Measuring Herpetofaunal Biodiversity in Southwest Missouri

Kelsea Tyson[2], Lexis Mader[2], Thomas Zapletal[2], Jeremiah Cline[2], Alyssa Farney[2], Loegan Hill[2], Jainee Cowen[2], Camron Matteson[2], and David Penning[1,2]

[1]Corresponding author E-mail: davidapenning@gmail.com
[2]Department of Biology and Environmental Health, Missouri Southern State University, Joplin, Missouri, USA 64801

ABSTRACT - With amphibian and reptile population declines and extinctions increasing, continued ecological surveying is needed to detect any potential changes in populations, especially near geopolitical boundaries. From May 20th to August 8th, 2020, a survey of Kellogg Lake (Carthage, MO) was conducted to catalogue species richness and abundance. Individuals caught had morphological measurements taken and reptiles were marked for potential recapture. Individuals observed but not captured were also noted. In total, species found included *Anaxyrus americanus*, *Lithobates catesbeianus*, *L. sphenocephalus*, *Apalone spinifera*, *Chelydra serpentina*, *Nerodia erythrogaster*, *N. rhombifer*, *N. sipedon*, *Regina grahamii*, *Sternotherus odoratus*, *Storeria dekayi*, and *Trachemys scripta*. Several of these species had not been reported in Jasper County for decades. In three species (*S. odoratus*, *T. scripta*, and *R. grahamii*), enough information was available to describe the sex ratios and test for sexual dimorphism. For both *S. odoratus* and *T. scripta*, we detected no sexual dimorphism. For *S. odoratus* and *R. grahamii*, the populations were significantly female skewed in their sex ratios and female *R. grahamii* were significantly larger than males. Lastly, using historical records, neighboring Cherokee County, KS and Jasper County, MO were compared to detect potential differences in record abundance across state lines. The oldest documented records for herpetofaunal species between the two counties did not differ. However, Cherokee County has significantly more recent species detections and in significantly greater numbers than Jasper County. Future work should continue to consider the implications of geopolitical boundaries when monitoring populations.

Introduction

In less than a century, reptiles and amphibians have shown increasingly rapid rates of population declines and extinctions (Daszak et al., 1999; Falaschi et al., 2020; McCallum 2007). As reptile and amphibian populations continue to decline, regular reporting of species abundances and diversity can aid in monitoring and conservation efforts. An important factor in species monitoring involves the use of field surveys that regularly sample an area of interest (Elton and Miller, 1954; Hawlitschek, 2011). These surveys are integral pieces of baseline information that allow for immediate and long-term conservation efforts (Stroud and Thompson, 2019). Given the rate of global species decline (Sodhi et al., 2008), it is becoming increasingly important to establish long-term population monitoring programs (Andrei, et. al., 2012; Jiménez-Franco et al., 2020).

Detecting population declines can be quite difficult without the use of regular inventory surveys and up-to-date reporting (Gibbons et al., 2000). Further, documenting long-term patterns can allow for the observation of naturally occurring variation both within and across seasons and years (Fedy and Aldridge, 2011). Increased rates of population monitoring are needed, especially considering the rates of animal distribution changes caused by anthropogenic climate change (Hickling et al., 2006).

Coupled with the challenges involved in monitoring any given species are the geopolitical boundaries that arbitrarily divide the geographic distributions. Accompanying these geopolitical divides are changing regulations and laws that often govern how organisms are studied and used (Roger et al., 2011; Manfredo et al., 2017). Therefore, differences in the reported abundance and distribution

of any given organism may partially be determined more by local regulations than biological reality. For example, many commonly occurring reptile and amphibian species that span across Missouri and Kansas show large differences in abundance between neighboring counties (Daniel and Edmonds, 2020; Taggart, 2021). The area of SW Missouri, SE Kansas, NW Arkansas, and NE Oklahoma is of special importance because it is the area often reported as the NW most edge of many reptile and amphibian ranges in the United States (Powell et al., 2016).

