

AN ABSTRACT FOR THE THESIS OF

Jennifer Singleton for the Master of Science Degree

in Biological Sciences presented on June 18, 2012

Title: Selected aspects of the biology of semi-aquatic turtles in east-central Kansas:
winter thermal profiles and escape behavior

Abstract approved: _____

Temperate-zone semi-aquatic turtles encounter a wide range of temperatures within their aquatic habitats. However, most of the temperature-related research on these turtles has been conducted during their active season (late March – early October), and information on winter thermal profiles is relatively limited. The development of ThermoChron® iButtons, an inexpensive thermal monitoring device, has greatly facilitated such studies. I attached iButtons to 20 male and 20 female *Chrysemys picta* during summer 2010. These iButtons were preprogrammed to record temperatures at 12 min intervals from 5 December 2010 to 9 April 2011. However, given the paucity of winter thermal profiles in these animals, my analyses focused on winter thermal profiles (5 December 2010 - 21 March 2011). *Chrysemys picta* shell temperatures ranged from 0.5 to 14 °C between 5 December 2010 and 21 March 2011. In addition, the first basking activity of *C. picta* in 2011 occurred 23 February at an air temperature of 10.5 °C and maximum water temperature of 8.1 °C. Turtle temperatures were similar to the minimum water temperatures in the study pond throughout most of the winter. These results were consistent with the conclusions of previous studies that *C. picta* may voluntarily select

low temperatures during winter to delay metabolic acidosis and better conserve stored energy.

Researchers commonly use traps to obtain turtles for use in experimentation and to sample populations and assemblages to generate estimates of various community or population level parameters. However, most traps are biased with respect to the probability of capturing different species, individuals of different sizes, or different sexes. An improved understanding of such biases may help researchers generate more accurate estimates of such parameters. Some turtles may escape from traps, but previous studies of escape frequency have reported very different results. Also, past studies have failed to compare escape rates among species or between trap types. To examine trap escape rates, uniquely marked *Trachemys scripta* and *C. picta* were placed into basking traps or funnel traps, which were checked after ~24 hr to determine escape. Overall, turtles escaped from traps during 73.6% of the trials. Adult females of both species escaped from basking traps more frequently than males or juveniles. In general, larger individuals (of both species) were significantly more likely to escape from basking traps than smaller individuals. In contrast, body size and sex were not significant predictors of escape from funnel traps for either species. Therefore, funnel traps may provide the least biased sample of these species with respect to sex and body size.

SELECTED ASPECTS OF THE BIOLOGY OF FRESHWATER TURTLES IN EAST-
CENTRAL KANSAS

A Thesis

Presented to

The Department of Biological Sciences

EMPORIA STATE UNIVERSITY

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

By

Jennifer Marie Singleton

2 July 2012

Approved by Major Advisor
(Dr. R. Brent Thomas)

Approved by Committee Member
(Dr. David Edds)

Approved by Committee Member
(Dr. Lynnette Sievert)

Approved by Department Chair
(Dr. R. Brent Thomas)

Approved by Dean of Graduate School and
Distance Education
(Dr. Kathy Ermler)

ACKNOWLEDGEMENTS

I thank Jodie Hearlson, Tommy Sterling, and Skyler Delmott for their help and companionship in the field. I am very grateful to the David Traylor Zoo of Emporia and local landowners for access to their properties. I thank my thesis advisor, Dr. R. Brent Thomas, for his assistance in every step of the thesis process, and I thank my committee members Dr. David Edds and Dr. Lynette Sievert, and Dr. Larry Scott for their advice and contributions to this thesis. I also give special thanks to Emporia State University for the awards of a Faculty Research & Creativity Grant to Dr. R. Brent Thomas and Graduate Student Research Grants to support this project. All collection took place under Kansas Department of Wildlife & Parks permit# SC-120-2010 and with approval from the ESU Animal Care and Use Committee (Protocol -10-011).

PREFACE

This is a multi-chaptered thesis that includes four chapters. Chapter 1 provides a brief introduction to the entire thesis and Chapter 4 provides a summary of the major conclusions. Chapters 2 and 3 will be submitted to peer-reviewed professional journals for possible publication (and are formatted according to the style required for those journals). Chapter 2 will be submitted to *Transactions of the Kansas Academy of Sciences* and Chapter 3 will be submitted to *Herpetological Review*.

