small concrete weights. Twine was tied from the bottle to an empty gallon milk jug to keep the trap inverted and to aid in trap recovery. Two funnels were deployed before darkness at each lake. Sites for deployment coincided with the beginning of the first plankton tow and the end of the second tow. This spacing (about 300 m apart) minimized the possibility of pseudoreplication (Hurlburt 1984). Traps were collected before 10:00 hours the next day, and contents from the collecting bottle were filtered with 0.80 µm mesh and preserved in 90% ethanol.

Water chemistry parameters were measured once monthly at each site at the terminal location of the first plankton tow. Surface readings for water temperature (^{o}C), pH, specific conductance (mS/cm), turbidity (NTU), and dissolved oxygen (mg/ l and % saturation) were measured with a hand held water quality multiprobe (YSI model no. 6820, YSI, Inc., Yellow Springs, OH). Water velocity was measured with a SonTek flowmeter (cm/ sec; YSI, Inc.,

Yellow Springs, OH). Surface water samples were collected in brown 1- l Nalgene bottles (Thermo Fisher Scientific, Rochester, NY) at each site to be analyzed for concentrations of orthophosphate (PO_4, Standard Methods 4500 P-E, mg/ l), nitrate (NO3, Hach Method 8192 Cadmium Reduction Method, mg/ l), nitrite (NO2, Hach Method 8507 (USEPA Approved) Diazotization Method, mg/ l), and chlorophyll *a* (Standard Methods 10200H Chlorophyll, Turner Designs Model TD-700, µg/ l). PO_4, NO3 and NO2 were analyzed with a spectrophotometer (Hach Spectrophotometer, DR 2500). Chlorophyll *a* was measured with a spectrophotometer for the sample month of August, and subsequently measured with a fluorometer for sample months October through July. Chlorophyll *a* values for September were omitted from analysis due to suspected unreliability of low values obtained from the spectrophotometer.

Laboratory Methodology

Plankton samples were transferred into a glass beaker and were either condensed, by allowing samples to settle and extracting surface liquid, or diluted with 90% ethanol to obtain a volume between 50ml and 100 ml. Slides were prepared by etching the inside of a 3 x 1 inch frosted-end slide with a dissecting needle, and a thin bead of Vaseline® was applied to the seam where the frosted portion met the slide body. This practice kept sample liquid from flowing onto the frosted end. Samples were homogenized on a stirring plate prior to extraction of four 0.5 ml sub-samples with a 1.0 ml glass pipette. Subsamples were placed onto prepared slides, and the slides were placed on a hot plate to quicken evaporation of some of the liquid. Once most of the liquid had evaporated, slides were ringed with CMC-10 Mounting Media (Masters Company, Inc., Wood Dale, IL) and fitted with a cover glass. Slides were allowed to dry for 48-72 hours to ensure that the mounting media had dried. Zooplankters were identified to the lowest practical taxonomic level with a binocular compound microscope (40x to 400x) and classified with keys from Smith (2001), Dodson et al. (2010) and Reid and Williamson (2010).

Statistical Methodology

To assess any mean monthly river stage differences of the Ouachita River at Monroe, LA (United States of America Corps of Engineers, station ID CE40C410) between the historical hydrograph (1973 – 2009) and my twelve months of sampling, I performed an analysis of variance (ANOVA) with a Tukey-Kramer *post hoc* adjustment comparing my monthly observations with mean monthly averages (PROC MIXED, SAS Institute, Cary, North Carolina, vers. 9.1.3).

I also used ANOVA (PROC MIXED) to examine density differences of the three large zooplankton groups (rotifers, copepods, cladocerans) between high and low river stages. Tukey-Kramer *post hoc* adjustments were applied to compare monthly plankton densities among sites.

Principal component analysis (PCA, Canoco for Windows 4.5, Micro Power Power, Ithaca, NY) biplots were constructed to investigate correlations among zooplankton groups with environmental variables and sites. To determine which biplot was most appropriate, I first conducted a detrended correspondence analysis (DCA, ter Braak 1995) to investigate curvature in the data. Upon inspection, I determined that the data was approximately linear, and thus it was appropriate to use a PCA. The exploratory PCA biplot investigated correlations among the three large zooplankton groups (rotifers, copepods, cladocerans) with environmental variables and individual sites (DO, water temperature, chlorophyll *a*, PO_4 and Secchi depth, NO3, increasing water stage, decreasing water stage, pH, specific conductance, BL, SL, UPC, MPC, CC, LPC, OR).

An exploratory PCA and compositional MANOVA (PROC GLM) examined relationships with environmental variables and sites (PCA) and linear and quadratic relationships between sites and months, as well as linear, quadratic and cubic correlations among cladoceran taxa with the four highest overall densities (*Bosmina longirostris*, *Ceriodaphnia* spp.,

Diaphanosoma birgei, and *Moina micrura*) with pertinent environmental variables (DO, water temperature, chlorophyll *a*, PO_4 and Secchi depth; MANOVA). I also used ANOVA (PROC GLM) to examine density differences of these taxa between high and low river stages.

RESULTS

Hydrograph Results

Monthly mean river stages from 1973 to 2009 illustrate the typical pattern of high water months during the fall and winter, and low water months during spring and summer (Figure 3). Stage values higher than 8.0 m resulted in floodplain inundation. Daily stage data during my study period showed a fluctuation from 14.5 m in November 2009 to 6.4 m in June 2010, with an average stage of 9.6 m over the 12 months. River stages from August through March were above the historic averages for each corresponding month, whereas river stages from April through July were below historic levels. Above-average stage values during October and November were due to record rainfall in the area, and were significantly higher than the 27-year average river stages for these months (Oct. Tukey-Kramer Adj. $p = 0.0098$; Nov. Tukey-Kramer Adj. $p = 0.0371$).

Physiochemical Results

Temperature ranged from 28.76 ^{o}C ± 0.255 (SE) in August, to 4.94 ± 0.078 ^{o}C in January, and 33.98 ± 0.479 ^{o}C by July (Figure 4). Temperature values for a given month varied little between sites. Mean chlorophyll *a* values varied widely, ranging from 0.028 ± 0.01 µg/ l in October to 39.77 ± 2.80 µg/ l in July, and were below 1.0 µg/ l from October through February. Dissolved oxygen ranged from 1.43 $\pm$ 0.06 mg/ l in November to 10.43 ± 0.05 mg/l in February, with an average of 6.61 $\pm$ 0.26 mg/ l. I found consistently low PO_4 values that ranged between 0.1 - 0.2 mg/ l for all months except August (0.538 $\pm$ 0.01 mg/ l), April (0.465 ± 0.009 mg/ l), and July (0.356 ± 0.017 mg/ l; Figure 5). Average Secchi depth fluctuated from 32.5 ± 1.94 cm in May to 140.71 ± 2.05 cm in December, and averaged 72.38 ± 1.24 cm for the study period. Additionally, specific conductance varied from 0.033 ± 0.0003 mS/cm in January to 0.171 ± 0.004 mS/cm in July, averaging 0.086 ± 0.001 mS/cm for the twelve months sampled.

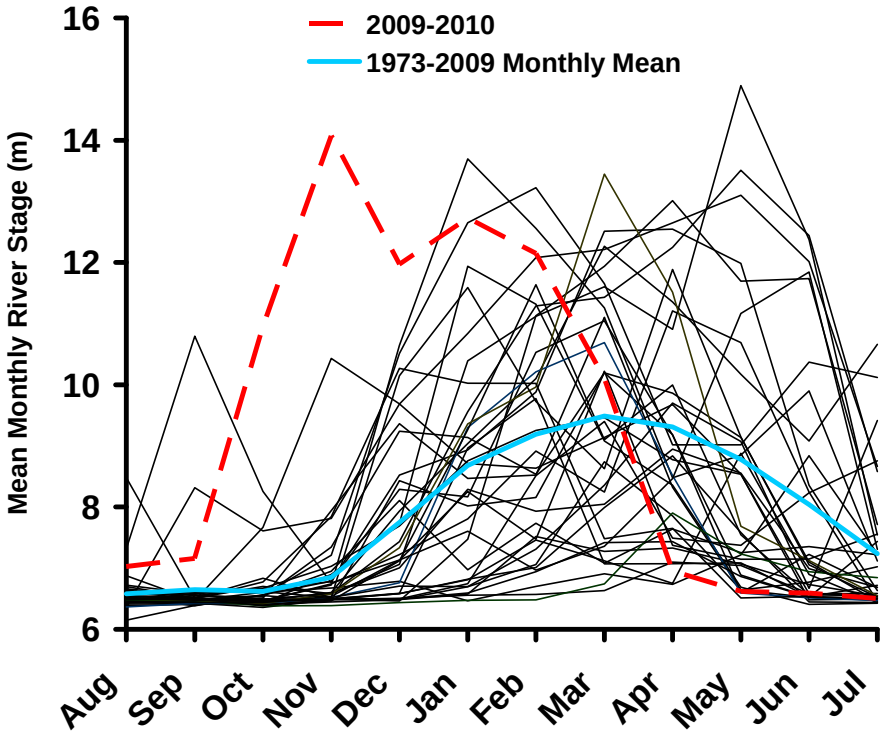

Figure 3. Mean monthly river stages of the Ouachita River during years 1973-2009 (black), my sampling period during 2009-10 (red) and the 27 year monthly mean stage (blue), showing above average data during the fall and winter during my study.

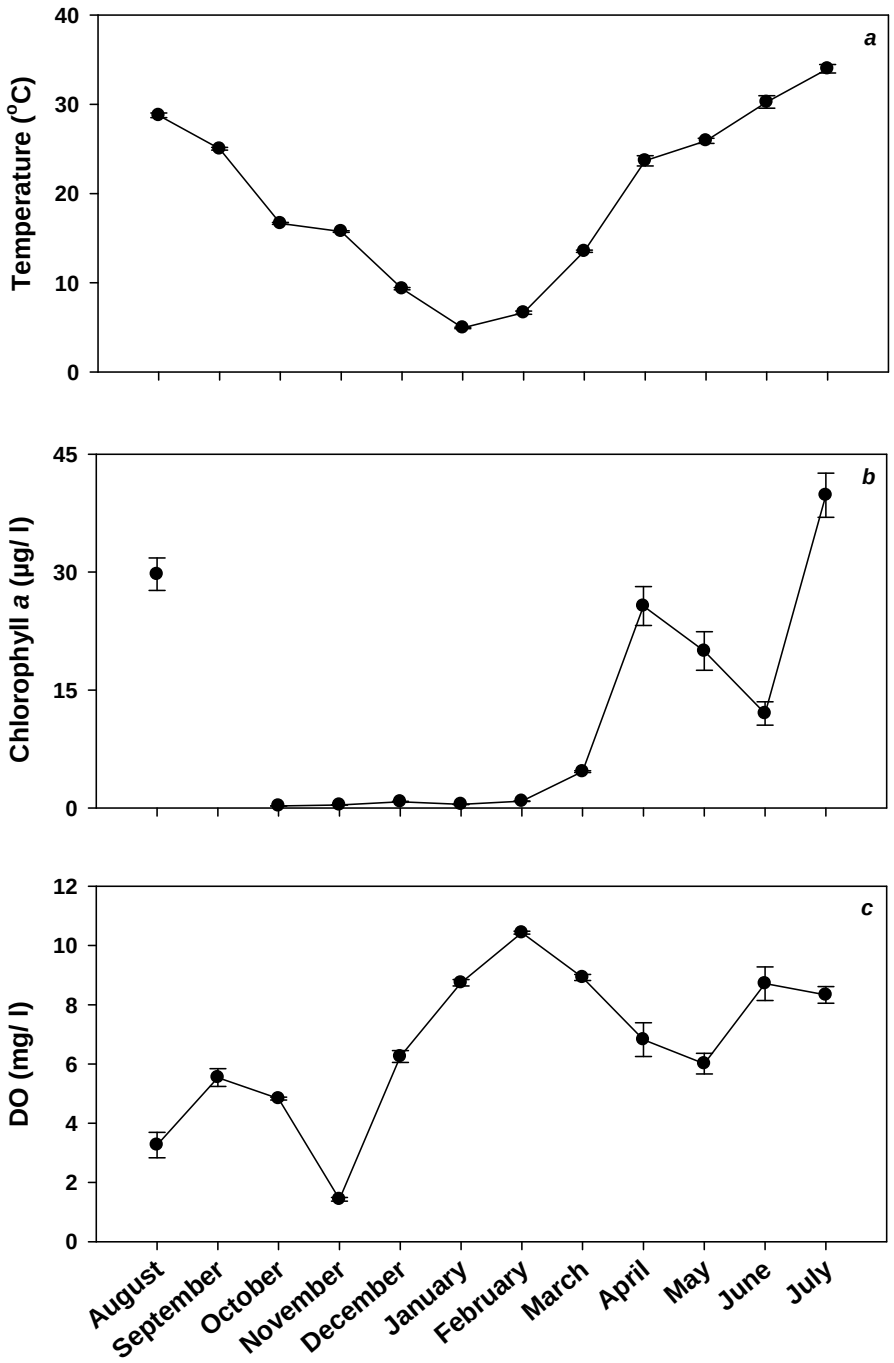

Figure 4. Monthly mean (± SE) physiochemical measurements from August 2009 through July 2010 from all seven sites on the Ouachita River floodplain. (*a*) Temperature, (*b*) chlorophyll a, (*c*) DO, (*d*) PO_4, and (*e*) Secchi depth.

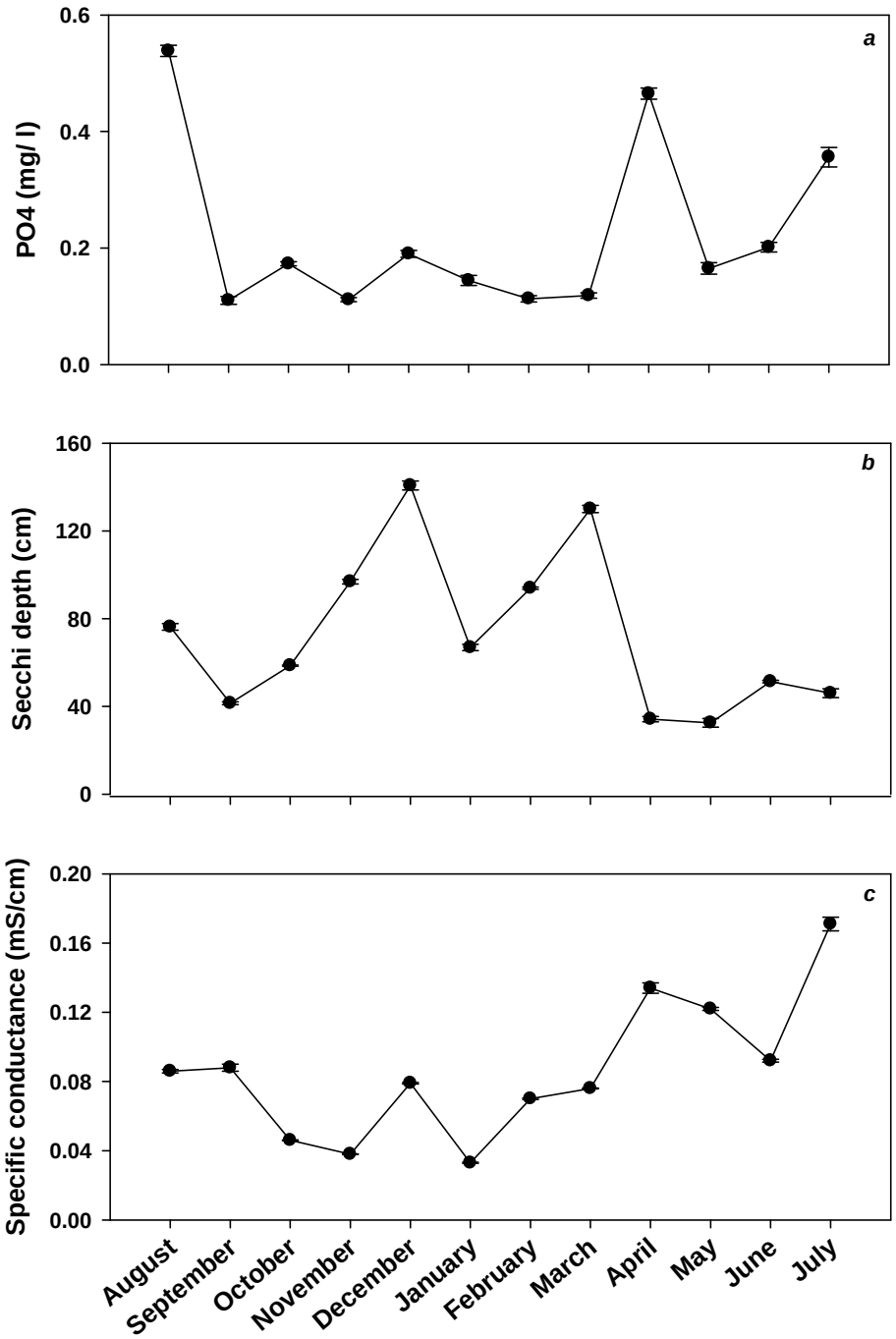

Figure 5. Monthly mean (± SE) physiochemical measurements from August 2009 through July 2010 from all seven sites on the Ouachita River floodplain. (*a*) PO_4, (*b*), Secchi depth and (*c*) specific conductance.