Given the need for increased survey efforts at range edges and near state boundaries, we conducted a survey of reptiles and amphibians at Kellogg Lake in Carthage, MO (Figure 1). This man-made lake is approximately 29 kilometers east of the KS state line. The 10.1-hectare lake is co-managed by the Missouri Department of Conservation and the City of Carthage and has no regulations on wildlife apart from game fish. Our goal was to take preliminary data in the area in hopes of starting long-term population monitoring efforts in SW Missouri. Further, we hope to better quantify and describe reptiles and amphibians in a considerably understudied region of Missouri. Lastly, we make comparisons of species detected in the region between neighboring Kansas and Missouri counties.

Methods and Materials

We sampled Kellogg Lake from May 20th to August 8th, 2020. Our trap placement and searching methods remained systematic across our sampling days but our trap efforts increased throughout the season as we gained access to grant funding (and therefore more traps). In total, 328 person-hours were logged in exploring the region for visual confirmation of any reptiles and amphibians. When possible, species were caught and had morphological measurements recorded.

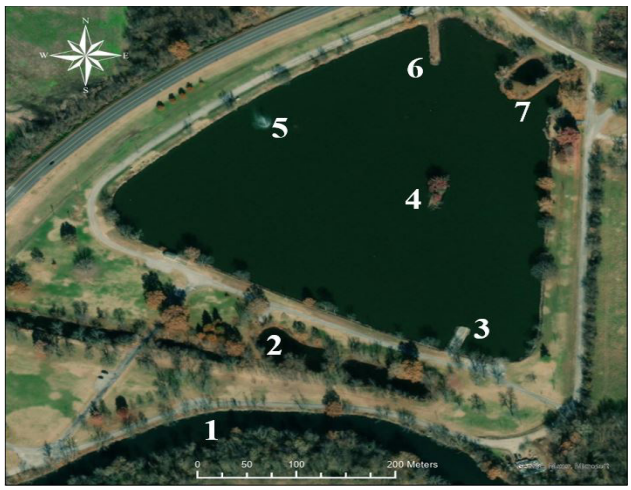

Figure 1. Overhead view of Kellogg Lake in Carthage, Missouri. Numbers denote specific features of the area including Spring River (1), permanent wetland (2), fishing peninsulas (3,6,7), a small island (4), and an aeration system (5).

Hoop nets (0.91 × 1.82 m, n = 7), crab traps (0.4 × 1 m, n = 34), and minnow traps (n = 13) were baited with sardines (oil, hot sauce, and mustard) or smoked oysters. Each trap type received each bait type and each bait × trap combination was spread evenly throughout the sampling area. The large hoop nets were modified to be held open using two pvc pipes. These were placed on the bank so that a portion of the trap was always above the water so that any caught animals could breathe. All crab and minnow traps had flotation devices within them (pieces of pool noodles) so that a portion of their netting would remain above water at all times. Each trap was placed at approximately 6pm and pulled the following morning by approximately 11am. Overall, data derives from 133 trap-nights, manual captures, and sightings.

For each animal caught, morphological measurements (length, mass, sex) were taken. We also kept voucher specimens of most species captured; all other individuals were released. For species in which we captured considerable samples, we tested sex ratios against an expected 1:1 using Chi-square tests. We also tested for sexual dimorphism using standard major-axis regressions with body mass and length as continuous measures and sex as a categorical predictor. Lastly, we compare our data to prior literature from the region using the Kansas Herpetological Atlas (Taggart, 2021) and the Missouri Herpetological Atlas (Daniel and Edmonds, 2020). Specifically, we compared data from Cherokee County, KS to Jasper County, MO. The age of the oldest record, newest record, and total specimens reported between these two counties were compared using paired t-tests or Wilcoxon sign-rank tests (paired by species) based on model assumptions. We only used species that were reported in both counties and modified data where appropriate (ex; we combined *Hyla chrysocelis* and *H. versicolor* data for KS into data for the *H. chrysocelis* × *H. versicolor* complex). We assume significance when $p < 0.05$.

Results

Eleven species were captured and a twelfth was visually identified. Listed below is the abundance (captured, spotted) for each species from highest to lowest. In total, we were able to find *Sternotherus odoratus* (captured = 93, spotted = 10), *Trachemys scripta* (n = 48, n = 11), *Regina grahamii* (n = 15, n = 18), *Lithobates catesbeianus* (n = 8, n = 4), *Apalone spinifera* (n = 3, n = 1), *Anaxyrus americanus* (n = 3, n = 1), *Lithobates sphenocephalus* (n = 3, n = 0), *Nerodia sipedon* (n = 1, n = 0), *Nerodia erythrogaster* (n = 1, n = 0), *Storeria dekayi* (n = 1, n = 0), *Nerodia rhombifer* (n = 0, n = 3), and *Chelydra serpentina* (n = 0, n = 1).