TABLE OF CONTENTS

| | <u>Page</u> |
|---|-------------|
| ACKNOWLEDGEMENTS..... | iii |
| PREFACE..... | iv |
| TABLE OF CONTENTS..... | v |
| LIST OF TABLES..... | vii |
| LIST OF FIGURES..... | viii |
| <u>CHAPTER</u> | |
| 1. Introduction..... | 1 |
| 2. Winter thermal profiles of Painted Turtles (<i>Chrysemys picta</i>) in eastern Kansas..... | 10 |
| ABSTRACT..... | 11 |
| INTRODUCTION..... | 12 |
| METHODS..... | 14 |
| RESULTS..... | 16 |
| DISCUSSION..... | 17 |
| LITERATURE CITED..... | 23 |
| 3. Escape rates of aquatic turtles from funnel traps and basking traps..... | 29 |
| INTRODUCTION..... | 30 |
| METHODS and MATERIALS | 31 |
| RESULTS..... | 33 |
| DISCUSSION..... | 37 |
| LITERATURE CITED..... | 39 |
| 4. CONCLUSIONS..... | 43 |

PERMISSION TO COPY STATEMENT.....47

LIST OF TABLES

| | <u>Page</u> |
|--|-------------|
| Table 2-1. Winter basking of <i>Chrysemys picta</i> , daily water temperature, and daily air temperature from 23 February to 21 March 2011 in Lyon County, Kansas..... | 20 |
| Table 3-1. Escape rates of <i>Chrysemys picta</i> and <i>Trachemys scripta</i> from basking traps over a 24-hr period, 8 June to 26 September 2010 in Lyon County, Kansas..... | 34 |
| Table 3-2. Escape rates of <i>Chrysemys picta</i> and <i>Trachemys scripta</i> from funnel traps over a 24-hr period, 8 June to 26 September 2010 in Lyon County, Kansas..... | 36 |

LIST OF FIGURES

| | <u>Page</u> |
|--|-------------|
| Figure 2-1. Weekly mean (\pm SE) <i>Chrysemys picta</i> shell temperature, weekly mean minimum water temperature, weekly mean maximum water temperature, and weekly mean air temperature from 5 December 2010 to 21 March 2011..... | 18 |

CHAPTER 1

INTRODUCTION

Temperate-zone semi-aquatic turtles encounter a wide range of temperatures within their aquatic habitats (Peterson 1987; Grayson and Dorcas 2004; Rowe and Dalgarn 2010). Turtles in temperate climates may select specific areas/temperatures within their overwintering habitat in order to minimize risk of freezing (Brown and Brooks 1994; King, Kuchling and Bradshaw 1998; Ultsch 2006) or to delay metabolic acidosis and conserve energy (Rollinson, Tattersall, and Brooks 2008). However, some turtles (e.g., *Trachemys scripta*, *Chrysemys picta*, *Graptemys pseudogeographica* and *G. ouachitensis*) often “bask” on unseasonably warm and sunny winter days (Auth 1975; Lardie 1980; Grayson and Dorcas 2004; Thomas 2006; Coleman and Gutberlet 2008) to increase body temperature (Boyer 1965; Auth 1975; Bulté and Blouin-Demers 2010). Most of the temperature-related research on these species has been conducted during their active season, and studies of winter thermal profiles are relatively uncommon (Ernst 1972; Crawford 1994; Crocker et al. 2000). However, recent improvements in temperature-monitoring technology have facilitated such studies (e.g., Grayson and Dorcas 2004; Rollinson Tattersall, and Brooks 2008). The Thermochron® iButton (Dallas Semiconductors, Dallas, Texas, USA) is a small, pre-programmable temperature recorder used successfully in a number of biological studies (Davidson et al. 2003; Bernstein and Black 2005; Lutterschmidt, LeMaster and Mason 2006; Munn, Barboza and Dehn 2009). I attached 80 iButtons to 20 male and 20 female *C. picta* (2 iButtons per individual) and recorded temperatures (at 12 min intervals) from 5 December 2010 to 9 April 2011. However, given the paucity of winter thermal profiles in these animals, I chose to specifically focus my analyses on the winter months. I used those recordings to

describe the winter temperature profiles and winter basking activity of *C. picta* in east-central Kansas during the winter of 2010-2011.

Sampling methods may assist researchers in estimating population-level parameters for a particular species (Krebs 1999) and developing informed conservation and management plans (Gelatt and Siniff 1999). However, sampling methods exhibit various biases with respect to capture probabilities for different individuals within the population (e.g., Noyce, Garshelis and Coy 2001; Ryberg and Cathey 2004; Lambert, Malcolm and Zimmerman 2005; Willson, Winne, and Keck 2008).

Various traps are commonly used to sample freshwater turtle populations (Plummer 1979). However, capture biases have been reported for many of these traps (Cagle and Cheney 1950; Ream and Ream 1966; Brown and Hecnar 2005; Fidenci 2005; Sterret et al. 2010; Bluett et al., 2011). Basking traps and funnel traps, two commonly used traps for semi-aquatic turtles, may be vulnerable to biases that result from the ability of some individuals to escape from the traps (Frazer, Gibbons and Owens 1990; Gamble 2006; Brown, DeVold and Forstner 2011). Frazer, Gibbons and Owens (1990) reported that 80% of female *C. picta* escaped from funnel traps during their study. In contrast, Brown, DeVold, and Forstner (2011) observed that escape from funnel traps was relatively infrequent for *T. scripta* (i.e., 0.04%). Possible explanations for these observed differences between the escape rates reported in these two studies have not been examined. Also, no published study has examined escape rates from basking traps. I compared the escape frequency of *C. picta* and *T. scripta* from both basking traps and funnel traps in summer 2010.