Zooplankton

I counted 164,686 rotifers, copepods, and cladocerans from my samples, with rotifers (115,267) accounting for 70.0% of the total number of organisms enumerated. I also counted 42,572 copepods (25.8%), separated into nauplii (37,656), copepodids (4,030), cyclopoids (509), and calanoids (377). Additionally, I identified 6,847 cladocerans from the samples (4.2% of the total zooplankton count), which were separated into 23 taxa (Table 1). *B. longirostris* was the most abundant cladoceran recorded (53.7%), followed by *Ceriodaphnia* spp. (13.4%), *M. micrura* (12.3%), and *D. birgei* (7.1%). Together, these four taxa constituted 86.4% of the total number of cladocerans identified, and no other taxon accounted for more than 3.0% of the total number of cladocerans collected during the study.

Rotifera, Copepoda, and Cladocera

Compared by month, rotifers generally displayed larger fluctuations in density than did copepods and cladocerans (Figure 6), ranging from 230.5 ± 16.83 m^{-3} in January to 7,355.54 ± 851.79 m^{-3} in July, with an overall mean density of 2,560.62 ± 248.45 m^{-3}. Copepod densities fluctuated from 87.35 ± 7.07 m^{-3} in February to 4,101.45 ± 376.66 m^{-3} in August (overall mean density: 877.29 ± 90.26 m^{-3}). Monthly cladoceran densities showed an overall mean of 146.77 ± 16.78 m^{-3}, ranging from 396.78 ± 19.15 m^{-3} in October to 5.58 ± 1.73 m^{-3} in June.

Rotifers showed fairly uniform densities among sites during the fall and winter months, but exhibited greater variation in density among sites during the spring and summer months (Figure 7). Density peaks were exhibited at sites August (BL), September, November, March, and July (SL), March, May, and July (UPC), and July in MPC. In contrast, rotifers displayed generally low densities at sites OR and LPC.

Table 1. Total enumerations separated by taxonomic group, including proportions that each contributing group made to the overall count, as well as to the proportion of the respective group.

Zooplankton Group	Total Counted	Proportion of Total	Proportion within Group
Rotifera	115,267	0.699	1.0
Nauplii	37,656	0.228	0.884
Copepodid	4,030	0.024	0.094
Cyclopidae	509	0.003	0.011
Calanoida	377	0.002	0.008
Total Copepoda	42,572	0.258	1.0
Bosmina longirostris	3,675	0.022	0.536
Ceriodaphnia spp.	915	0.005	0.133
Moina micrura	842	0.005	0.122
Diaphanosoma birgei	483	0.002	0.070
Bosminopsis deitersi	204	0.001	0.029
Chydorus spp.	173	0.001	0.025
Daphnia spp.	121	0.001	0.017
Ilyocryptus spp.	110	0.001	0.016
Simocephalus spp.	108	0.001	0.015
Eurycercus spp.	71	< 0.001	0.010
Sida spp.	31	< 0.001	0.004
Alona spp.	21	< 0.001	0.003
Leydigia spp.	17	< 0.001	0.002
Chydoridae	16	< 0.001	0.002
Camptocercus spp.	12	< 0.001	0.002
Disparalona spp.	12	< 0.001	0.002
Kurzia spp.	10	< 0.001	0.001
Pleuroxus spp.	9	< 0.001	0.001
Macrothrix spp.	5	< 0.001	0.001
Oxyruella spp.	5	< 0.001	0.001
Notoalona spp.	3	< 0.001	< 0.001
Ophryoxus spp.	2	< 0.001	< 0.001
Holopedium spp.	1	< 0.001	< 0.001
Pseudochydorus spp.	1	< 0.001	< 0.001
Total Cladocera	6,847	0.042	1.0
Total	164,686	1.0	1.0

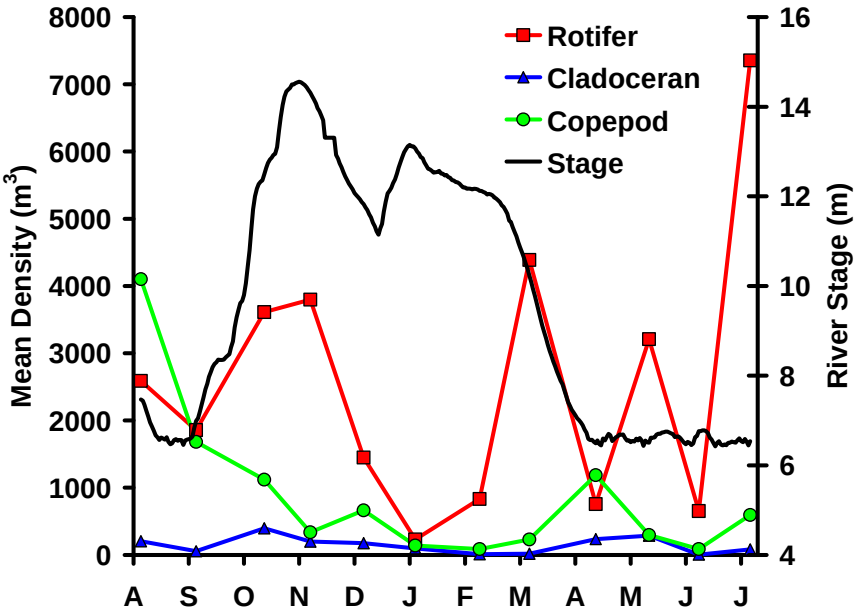

Figure 6. River stage (black) and mean monthly densities of rotifers (red), cladocerans (blue), and copepods (green) collected from August 2009 through July 2010 on the Ouachita River floodplain.

Mean monthly copepod densities exhibited larger variations among sites during low water months (August, September, April – July) than during high water months (October - March; Figure 8). The largest density variation among sites was in August (range: 802.0 – 8,891.0 m^{-3}), whereas density variations among sites from October through March were less than 665.0 m^{-3}. Floodplain lake sites BL and SL exhibited the highest mean densities during August (8,890.87 ± 339.03 m^{-3} and 6,835.6 ± 265.31 m^{-3}, respectively), and UPC exhibited an April density peak of 3,414.21 ± 444.26 m^{-3}. Generally, monthly cladoceran densities showed large variations among sites during the twelve month sampling period, especially in comparison to rotifers and copepods (Figure 9). Whereas copepod densities were highest at BL and SL, cladoceran densities were high at BL, LPC, OR, and CC, and cladocerans exhibited prominent density spikes in six of the sampling months, compared to only two by copepods.

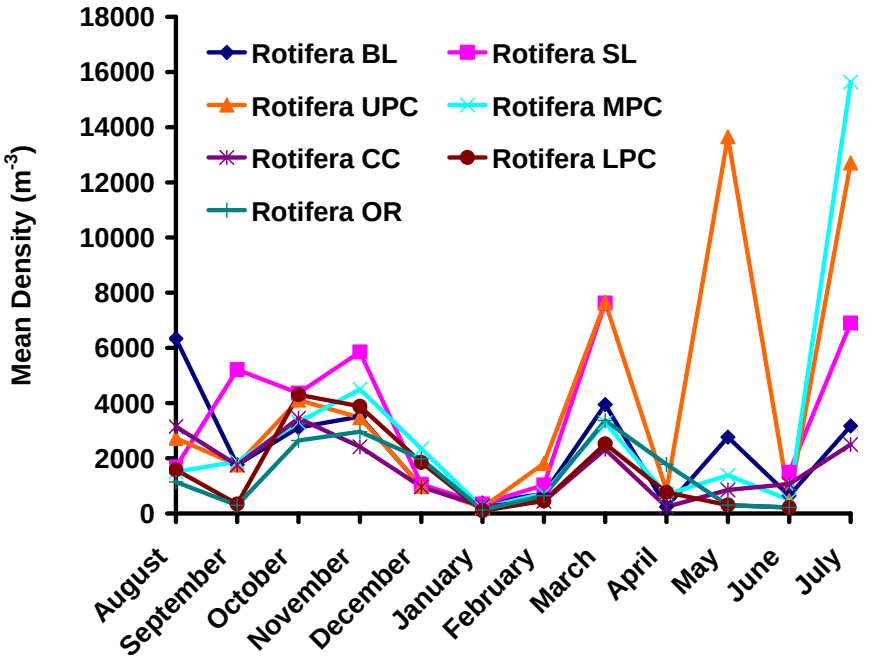

Figure 7. Mean monthly rotifer densities from August 2009 through July 2010 at sites BL (blue), SL (pink), UPC (orange), MPC (aqua), CC (purple), LPC (brown) and OR (teal) on the Ouachita River floodplain.

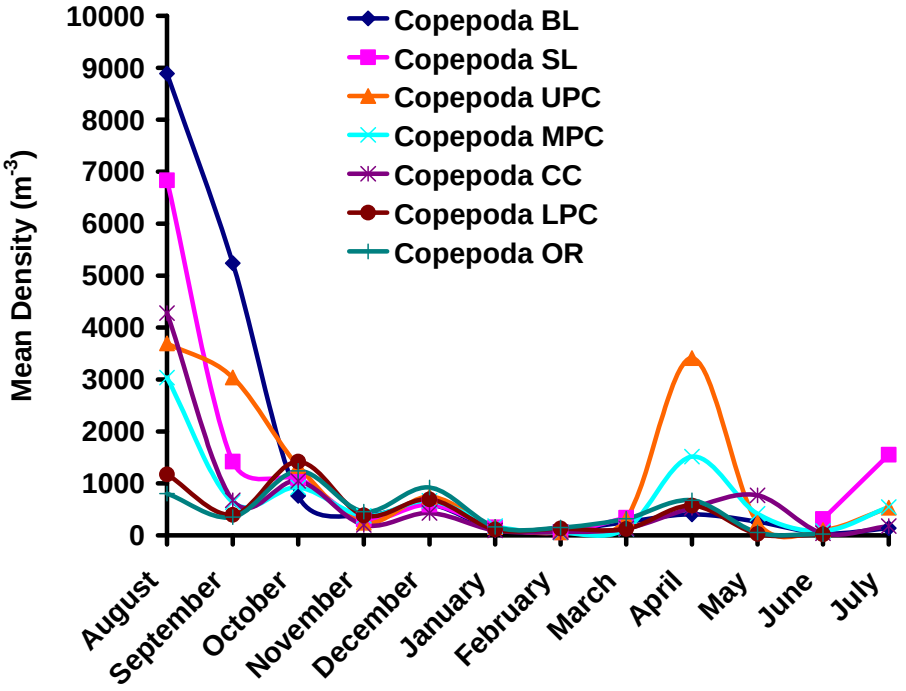

Figure 8. Mean monthly copepod densities from August 2009 through July 2010 at sites BL (blue), SL (pink), UPC (orange), MPC (aqua), CC (purple), LPC (brown) and OR (teal) on the Ouachita River floodplain.

High versus Low Water

Mean densities of total zooplankton were significantly greater during low water periods (August and September, April through July) than during high water (October through March) for sites BL ($t = 4.90$, $p = 0.0001$), SL ($t = 3.96$, $p = 0.0064$) and UPC ($t = 6.80$, $p < 0.0001$). Mean copepod densities were significantly greater during low water for sites BL ($t = 12.23$, $p < 0.0001$), SL ($t = 9.82$, $p < 0.0001$), UPC ($t = 8.72$, $p < 0.0001$), MPC ($t = 5.06$, $p < 0.0001$) and CC ($t = 5.91$, $p < 0.0001$). Mean rotifer densities were significantly greater during low water only at site UPC ($t = 4.28$, $p = 0.0018$), and cladocerans densities exhibited no relationship to high or low river stage.

Zooplankton Relationships with Environmental Variables

The PCA investigating potential relationships among rotifer, copepod, and cladoceran densities with measured environmental parameters and sites accounted for 77.2% of the correlations in the data (Figure 10). All variables fell within one standard deviation of the origin, suggesting low variability in these relationships. Rotifers were positively correlated with high levels of specific conductance and UPC and SL, and inversely correlated with high levels of turbidity. Copepods were found to be positively correlated with high levels of PO_4, increasing water stage and BL, and inversely correlated with high levels of DO and pH. Cladocerans showed a positive correlation with high levels of water temperature and chlorophyll *a* and an inverse correlation with high levels of nitrate.

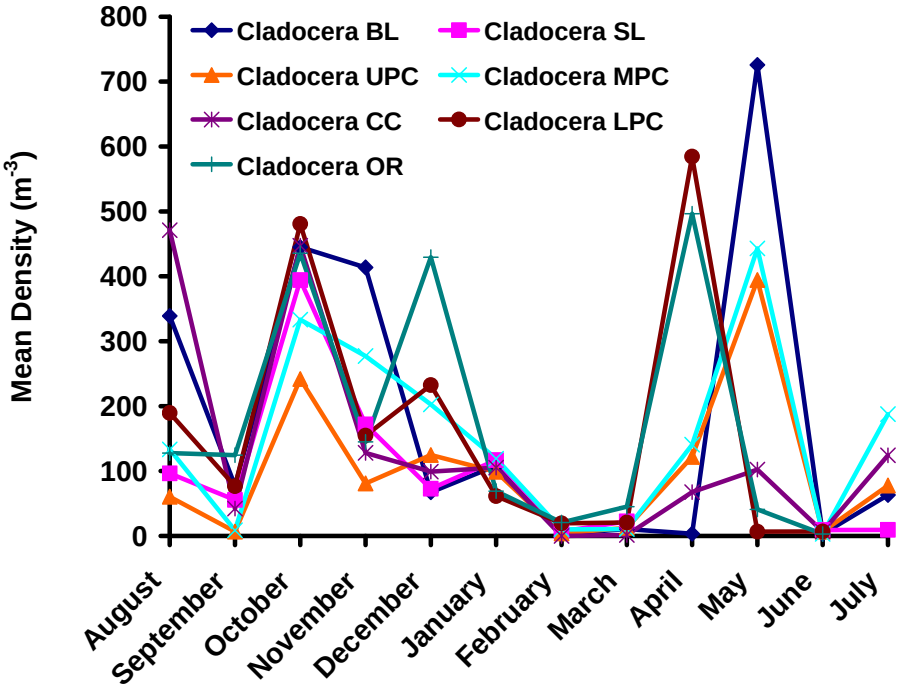

Figure 9. Mean monthly cladoceran densities from August 2009 through July 2010 at sites BL (blue), SL (pink), UPC (orange), MPC (aqua), CC (purple), LPC (brown) and OR (teal) on the Ouachita River floodplain.

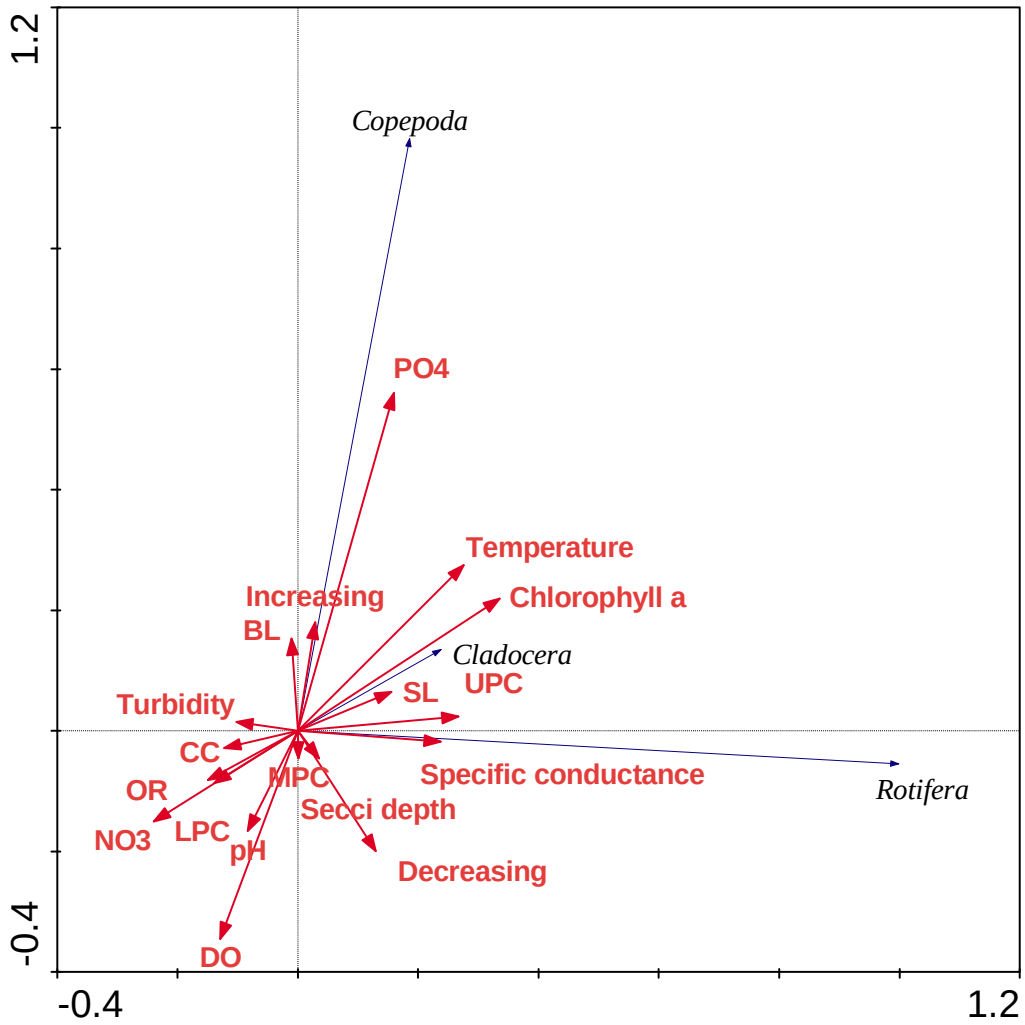

Figure 10. Results of the PCA of rotifers, copepods, and cladocerans, measured environmental variables, and collecting sites on the western Ouachita River floodplain during 2009-10.

