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An Analysis of the Turtle Assemblage in the Freed-Hardeman University Research Ponds

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Abstract. — Studies of assemblages of common turtle species from small ponds are rare. Here we describe a turtle assemblage occupying two small ponds on a university campus in rural west Tennessee. We deployed two double-throated hoop nets and two wire catfish nets in each pond during each sampling session. We captured a total of 56 individuals representing five species between 2019 and 2021. The most abundant species was the Southern Painted Turtle (*Chrysemys dorsalis*) followed by the Eastern Musk Turtle (*Sternotherus odoratus*), the Pond Slider (*Trachemys scripta*), the Snapping Turtle (*Chelydra serpentina*), and the River Cooter (*Pseudemys concinna*). Survey area H' was 1.37, J' was 0.85, and S was five. Sex ratios did not significantly differ from 1:1 within species. Morphometric variables only significantly differed between sexes of the Southern Painted Turtle. Species richness in each pond was four. H' between the two ponds was not significantly different. The Eastern Musk Turtle was the only species that used one pond significantly more than the other. This information serves as a baseline to identify future changes in the assemblage. Identifying negative impacts on populations and their potential causes is a reasonable first step in the goal of keeping common species common.

Key Words. — Community, Lentic, Species Diversity, Species Richness, Small Ponds, Tennessee

Originally presumed stable and flourishing in their geographic ranges, native populations of many turtles are imperiled globally (Gibbons et al. 2000). Of the 357 turtle species identified worldwide, the International Union for Conservation of Nature (IUCN) has classified 171 of those as threatened, signifying that 47.9% of the total turtle species are Critically Endangered, Endangered, or Vulnerable (Turtle Taxonomy Working Group [TTWG] 2021). A turtle species placed on the IUCN Red List under such a categorization is facing threats to either its population stability, geographic range, or both, which can be traced to anthropogenic origins, including habitat destruction and modification, disturbance, and exploitation for food and the pet trade (Burger and Garber 1995; TCF 2002; IUCN 2012).

Turtles offer many unique services to the ecosystem in which they inhabit (Agha et al. 2018). Specifically, turtles are major contributors to the overall biomass of an ecosystem, which indicates the availability of energy within a system. As ectotherms, turtles incorporate acquired energy more efficiently into their biomass than their endotherm counterparts (Iverson 1982; Agha et al. 2018). Consequently, predators of turtles will have access to more bioavailable energy. Acting as both prey and predators, turtles can exhibit both top-down and bottom-up cascades. Through top-down effects as predators, turtles can have profound effects on the landscape of an ecosystem (Davenport et al. 2020). As prey, turtles influence the available food for predators at higher trophic levels (Colbert et al. 2010). Furthermore, by digging burrows for shelter and concealment of eggs, turtles offer safe refuge for other species from predators (Agha et al. 2018; Goodman et al. 2018; Madden et al. 2008). Some turtles, such as the Eastern Musk Turtle (*Sternotherus odoratus*), use the burrows of other turtles for egg deposition. (Niemiller et al. 2013). Therefore, turtles play a critical role in the functioning of healthy ecosystems.

While there are many studies on the role of turtles in their ecosystems, much less appears to be known about the community structure of turtles inhabiting small ponds, especially when compared with lotic environments (House et al. 2011). The few studies on small ponds concentrate their efforts on analyzing abundance, biomass, richness, and population density (Stone et al. 2005; House et al. 2011). One study conducted on small ponds surveyed differences in species diversity, richness, abundance, and sex ratios between ponds located on agricultural and golf course lands (Dorcas et al. 2007).

Figure 1. Freed-Hardeman University North Pond (A) and Middle Pond (B) within FHU Wetland, Henderson, Tennessee, USA.