LITERATURE CITED

- Auth, D. L. 1975. Behavioral ecology of basking in the yellow-bellied turtle, *Chrysemys scripta scripta*. Bulletin of the Florida State Museum, Biological Sciences 20:1-45.
- Bernstein, N. P. and Black, R. W. 2005. Thermal environment of overwintering ornate box turtles, *Terrapene ornate ornata*, in Iowa. American Midland Naturalist 153:370-377.
- Bluett, R. D., E. M. Schauber, C. K. Bloomquist, and D. A. Brown. 2011. Sampling assemblages of turtles in central Illinois: A case study of capture efficiency and species coverage. Transactions of the Illinois Academy of Science 104:127-136.
- Boyer, D. R. 1965. Ecology of the basking habit in turtles. Ecology 46:99-118.
- Brown, C. L. and Hecnar, S. J. 2005. Capture success of Northern Map Turtles (*Graptemys geographica*) and other turtle species in basking vs. baited hoop traps. Herpetological Review 36:145-147.
- Brown, D. J., DeVold, B. and Forstner, M. R. J. 2011. Escapes from hoop nets by Red-eared Sliders (*Trachemys scripta*). Southwestern Naturalist 56:124-127.
- Brown, G. P. and Brooks, R. J. 1994. Characteristics of and fidelity to hibernacula in a northern population of snapping turtles, *Chelydra serpentina*. Copeia 1994:222-226.
- Bulté, G. and Blouin-Demers, G. 2010. Estimating the energetic significance of basking behavior in a temperate-zone turtle. Ecoscience 17:387-393.
- Cagle, F. R. and Cheney, A. H. 1950. Turtle populations in Louisiana. American Midland Naturalist 43:383-388.

- Coleman, J. L. and Gutberlet, R. L. 2008. Seasonal variation in basking in two syntopic species of map turtles (Emydidae: *Graptemys*). *Chelonian Conservation and Biology* 7:276-281.
- Crawford, K. M. 1994. Patterns of energy substrate utilization in overwintering Painted Turtles, *Chrysemys picta*. *Comparative Biochemistry and Physiology A* 109:495-502.
- Crocker, C. E., Feldman, R. A., Ultsch, G. R., and Jackson, D. C. 2000. Overwintering behavior and physiology of Eastern Painted Turtles (*Chrysemys picta picta*) in Rhode Island. *Canadian Journal of Zoology* 78:936-942.
- Davidson, A. J., Aujard, F., London, B., Menaker, M., and Block, G. D. 2003. Thermochron iButtons: An inexpensive method for long-term recording of core body temperature in untethered animals. *Journal of Biological Rhythms* 18:430-432.
- Ernst, C. H. 1972. Temperature-activity relationship in the Painted Turtle, *Chrysemys picta*. *Copeia* 1972:217-222.
- Fidenci, P. 2005. A new technique for capturing Pacific Pond Turtles (*Actinemys marmorata*) and a comparison with traditional trapping methods. *Herpetological Review* 36:266-267.
- Frazer, N. B., Gibbons, J. W., and Owens, T. J. 1990. Turtle trapping: Preliminary tests of conventional wisdom. *Copeia* 1990:1150-1152.
- Gamble, T. 2006. The relative efficiency of basking and hoop traps for Painted Turtles (*Chrysemys picta*). *Herpetological Review* 37:308-312.

- Gelatt, T. S. and Siniff, D. B. 1999. Line transect survey of crabeater seals in the Amundsen-Bellingshausen Seas, 1994. *Wildlife Society Bulletin* 27:330-336.
- Grayson, K. L., and Dorcas, M. E. 2004. Seasonal temperature variation in the painted turtle (*Chrysemys picta*). *Herpetologica* 60:325-336.
- King, J. M., Kuchling, G., and Bradshaw, S. D. 1998. Thermal environment, behavior, and body condition of wild *Pseudemydura umbrina* (Testudines: Chelidae) during late winter and early spring. *Herpetologica* 54:103-112.
- Krebs, C. J. 1999. *Ecological methodology* (2nd ed.). Addison Wesley Longman. Menlo Park, California.
- Lambert, T. D., Malcolm, J. R., and Zimmerman, B. L. 2005. Variation in small mammal species richness by trap height and trap type in southeastern Amazonia. *Journal of Mammalogy* 86:982-990.
- Lardie, R. L. 1980. Winter activity of *Chrysemys scripta elegans* (Wied-Neuwied) in north-central Texas. *Bulletin of the Oklahoma Herpetological Society* 4:72-76.
- Lutterschmidt, D. I., LeMaster, M. P., and Mason, R. T. 2006. Minimal overwintering temperatures of Red-sided Garter Snakes (*Thamnophis sirtalis parietalis*): A possible cue for emergence? *Canadian Journal of Herpetology* 84:771-777.
- Munn, A. J., Barboza, P. S. and Dehn, J. 2009. Sensible heat loss from Musk oxen (*Ovibos moschatus*) feeding in winter: Small calves are not at a thermal disadvantage compared with adult cows. *Physiological and Biochemical Zoology* 82:455-467.