Four Most Abundant Cladocerans

The cladocerans *B. longirostris*, *Ceriodaphnia* spp., *D. birgei* and *M. micrura* represented the four taxa with the highest overall mean densities during my study, and these taxa displayed unique and varying increases and decreases in mean densities over the course of the 2009-10 sampling period (Figure 11). Among taxa, *B. longirostris* displayed the highest mean density spike, averaging 341.23 ± 16.89 m^{-3} in October for all seven sites (Wilks' Lambda = 0.01, $F_{44, 2115.8} = 109.61$, $p < 0.0001$). *Ceriodaphnia* spp. produced the next significant density spike in December (Wilks' Lambda = 0.01, $F_{44, 2115.8} = 109.61$, $p < 0.0001$), averaging 84.00 ± 12.5 m^{-3}.

Chronologically, *B. longirostris* showed the next density spike, relative to the other taxa, in April, averaging 204.37 ± 47.01 m^{-3} (Wilks' Lambda = 0.01, $F_{44, 2115.8} = 109.61$, $p < 0.0001$). May was dominated by *M. micrura*, which averaged 258.90 ± 41.60 m^{-3} among all sites (Wilks' Lambda = 0.01, $F_{44, 2115.8} = 109.61$, $p < 0.0001$). Lastly, *D. birgei* displayed a density increase during July that averaged 79.98 ± 11.82 m^{-3} for all sites sampled (Wilks' Lambda = 0.01, $F_{44, 2115.8} = 109.61$, $p < 0.0001$).

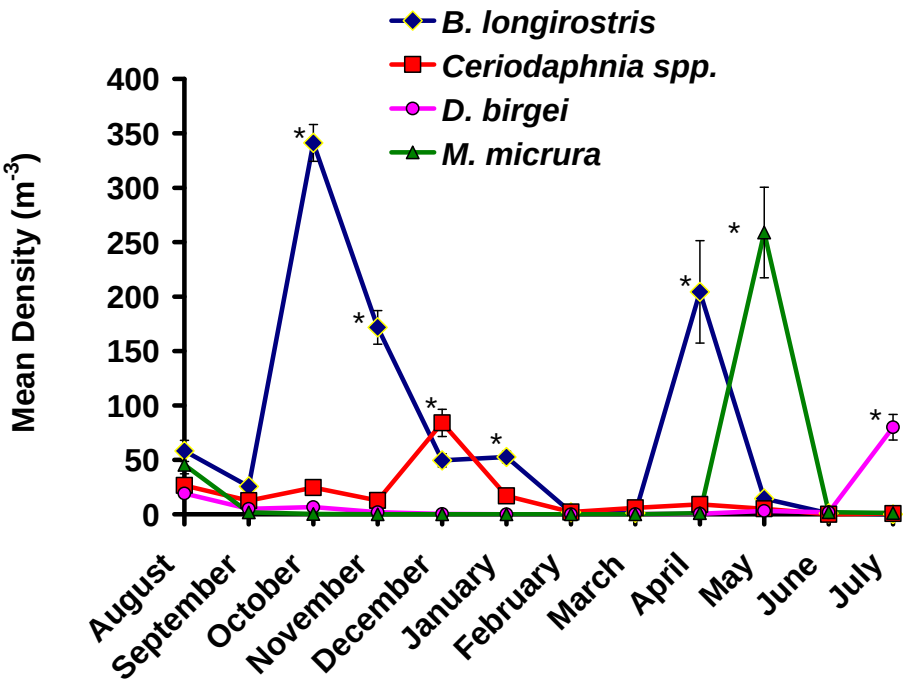

Figure 11. Mean monthly densities (± SE) for the four most prevalent cladoceran taxa from August 2009 through July 2010. Asterisks denote statistically different densities within each month.

Comparing mean densities among sites showed *B. longirostris* having uniform densities among sites during September, December - March, and May - July, and larger variations among sites during months August, October, November, and April (Figure 12). Monthly densities among sites for *Ceriodaphnia* spp. were fairly uniform except for December, when peaks were observed at OR (243.98 ± 35.33 m^{-3}), LPC (132.99 ± 18.33 m^{-3}), and MPC (123.71 ± 18.48 m^{-3}) (Figure 13). Monthly densities among sites for *D. birgei* were also quite uniform, except for July

when densities ranged from 187.82 ± 6.96 m^{-3} at MPC, to 9.40 ± 6.16 m^{-3} at SL (Figure 14). Additionally, monthly densities among sites for *M. micrura* stayed relatively constant until May when densities peaked at sites BL (686.92 ± 44.76 m^{-3}), MPC (434.14 ± 66.88 m^{-3}), and UPC (360.16 ± 84.40 m^{-3}; Figure 15).

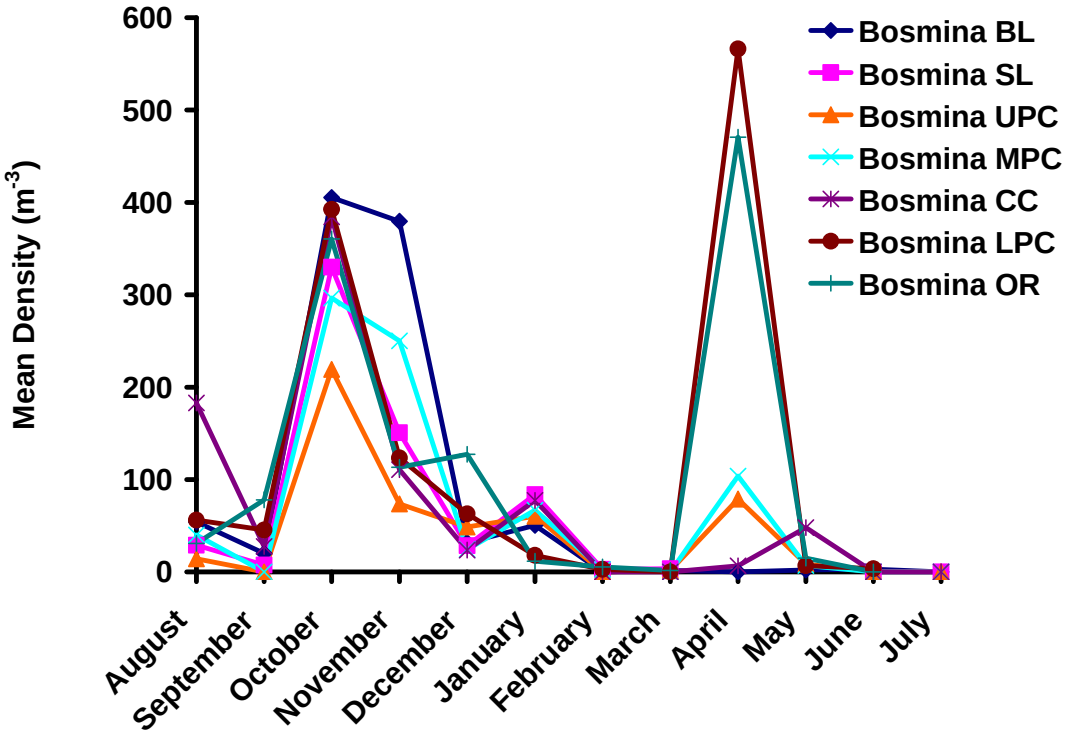

Figure 12. Mean monthly density from August 2009 through July 2010 of *B. longirostris* at sites BL (blue), SL (pink), UPC (orange), MPC (aqua), CC (purple), LPC (brown), and OR (green) on the Ouachita River floodplain.

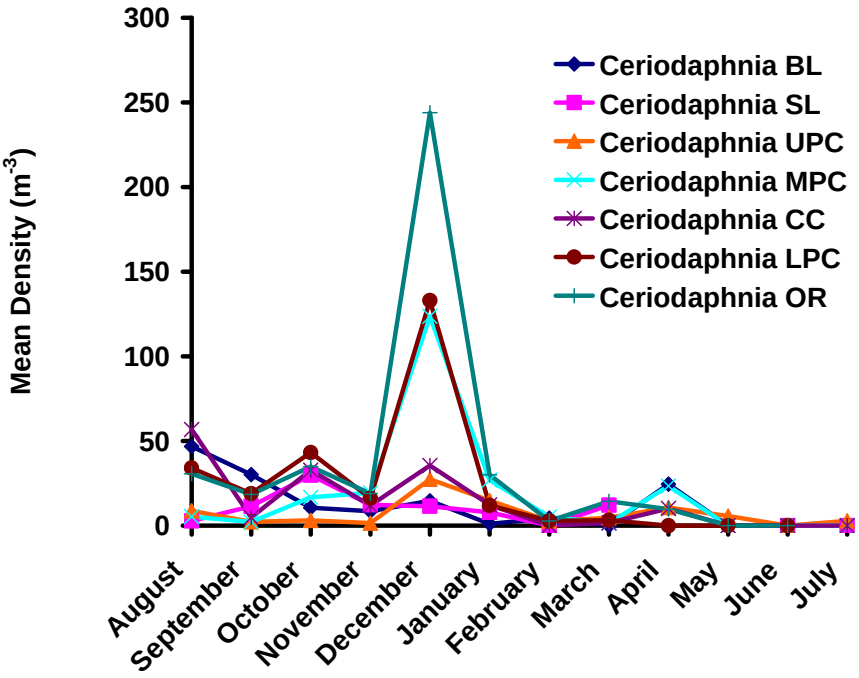

Figure 13. Mean monthly density from August 2009 through July 2010 of *Ceriodaphnia* spp. at sites BL (blue), SL (pink), UPC (orange), MPC (aqua), CC (purple), LPC (brown), and OR (green) on the Ouachita River floodplain.

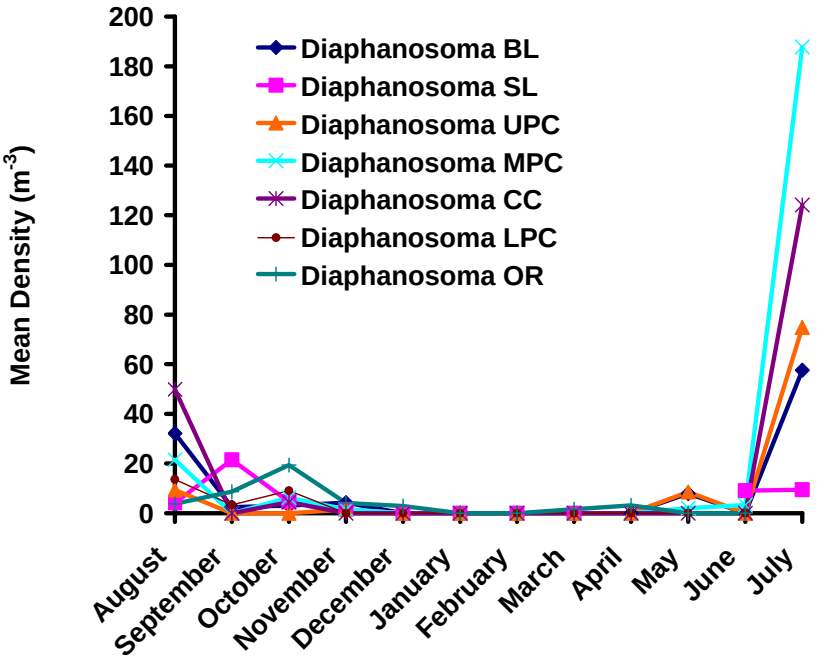

Figure 14. Mean monthly density from August 2009 through July 2010 of *D. birgei* at sites BL (blue), SL (pink), UPC (orange), MPC (aqua), CC (purple), LPC (brown), and OR (green) on the Ouachita River floodplain .

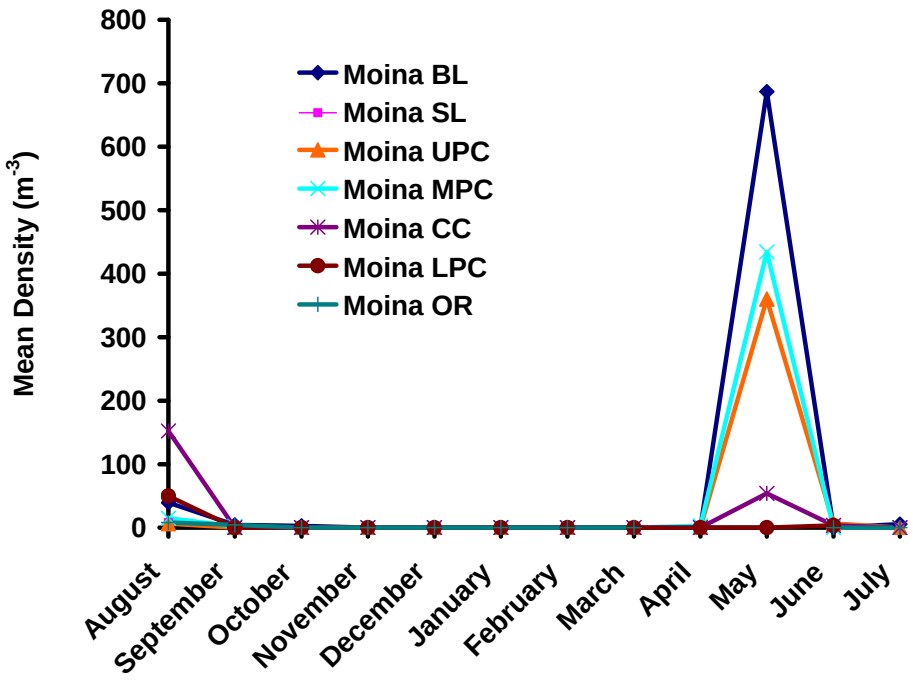

Figure 15. Mean monthly density of *M. micrura* at sites BL (blue), SL (pink), UPC (orange), MPC (aqua), CC (purple), LPC (brown), and OR (green) on the Ouachita River floodplain during 2009-10.

High versus Low Water

Mean densities of *B. longirostris* at BL were found to be significantly greater during the high water period than during the low water period ($t = -3.94$, $p = 0.0069$), as were mean densities of *Ceriodaphnia* spp. at OR ($t = -5.62$, $p < 0.0001$). In contrast, mean densities of *D. birgei* were significantly greater during low water at sites MPC ($t = 3.71$, $p = 0.0160$) and CC ($t = 5.17$, $p < 0.0001$). Mean densities of *M. micrura* were also significantly greater during low water, specifically at sites BL ($t = 5.80$, $p < 0.0001$) and MPC ($t = 3.82$, $p = 0.0106$).

Cladoceran Relationships with Environmental Variables

The PCA investigating relationships among the four cladoceran taxa and the measured environmental variables and sites explained 67.7% of the correlations in the data (Figure 16). All variables fell within one standard deviation of the origin, again suggesting low variability in these relationships. Environmental variables chlorophyll *a*, turbidity, temperature and specific

conductance were all positively correlated with each other. Environmental variables pH, DO, and PO_4 also were positively correlated to each other, but showed very little correlation to the first group of variables. *B. longirostris* and *M. micrura* were the most influential cladocerans in the analysis, and their orientation in the bi-plot shows no correlation between them. Consequently, variables correlated with these two species were species specific. *B. longirostris* was positively correlated with increasing stage, while inversely correlated with higher pH, DO, and PO_4. Conversely, *M. micrura* was positively correlated with higher turbidity, chlorophyll *a*, specific conductance, and temperature, and showed a weak inverse correlation with Secchi depth.