Large enough samples from three species were caught to make inferences about their population demographics. Of the *S. odoratus* captured (n = 93), three individuals were juveniles (body mass = 8–20 g), 27 were male (35–175 g), and 63 were female (35–145 g). The *S. odoratus* population was heavily female skewed and was significantly different from an expected 1:1 ratio ($X21 = 20.57$, $p < 0.0001$). While there was a significant difference in the sex ratio of *S. odoratus*, there was no significant difference between their sizes ($F1,88 = 0.098$, $p > 0.75$; Figure 2A).

For *T. scripta*, a similar number of juveniles (n = 17; 9.5–130 g), males (n = 14; 80–810 g), and females (n = 17; 75–700 g) were found. For several smaller *T. scripta*, we categorized them as juvenile if there were no obvious external characters to distinguish them between either a small female or large juvenile. No significant difference was found between the ratio of females and males and that of a 1:1 sex ratio ($X21 = 0.52$, $p > 0.46$). There was also no significant difference in the sizes of *T. scripta* caught ($F1,29 = 0.025$, $p > 0.87$; Figure 2B). We also caught fifteen adult *R. grahamii* that were heavily female (n =11) skewed compared to an expected 1:1 sex ratio ($X21 = 12.25$, $p < 0.001$). Female *R. grahamii* (150–610 g) were also significantly heavier than males (85–110 g; $t13 = 3.0$, $p < 0.02$).

When looking at historical records of herpetofaunal populations that span both Missouri and Kansas, there is a high number of overlapping species occurrences. There are a total of 53 species of reptiles and amphibians currently documented in Jasper County, MO (n=50; Daniel and Edmonds, 2020) and Cherokee County, KS (n=48; Taggart, 2021). Jasper county had reports of two Ophisaurus attenuatus (1899), and recent reports of the invasive *Podarcis siculus* (n = 5, 2013-2019). There was a total of 46 species reported in both counties. Two species (*Eurycea lucifuga* and *Kinosternon flavescens*) were removed from the comparison because there was incomplete data from Jasper County. All individual datasets are not normally distributed, so we report median values and visualize data using probability density functions. The oldest records date to 1899 (Jasper County) and 1911 (Cherokee County). There is no significant difference between the oldest reported records between counties (Jasper County = 1931.5, Cherokee County = 1932; $t45 = 0.03$, $p > 0.95$; Fig 3A). However, the most recent records for each species were significantly newer from Cherokee County (median = 2018) compared to Jasper County (median = 2008; $z = 4.88$, $p < 0.0001$; Fig 3B). Further, there have been significantly more specimens reported in Cherokee County (median = 34) compared to Jasper County (median = 3; $z = 5.79$, $p < 0.0001$; Fig 4).

Discussion

In general, we found many of the species expected to be found in the region (*A. americanus*, *L. catesbianus*, *T. scripta*, etc.). However, multiple species were found in high abundance that had few or no natural history records for Jasper County. For example, we found 93 *S. odoratus*, and to our knowledge, the last and only report of this species in Jasper County, Missouri comes from Julius Hurter's original thesis on the reptiles and amphibians of Missouri where he mentions having seen one in Carthage (Hurter, 1911). Reports from the surrounding counties are generally old or rare, including counties to the north (Barton County, MO; 2010) and south (Newton County, MO; 1976) of our study location. There are no reports of *S. odoratus* in the counties directly to the east of Jasper County in Missouri. However, there are 13 reports of *S. odoratus* to the west in Cherokee County, KS (multiple reports from 1934–2004).