- Noyce, K. V., Garshelis, D. L. and Coy, P. L. 2001. Differential vulnerability of Black bears to trap and camera sampling and resulting biases in mark-recapture estimates. *Ursus* 12:211-225.
- Peterson, C. C. 1987. Thermal relations of hibernating Painted Turtles, *Chrysemys picta*. *Journal of Herpetology* 21:16-20.
- Plummer, M. V. 1979. Collecting and marking. In M. Harless and H. Morlock (eds.), *Turtles: Perspectives and Research*, pp. 45-60. Robert E. Krieger Publishing Company, Malabar, Florida.
- Ream, C. and Ream, R. 1966. The influence of sampling methods on the estimation of population structure in Painted Turtles. *American Midland Naturalist* 75:325-338.
- Rollinson, N., Tattersall, G. J., and Brooks, R. J. 2008. Overwintering habitats of a northern population of Painted Turtles (*Chrysemys picta*): Winter temperature selection and dissolved oxygen concentrations. *Journal of Herpetology* 42:312-321.
- Rowe, J. W. and Dalgarn, S. F. 2010. Home range size and daily movements of Midland Painted Turtles (*Chrysemys picta marginata*) in relation to body size, sex, and weather patterns. *Herpetological Conservation and Biology* 5:461-473.
- Ryberg, W. A. and Cathey, J. C. 2004. A box-trap design to capture alligators in forested wetland habitats. *Wildlife Society Bulletin* 32:183-187.
- Sterret, S. C., Smith, L. L, Schweitzer, S. H., and Maerz, J. C. 2010. An assessment of two methods for sampling river turtle assemblages. *Herpetological Conservation Biology* 5:490-497.

Thomas, R. B. 2006. *Trachemys scripta* – slider or yellow-bellied slider. Chelonian Research Monographs 3:296-312.

Ultsch, G. R. 2006. The ecology of overwintering among turtles: Where turtles overwinter and its consequences. Biological Reviews 81:339-367.

Willson, J. D., Winne, C. T., and Keck, M. B. 2008. Empirical tests of biased body size distributions in aquatic snake captures. Copeia 2008:401-408.

CHAPTER 2
WINTER THERMAL PROFILES OF PAINTED TURTLES (*CHRYSEMYS PICTA*) IN
EASTERN KANSAS

Chrysemys picta and other semi-aquatic temperate-zone turtles commonly experience low winter temperatures within their aquatic environments. However, turtles bask during both the active season and occasionally during winter in order to elevate their body temperature. I attached 80 delayed-start iButtons to 40 *C. picta* in summer 2010 to record winter (5 December 2010 - 21 March 2011) thermal profiles and basking activity of *C. picta* in east-central Kansas. Additional iButtons were used to record winter water temperatures at different depths and locations in the pond. Eleven functional iButtons were retrieved from turtles in Summer 2011. *Chrysemys picta* experienced temperatures of 0.5 to 14 °C between 5 December 2010 and 21 March 2011. Study animals did not bask during most of the winter (i.e., no basking during December and January). The first basking event occurred on 23 February 2011 at an air temperature of 10.5 °C and maximum water temperature of 8.1 °C. Turtle temperatures were similar to the minimum water temperatures in the study pond throughout most of the winter. These results were consistent with the conclusions of previous studies that *C. picta* may voluntarily select low temperatures during winter to delay metabolic acidosis and better conserve stored energy.

INTRODUCTION

Temperate-zone semi-aquatic turtles experience a wide range of body temperatures within their aquatic habitats (Peterson 1987; Grayson and Dorcas 2004; Rowe and Dalgarn 2010). The temperatures a turtle experiences during winter and possible winter basking bouts have implications for metabolic processes (Crawford 1991; Rollinson, Tattersal, and Brooks 2008). Researchers have quantified turtle thermal profiles during both their active periods (March-October; Ernst 1972; Grayson and Dorcas 2004) and during the winter (Ernst 1972; Crawford 1994; Crocker et al. 2000; Rollinson, Tattersall, and Brooks 2008). Many semi-aquatic turtles overwinter within their aquatic habitats (Peterson 1987; Greaves and Litzgus 2007) and may select specific microhabitats to enhance survival (Brown and Brooks 1994; King, Kuchling, and Bradshaw 1998; Ultsch 2006) or to delay metabolic acidosis and better conserve stored energy (Rollinson, Tattersall, and Brooks 2008).