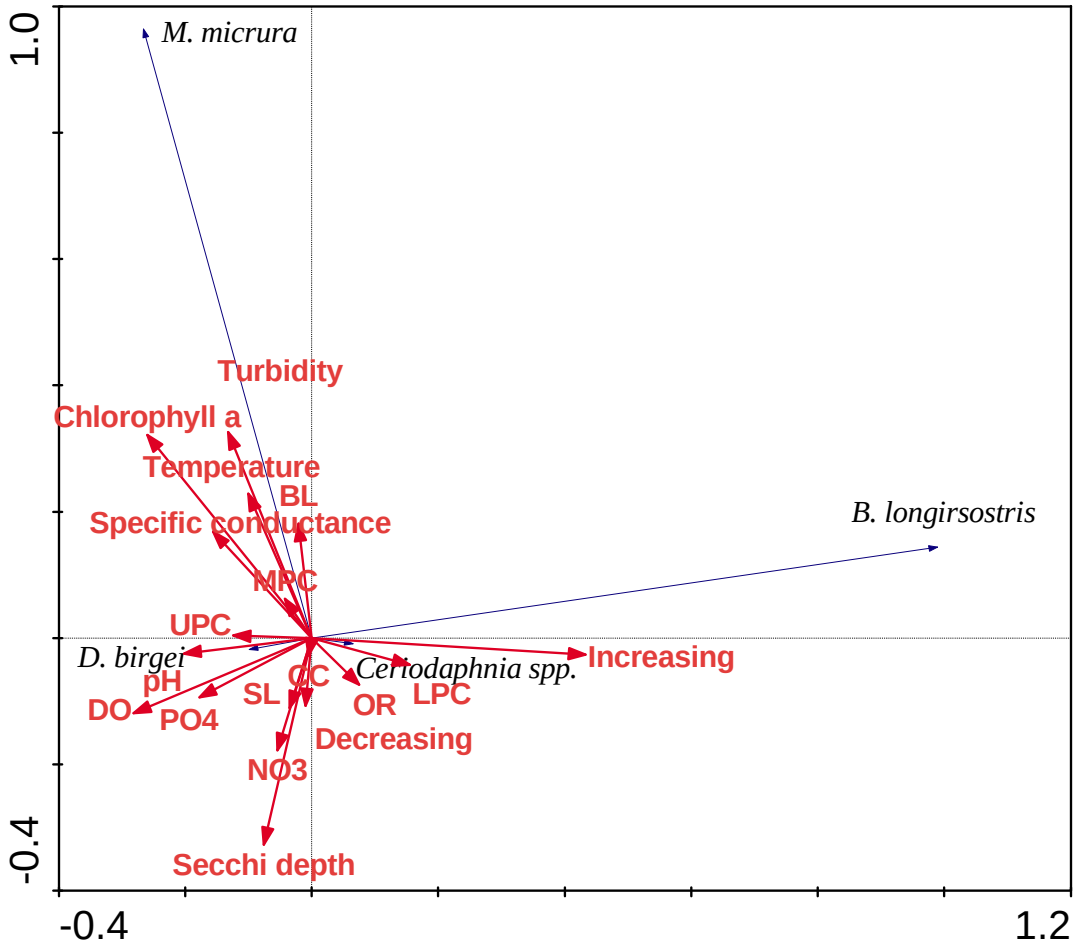

Figure 16. Results of the PCA of the four most abundant cladocerans, environmental variables, and sites on the Ouachita River floodplain during 2009-10.

Results of the MANOVA assessing the influence of DO, chlorophyll *a*, temperature, Secchi depth and PO_4 (Figures 17 – 20) on the density of the four most abundant cladocerans indicated that DO (cubic) significantly influenced cladocerans densities (Wilks' Lambda = 0.92, $F_{4, 470} = 10.32$, $p < 0.0001$). Moreover, monthly mean densities for *B. longirostris* ($F = 4.82$, $p = 0.0286$), *Ceriodaphnia* spp. ($F = 19.42$, $p < 0.0001$), and *M. micrura* ($F = 27.16$, $p < 0.0001$) were all inversely related to DO at the study sites. The relative abundances of these cladocerans also changed in relation to chlorophyll *a* (cubic; Wilks' Lambda = 0.97, $F_{4, 470} = 4.19$, $p = 0.0024$), which was positively related to the monthly mean densities of both *Ceriodaphnia* spp. ($F = 12.10$, $p = 0.0006$) and *M. micrura* ($F = 7.36$, $p = 0.0069$). The relative abundances of these taxa also changed in relation to temperature (cubic; Wilks' Lambda = 0.98, $F_{4, 470} = 2.87$, $p = 0.0226$), which was positively related to monthly mean densities of *Ceriodaphnia* spp. ($F = 6.53$, $p = 0.0109$) and *D. birgei* ($F = 5.16$, $p = 0.0235$). Similarly, the relative abundances of these four cladoceran taxa changed in relation to Secchi depth (cubic; Wilks' Lambda = 0.60, $F_{4, 470} = 78.06$, $p < 0.0001$), with deeper Secchi depths positively associated with monthly mean densities of *Ceriodaphnia* spp. ($F = 28.54$, $p < 0.0001$), *D. birgei* ($F = 9.15$, $p = 0.0026$) and *M. micrura* ($F = 224.81$, $p < 0.0001$). Lastly, the relative abundances of these taxa changed in relation to PO_4 (cubic; Wilks' Lambda = 0.89, F4, 470 = 14.73, $p < 0.0001$), with higher PO_4 positively associated with the monthly mean densities of *Ceriodaphnia* spp. ($F = 6.59$, $p = 0.0105$), *D. birgei* ($F = 15.17$, $p = 0.0001$) and *M. micrura* ($F = 27.63$, $p < 0.0001$).

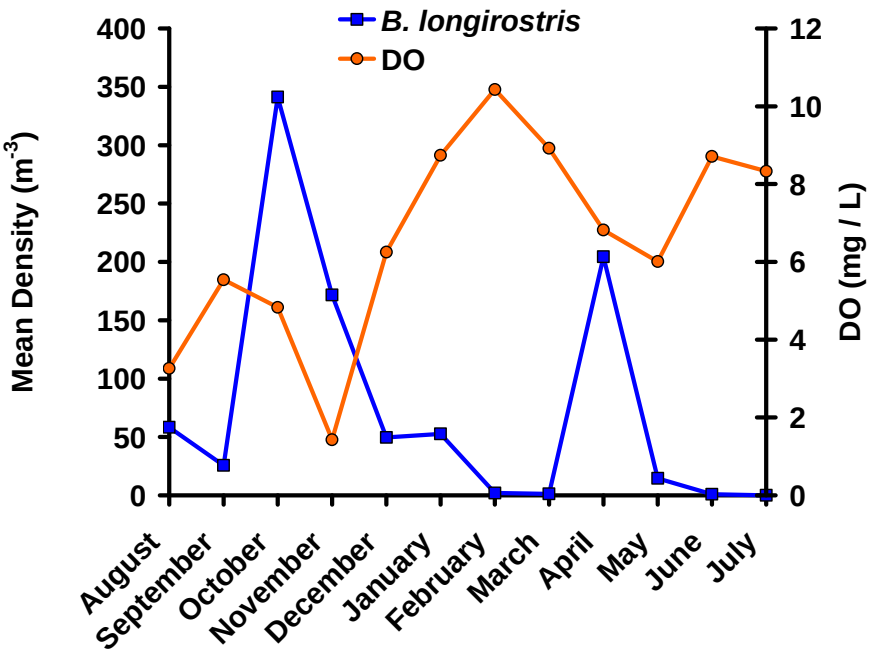

Figure 17. Mean monthly density of *B. longirostris* (blue) changed significantly in relation to mean monthly DO (orange, Wilks' Lambda = 0.92, $F_{4, 470} = 10.32$, p = 0.0286) on the Ouachita River floodplain during 2009-10.

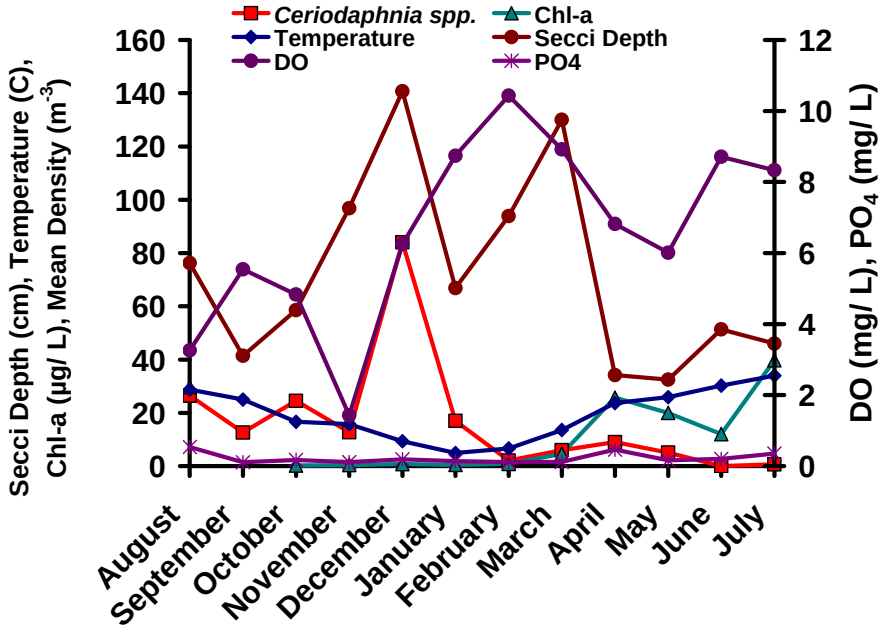

Figure 18. Mean monthly density of *Ceriodaphnia* spp. (red) changed significantly in relation to mean monthly Secchi depth (brown, Wilks' Lambda = 0.60, $F_{4, 470} = 78.06$, p < 0.0001), temperature (blue, Wilks' Lambda = 0.98, $F_{4, 470} = 2.87$, p = 0.0109), chlorophyll *a* (teal, Wilks' Lambda = 0.97, $F_{4, 470} = 4.19$, p = 0.0006), DO (purple, Wilks' Lambda = 0.92, $F_{4, 470} = 10.32$, p < 0.0001) and PO_4 (purple asterisk, Wilks' Lambda = 0.89, F4, 470 = 14.73, p = 0.0105) on the Ouachita River floodplain during 2009-10.

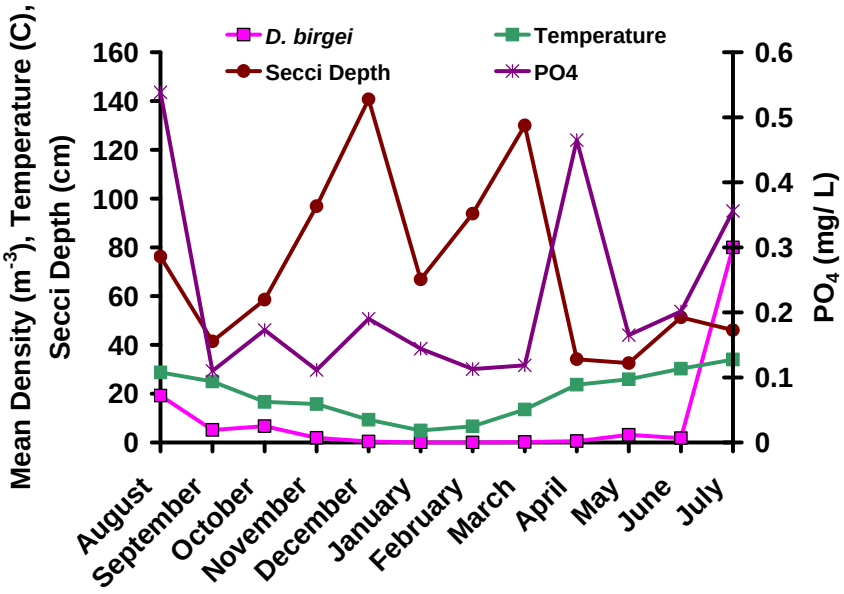

Figure 19. Mean monthly density of *D. birgei* (pink) changed significantly in relation to mean monthly temperature (green, Wilks' Lambda = 0.98, $F_{4, 470} = 2.87$, p = 0.0235), Secchi depth (brown, Wilks' Lambda = 0.60, $F_{4, 470} = 78.06$, p = 0.0026) and PO_4 (purple asterisk, Wilks' Lambda = 0.89, F4, 470 = 14.73, p = 0.0001) on the Ouachita River floodplain during 2009-10.

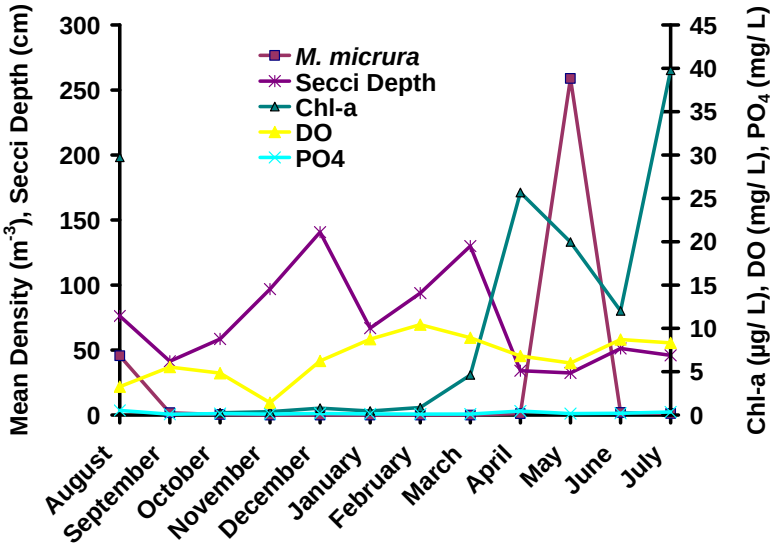

Figure 20. Mean monthly density of *M. micrura* (purple) changed significantly in relation to mean monthly Secchi depth (purple asterisk, Wilks' Lambda = 0.60, $F_{4, 470} = 78.06$, p < 0.0001), chlorophyll *a* (teal, Wilks' Lambda = 0.97, $F_{4, 470} = 4.19$, p = 0.0069), DO (yellow, Wilks' Lambda = 0.92, $F_{4, 470} = 10.32$, p < 0.0001) and PO_4 (aqua, Wilks' Lambda = 0.89, F4, 470 = 14.73, p < 0.0001) on the Ouachita River floodplain during 2009-10.

Funnel Trap Data

Funnel trap data were not used in analysis due to the low number of zooplankton collected and enumerated. For all funnels combined, only 215 total organisms were counted. Success using funnel traps in lakes has been demonstrated in previous research (Hann and Turner 2000; Einarsson and Ornolfsdottir 2004). Depths at BL and SL were much greater than those described in other studies, which may have contributed to my low densities. However, it seems that zooplankton densities in the Ouachita River system are very low in general, and thus collecting few individuals in traps is not surprising.

DISCUSSION

This study examined multiple aspects of zooplankton dynamics. Originally, I intended to investigate how sampling at varying distances from the Ouachita River would affect zooplankton density and composition. This component was altered, however, once the sampling program commenced, because of the inability to track water movements on the floodplain during high water, and the disconnection of water bodies during low water. A better way to assess the changes among densities over time and space was to analyze these factors in relation to water residence time (WRT), as well as make direct comparisons of zooplankton and environmental characteristics between floodplain lakes with the Ouachita River. I was also able to successfully investigate which of the measured environmental parameters were associated with the density patterns of specific cladoceran taxa.

Overall mean zooplankton densities from my study area ranged from 2,424.38 m^{-3} for rotifers to 145.78 m^{-3} for cladocerans, both of which are low in comparison to studies from other geographic regions. Rotifer and cladoceran densities from the Danube River floodplain averaged 698,400 m^{-3} and 52,500 m^{-3}, respectively (Baranyi et al. 2002), and as high as 550,300 m^{-3} and 30,300 m^{-3}, respectively, from floodplain lakes within the Parana River system (Jose de Paggi and Paggi 2008). In contrast, rotifers sampled from within the Ohio River averaged 7,201 m^{-3} (Thorp et al. 1994), and combined microcrustacean (cladocerans and copepods) densities found in the Atchafalaya River floodplain, also in Louisiana, typically averaged below 10,000 m^{-3} (Halloran 2010). Low densities in the Ouachita River system could simply be a consequence of low overall productivity, as evidenced by chlorophyll *a* values that averaged < 1.0 µg/ l from October through February at all sites, and all year at sites near and within the Ouachita River. Although the study sites apparently supported at least minimum algal densities necessary for zooplankton survival, perhaps algal resources were not sufficient to support the high zooplankton

densities reported from other floodplain systems. Other factors, such as macrophyte coverage (Cottenie and de Meester 2004) and aquatic predators (both of which influence zooplankton densities, e.g. Czerniawski and Domagala 2010), are potential factors that were either lacking at my sites (macrophytes) or were not studied. Alternatively, these zooplankton densities could be normal for this region; however, comparable studies in other river-floodplain systems in the southcentral U.S. are lacking, and additional research is necessary.