Much like small pond systems, common species are routinely overlooked and understudied (Gaston 2010). Despite the lack of interest and concern for abundant species, these species and their habitats are often exploited (Gaston 2010). For example, the Snapping Turtle (*Chelydra serpentina*) is harvested in the United States and exported to Asian countries for consumption (TCF 2002). Thus, it is imperative to understand the community structure of common turtles before they become less common. Such work can provide baseline knowledge which may demonstrate the root causes of population declines in the future.

The purpose of our study was to describe the turtle community, made up of species considered common in Freed-Hardeman University's (FHU) small pond system. Specifically, we assessed species richness, species diversity, and relative abundance, sex ratios, and morphology for turtles within the system between 2019 and 2021. We also compared species richness, species diversity, and species usage between the two ponds to explore possible differences in habitat use.

Methods and Materials

Study Site. — Our survey area was two small ponds (North Pond and Middle Pond) (Fig. 1) within the FHU Wetland, Henderson, TN, USA (Fig. 2). The FHU Wetland is a 2 ha. restored wetland that formally was an agricultural field that lies on the edge of the South Fork Forked Deer River floodplain. FHU Wetland is bordered on the north by a field containing a cross country course, on the south by TN Highway 100, on the east by South Mifflin Avenue, and on the west by a field containing a cross country course and disc golf course. Municipal sewage lagoons and a forested flood plain including Sugar Creek lie south of TN Highway 100. North Pond lies east to west and has a length of 68 m and a width of 19 m. South Pond has a north south orientation and has a length of 89 m and a width of 19 m. The southern edge of North Pond is approximately 30 m from the northern edge of Middle Pond. Both ponds are approximately 1.5 m deep full pool. The banks of both ponds are surrounded by trees dominated by Oak (*Quercus* sp.). More than 30% of the surface of each pond is covered with Water Lilies (*Nymphaea* sp.).

Data Collection. — From late-March to early-May and mid-August to early-October of 2019 through 2021, the FHU Turtle Team sampled the two ponds by deploying two types of nets. Two double-throated hoop nets (76 cm diameter, 193 cm length; Memphis Net and Twine, Memphis, Tennessee, USA) and two wire catfish nets (43 cm diameter, 122 cm length; Memphis Net and Twine, Memphis, Tennessee, USA) were set in each pond. Nets were set by submerging one-half of the net in the water, leaving the other half open to air to allow captured turtles to breathe. On days that heavy rain was expected, the nets were set higher to ensure they did not become completely submerged. Nets were secured by iron rods and baited with raw chicken, chicken nuggets, fish scraps or meat scraps based on availability. After a 24-hour interval, the nets were checked for turtles and rebaited. The same type of bait was used in all nets in both ponds during each trapping session.

Figure 2. Freed-Hardeman University Wetland and surrounding area. Henderson, Tennessee, USA. N = North Pond and M = Middle Pond.

Table 1. Comparison of turtle species composition in Freed-Hardeman University Research Ponds, Henderson, Tennessee, USA. Data presented as number of individuals (relative abundance). S = species richness, H' = Shannon Index, J' = Equitability

Common Name	Scientific Name	North Pond	Middle Pond	Survey Area
Snapping Turtle	*Chelydra serpentina*	5(0.19)	5(0.13)	7(0.13)
Southern Painted Turtle	*Chrysemys dorsalis*	13(0.48)	12(0.31)	23(0.44)
River Cooter	*Pseudemys concinna*	1(0.04)	0(0)	1(0.02)
Pond Slider	*Trachemys scripta*	8(0.3)	10(0.26)	13(0.23)
Eastern Musk Turtle	*Sternotherus odoratus*	0(0)	12(0.31)	12(0.21)
S		4	4	5
H'		1.15	1.48	1.37
J'		0.83	0.96	0.85

Captured turtles were identified to species and sexed based on secondary sexual characteristics, such as tail and claw length (Ernst and Lovich 2009). Turtles were measured with 40 cm tree calipers (Haglof Inc., Madison, Mississippi, USA) to obtain straight-line measurements of maximum carapace length (CL), maximum plastron length (PL), maximum carapace width (CW), and shell height (SH), recorded to the nearest mm. All turtles were weighed to the nearest g using Ohaus top loading digital scales (Ohaus, Parsippany, New Jersey, USA) or Pesola digital scales (Pesola, AG, Baar, Switzerland). The carapace of each turtle was marked with a unique notching pattern, a variation of the technique described by Cagle (1939). Each turtle was then examined for damage or injury. After physical examinations were completed, turtles were returned to the pond from which they were trapped.