The Painted Turtle, *Chrysemys picta*, occupies the most northerly range for any turtle in North America (Ernst and Lovich 2009) and must be well-equipped to survive the low temperatures common within their aquatic habitat during the winter. They accomplish this through a combination of anaerobic metabolism (Jackson, Crocker, and Ultsch 2000; Reese, Jackson, and Ultsch 2002) and extra-pulmonary oxygen consumption (Reese et al. 2001; Jackson et al. 2004), depending on the available oxygen in the water and the available range of temperatures (St. Clair and Gregory 1990; Crawford 1991; Rollinson, Tattersal, and Brooks 2008). Taylor and Nol (1989) found that Painted Turtles survive temperatures of 4 to 6 °C during the winter in Ontario, Canada.

Emydid turtles exhibit low-temperature thresholds for basking and other behaviors (Ernst 1972; Auth 1975; Lardie 1980; Koper and Brooks 2000; Grayson and Dorcas 2004; Rowe and Dalgarn 2010), below which they are presumed inactive (Ernst 1972; Lardie 1980). However, many semi-aquatic turtles may emerge from the water onto logs, rocks, or other emergent structures to “bask” in the sunlight during winter months on unseasonably warm days (Auth 1975; Lardie 1980; Grayson and Dorcas 2004; Thomas 2006; Coleman and Gutberlet 2008). The primary purpose of these basking behaviors is to adjust body temperature (Boyer 1965; Auth 1975; Bulté and Blouin-Demers 2010). Auth (1975) observed basking of the Yellow-Bellied Slider (*Trachemys scripta scripta*) in December in northern Florida, Grayson and Dorcas (2004) observed basking of Painted Turtles (*Chrysemys picta*) during December and January in North Carolina, and Coleman and Gutberlet (2008) observed frequent winter basking in *Graptemys pseudogeographica* and *G. ouachitensis* in east Texas.

Studies of winter thermal profiles and winter basking activity have been hindered by the difficulty of long-term, consistent monitoring of individuals (Grayson and Dorcas 2004; Rollinson, Tattersall and Brooks 2008). The Thermochron iButton (model DS1922L, Dallas Semiconductors, Dallas, Texas, USA) is a small circular device (17.4 mm in diameter; 5.9 mm thick) that has been used in a variety of biological research settings (Davidson et al. 2003; Bernstein and Black 2005; Lutterschmidt, LeMaster and Mason 2006; Munn, Barboza and Dehn 2009). It is a lightweight device (ca. 3.1 g) likely to approximate about 1% of an adult Painted Turtle's body mass, and is unlikely to interfere with locomotor activities (Grayson and Dorcas 2004). Several studies have established the reliability and accuracy of the iButton for biological research (Angilleta

and Krochmal 2003; Davidson et al. 2003) and as a tool to approximate internal body temperature (Grayson and Dorcas 2004; Rollinson, Tattersall, and Brooks 2008).

Grayson and Dorcas (2004) found that iButtons recorded an average of 0.26 °C lower than cloacal temperature. Roznik and Alford (2012) found that waterproofing iButtons with plastic could cause differences in temperature readings but the majority of these differences were $\leq \pm 0.7$ °C; however, when iButtons were placed in direct sun, this difference rose to an average of +1.3 °C for waterproofed iButtons.

I attached 80 iButtons to 20 male and 20 female *C. picta* (2 iButtons per individual) and recorded temperatures (at 12 min intervals) from 5 December 2010 to 9 April 2011. However, given the paucity of winter thermal profiles in these animals, I specifically focused my analyses on the winter months. I used those recordings to describe the winter temperature profiles and winter basking activity of *C. picta* in east-central Kansas during the winter of 2010-2011.

METHODS

Basking traps and baited frame nets (described in House, Nall and Thomas 2011) were used to capture 40 adult *C. picta* (20 males + 20 females) from 18 May to 10 July 2010. Each individual was uniquely marked by filing notches into the marginal scutes with a rounded file (Cagle 1939). Sex was determined using a combination of attainment of a specific body size and the presence or absence of male secondary sex characteristics. Individuals with a PL >90 mm and elongated foreclaws and tails with cloaca located past the margin of the carapace were categorized as adult males, and individuals >130 mm that lacked these characters were categorized as adult females (Cagle 1954; Ernst 1971;

House 2009). The study pond was located within the David Traylor Zoo (Emporia, Kansas). This pond was completely surrounded by a chain-link fence that substantially reduced the possibility of research animal emigration (thus, increasing probability of recapture and ultimate recovery of iButtons).

Upon capture, turtles were brought into the lab for iButton attachment. Two iButtons were attached to each of the 40 *C. picta* (n=80 iButtons) using the methods described by Grayson and Dorcas (2004). Each iButton was waterproofed using Plasti Dip plastic tool dip (Plasti Dip International, Blaine, Minnesota, USA) and attached to a plastic cable tie with a drop of silicon, followed by a second application of the tool dip. In addition to the methods of Grayson and Dorcas (2004), nylon netting was sewn over the iButton and cable tie to aid iButton retention. Two holes were drilled using a 0.32 cm drill bit in the posterior marginal scutes and 0.32 cm cable ties threaded through the holes to attach the iButtons to each study animal.