One objective of this study was to determine whether or not zooplankton densities and community composition changed in relation to their distance from the Ouachita River. Zooplankton density and composition did exhibit relationships with distance from the Ouachita River, and I propose two possible explanations for the observed patterns. First, these relationships could be due to differences in WRT in the various habitats I sampled. Second, these relationships could also be due to multiple physical and chemical differences between floodplain lakes and the river, which were clearly evident in the relationships among environmental variables at the study sites. Available literature is generally in agreement with my findings that floodplain lakes had higher zooplankton densities than rivers. Reasons for the marked variance in densities between habitat types can be attributed to the unique environmental parameters that each habitat possesses, although teasing out specific driving forces is difficult.

For my study area, an increase in distance from the river equates to those sites being more lentic/isolated in nature, and consequently experiencing a longer WRT. Although I did not specifically measure WRT, it can be assumed that, under normal conditions, sites more isolated and/or further from the Ouachita River mainstem (UPC, MPC, BL, SL) exhibited a longer WRT than sites less isolated and/or closer to the mainstem (CC, LPC, OR). Distance from the mainstem and WRT are not always interchangeable variables, i.e., a site on a high-velocity tributary will have a short WRT, even if it is located far from the mainstem, and a floodplain lake

located immediately adjacent to the mainstem can have a long WRT if the land barrier between the two water bodies is sufficiently elevated. However, these variables appear to be interchangeable for my study sites, and results indicated that overall mean rotifer densities followed the isolation gradient, i.e., densities were highest at sites further from the Ouachita River (UPC, SL, MPC), and lowest at LPC and OR. Rotifer abundance has been shown to be highest in backwater areas of the upper Mississippi River (Burdis and Hoxmeier 2011), and Jose de Paggi and Paggi (2008) found that mean zooplankton abundances within two floodplain lakes along the Parana River were greater for the lake that had the longer WRT. Interestingly, Aoyagui and Bonecker (2004) reported a rotifer abundance gradient from connected floodplain lakes (highest) → isolated floodplain lakes → the river channel (lowest). In addition, Obertegger et al. (2007) specifically measured WRT within Lake Tovel, Italy, and reported that rotifer biomass was highest when WRT was short. It is apparent that the relationship between rotifer abundance and WRT is quite variable among systems, and is likely a spatially and temporally complex function of the species present, water movements, predator densities and food resource levels.

My results indicated that copepods also had the highest densities in the more lentic/isolated sites (BL, SL, UPC, MPC, CC) relative to LPC and OR. This is consistent with findings reported by Wahl et al. (2008), but contrasts with literature that shows copepods thriving in more lotic habitats such as river channels (Burdis and Hoxmeier 2011). Clearly, copepods of the Ouachita River system are successful in reproducing in lentic environments, as evidenced by their higher densities at floodplain sites during the low water period. Hence WRT appears to play a role in the distribution and abundance of copepods, although other variables such as algal densities are likely to be influential as well.

Cladocerans, alternatively, did not follow a clear density trend in relation to distance from the Ouachita River. Site BL, an isolated lake, had the highest overall mean cladoceran density, but the more lotic sites OR and LPC had the second and third highest mean densities, respectively. UPC and SL, the other two isolated sites that were sampled, were sixth and seventh, respectively, for total mean cladoceran density. Havel et al. (2009) reported low cladoceran densities in the more lotic portions of the lower Missouri River, similar to cladoceran abundance patterns reported by Lima et al. (1998) for lakes and rivers in Brazil. Obertegger et al. (2007) found that cladoceran biomass was greatest when WRT was longer than 193 d, whereas a WRT < 193 d promoted dominance of rotifer biomass in the zooplankton community. However, mean cladoceran densities were similar between the main channel and backwater habitat of the Upper Mississippi River (Burdis and Hoxmeier 2011), two habitat types that at least spatially appear to be similar to OR and BL. These studies suggest that relationships between cladoceran densities and WRT are not consistent, and it may be that overall abundance patterns for the cladoceran assemblage as a whole are significantly influenced by the abundances of dominant taxa, which can change both spatially and temporally in complex systems such as river-floodplains (see below).

My study offers evidence that the dynamic patterns of zooplankton density and taxonomic composition are the result of spatiotemporal changes in multiple physicochemical factors that characterize floodplain lakes and adjacent river habitats. Results from this study indicated that overall, floodplain lakes had higher densities of organisms than did the Ouachita River, even though mean densities for individual zooplankton groups did not always follow this pattern. BL had higher mean densities of total organisms, rotifers, cladocerans and copepods than did either OR or adjacent LPC sites. SL also had higher densities of total organisms,

rotifers and copepods in comparison to sites OR and LPC, and cladocerans may have also followed this pattern if I would have been able to collect samples in April and May.

Because the two floodplain lakes also possess a longer WRT than the Ouachita River mainstem, it is difficult to separate the effects of WRT versus lacustrine habitat on zooplankton abundance at the study sites. Multiple studies within the Upper Parana River system have found rotifer densities to be higher in floodplain lakes and lower in rivers (Rossa and Bonecker 2003; Bonecker et al. 2005). These results, however, are in contrast to studies that found rotifers more prevalent in the channelized portions of the lower Missouri River (Havel et al. 2009), the Illinois River (Wahl et al. 2008), or when lotic conditions exist on large-river floodplains (Baranyi et al. 2002). Additionally, Bonecker and Lansac-Toha (1996) found that rotifer densities were similar between samples of the Upper Parana River and their open water floodplain-lake site; however, both of those sites showed lower mean densities in comparison to their littoral samples within the floodplain lake. Because of differences in connectivity, productivity, depth, and water level fluctuations, floodplain lakes along the Ouachita River may function differently than other floodplain-river systems, and pinpointing the specific cause for high rotifer densities on the floodplain will likely require additional studies in lakes with variable WRT.

Overall mean copepod densities were three times higher in BL and SL compared to OR, indicating this zooplankton group is much more successful in lentic areas with longer WRT. Research by Casanova and Henry (2004) showed that copepods flourished in the two floodplain lakes sampled along the Paranapanema River compared to their riverine sampling sites. More importantly, densities of nauplii and copepodids were also found in higher densities in the floodplain lakes compared to riverine sites. This is particularly relevant to my research because the majority of copepods encountered in the samples were either nauplii or copepodids, and most studies focus solely on adults. More lentic water bodies, such as floodplain lakes, allow larval

and juvenile copepods to grow and mature without having to allocate energy towards holding their position in the water column, and also decrease their susceptibility to being washed downstream (Casanova and Henry 2004).

Mean cladoceran densities were higher in floodplain lakes along the Upper Parana River, especially when water levels were low (Lima et al. 1998). This is consistent with the cladoceran abundance found at site BL, and also suggests that had I been able to collect samples at SL for the full twelve month period (including April and May), a similar pattern would have emerged.

Results from the seven Ouachita River/floodplain sites showed a one-month lag in elevated abundance between rotifers and cladocerans/copepods during the spring months. Thorp et al. (1994) found this relationship as well when assessing zooplankton densities along the Ohio River. One explanation for this community transition is that rotifers, which can be characterized as r-strategists (Pociecha and Wilk-Wozniak 2006), are able to exploit food resources more rapidly than cladocerans or copepods, which exhibit more K-strategist life histories. Under optimal conditions, rotifers can use available nutrients to quickly reproduce and increase in density within a short period of time (Walz 1983), whereas cladocerans and copepods respond more slowly to available resources (Pociecha and Wilk-Wozniak 2006).

Interestingly, when zooplankton densities were compared between high water and low water phases of the river, rotifer densities varied at only one site, cladoceran densities did not vary among any sites, and copepod densities varied among all but two sites. For all of these statistically significant results, densities were higher during the low water phase. Explanations for greater densities during low water include the concentration/ dilution effect (Aoyagui and Bonecker 2004; Grosholz and Gallo 2006; Nadai and Henry 2009) and lower water velocity (Aoyagui and Bonecker 2004). Other studies have also shown higher densities of zooplankton during low water phases (Aoyagui and Bonecker 2004; Nadai and Henry 2009), although

contrasting results have been reported as well (Lima et al. 1998; Bonecker et al. 2005). Copepods had significantly greater densities during the low water phase compared to the high water phase at five sites (BL, SL, UPC, MPC, CC), which I attribute to the dilution and homogenization of habitats during the high water months when all sites were inundated with river water (Bozelli 1992). During the low water phase, riverine water was limited to site OR, and to some extent, site LPC, which allowed the five upper sites to stabilize and develop more lentic conditions. Sites OR and LPC were always inundated by Ouachita River water (during both high and low water phases), which is likely the reason that mean densities at these sites did not significantly change during the year.

Statistical differences were observed by site between high water and low water densities for each of the four cladoceran taxa that I looked at in detail. *M. micrura* and *D. birgei* both exhibited greater densities at two sites during the low water phase, while *B. longirostris* and *Ceriodaphnia* spp. both exhibited greater densities during the high water phase at one site each. These results are opposite of those found by Lima et al. (1998), who reported that bosminids were more abundant during low water, and other planktonic cladocerans, including species of *Moina* and *Diaphanosoma*, were prominent during high water. Illyova (2006) reported *B. longirostris* at greater densities during the high water phase within one arm of the Slovakian Morava River, but also observed greater densities during the low water phase in a different arm of the river. These results highlight the highly variable density patterns exhibited by riverine cladocerans, even within the same river system, and they also suggest considerable plasticity in the abilities of cladocerans to exploit temporally-dynamic environmental conditions throughout the annual river cycle.

The positive association between Ouachita River rotifer abundance and specific conductance has also been reported in other studies (Arora and Mehra 2003), as have positive

abundance relationships with chlorophyll *a* (Bonecker and Lansac-Toha 1996; Bass et al. 1997; May and Bass 1998; Lair 2005; Havel et al. 2009; Negreiros et al. 2010). Interestingly, rotifer abundance has been reported to be both positively (Bonecker and Lansac-Toha 1996; Bonecker et al. 2005; Lair 2005; Havel et al. 2009) and negatively (Obertegger et al. 2007) related to temperature. These conflicting reports probably highlight the multivariate nature of zooplankton-environment relationships, with zooplankton abundance varying through time and space based on complex interactions with both biotic and abiotic factors that can change quickly.

Copepod abundance showed a strong positive correlation with PO_4, mild positive correlations with temperature and chlorophyll *a*, and a strong negative correlation with DO. Previous studies have reported similar associations between copepod abundance and PO_4 concentrations (Beaver et al. 1999, Carrillo et al. 2001), which, together with chlorophyll *a* (Illyova et al. 2008) indicate that copepods in the Ouachita River system (mostly nauplii and copepodids in my study) were responding to increased production of algal food resources (Beaver et al. 1999) during April and May. Additionally, copepod nauplii have been found to assimilate PO_4 during growth and release PO_4 during molting (Carrillo et al. 2001), which could also have contributed to the positive association between PO_4 concentrations and copepod density found in my study. Positive relationships between copepod density and temperature (Illyova et al. 2008) likely reflect improved conditions for reproduction and growth during warmer months, although negative associations with temperature have also been reported (Czerniawski and Domagala 2010). The negative association between copepod abundance and DO is contrary to results reported by Czerniawski and Domagala (2010). However, this association is not likely to be important to Ouachita River copepods, as DO levels never appeared to approach hypoxic levels (<0.3-1.0 mg/l; Stalder and Marcus 1997). Rather than

cause and effect, this relationship is probably a reflection of differential patterns of copepod abundance (higher in fall) and DO concentrations (higher in spring) through time.

Cladoceran densities exhibited strong positive correlations with both temperature and chlorophyll *a*, variables commonly associated with cladoceran productivity. Temperature (Obertegger et al. 2007) and chlorophyll *a* (Beaver et al. 1999) have been found in other studies to positively influence cladoceran densities, though these relationships are not always evident (Illyova et al. 2008). Research by Wetzel (2001), however, has found that increases in temperature help facilitate molting and egg production in cladocerans, and are important for algal production, both of which may have influenced cladoceran densities in the Ouachita River system.

During my study, the four most abundant cladoceran taxa peaked in density during different months, which is a common phenomenon in freshwater systems (DeMott and Kerfoot 1982; Kim et al. 2001; Lindholm and Hessen 2007; Wahl et al. 2008; Burdis and Hoxmeier 2011; Stankovic et al. 2011). Possible explanations for cladoceran taxa exploiting temporal niches include competition (DeMott and Kerfoot 1982), shifts in food resources (Porter 1977; DeMott and Kerfoot 1982; Lindholm and Hessen 2007), hatching of diapause eggs on the floodplain during flood events (Jenkins and Boulton 2003; Lindholm and Hessen 2007; Nadai and Henry 2009), and varying tolerances to turbidity (Wahl et al. 2008).

I observed an inverse relationship between *B. longirostris* densities and DO, but similar to copepods, DO levels did not appear to be problematic, and several publications have found *Bosmina* spp. abundance to be positively associated with DO (Davidson et al. 1998; Panarelli et al. 2010; Stankovic et al. 2011). Temperature has also been shown to be positively associated with *B. longirostris* abundance (Dejen et al 2004; Obertegger et al. 2007). This relationship was not evident in my study, probably because of low *B. longirostris* densities during the warmest

months, and it is clear that temperature alone does not account for the temporal changes in abundance exhibited by this species. Chlorophyll *a* levels increased in April, and *Bosmina* spp. abundance has been found to be positively associated with chlorophyll *a* levels (Lima et al. 1998; Illyova 2006) and depth (DeMott and Kerfoot 1982; Jaramillo-Londono and Pinto-Coelho 2010); perhaps at some moderate threshold of temperature, food availability becomes a more important factor for population growth.

High densities of *B. longirostris* were found at sites LPC and OR during April, which would not support the idea that WRT shapes densities of this cladoceran. A potential explanation for this density spike at riverine sites is higher predation on the floodplain. Spring months often result in high densities of larval fishes on the floodplain (Halloran 2010), and it could be that increased levels of fish reproduction and larval predation at this time can suppress population growth of this bosminid. *B. longirostris* was found to be an important larval fish food source in a California floodplain system, with *Bosmina* or *Daphnia* comprising as much as 85% of larval fish stomach contents (Grosholz and Gallo 2006). Alternatively, zooplankton densities have been shown to peak 21 days after post-flood disconnection on the floodplain (Grosholz and Gallo 2006), and it could be that my monthly sampling was unable to capture an increase and decrease in abundance of this species.

B. longirostris was the most prevalent cladoceran genera in my study, accounting for 53.7% of cladoceran organisms counted. *B. longirostris* is a globally common zooplankter, and have been reported to be an r-strategist relative to other cladocerans (Pociecha and Wilk-Wozniak 2006). Dominance of *Bosmina* spp. in such varying systems may be due to their highly efficient feeding abilities, as well as their ability to switch primary food sources (DeMott and Kerfoot 1982). DeMott and Kerfoot (1982) found that *B. longirostris* reached its maximum ingestion rate at phytoplankton densities of approximately 5,000 cells/ ml, three to four times

lower than what was needed for *Daphnia*. Chlorophyll *a* concentrations in the Ouachita River system were very low throughout the study, potentially too low at times for other taxa to thrive, but they may have been high enough for *B. longirostris* to proliferate.

As *D. birgei* was found in highest densities during the summer months of August 2009 and July 2010, it is not surprising that this species was positively associated with temperature. Previous studies have also found this genus to be abundant in warm months (DeMott and Kerfoot 1982; Davidson et al. 1998; Han et al. 2011; Stankovic et al. 2011), positively associated with chlorophyll *a* (Dejen et al. 2004) and negatively associated with both DO and pH (Panarelli et al. 2010). It is interesting to note that *D. birgei* was the dominant cladoceran species on the Ouachita floodplain during July, and less so in August, time periods that were characterized by high temperatures, higher chlorophyll *a* levels, and (at least in August), lower DO. One hypothesis for this pattern is that *D. birgei* was competing with other zooplankters (DeMott and Kerfoot 1982), and was able to out-compete them during this portion of the year. A laboratory study by Lemke and Benke (2003) showed that under warm temperatures, the somatic growth rate of *Diaphanosoma brachyurum* can be as high as 91% / day, which was higher than some of the other cladoceran species tested. Another possibility is that suspended solids could affect *D. birgei* more than other cladocerans (Dejen et al. 2004), as Secchi depth was relatively low during months when *D. birgei* peaked (76.25 cm in August, 46 cm in July).