During our survey, 33 *R. grahamii* were caught or spotted. Over the past century only seven individuals have been reported in the area: one in Newton County, MO in 1906 (juvenile), two in Barton County, MO (1982 and 2016), and four in Cherokee County, KS (1964 – 1978). Based on our gathered data, *R. grahamii* are sexually dimorphic in size with fe-

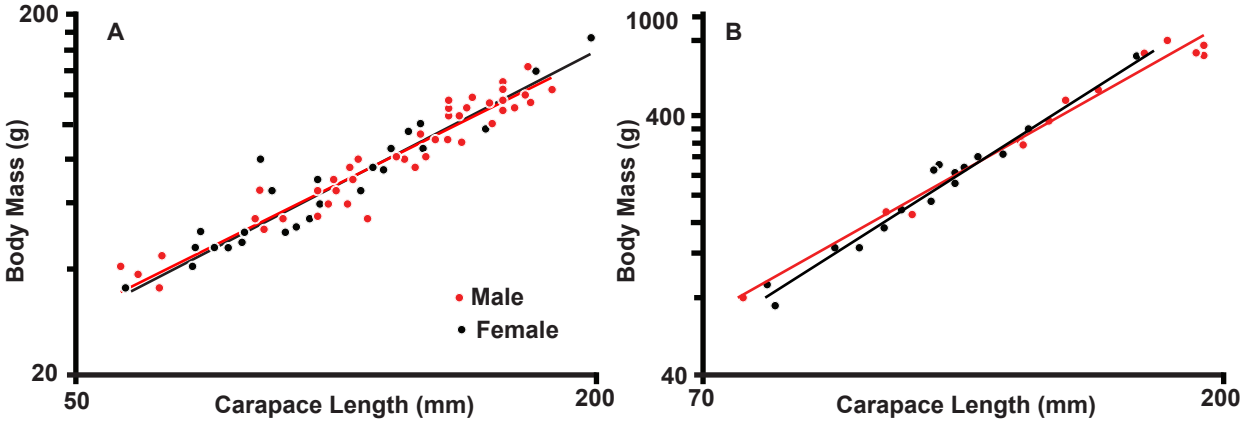

Figure 2. Scatterplot of body mass (g) regressed against carapace length (mm) for *Sternotherus odoratus* (A) and *Trachemys scripta* (B).

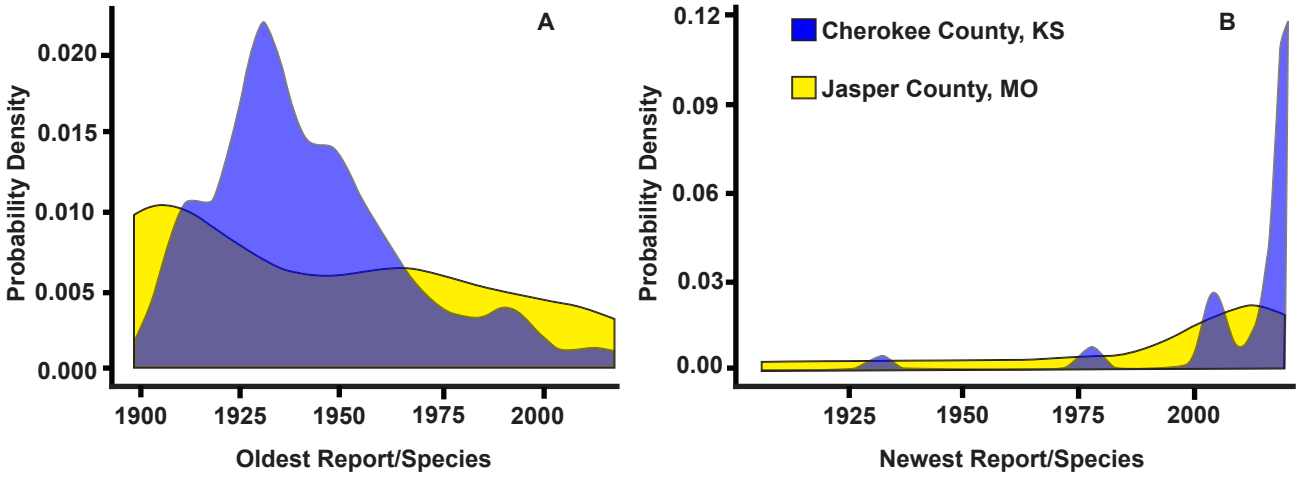

Figure 3. Probability density plots for the oldest (A) and newest (B) reports for 46 species of reptiles and amphibians from Jasper County, MO and Cherokee County, KS.