Each iButton was capable of storing 8,192 temperature measurements. On each of the 40 study animals, one iButton was programmed to begin recording temperature measurements at 12 min intervals on 5 December 2010, and the other was programmed to begin recording on 31 January 2011. Using two iButtons per study animal allowed a total of 16,384 temperature readings per turtle to be obtained over about four months (5 December - 9 April). In addition, iButtons were attached in pairs to 3 wooden stakes that were placed in areas of shallow water depth within the study pond so that each stake had iButtons at depths of 25 cm, 50 cm, and 1 meter (n=18 iButtons). In addition, iButtons were placed on two plastic jugs (n=4) at >1.5 meters depth within the pond to monitor water temperature in deeper areas. I resumed trapping on 23 April 2011 to recapture

study animals and retrieve the iButtons, and retrieval was completed 10 October 2011. Data were acquired from iButtons using the OneWireViewer program (Dallas Semiconductors; Dallas, Texas, USA). Ambient air temperatures for Emporia, Kansas during the study period were obtained from weatherunderground.com. Basking events were defined as anytime the turtle-attached iButton temperature (hereafter referred to as shell temperature) exceeded maximum recorded water temperature by $>2.3^{\circ}\text{C}$. I chose 2.3°C as the threshold to account for the manufacturer-estimated $\pm 1^{\circ}\text{C}$ possible variation in the iButtons themselves, and the $+1.3^{\circ}\text{C}$ error that is possible due to the waterproof coating (Roznik and Alford 2012). Weekly mean shell temperature, weekly mean minimum water temperature, weekly mean maximum water temperature, and weekly mean ambient air temperature were calculated. Weekly mean shell temperature was compared to the weekly mean minimum and maximum water temperatures and the weekly mean air temperature.

RESULTS

I observed a low return rate for iButtons attached to turtles. In 57 cases, the area between the carapace edge and the drilled hole fractured and the iButtons were lost. In addition, 11 iButtons exhibited data loss due to water damage. The failure of iButtons due to poor waterproofing has been observed in past studies (Grayson and Dorcas 2004; Wolaver and Sharp 2007; but see Roznik and Alford 2012). In total, I successfully retrieved six turtle iButtons with December-February data and five turtle iButtons with January-April data. I also retrieved four iButtons with December-February and five iButtons with January-April data from jugs or stakes.

I obtained 8,194 shell temperature readings in 12-min intervals per turtle for 11 turtles. Turtles experienced winter (5 December 2010 – 21 March 2011) temperatures between 0.5 and 14.0 °C in the water (Fig 2-1). Mean shell temperature was very similar to minimum water temperature through December, January, and February (Fig 2-1). However, this pattern changed during the week of 7 March when shell temperatures closely approximated maximum water temperature (Fig. 2-1). Turtle temperatures surpassed minimum water temperatures by about 3 °C during the week of 14 March. During this time period, air temperature reached a minimum and maximum of -2.2 and 27.2 °C, respectively (weekly average of 11.3 °C).

The first basking event occurred on 23 February, when ambient temperature increased to a maximum of 10.5°C and the maximum recorded water temperature was 8.1 °C (Table 2-1). One turtle basked on this date for 2 hours, between 2:30 and 4:30 pm (central standard time). This turtle basked again on 3 March and was joined by another turtle on 10 March (ambient temperature = 3.8 °C; maximum water temperature = 7.7 °C). The remaining three turtles began basking 17 March (ambient temperature = 20 °C; maximum water temperature = 15.6 °C).

DISCUSSION

Chrysemys picta shell temperatures ranged between 0.5 and 14.0 °C between 5 December 2010 and 21 March 2011. Turtle shell temperatures were similar to the minimum recorded water temperatures from 5 December to 14 March. Turtle temperatures began to diverge from the minimum water temperature during mid-February, finally averaging higher than the maximum recorded water temperature for the last 2 weeks of winter.

Figure 2-1. Weekly mean (\pm SE) *Chrysemys picta* shell temperature, weekly mean minimum water temperature, weekly mean maximum water temperature, and weekly mean air temperature from 5 December 2010 to 21 March 2011.