The PCA revealed a positive correlation between *M. micrura* and temperature, which has been noted by other researchers (Davidson et al. 1998; Illyova 2006). Nandini and Sarma (2000) also found that *Moina macrocopa* could exploit minimal algal resources better than other cladoceran species tested, which could be advantageous during periods of low food abundance. Mean chlorophyll *a* values for April and May were third and fourth highest among all other months, respectively, but were still generally low. Perhaps these values were high enough to

meet the minimum threshold needed for reproduction, and allowed *M. micrura* to quickly reproduce.

In concert with my findings, previous studies have shown correlations between *Ceriodaphnia* spp. and low temperature (Davidson et al. 1998; Panarelli et al. 2010), high DO (Davidson et al. 1998), and high chlorophyll *a* (Dejen et al. 2004). In contrast to my results, however, a study involving small Croatian lakes found certain species of *Ceriodaphnia* to peak in abundance in June (22.0 ^{o}C), as opposed to colder months (Stankovic et al. 2011). Obviously this cladoceran is able to exploit conditions for growth and reproduction that are sub-optimal for other taxa, likely resulting in minimal interspecific competition for the limited food resources (at least algal resources, based on chlorophyll *a* levels) during this time.

Summary

Although they were present throughout the year on the Ouachita River floodplain, densities of rotifers, copepods and cladocerans were generally much lower than reported in other river-floodplain systems. WRT appeared to play a role in zooplankton abundance patterns, as all zooplankton groups exhibited greater densities on the floodplain than in the river, i.e., sites that were more lentic displayed greater densities than sites that were more riverine. Generally, zooplankter densities were either similar between the high and low water phases, or were higher during the low water phase. Four taxa comprised the majority of cladocerans during my study, each peaking in density at different times of the year. These abundance patterns indicate that these taxa were able to exploit temporally transient environmental conditions, which appeared to minimize interspecific interactions throughout the year.

High zooplankton densities in systems where fishes use floodplains for reproduction are necessary to give larval fishes adequate foraging opportunities. Based on these findings, connected river-floodplains, such as the western floodplain of the Ouachita River, should provide

larval fishes more opportunities to forage and grow compared to riverine-only habitats. Furthermore, my results indicate that reconnection of other river-floodplain systems, such as what is being accomplished with the Mollicy Farms Unit of the Upper Ouachita National Wildlife Refuge, will be beneficial for resident fishes. Lastly, documenting zooplankton densities on the connected river-floodplain of the Ouachita River will allow for future studies to document changes that occur on the western floodplain, as well as to track restoration progress made on the eastern floodplain. Establishing the time frame needed for zooplankton populations in a recently reconnected floodplain system to mirror those found in historically connected floodplain habitats will be useful to managers monitoring development of restored floodplain habitats.

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APPENDIX: MEAN ZOOPLANKTON DENSITY (ind. m^{-3}) AND STANDARD ERROR

August	BL	CC	LPC	MPC	OR	SL	UPC
Rotifer	6338.60	3145.67	1580.10	1514.36	1139.80	1683.31	2722.35
Rotifer SE	423.61	269.38	113.04	146.71	118.75	129.95	214.44
Nauplii	8532.52	3782.75	991.00	2816.43	650.76	6621.80	3579.38
Nauplii SE	314.11	144.07	82.97	395.24	72.02	249.26	288.90
Copepodid	346.66	466.15	153.59	193.17	132.16	201.60	104.88
Copepodid SE	34.37	34.83	14.02	23.98	14.22	24.16	16.88
Cyclopidae	8.78	27.74	21.98	12.60	14.24	6.77	10.30
Cyclopidae SE	5.75	4.67	3.59	4.01	3.82	2.84	3.72
Calanoid	2.90	2.78	4.91	12.60	5.07	5.43	1.23
Calanoid SE	1.90	1.82	1.85	4.42	2.68	2.05	1.23
Bosmina longirostris	54.14	182.82	56.19	40.22	30.95	28.96	14.30
***Bosmina longirostris* SE**	19.17	41.83	11.14	9.21	6.49	7.60	3.95
***Ceriodaphnia* spp.**	46.82	56.83	34.12	5.42	30.68	2.74	8.75
***Ceriodaphnia* spp. SE**	22.58	9.19	4.07	2.95	5.62	1.79	5.07
Diaphanosoma birgei	32.13	49.85	13.57	21.53	3.84	4.08	9.39
***Diaphanosoma birgei* SE**	8.79	12.88	7.45	7.37	1.87	2.85	4.78
Moina micrura	39.49	152.35	49.99	15.05	47.25	8.31	6.46
***Moina micrura* SE**	14.34	35.08	6.79	5.30	10.45	3.49	3.38
Bosminopsis deitersi	128.41	20.79	13.46	36.75	6.30	42.89	11.37
***Bosminopsis deitersi* SE**	16.92	4.87	5.22	10.43	4.93	11.71	4.43
***Ilyocryptus* spp.**	13.10	6.95	18.31	2.45	5.20	5.47	5.07
***Ilyocryptus* spp. SE**	4.63	3.60	4.35	1.60	1.97	2.07	2.67
***Simocephalus* spp.**	2.92	0.00	0.00	2.45	1.23	2.69	1.39
***Simocephalus* spp. SE**	1.91	0.00	0.00	1.60	1.23	1.76	1.39
***Chydorus* spp.**	0.00	0.00	0.00	0.00	1.23	0.00	1.23
***Chydorus* spp. SE**	0.00	0.00	0.00	0.00	1.23	0.00	1.23
***Daphnia* spp.**	17.50	0.00	0.00	8.04	0.00	1.39	1.39
***Daphnia* spp. SE**	6.63	0.00	0.00	4.47	0.00	1.39	1.39
***Alona* spp.**	0.00	1.39	3.70	1.40	1.23	0.00	0.00
***Alona* spp. SE**	0.00	1.39	2.60	1.40	1.23	0.00	0.00
***Camptocercus* spp.**	1.46	0.00	0.00	0.00	0.00	0.00	0.00
***Camptocercus* spp. SE**	1.46	0.00	0.00	0.00	0.00	0.00	0.00
***Disparalona* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Disparalona* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Eurycercus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Eurycercus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Holopedium* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Holopedium* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Kurzia* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Kurzia* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Leydigia* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Leydigia* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Macrothrix* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	1.23
***Macrothrix* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	1.23
***Notoalona* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Notoalona* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ophryoxus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ophryoxus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00

***Pleuroxus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pleuroxus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pseudochydorus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pseudochydorus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Sida* spp.**	2.90	0.00	0.00	0.00	0.00	0.00	0.00
***Sida* spp. SE**	2.90	0.00	0.00	0.00	0.00	0.00	0.00
Chydoridae	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chydoridae SE	0.00	0.00	0.00	0.00	0.00	0.00	0.00

September	**BL**	**CC**	**LPC**	**MPC**	**OR**	**SL**	**UPC**
Rotifer	1760.02	1748.02	339.46	1874.75	297.72	5209.89	1761.01
Rotifer SE	178.52	99.20	73.70	114.07	56.23	296.67	232.42
Nauplii	4869.47	537.79	128.88	570.14	84.85	1303.56	2890.68
Nauplii SE	723.05	45.86	28.25	61.22	19.85	45.75	368.87
Copepodid	368.07	134.66	257.08	67.61	244.56	115.72	146.87
Copepodid SE	28.43	26.00	75.43	9.05	27.42	35.35	22.37
Cyclopidae	0.00	1.61	8.80	2.34	13.89	2.49	2.25
Cyclopidae SE	0.00	1.61	4.65	2.34	5.52	2.49	2.25
Calanoid	0.00	3.22	1.58	0.00	7.87	0.00	0.00
Calanoid SE	0.00	2.11	1.58	0.00	3.38	0.00	0.00
Bosmina longirostris	20.28	27.56	45.37	0.00	78.16	7.48	0.00
***Bosmina longirostris* SE**	8.88	8.21	9.76	0.00	17.89	3.65	0.00
***Ceriodaphnia* spp.**	30.20	4.83	18.96	2.18	18.46	11.52	2.25
***Ceriodaphnia* spp. SE**	10.91	2.36	6.63	2.18	8.62	5.09	2.25
Diaphanosoma birgei	2.38	0.00	3.39	0.00	8.72	21.50	0.00
***Diaphanosoma birgei* SE**	2.38	0.00	2.22	0.00	5.18	11.00	0.00
Moina micrura	4.37	0.00	0.00	2.18	1.36	4.51	0.00
***Moina micrura* SE**	2.88	0.00	0.00	2.18	1.35	2.98	0.00
Bosminopsis deitersi	0.00	1.61	7.00	0.00	9.57	0.00	0.00
***Bosminopsis deitersi* SE**	0.00	1.61	2.65	0.00	2.38	0.00	0.00
***Ilyocryptus* spp.**	7.15	0.00	0.00	2.18	0.00	8.55	2.28
***Ilyocryptus* spp. SE**	3.49	0.00	0.00	2.18	0.00	4.47	2.28
***Simocephalus* spp.**	1.99	0.00	0.00	2.34	1.10	0.00	0.00
***Simocephalus* spp. SE**	1.99	0.00	0.00	2.34	1.10	0.00	0.00
***Chydorus* spp.**	8.75	3.22	0.00	0.00	0.00	2.02	0.00
***Chydorus* spp. SE**	3.33	2.11	0.00	0.00	0.00	2.02	0.00
***Daphnia* spp.**	0.00	0.00	0.00	0.00	3.56	0.00	0.00
***Daphnia* spp. SE**	0.00	0.00	0.00	0.00	1.75	0.00	0.00
***Alona* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Alona* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Camptocercus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Camptocercus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Disparalona* spp.**	0.00	1.61	0.00	0.00	0.00	0.00	0.00
***Disparalona* spp. SE**	0.00	1.61	0.00	0.00	0.00	0.00	0.00
***Eurycercus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Eurycercus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Holopedium* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Holopedium* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Kurzia* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Kurzia* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Leydigia* spp.**	0.00	0.00	0.00	0.00	1.10	0.00	0.00

***Leydigia* spp. SE**	0.00	0.00	0.00	0.00	1.10	0.00	0.00
***Macrothrix* spp.**	0.00	3.22	0.00	0.00	1.35	0.00	0.00
***Macrothrix* spp. SE**	0.00	2.11	0.00	0.00	1.35	0.00	0.00
***Notoalona* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Notoalona* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ophryoxus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ophryoxus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pleuroxus* spp.**	0.00	0.00	1.81	0.00	0.00	0.00	0.00
***Pleuroxus* spp. SE**	0.00	0.00	1.81	0.00	0.00	0.00	0.00
***Pseudochydorus* spp.**	2.38	0.00	0.00	0.00	0.00	0.00	0.00
***Pseudochydorus* spp. SE**	2.38	0.00	0.00	0.00	0.00	0.00	0.00
***Sida* spp.**	0.00	0.00	0.00	0.00	1.10	0.00	2.25
***Sida* spp. SE**	0.00	0.00	0.00	0.00	1.10	0.00	2.25
Chydoridae	0.00	0.00	3.61	0.00	0.00	0.00	0.00
Chydoridae SE	0.00	0.00	3.61	0.00	0.00	0.00	0.00

October	**BL**	**CC**	**LPC**	**MPC**	**OR**	**SL**	**UPC**
Rotifer	3112.77	3450.26	4299.50	3303.57	2641.56	4360.50	4112.57
Rotifer SE	268.62	103.45	190.91	172.36	89.77	110.85	175.04
Nauplii	592.61	811.17	1012.81	722.72	824.14	859.80	1015.40
Nauplii SE	43.87	44.84	49.10	36.83	49.54	51.62	115.76
Copepodid	103.25	171.66	314.91	130.80	302.91	154.63	195.22
Copepodid SE	16.12	17.93	29.01	22.35	15.69	23.77	31.75
Cyclopidae	35.25	29.87	32.29	43.96	43.10	46.82	62.30
Cyclopidae SE	9.00	6.00	5.68	11.43	8.59	9.17	15.71
Calanoid	27.51	37.27	60.38	26.19	73.62	43.57	60.86
Calanoid SE	7.55	5.66	11.32	7.35	8.38	11.27	13.31
Bosmina longirostris	405.36	384.35	392.45	296.49	360.55	330.04	219.34
***Bosmina longirostris* SE**	34.74	58.57	33.41	16.05	19.84	65.23	36.42
***Ceriodaphnia* spp.**	10.68	32.83	43.24	16.83	34.83	29.85	3.23
***Ceriodaphnia* spp. SE**	3.63	5.88	9.54	5.99	8.66	11.25	2.12
Diaphanosoma birgei	3.07	4.44	9.08	6.24	19.35	4.55	0.00
***Diaphanosoma birgei* SE**	2.01	3.12	3.82	3.41	6.47	2.22	0.00
Moina micrura	2.94	0.00	0.00	0.00	0.00	0.00	0.00
***Moina micrura* SE**	1.93	0.00	0.00	0.00	0.00	0.00	0.00
Bosminopsis deitersi	0.00	0.00	1.82	0.00	1.41	0.00	0.00
***Bosminopsis deitersi* SE**	0.00	0.00	1.82	0.00	1.41	0.00	0.00
***Ilyocryptus* spp.**	7.35	10.46	11.78	7.74	5.56	11.06	11.20
***Ilyocryptus* spp. SE**	3.09	3.52	5.06	4.52	2.10	3.75	4.43
***Simocephalus* spp.**	9.34	2.96	12.98	0.00	5.59	1.59	1.58
***Simocephalus* spp. SE**	3.17	1.94	2.32	0.00	3.00	1.59	1.58
***Chydorus* spp.**	0.00	0.00	1.82	0.00	0.00	0.00	0.00
***Chydorus* spp. SE**	0.00	0.00	1.82	0.00	0.00	0.00	0.00
***Daphnia* spp.**	6.14	11.98	3.01	4.61	4.15	10.84	6.39
***Daphnia* spp. SE**	2.33	5.07	3.01	2.25	2.90	3.67	3.40
***Alona* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Alona* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Camptocercus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Camptocercus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Disparalona* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Disparalona* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00

***Eurycercus* spp.**	0.00	0.00	0.00	0.00	1.37	0.00	0.00
***Eurycercus* spp. SE**	0.00	0.00	0.00	0.00	1.37	0.00	0.00
***Holopedium* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Holopedium* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Kurzia* spp.**	0.00	0.00	0.00	0.00	1.37	1.52	0.00
***Kurzia* spp. SE**	0.00	0.00	0.00	0.00	1.37	1.52	0.00
***Leydigia* spp.**	0.00	0.00	3.01	1.49	0.00	4.70	0.00
***Leydigia* spp. SE**	0.00	0.00	3.01	1.49	0.00	2.29	0.00
***Macrothrix* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Macrothrix* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Notoalona* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Notoalona* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ophryoxus* spp.**	0.00	0.00	1.51	0.00	1.41	0.00	0.00
***Ophryoxus* spp. SE**	0.00	0.00	1.51	0.00	1.41	0.00	0.00
***Pleuroxus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pleuroxus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pseudochydorus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pseudochydorus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Sida* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Sida* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chydoridae	0.00	0.00	1.51	0.00	4.15	1.59	1.58
Chydoridae SE	0.00	0.00	1.51	0.00	2.90	1.59	1.58

November	**BL**	**CC**	**LPC**	**MPC**	**OR**	**SL**	**UPC**
Rotifer	3510.84	2413.57	3884.75	4498.82	2958.10	5850.97	3474.61
Rotifer SE	162.08	219.05	234.35	138.29	114.59	610.88	127.53
Nauplii	255.62	135.46	297.37	269.69	350.33	213.85	170.51
Nauplii SE	21.05	22.95	19.88	26.20	30.75	19.01	12.66
Copepodid	92.33	50.34	73.58	74.79	89.10	58.07	61.62
Copepodid SE	6.50	11.57	12.73	10.75	15.46	12.39	8.19
Cyclopidae	34.23	11.96	7.36	26.92	12.30	22.78	8.81
Cyclopidae SE	6.91	5.10	3.10	9.19	3.23	6.57	2.92
Calanoid	8.48	3.01	4.42	6.04	4.12	12.32	2.91
Calanoid SE	4.12	1.97	3.10	3.23	2.89	6.19	1.90
Bosmina longirostris	379.62	110.74	123.47	250.32	113.46	150.63	73.69
***Bosmina longirostris* SE**	36.60	7.14	21.81	22.98	18.78	7.85	20.40
***Ceriodaphnia* spp.**	8.54	11.96	16.19	19.45	19.11	12.23	1.54
***Ceriodaphnia* spp. SE**	3.56	5.58	4.42	5.53	5.35	4.64	1.54
Diaphanosoma birgei	4.27	0.00	0.00	1.51	4.12	1.50	1.45
***Diaphanosoma birgei* SE**	2.08	0.00	0.00	1.51	2.01	1.50	1.45
Moina micrura	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Moina micrura* SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bosminopsis deitersi	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Bosminopsis deitersi* SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ilyocryptus* spp.**	5.68	0.00	0.00	0.00	1.38	1.55	1.45
***Ilyocryptus* spp. SE**	3.72	0.00	0.00	0.00	1.38	1.55	1.45
***Simocephalus* spp.**	9.95	4.42	1.48	4.48	4.10	3.05	1.45
***Simocephalus* spp. SE**	3.99	3.14	1.48	2.19	2.00	1.99	1.45
***Chydorus* spp.**	0.00	0.00	1.48	0.00	0.00	0.00	0.00
***Chydorus* spp. SE**	0.00	0.00	1.48	0.00	0.00	0.00	0.00
***Daphnia* spp.**	1.40	0.00	0.00	1.48	1.36	0.00	0.00