Data Analysis. — We counted the number of species captured at each pond and collectively in the survey area to determine species richness (S) and calculated relative abundance (RA) of each species by determining the proportion of each species relative to the total number of individual turtles captured. We calculated a natural log Shannon Index (H') to describe diversity and Equitability (J') to estimate heterogeneity for each pond and the sampling area collectively.

We performed a chi-square test to determine if observed sex ratios for each species differed significantly from 1:1. We compared means of each morphometric variable between sexes within each species with t-tests. We used one-tailed t-tests for the Snapping Turtle, Southern Painted Turtle, and Pond Slider because male Snapping Turtles are known to be larger than females, and female Southern Painted Turtles and Pond Sliders are known to be larger than males. We used a two-tailed t-test to compare CL between sexes of the Eastern Musk Turtles because sizes are often similar in other populations (Niemiller et al. 2013).

We compared H' between North Pond and South Pond with a Hutchison t-test. We searched for differences in pond usage within species with two-tailed Wilcoxon-Signed Rank tests. For all tests, $\alpha = 0.05$.

Results

We captured a total of 56 individuals representing five species. The most abundant species was the Southern Painted Turtle (*Chrysemys dorsalis*) followed by the Eastern Musk Turtle (*Sternotherus odoratus*), the Pond Slider (*Trachemys scripta*), the Snapping Turtle (*Chelydra serpentina*) and the River Cooter (*Pseudemys concinna*) (Table 1). Survey area H' was 1.37, J' was 0.85, and S was 5 (Table 1). Sex ratios did not significantly differ from 1:1 (Table 2) within species. Shell morphology did not differ between sex save that all morphometric variables significantly differed between sexes of the Southern Painted Turtle (Table 3).

Species richness in each pond was four (Table 1). H' between North and Middle ponds was not significantly different ($t = 1.48$, df = 39, $p = 0.15$). The Eastern Musk Turtle was not captured from North Pond and the River Cooter was not captured from Middle Pond. The Eastern Musk Turtle was the only species that used one pond significantly more than the other (Table 4). Individuals of three species moved between ponds. Three of 7 Snapping Turtles, 7 of 13 Pond Sliders and 2 of 23 Southern Painted Turtles were captured in both ponds, respectively.

Table 2. Sex ratios of turtles in the Freed-Hardeman University Research Ponds, Henderson, Tennessee, USA.

Common Name	Scientific Name	Male	Female	Sex Ratio	X^2	*p*
Snapping Turtle	*Chelydra serpentina*	3	4	0.75:1	0.14	0.71
Southern Painted Turtle	*Chrysemys dorsalis*	13	9	1.44:1	0.73	0.39
Pond Slider	*Trachemys scripta*	5	8	0.63:1	0.70	0.41
Eastern Musk Turtle	*Sternotherus odoratus*	8	2	4:1	3.60	0.06

Table 3. Mean comparisons of morphometric variables between sexes within turtle species in the Freed-Hardeman University Research Ponds, Henderson, Tennessee, USA. Values given ± one standard error. Asterisks (*) indicate significance at alpha 0.05.