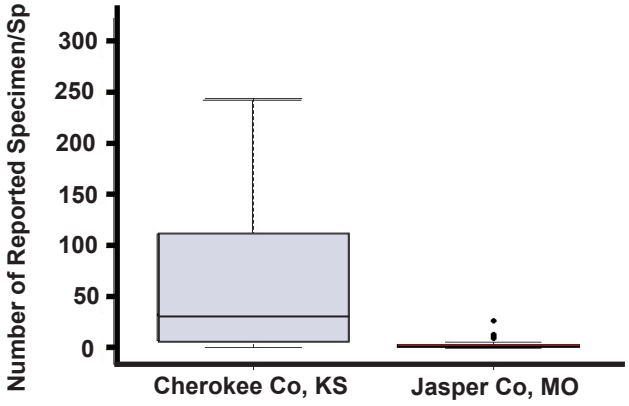

Figure 4. Box and Whisker plot of the total specimen count for 46 species of reptiles and amphibians found in both Cherokee and Jasper counties. The belt is the median, the box is the middle 50% of the data, the whiskers are the 95% confidence intervals, and the individual dots are values outside the 95% confidence intervals.

males being much larger. While we report a highly skewed female population, this is likely an artifact of our data collection methods and does not reflect the true male:female ratio. The captured males were considerably smaller than the females and all but one of our captures came from hand-capture (non-trap). It is likely that the smaller size of the males made them harder to detect than females but other behavioral or physiological factors may be causing the difference in detection. Further work using traps with similar detection probabilities of both sexes should help reveal the true biological ratio of this species. The size of our largest female *R. grahamii* is also worth noting. We captured a gravid female weighing 610 grams (SVL = 77.5 cm; tail length = 15.5 cm) containing 50 developing embryos (weighing 116.1 grams). Based on Johnson (2000),

this individual is the largest to be captured in Missouri.

While we did not physically catch any *N. rhombifer*, we had three confirmed sightings (by D. Penning) based on dorsal pattern. There are two reported locations of this species being found in Jasper County, Missouri (1899–1935), no reports to the east or south, and 69 reports from the north (Barton County; 1935–2018), the large majority of which come from a single report from 1935. There are six records to the east in Cherokee County, KS (1965–2004).

While there appears to be little difference in the species composition between Jasper County, MO and Cherokee County, KS, there are significant differences in the overall numbers and dates of the reported specimen. In both counties, collection efforts have varied considerably. Cherokee County, KS had a large collection effort in the 1930s. In Jasper County, MO there appears to be no focused collection effort when evaluating the first reports of species; the earliest collection dates are evenly dispersed across the early 1900s. In Jasper County, the median age of the most recent reports for amphibians and reptiles is 2008; a thirteen-year gap between then and this study. Meanwhile, the most recent reports from Cherokee County are far more up to date with a median age of 2018. Moreover, the overall abundance of the species within museums is very different between counties with Cherokee County having 10× the representation in museum collections (Fig 4). The causes for the differences between the reported modern collections between states is likely multifactorial. First, there are likely to be different reporting parameters between the two state-level resources used. Beyond the available natural history data, there are certainly differences between state-level rules, wildlife codes, and legislation. Further, the state of Kansas has had a long and robust history of reporting and collecting reptiles and amphibians whereas, based on historical data, Missouri has not seen the same overall efforts applied to its amphibians and reptiles. Regardless of the cause, we would encourage all natural history biologists to continue their collection and reporting efforts, and if possible, to publish their findings.

Local species' populations are in flux for a number of reasons, but this often goes undetected due to a lack of continuous monitoring. Data collection is commonly regulated and/or sponsored by state and educational organizations, and therefore varies widely, especially in areas in proximity of geopolitical borders. This is largely due to specific state or federal permits, licenses, and a range of variables governing the monitoring and collection of species. Natural history data is important because it shows species history and current productivity, which allows researchers to predict possible future population changes. This kind of information has helped researchers track species' migration north due to warming climates (Hickling et al., 2006), impacts from habitat loss and human disturbance (Lehtinen et al., 1999), and local/complete species extinctions. Given all of this, the need to keep natural history data consistently updated is more important than ever before.

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