***Daphnia* spp. SE**	1.40	0.00	0.00	1.48	1.36	0.00	0.00
***Alona* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	1.54
***Alona* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	1.54
***Camptocercus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Camptocercus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Disparalona* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Disparalona* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Eurycercus* spp.**	1.43	0.00	0.00	0.00	0.00	1.55	0.00
***Eurycercus* spp. SE**	1.43	0.00	0.00	0.00	0.00	1.55	0.00
***Holopedium* spp.**	0.00	0.00	1.48	0.00	0.00	0.00	0.00
***Holopedium* spp. SE**	0.00	0.00	1.48	0.00	0.00	0.00	0.00
***Kurzia* spp.**	2.87	0.00	0.00	0.00	0.00	0.00	0.00
***Kurzia* spp. SE**	1.88	0.00	0.00	0.00	0.00	0.00	0.00
***Leydigia* spp.**	0.00	0.00	0.00	0.00	0.00	1.55	0.00
***Leydigia* spp. SE**	0.00	0.00	0.00	0.00	0.00	1.55	0.00
***Macrothrix* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Macrothrix* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Notoalona* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Notoalona* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ophryoxus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ophryoxus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pleuroxus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pleuroxus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pseudochydorus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pseudochydorus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Sida* spp.**	0.00	0.00	2.94	0.00	1.36	0.00	0.00
***Sida* spp. SE**	0.00	0.00	1.93	0.00	1.36	0.00	0.00
Chydoridae	1.40	1.41	0.00	3.02	0.00	0.00	0.00
Chydoridae SE	1.40	1.41	0.00	1.98	0.00	0.00	0.00

December	**BL**	**CC**	**LPC**	**MPC**	**OR**	**SL**	**UPC**
Rotifer	970.16	961.05	1848.26	2344.18	1975.01	1051.85	989.31
Rotifer SE	59.18	34.54	135.06	435.08	106.41	48.90	53.83
Nauplii	447.36	343.64	549.02	566.66	712.79	482.01	584.76
Nauplii SE	31.57	37.75	62.92	92.66	59.29	46.36	27.63
Copepodid	131.10	77.03	120.63	83.20	173.08	78.15	131.41
Copepodid SE	14.36	15.04	14.78	9.15	27.21	19.18	15.17
Cyclopidae	15.95	4.44	12.17	6.54	14.16	15.43	23.17
Cyclopidae SE	4.37	2.17	4.01	4.39	4.15	7.33	9.19
Calanoid	2.87	4.44	10.87	6.97	21.25	17.17	4.42
Calanoid SE	1.88	2.17	4.35	3.00	4.50	2.98	3.10
Bosmina longirostris	31.69	23.70	62.98	24.24	127.50	28.46	48.58
***Bosmina longirostris* SE**	3.82	6.34	18.36	8.38	15.19	8.20	8.99
***Ceriodaphnia* spp.**	12.77	35.53	132.99	123.71	243.98	11.56	27.45
***Ceriodaphnia* spp. SE**	4.48	8.37	18.33	18.48	35.33	3.14	9.40
Diaphanosoma birgei	0.00	0.00	0.00	0.00	2.83	0.00	0.00
***Diaphanosoma birgei* SE**	0.00	0.00	0.00	0.00	1.85	0.00	0.00
Moina micrura	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Moina micrura* SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bosminopsis deitersi	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Bosminopsis deitersi* SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00

***Ilyocryptus* spp.**	0.00	1.48	6.09	0.00	0.00	0.00	0.00
***Ilyocryptus* spp. SE**	0.00	1.48	3.99	0.00	0.00	0.00	0.00
***Simocephalus* spp.**	4.26	2.96	3.04	8.42	12.71	4.28	11.51
***Simocephalus* spp. SE**	2.08	1.94	1.99	2.87	5.40	2.98	3.80
***Chydorus* spp.**	8.51	20.73	7.64	15.10	7.09	8.48	22.68
***Chydorus* spp. SE**	4.66	4.88	3.24	5.39	2.99	2.82	6.32
***Daphnia* spp.**	0.00	1.48	6.15	6.97	9.92	2.87	4.35
***Daphnia* spp. SE**	0.00	1.48	2.32	3.00	4.52	1.88	3.08
***Alona* spp.**	4.16	0.00	1.49	1.45	0.00	1.40	0.00
***Alona* spp. SE**	4.16	0.00	1.49	1.45	0.00	1.40	0.00
***Camptocercus* spp.**	0.00	1.48	4.53	0.00	2.83	0.00	1.40
***Camptocercus* spp. SE**	0.00	1.48	2.21	0.00	1.85	0.00	1.40
***Disparalona* spp.**	0.00	0.00	0.00	0.00	1.42	1.40	0.00
***Disparalona* spp. SE**	0.00	0.00	0.00	0.00	1.42	1.40	0.00
***Eurycercus* spp.**	5.74	4.44	4.47	14.23	11.34	12.89	8.77
***Eurycercus* spp. SE**	3.13	3.12	2.18	5.64	4.29	4.94	3.69
***Holopedium* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Holopedium* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Kurzia* spp.**	0.00	0.00	1.49	2.90	0.00	0.00	0.00
***Kurzia* spp. SE**	0.00	0.00	1.49	1.90	0.00	0.00	0.00
***Leydigia* spp.**	0.00	0.00	0.00	4.21	2.85	1.40	0.00
***Leydigia* spp. SE**	0.00	0.00	0.00	2.06	2.85	1.40	0.00
***Macrothrix* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Macrothrix* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Notoalona* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Notoalona* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ophryoxus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ophryoxus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pleuroxus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pleuroxus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pseudochydorus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pseudochydorus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Sida* spp.**	0.00	4.44	1.49	1.31	7.10	0.00	0.00
***Sida* spp. SE**	0.00	2.17	1.49	1.31	2.99	0.00	0.00
Chydoridae	0.00	0.00	0.00	0.00	0.00	1.40	0.00
Chydoridae SE	0.00	0.00	0.00	0.00	0.00	1.40	0.00

January	**BL**	**CC**	**LPC**	**MPC**	**OR**	**SL**	**UPC**
Rotifer	383.61	258.85	97.15	201.88	121.87	342.87	207.45
Rotifer SE	45.38	31.02	18.43	12.06	12.48	39.46	25.91
Nauplii	107.66	82.07	101.09	164.67	147.06	139.13	158.41
Nauplii SE	14.59	22.01	18.57	12.99	12.08	19.54	35.80
Copepodid	14.71	12.26	10.45	10.39	15.47	12.66	5.92
Copepodid SE	5.25	4.68	4.83	2.74	3.73	3.38	3.18
Cyclopidae	0.00	0.00	0.00	0.00	1.56	0.00	0.00
Cyclopidae SE	0.00	0.00	0.00	0.00	1.56	0.00	0.00
Calanoid	0.00	0.00	0.00	2.96	1.32	0.00	0.00
Calanoid SE	0.00	0.00	0.00	1.94	1.32	0.00	0.00
Bosmina longirostris	50.46	77.51	17.91	66.88	11.51	83.69	60.38
***Bosmina longirostris* SE**	6.71	19.09	4.47	10.25	3.11	13.80	12.15
***Ceriodaphnia* spp.**	14.71	12.32	11.99	26.94	30.00	7.92	14.88

***Ceriodaphnia* spp. SE**	4.77	5.25	4.59	6.08	11.79	2.32	7.41
Diaphanosoma birgei	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Diaphanosoma birgei* SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Moina micrura	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Moina micrura* SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bosminopsis deitersi	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Bosminopsis deitersi* SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ilyocryptus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ilyocryptus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Simocephalus* spp.**	7.50	3.00	8.99	4.30	4.20	0.00	0.00
***Simocephalus* spp. SE**	3.91	3.00	2.96	3.02	2.87	0.00	0.00
***Chydorus* spp.**	13.31	6.26	8.99	10.65	13.68	15.76	14.88
***Chydorus* spp. SE**	4.66	4.73	4.99	5.83	4.50	6.18	6.29
***Daphnia* spp.**	0.00	1.56	0.00	1.43	2.88	0.00	0.00
***Daphnia* spp. SE**	0.00	1.56	0.00	1.43	1.89	0.00	0.00
***Alona* spp.**	1.51	0.00	0.00	0.00	0.00	0.00	0.00
***Alona* spp. SE**	1.51	0.00	0.00	0.00	0.00	0.00	0.00
***Camptocercus* spp.**	5.81	0.00	0.00	0.00	0.00	0.00	0.00
***Camptocercus* spp. SE**	4.39	0.00	0.00	0.00	0.00	0.00	0.00
***Disparalona* spp.**	1.45	0.00	0.00	0.00	0.00	0.00	1.49
***Disparalona* spp. SE**	1.45	0.00	0.00	0.00	0.00	0.00	1.49
***Eurycercus* spp.**	2.97	3.00	2.92	4.39	5.28	1.59	2.93
***Eurycercus* spp. SE**	1.94	3.00	1.91	3.05	2.82	1.59	1.92
***Holopedium* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Holopedium* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Kurzia* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	1.44
***Kurzia* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	1.44
***Leydigia* spp.**	3.02	0.00	0.00	0.00	0.00	0.00	0.00
***Leydigia* spp. SE**	3.02	0.00	0.00	0.00	0.00	0.00	0.00
***Macrothrix* spp.**	1.45	0.00	0.00	0.00	0.00	0.00	0.00
***Macrothrix* spp. SE**	1.45	0.00	0.00	0.00	0.00	0.00	0.00
***Notoalona* spp.**	1.45	0.00	0.00	0.00	0.00	0.00	0.00
***Notoalona* spp. SE**	1.45	0.00	0.00	0.00	0.00	0.00	0.00
***Ophryoxus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ophryoxus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pleuroxus* spp.**	2.97	0.00	1.46	0.00	0.00	4.74	1.49
***Pleuroxus* spp. SE**	1.94	0.00	1.46	0.00	0.00	2.31	1.49
***Pseudochydorus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pseudochydorus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Sida* spp.**	1.51	1.56	7.46	4.39	0.00	1.57	1.44
***Sida* spp. SE**	1.51	1.56	3.11	2.14	0.00	1.57	1.44
Chydoridae	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chydoridae SE	0.00	0.00	0.00	0.00	0.00	0.00	0.00

February	**BL**	**CC**	**LPC**	**MPC**	**OR**	**SL**	**UPC**
Rotifer	710.83	442.04	453.13	726.22	641.71	1032.63	1816.47
Rotifer SE	62.45	50.34	31.11	30.11	31.63	122.00	97.73
Nauplii	92.55	57.03	110.22	51.29	122.27	55.49	51.00
Nauplii SE	10.43	12.19	22.73	6.27	9.08	9.56	9.25
Copepodid	6.52	5.70	20.89	2.53	23.49	1.41	4.26
Copepodid SE	2.82	3.05	6.05	1.66	6.38	1.41	2.08

Cyclopidae	0.00	1.43	0.00	0.00	1.33	0.00	0.00
Cyclopidae SE	0.00	1.43	0.00	0.00	1.33	0.00	0.00
Calanoid	0.00	0.00	0.00	0.00	2.65	0.00	1.40
Calanoid SE	0.00	0.00	0.00	0.00	1.74	0.00	1.40
Bosmina longirostris	0.00	0.00	2.77	2.57	5.44	2.86	0.00
***Bosmina longirostris* SE**	0.00	0.00	2.77	1.69	2.06	1.87	0.00
***Ceriodaphnia* spp.**	1.08	0.00	2.81	5.10	2.79	0.00	2.80
***Ceriodaphnia* spp. SE**	1.08	0.00	1.84	2.72	1.83	0.00	1.83
Diaphanosoma birgei	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Diaphanosoma birgei* SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Moina micrura	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Moina micrura* SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bosminopsis deitersi	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Bosminopsis deitersi* SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ilyocryptus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ilyocryptus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Simocephalus* spp.**	0.00	0.00	1.38	1.26	0.00	0.00	0.00
***Simocephalus* spp. SE**	0.00	0.00	1.38	1.26	0.00	0.00	0.00
***Chydorus* spp.**	2.17	0.00	1.38	1.31	1.46	1.41	1.40
***Chydorus* spp. SE**	2.17	0.00	1.38	1.31	1.46	1.41	1.40
***Daphnia* spp.**	0.00	0.00	1.38	0.00	5.44	0.00	0.00
***Daphnia* spp. SE**	0.00	0.00	1.38	0.00	2.87	0.00	0.00
***Alona* spp.**	0.00	0.00	0.00	0.00	1.46	1.41	0.00
***Alona* spp. SE**	0.00	0.00	0.00	0.00	1.46	1.41	0.00
***Camptocercus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Camptocercus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Disparalona* spp.**	0.00	0.00	7.00	0.00	1.46	0.00	0.00
***Disparalona* spp. SE**	0.00	0.00	3.64	0.00	1.46	0.00	0.00
***Eurycercus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Eurycercus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Holopedium* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Holopedium* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Kurzia* spp.**	0.00	0.00	1.38	0.00	1.33	0.00	0.00
***Kurzia* spp. SE**	0.00	0.00	1.38	0.00	1.33	0.00	0.00
***Leydigia* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Leydigia* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Macrothrix* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Macrothrix* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Notoalona* spp.**	0.00	0.00	1.38	0.00	1.46	0.00	0.00
***Notoalona* spp. SE**	0.00	0.00	1.38	0.00	1.46	0.00	0.00
***Ophryoxus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ophryoxus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pleuroxus* spp.**	0.00	0.00	0.00	0.00	0.00	1.41	0.00
***Pleuroxus* spp. SE**	0.00	0.00	0.00	0.00	0.00	1.41	0.00
***Pseudochydorus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pseudochydorus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Sida* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Sida* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chydoridae	0.00	1.43	0.00	0.00	0.00	1.41	0.00
Chydoridae SE	0.00	1.43	0.00	0.00	0.00	1.41	0.00

March	BL	CC	LPC	MPC	OR	SL	UPC
Rotifer	3944.49	2322.92	2518.52	3288.02	3368.65	7625.40	7648.83
Rotifer SE	494.22	181.06	241.88	372.45	256.37	349.62	494.83
Nauplii	212.57	107.36	100.10	118.10	225.00	320.66	303.29
Nauplii SE	33.00	25.84	14.31	21.14	39.39	25.88	63.22
Copepodid	27.48	12.83	19.23	5.98	69.08	13.80	17.50
Copepodid SE	11.05	3.43	6.25	2.26	17.04	3.65	4.73
Cyclopidae	12.14	8.02	3.38	2.89	20.97	3.49	1.56
Cyclopidae SE	3.27	4.81	3.38	2.89	9.48	2.28	1.56
Calanoid	3.03	1.60	0.00	0.00	8.05	1.71	0.00
Calanoid SE	1.98	1.60	0.00	0.00	3.40	1.71	0.00
Bosmina longirostris	1.53	0.00	0.00	0.00	1.62	3.49	1.56
***Bosmina longirostris* SE**	1.53	0.00	0.00	0.00	1.62	2.28	1.56
***Ceriodaphnia* spp.**	4.49	1.61	3.26	1.45	14.36	12.16	4.69
***Ceriodaphnia* spp. SE**	3.15	1.60	2.14	1.45	2.90	4.86	3.29
Diaphanosoma birgei	0.00	0.00	0.00	0.00	1.62	0.00	0.00
***Diaphanosoma birgei* SE**	0.00	0.00	0.00	0.00	1.62	0.00	0.00
Moina micrura	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Moina micrura* SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bosminopsis deitersi	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Bosminopsis deitersi* SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ilyocryptus* spp.**	0.00	0.00	0.00	1.45	0.00	0.00	0.00
***Ilyocryptus* spp. SE**	0.00	0.00	0.00	1.45	0.00	0.00	0.00
***Simocephalus* spp.**	0.00	0.00	0.00	0.00	1.62	0.00	0.00
***Simocephalus* spp. SE**	0.00	0.00	0.00	0.00	1.62	0.00	0.00
***Chydorus* spp.**	4.52	0.00	7.98	7.52	11.25	3.49	1.56
***Chydorus* spp. SE**	2.21	0.00	3.34	3.21	5.15	2.28	1.56
***Daphnia* spp.**	0.00	0.00	0.00	0.00	6.48	1.71	0.00
***Daphnia* spp. SE**	0.00	0.00	0.00	0.00	3.46	1.71	0.00
***Alona* spp.**	0.00	0.00	0.00	0.00	1.62	0.00	4.79
***Alona* spp. SE**	0.00	0.00	0.00	0.00	1.62	0.00	2.34
***Camptocercus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Camptocercus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Disparalona* spp.**	0.00	0.00	0.00	0.00	1.62	0.00	0.00
***Disparalona* spp. SE**	0.00	0.00	0.00	0.00	1.62	0.00	0.00
***Eurycercus* spp.**	0.00	0.00	9.45	0.00	3.20	1.78	0.00
***Eurycercus* spp. SE**	0.00	0.00	4.61	0.00	2.09	1.78	0.00
***Holopedium* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Holopedium* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Kurzia* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Kurzia* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Leydigia* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Leydigia* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Macrothrix* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Macrothrix* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Notoalona* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Notoalona* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ophryoxus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ophryoxus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pleuroxus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pleuroxus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00