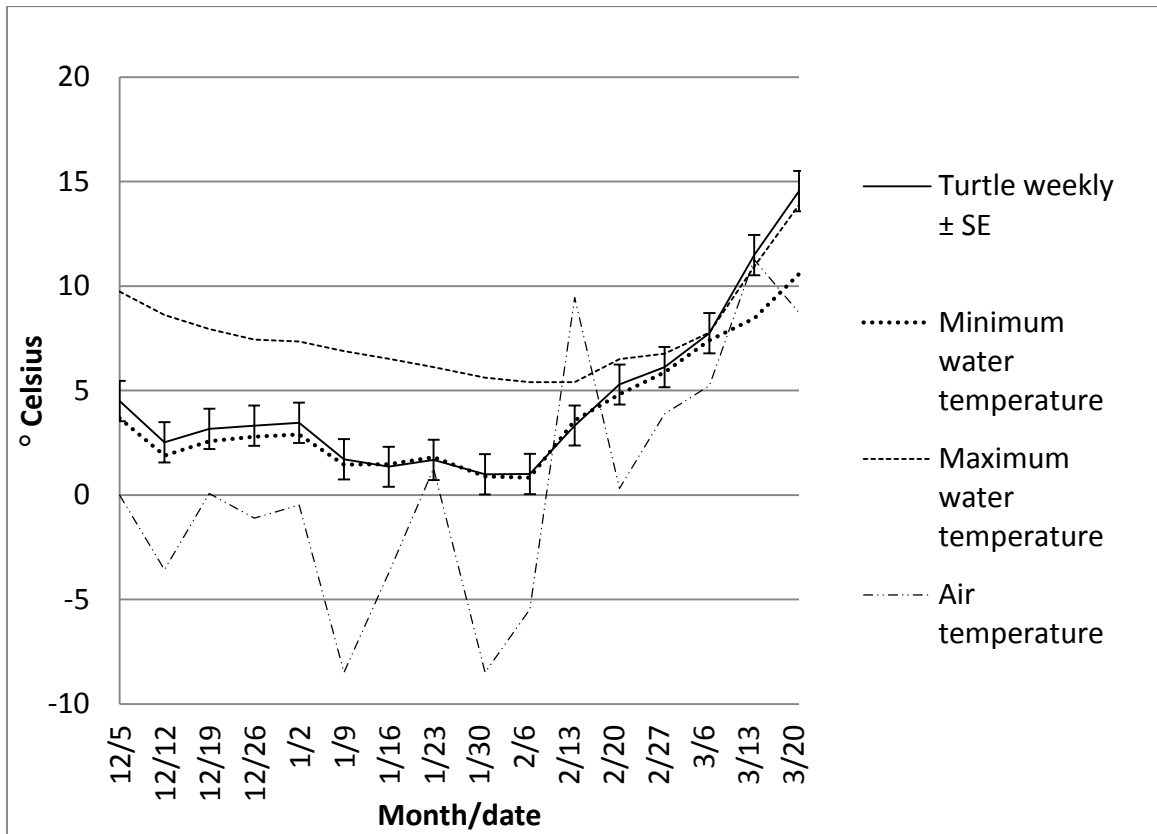


Table 2-1. Winter basking of *Chrysemys picta*, daily water temperature, and daily air temperature from 23 February to 21 March 2011 in Lyon County, Kansas.

| Date | Number of Basking Turtles | Total Number of Basking Events | Mean Water Temperature | Mean Air Temperature |
|--------------------|--------------------------------------|---|-----------------------------------|---------------------------------|
| February 23 | 1 | 1 | 6.4 | 10.5 |
| March 3 | 1 | 1 | 7.0 | 9.4 |
| March 10 | 1 | 2 | 6.6 | 3.9 |
| March 11 | 2 | 2 | 7.9 | 12.2 |
| March 12 | 1 | 2 | 9.0 | 7.2 |
| March 15 | 1 | 4 | 7.6 | 6.7 |
| March 16 | 2 | 4 | 9.1 | 12.2 |
| March 17 | 5 | 13 | 11.1 | 20.0 |
| March 18 | 3 | 6 | 12.0 | 12.2 |
| March 20 | 5 | 9 | 11.5 | 18.3 |
| March 21 | 5 | 12 | 13.6 | 20.0 |

The winter of 2010-2011 had few days appropriate for basking, given that basking usually ceases below 10°C air temperature (Auth 1975), and Emporia had only three days with average temperatures >10 °C between December and February (17 February, 20 February, 23 February). Use of a more conservative threshold of 6.0 °C above maximum water temperature to detect basking events (used by Grayson and Dorcas 2004) would have yielded the same basking-start date (23 February), but a more conservative threshold might have missed shorter basking bouts. However, no matter which criteria were used, the conclusion that winter basking was relatively uncommon among the study animals would not have changed. Future studies conducted during more typical winters may be more suitable for winter basking research, and should focus on reported variations in winter basking activity between males and females (Auth 1975; Grayson and Dorcas 2004; Coleman and Gutberlet 2008). I also observed heavy loss of iButtons from study animals; it is possible that this population may have had weak marginal shell growth, and holes drilled may have led to breakage. Future studies should examine methods to enhance iButton attachment and minimize breakage of the rear marginal scutes. My study was the first to examine temperature profiles and winter basking activity of wild *C. picta* in fine (12 min) intervals; the use of fine intervals allowed for precise and consistent documentation of shell temperatures and was more likely to identify all basking events. *Chrysemys picta* in this study population experienced winter temperatures between 0.5 and 14.0 °C, and the first basking bout occurred 23 February 2011.