Variable	Male	Female	*t*	*P*
Chelydra serpentina	n = 3	n = 4		
Carapace Length	324.3±17.7	293.5±24.4	0.95[a]	0.19
Carapace Width	285.0±18.0	233.8±23.0	1.65[a]	0.08
Plastron Length	227.3±13.2	197.3±14.8	1.45[a]	0.10
Shell Height	128.5±17.5[c]	113.3±8.7	0.90[a]	0.21
Mass	7590±1183	4770±1363	1.50[a]	0.10
Chrysemys dorsalis	n = 13	n = 9		
Carapace Length	96.9±6.0	124.7±9.7	2.57[a]	0.01*
Carapace Width	73.8±4.9	95.2±5.9	2.80[a]	0.01*
Plastron Length	88.9±5.7	118.8±8.7	2.97[a]	0.004*
Shell Height	34.2±2.0	47.3±3.4	3.49[a]	0.001*
Mass	135.7±12.5[d]	295.9±51.1	3.46[a]	0.001*
Pseudemys concinna	n = 1	n = 0		
Carapace Length	256			
Carapace Width	176			
Plastron Length	221			
Shell Height	86			
Mass	1530			
Trachemys scripta	n = 5	n = 8		
Carapace Length	205.0±7.9	214.8±11.4	0.61[a]	0.28
Carapace Width	155.2±5.7	164.1±9.1	0.71[a]	0.25
Plastron Length	187.0±7.7	197.5±9.9	0.75[a]	0.23
Shell Height	77.2±4.1	85.5±6.3	0.95[a]	0.18
Mass	1105.8±135.5	1464.6±243.2	1.10[a]	0.15
Sternotherus odoratus	n = 8	n = 2		
Carapace Length	89.6±3.8	82.5±0.5	0.90[b]	0.39
Carapace Width	60.4±2.4	57.5±2.5	0.57[b]	0.59
Plastron Length	63.4±2.4	55.0±1.0	1.64[b]	0.14
Shell Height	36.4±1.2	33.5±0.5	1.13[b]	0.29
Mass	112.8±15.8	100.0±10.1	0.39[b]	0.71

[a] = one-tailed test; [b]= two-tailed test; [c] Sample size was n = 2; [d] Sample size was n = 12

DISCUSSION

We documented the presence of every lentic turtle species expected to be in West Tennessee, except for the Eastern Mud Turtle (*Kinosternon subrubrum*), from our two ponds within the FHU Wetland (Niemiller et al. 2013). The most common of these turtle species captured included the Southern Painted Turtle, Eastern Musk Turtle, and Pond Slider, followed by the Snapping Turtle. All four lentic species are reported to be common members of the communities in which they inhabit in Tennessee (Niemiller et al. 2013).

Of these four common species, the Southern Painted Turtle represents one of the most abundant turtle species native to North America along with the closely related Painted Turtle (*Chrysemys picta*) (Niemiller et al. 2013). Similar studies on small pond systems have also documented painted turtles (*Chrysemys*) as the most abundant members of their communities with Pond Slider nearing the same levels of abundance (Stone et al. 2005; House et al. 2011; Niemiller et al. 2013). Still, other studies describe Pond Sliders as the dominant members of their community whereas Southern Painted Turtles are unable to attain the same densities (Dreslik et al. 2005; Niemiller et al. 2013). Although neither species is monitored as a species of concern, both are vulnerable to the impacts of harvesting and landscape alteration (Niemiller et al. 2013).

The other two lentic species captured in this study, the Eastern Musk Turtle and the Snapping Turtle are considered stable species of least concern globally on the IUCN Red List, and in Tennessee, both are reported to be common (Niemiller et al. 2013; van Dijk 2012; van Dijk 2015). Such reports on the Eastern Musk Turtle align with the findings of our study as the Eastern Musk Turtle represented 21% of the turtles recorded, approaching similar numbers to the Pond Slider. Though not as bountiful, the Snapping Turtle exhibited abundance levels comparable to House et al. (2011). Despite being evaluated as common species, both encounter threats to their stable populations. The Eastern Musk Turtle suffers

Table 4. Results of Wilcoxon-Signed Rank tests comparing turtle usage between North Pond and Middle Pond of the Freed-Hardeman University Research Ponds, Henderson, Tennessee, USA.