***Pseudochydorus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pseudochydorus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Sida* spp.**	0.00	0.00	0.00	0.00	1.62	0.00	0.00
***Sida* spp. SE**	0.00	0.00	0.00	0.00	1.62	0.00	0.00
Chydoridae	0.00	0.00	0.00	0.00	1.62	0.00	0.00
Chydoridae SE	0.00	0.00	0.00	0.00	1.62	0.00	0.00

April	**BL**	**CC**	**LPC**	**MPC**	**OR**	**SL**	**UPC**
Rotifer	234.39	234.88	761.04	693.86	1773.92	.	837.00
Rotifer SE	17.90	76.69	228.86	158.56	410.86	.	40.96
Nauplii	404.72	500.36	554.62	1465.15	603.46	.	3385.48
Nauplii SE	48.34	95.96	118.08	313.41	108.43	.	446.69
Copepodid	0.00	13.49	11.48	50.12	60.36	.	25.20
Copepodid SE	0.00	7.16	5.61	20.43	12.64	.	10.16
Cyclopidae	0.00	9.96	3.57	0.00	6.28	.	0.00
Cyclopidae SE	0.00	6.98	3.57	0.00	4.11	.	0.00
Calanoid	0.00	6.64	3.57	0.00	6.28	.	3.53
Calanoid SE	0.00	6.64	3.57	0.00	6.28	.	3.53
Bosmina longirostris	0.00	6.64	566.33	103.80	470.64	.	78.84
***Bosmina longirostris* SE**	0.00	4.35	201.63	29.10	57.43	.	10.68
***Ceriodaphnia* spp.**	0.00	10.17	0.00	23.43	9.72	.	10.79
***Ceriodaphnia* spp. SE**	0.00	4.97	0.00	7.88	6.82	.	7.60
Diaphanosoma birgei	0.00	0.00	0.00	0.00	3.14	.	0.00
***Diaphanosoma birgei* SE**	0.00	0.00	0.00	0.00	3.14	.	0.00
Moina micrura	0.00	0.00	0.00	3.34	3.24	.	0.00
***Moina micrura* SE**	0.00	0.00	0.00	3.34	3.24	.	0.00
Bosminopsis deitersi	0.00	0.00	0.00	0.00	0.00	.	0.00
***Bosminopsis deitersi* SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Ilyocryptus* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Ilyocryptus* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Simocephalus* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Simocephalus* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Chydorus* spp.**	0.00	0.00	3.95	0.00	6.48	.	14.22
***Chydorus* spp. SE**	0.00	0.00	3.95	0.00	6.48	.	7.58
***Daphnia* spp.**	3.59	50.86	14.29	6.67	0.00	.	17.95
***Daphnia* spp. SE**	3.59	10.56	5.40	6.67	0.00	.	5.26
***Alona* spp.**	0.00	0.00	0.00	3.34	0.00	.	0.00
***Alona* spp. SE**	0.00	0.00	0.00	3.34	0.00	.	0.00
***Camptocercus* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Camptocercus* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Disparalona* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Disparalona* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Eurycercus* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Eurycercus* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Holopedium* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Holopedium* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Kurzia* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Kurzia* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Leydigia* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Leydigia* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Macrothrix* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00

***Macrothrix* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Notoalona* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Notoalona* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Ophryoxus* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Ophryoxus* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Pleuroxus* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Pleuroxus* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Pseudochydorus* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Pseudochydorus* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Sida* spp.**	0.00	0.00	0.00	0.00	3.14	.	0.00
***Sida* spp. SE**	0.00	0.00	0.00	0.00	3.14	.	0.00
Chydoridae	0.00	0.00	0.00	0.00	0.00	.	0.00
Chydoridae SE	0.00	0.00	0.00	0.00	0.00	.	0.00

May	**BL**	**CC**	**LPC**	**MPC**	**OR**	**SL**	**UPC**
Rotifer	2763.43	848.31	302.23	1384.72	300.05	.	13655.10
Rotifer SE	274.46	30.96	41.43	90.78	30.35	.	1663.91
Nauplii	195.88	721.96	19.72	297.83	35.75	.	219.77
Nauplii SE	26.95	34.22	7.43	39.01	11.39	.	46.75
Copepodid	48.47	24.07	5.96	38.03	11.92	.	14.25
Copepodid SE	13.30	0.24	3.95	11.62	3.66	.	6.02
Cyclopidae	15.76	12.03	3.36	33.88	6.02	.	2.87
Cyclopidae SE	8.69	4.55	3.36	17.98	2.94	.	2.87
Calanoid	4.17	12.03	0.00	47.01	0.00	.	11.34
Calanoid SE	4.17	7.88	0.00	10.20	0.00	.	4.29
Bosmina longirostris	2.08	48.13	6.73	6.91	14.87	.	8.56
***Bosmina longirostris* SE**	2.08	17.03	6.73	3.43	6.42	.	4.18
***Ceriodaphnia* spp.**	24.55	0.00	0.00	0.00	0.00	.	5.74
***Ceriodaphnia* spp. SE**	8.28	0.00	0.00	0.00	0.00	.	3.75
Diaphanosoma birgei	7.88	0.00	0.00	2.07	0.00	.	8.56
***Diaphanosoma birgei* SE**	4.10	0.00	0.00	2.07	0.00	.	4.18
Moina micrura	686.92	54.15	0.00	434.14	18.05	.	360.16
***Moina micrura* SE**	44.76	13.47	0.00	66.88	7.07	.	84.40
Bosminopsis deitersi	0.00	0.00	0.00	0.00	2.95	.	0.00
***Bosminopsis deitersi* SE**	0.00	0.00	0.00	0.00	2.95	.	0.00
***Ilyocryptus* spp.**	0.00	0.00	0.00	0.00	0.00	.	2.87
***Ilyocryptus* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	2.87
***Simocephalus* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Simocephalus* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Chydorus* spp.**	2.08	0.00	0.00	0.00	2.01	.	8.52
***Chydorus* spp. SE**	2.08	0.00	0.00	0.00	2.01	.	4.16
***Daphnia* spp.**	0.00	0.00	0.00	0.00	2.95	.	0.00
***Daphnia* spp. SE**	0.00	0.00	0.00	0.00	2.95	.	0.00
***Alona* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Alona* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Camptocercus* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Camptocercus* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Disparalona* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Disparalona* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Eurycercus* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Eurycercus* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00

***Holopedium* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Holopedium* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Kurzia* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Kurzia* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Leydigia* spp.**	2.08	0.00	0.00	0.00	0.00	.	0.00
***Leydigia* spp. SE**	2.08	0.00	0.00	0.00	0.00	.	0.00
***Macrothrix* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Macrothrix* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Notoalona* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Notoalona* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Ophryoxus* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Ophryoxus* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Pleuroxus* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Pleuroxus* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Pseudochydorus* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Pseudochydorus* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Sida* spp.**	0.00	0.00	0.00	0.00	0.00	.	0.00
***Sida* spp. SE**	0.00	0.00	0.00	0.00	0.00	.	0.00
Chydoridae	0.00	0.00	0.00	0.00	0.00	.	0.00
Chydoridae SE	0.00	0.00	0.00	0.00	0.00	.	0.00

June	BL	CC	LPC	MPC	OR	SL	UPC
Rotifer	642.06	1064.48	210.13	484.81	217.75	1485.50	463.83
Rotifer SE	75.88	62.41	24.69	39.20	29.78	51.57	34.95
Nauplii	37.16	41.76	10.38	83.57	24.99	314.20	102.82
Nauplii SE	13.29	20.64	5.07	7.78	7.55	40.54	24.38
Copepodid	0.00	0.00	3.37	0.00	0.00	0.00	0.00
Copepodid SE	0.00	0.00	3.37	0.00	0.00	0.00	0.00
Cyclopidae	0.00	0.00	3.37	0.00	0.00	0.00	0.00
Cyclopidae SE	0.00	0.00	3.37	0.00	0.00	0.00	0.00
Calanoid	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Calanoid SE	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bosmina longirostris	3.01	0.00	3.51	0.00	0.00	0.00	0.00
***Bosmina longirostris* SE**	3.01	0.00	3.51	0.00	0.00	0.00	0.00
***Ceriodaphnia* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ceriodaphnia* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Diaphanosoma birgei	0.00	0.00	0.00	3.31	0.00	9.06	0.00
***Diaphanosoma birgei* SE**	0.00	0.00	0.00	3.31	0.00	6.36	0.00
Moina micrura	0.00	3.52	3.51	0.00	0.00	0.00	6.62
***Moina micrura* SE**	0.00	3.52	3.51	0.00	0.00	0.00	4.33
Bosminopsis deitersi	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Bosminopsis deitersi* SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ilyocryptus* spp.**	0.00	0.00	0.00	0.00	3.04	0.00	0.00
***Ilyocryptus* spp. SE**	0.00	0.00	0.00	0.00	3.04	0.00	0.00
***Simocephalus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Simocephalus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Chydorus* spp.**	0.00	3.52	0.00	0.00	0.00	0.00	0.00
***Chydorus* spp. SE**	0.00	3.52	0.00	0.00	0.00	0.00	0.00
***Daphnia* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Daphnia* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Alona* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00

***Alona* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Camptocercus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Camptocercus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Disparalona* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Disparalona* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Eurycercus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Eurycercus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Holopedium* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Holopedium* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Kurzia* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Kurzia* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Leydigia* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Leydigia* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Macrothrix* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Macrothrix* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Notoalona* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Notoalona* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ophryoxus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Ophryoxus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pleuroxus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pleuroxus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pseudochydorus* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Pseudochydorus* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Sida* spp.**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Sida* spp. SE**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chydoridae	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chydoridae SE	0.00	0.00	0.00	0.00	0.00	0.00	0.00

July	BL	CC	LPC	MPC	OR	SL	UPC
Rotifer	3169.21	2502.12	.	15641.14	.	6901.43	12706.61
Rotifer SE	172.22	94.79	.	286.83	.	891.24	762.78
Nauplii	140.27	174.27	.	542.59	.	1554.28	524.86
Nauplii SE	32.88	17.93	.	42.12	.	95.56	81.86
Copepodid	0.00	5.00	.	0.00	.	0.00	7.24
Copepodid SE	0.00	3.51	.	0.00	.	0.00	2.12
Cyclopidae	0.00	0.00	.	0.00	.	0.00	0.00
Cyclopidae SE	0.00	0.00	.	0.00	.	0.00	0.00
Calanoid	0.00	0.00	.	0.00	.	0.00	0.00
Calanoid SE	0.00	0.00	.	0.00	.	0.00	0.00
Bosmina longirostris	0.00	0.00	.	0.00	.	0.00	0.00
***Bosmina longirostris* SE**	0.00	0.00	.	0.00	.	0.00	0.00
***Ceriodaphnia* spp.**	0.00	0.00	.	0.00	.	0.00	2.87
***Ceriodaphnia* spp. SE**	0.00	0.00	.	0.00	.	0.00	2.87
Diaphanosoma birgei	57.63	124.14	.	187.82	.	9.40	74.83
***Diaphanosoma birgei* SE**	12.47	13.73	.	6.96	.	6.16	29.27
Moina micrura	5.50	0.00	.	0.00	.	0.00	0.00
***Moina micrura* SE**	3.86	0.00	.	0.00	.	0.00	0.00
Bosminopsis deitersi	0.00	0.00	.	0.00	.	0.00	0.00
***Bosminopsis deitersi* SE**	0.00	0.00	.	0.00	.	0.00	0.00
***Ilyocryptus* spp.**	0.00	0.00	.	0.00	.	0.00	0.00
***Ilyocryptus* spp. SE**	0.00	0.00	.	0.00	.	0.00	0.00

***Simocephalus* spp.**	0.00	0.00	.	0.00	.	0.00	0.00
***Simocephalus* spp. SE**	0.00	0.00	.	0.00	.	0.00	0.00
***Chydorus* spp.**	0.00	0.00	.	0.00	.	0.00	0.00
***Chydorus* spp. SE**	0.00	0.00	.	0.00	.	0.00	0.00
***Daphnia* spp.**	0.00	0.00	.	0.00	.	0.00	0.00
***Daphnia* spp. SE**	0.00	0.00	.	0.00	.	0.00	0.00
***Alona* spp.**	0.00	0.00	.	0.00	.	0.00	0.00
***Alona* spp. SE**	0.00	0.00	.	0.00	.	0.00	0.00
***Camptocercus* spp.**	0.00	0.00	.	0.00	.	0.00	0.00
***Camptocercus* spp. SE**	0.00	0.00	.	0.00	.	0.00	0.00
***Disparalona* spp.**	0.00	0.00	.	0.00	.	0.00	0.00
***Disparalona* spp. SE**	0.00	0.00	.	0.00	.	0.00	0.00
***Eurycercus* spp.**	0.00	0.00	.	0.00	.	0.00	0.00
***Eurycercus* spp. SE**	0.00	0.00	.	0.00	.	0.00	0.00
***Holopedium* spp.**	0.00	0.00	.	0.00	.	0.00	0.00
***Holopedium* spp. SE**	0.00	0.00	.	0.00	.	0.00	0.00
***Kurzia* spp.**	0.00	0.00	.	0.00	.	0.00	0.00
***Kurzia* spp. SE**	0.00	0.00	.	0.00	.	0.00	0.00
***Leydigia* spp.**	0.00	0.00	.	0.00	.	0.00	0.00
***Leydigia* spp. SE**	0.00	0.00	.	0.00	.	0.00	0.00
***Macrothrix* spp.**	0.00	0.00	.	0.00	.	0.00	0.00
***Macrothrix* spp. SE**	0.00	0.00	.	0.00	.	0.00	0.00
***Notoalona* spp.**	0.00	0.00	.	0.00	.	0.00	0.00
***Notoalona* spp. SE**	0.00	0.00	.	0.00	.	0.00	0.00
***Ophryoxus* spp.**	0.00	0.00	.	0.00	.	0.00	0.00
***Ophryoxus* spp. SE**	0.00	0.00	.	0.00	.	0.00	0.00
***Pleuroxus* spp.**	0.00	0.00	.	0.00	.	0.00	0.00
***Pleuroxus* spp. SE**	0.00	0.00	.	0.00	.	0.00	0.00
***Pseudochydorus* spp.**	0.00	0.00	.	0.00	.	0.00	0.00
***Pseudochydorus* spp. SE**	0.00	0.00	.	0.00	.	0.00	0.00
***Sida* spp.**	0.00	0.00	.	0.00	.	0.00	0.00
***Sida* spp. SE**	0.00	0.00	.	0.00	.	0.00	0.00
Chydoridae	0.00	0.00	.	0.00	.	0.00	0.00
Chydoridae SE	0.00	0.00	.	0.00	.	0.00	0.00

VITA

William Lowe Sheftall, IV, son of Carol H. Sheftall and William L. Sheftall, Jr, was born in Fort Myers, Florida, in June, 1985. He attended high school at Brookwood School in Thomasville, Georgia, and graduated in 2003. Will entered Rhodes College in Memphis, Tennessee, that same year, and graduated in 2007 with a Bachelor of Art degree in biology. Following a nine month internship with the Bureau of Land Management in Miles City, Montana, he entered graduate school at Louisiana State University in May 2008. Will plans to graduate in the summer of 2011 with a Master of Science in fisheries.