Common Name	Scientific Name	W	*P*
Snapping Turtle	*Chelydra serpentina*	14	>0.05
Southern Painted Turtle	*Chrysemys dorsalis*	128.5	>0.05
Pond Slider	*Trachemys scripta*	23.5	>0.05
Eastern Musk Turtle	*Sternotherus odoratus*	0	<0.05*

*significance at an alpha of 0.05.

more from habitat destruction and less from travel-related deaths from crossing roads as this species does not journey far from their residence unlike the Snapping Turtle (Niemiller et al. 2013). However, Snapping Turtles uniquely are at risk by potential overharvesting as they are considered a game species in Tennessee as well as many other states (Congdon et al. 1994; Colteaux 2017; Niemiller et al. 2013). Additionally, because populations of turtles in Asia are rapidly declining from overharvesting, demand for Snapping Turtle meat has dramatically increased (Colteaux 2017; TCF 2002).

The River Cooter was the least common species captured. Similar studies on small pond systems have documented the low occurrence of the River Cooter (Stone et al. 2005, House et al. 2011). House et al. (2011) attributes this to the habitat preference of the River Cooter, which is a species that selects lotic environments such as rivers as opposed to still water ponds. We suspect the lone River Cooter to be a transient that wandered to North Pond from the South Fork Forked Deer River floodplain.

We did not capture the Eastern Mud Turtle during our study. However, the turtle is known from the FHU Wetland (Butterfield et al. 2014) and FHU students previously captured individuals in turtle nets from both North Pond and Middle Pond between 1998 and 2007 (unpublished data). We suspect that development of the adjacent areas including the construction of athletic fields and paved roads have negatively impacted the Eastern Mud Turtle by hindering its access to the FHU Wetland. However, we do not know if our failure to detect the Eastern Mud Turtle during the time period of this study reflects a decline of the species within the area adjacent to the FHU Wetland.

Morphometric variables between sexes for all species did not differ significantly except for the Southern Painted Turtle. For the Southern Painted Turtle, Pond Slider, and River Cooter, sexual dimorphism is well documented, with females typically attaining larger sizes than males (Rowe 1997; Niemiller et al. 2013). This difference in size allows females more space for eggs (Rowe 1997). Yet, in the Snapping Turtle, males attain larger sizes than females, while the Eastern Musk Turtle does not display size dimorphism between the sexes (Niemiller et al. 2013). However, we found that Southern Painted Turtle males grew to larger sizes than adult females, which may be a consequence of our small sample size. Our failure to detect sexual size dimorphism among the other species may also be a consequence of small sample sizes. However, our morphometric variables between sexes of the Snapping Turtle and Pond Slider did trend in the predicted directions. That is, morphometric values for male Snapping Turtles were greater than females, and those for female Pond Sliders were greater than those for males.

We found no difference in diversity between the two ponds. We also documented moment between ponds for three species. This was not surprising because the ponds are near each other and have near identical habitat. The Southern Painted Turtle, Pond Slider, and Snapping Turtle were found in both ponds whereas, we found the Eastern Musk Turtle exclusively in Middle Pond. We currently have no convenient explanation why the Eastern Musk Turtle was not found in North Pond. The northern bank of North Pond is bordered by a cross country track which causes more human foot traffic near the pond. Further investigation is needed to assess a possible link between turtle behavior and human traffic in our study area, and with the recent installation of a disc golf course near the ponds, the turtles may be experiencing more disturbance than ever before.

Assemblages of common turtles in small ponds are largely understudied. Here we provide descriptive data from a turtle assemblage in small ponds on a university campus in rural Tennessee. This information serves as a baseline to identify future positive or negative changes in the assemblage. Identifying negative changes and potential causes of these changes to turtle assemblages is a reasonable first step in the goal of keeping common species common (Stone et al. 2014).

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