In conclusion, *C. picta* rarely participated in winter basking, possibly due to the relatively cold winter observed during the study period. Shell temperatures were similar

to the minimum water temperatures throughout most of the winter. These results were consistent with the conclusions of previous studies (Rollinson, Tattersall, and Brooks 2008) that *C. picta* (in some situations) may voluntarily select low temperatures during winter to delay metabolic acidosis and better conserve stored energy.

Literature Cited

- Angilletta, M. J. Jr., and Krochmal, A. R. 2003. The Thermochron: A truly miniature and inexpensive temperature-logger. *Herpetological Review* 34:31-32.
- Auth, D. L. 1975. Behavioral ecology of basking in the Yellow-Bellied Turtle, *Chrysemys scripta scripta*. *Bulletin of the Florida State Museum, Biological Sciences* 20:1-45.
- Bernstein, N. P. and Black, R. W. 2005. Thermal environment of overwintering ornate box turtles, *Terrapene ornate ornata*, in Iowa. *American Midland Naturalist* 153:370-377.
- Boyer, D. R. 1965. Ecology of the basking habit in turtles. *Ecology* 46:99-118.
- Brown, G. P. and Brooks, R. J. 1994. Characteristics of and fidelity to hibernacula in a northern population of snapping turtles, *Chelydra serpentina*. *Copeia* 1994:222-226.
- Bulté, G. and Blouin-Demers, G. 2010. Estimating the energetic significance of basking behavior in a temperate-zone turtle. *Ecoscience* 17:387-393.
- Cagle, F. R. 1939. A system of marking turtles for future identification. *Copeia* 1939:170-173.
- Cagle, F. R. 1954. Observations on the life cycles of painted turtles (genus *Chrysemys*). *American Midland Naturalist* 52:225-235.
- Coleman, J. L. and Gutberlet, R. L. 2008. Seasonal variation in basking in two syntopic species of map turtles (Emydidae: *Graptemys*). *Chelonian Conservation and Biology* 7:276-281.

- Crawford, K. M. 1991. The winter environments of Painted Turtles, *Chrysemys picta*: temperature, dissolved oxygen, and potential cues for emergence. *Canadian Journal of Zoology* 69:2493-2498.
- Crawford, K. M. 1994. Patterns of energy substrate utilization in overwintering Painted Turtles, *Chrysemys picta*. *Comparative Biochemistry and Physiology A* 109:495-502.
- Crocker, C. E., Feldman, R. A., Ultsch, G. R., and Jackson, D. C. 2000. Overwintering behavior and physiology of Eastern Painted Turtles (*Chrysemys picta picta*) in Rhode Island. *Canadian Journal of Zoology* 78:936-942.
- Davidson, A. J., Aujard, F., London, B., Menaker, M., and Block, G. D. 2003. Thermochron iButtons: An inexpensive method for long-term recording of core body temperature in untethered animals. *Journal of Biological Rhythms* 18:430-432.
- Ernst, C. H. 1971. Sexual cycles and maturity of the turtle, *Chrysemys picta*. *The Biological Bulletin: Published by The Marine Biological Laboratory* 140:191-200.
- Ernst, C. H. 1972. Temperature-activity relationship in the Painted Turtle, *Chrysemys picta*. *Copeia* 1972:217-222.
- Ernst, C. H. and Lovich, J. E. 2009. *Turtles of the United States and Canada* 2nd ed. Johns Hopkins University Press, Baltimore, Maryland. 827 pp.
- Grayson, K. L., and Dorcas, M. E. 2004. Seasonal temperature variation in the Painted Turtle (*Chrysemys picta*). *Herpetologica* 60:325-336.

- Greaves, W. F. and Litzgus, J. D. 2007. Overwintering ecology of Wood Turtles (*Glyptemys insculpta*) at the species' northern range limit. *Journal of Herpetology* 41:32-40.
- House, W. J. 2009. Selected aspects of the ecology of semi-aquatic turtles inhabiting ponds in east-central Kansas. M.S. Thesis, Emporia State University, Emporia, KS. 55 pp.
- House, W. J., Nall, I. M., and Thomas, R. B. 2011. Selected aspects of semi-aquatic turtles assemblages in east-central Kansas ponds. *Transactions of the Kansas Academy of Science* 114:239-244.
- Jackson, D. C., Crocker, C. E., and Ultsch, G. R. 2000. Bone and shell contribution to lactic acid buffering of submerged turtles *Chrysemys picta bellii* at 3°C. *American Journal of Physiology – Regulatory, Integrative, and Comparative Physiology* 278:1564-1571.
- Jackson, D. C., Rauer, E. M., Feldman, R. A., and Reese, S. A. 2004. Avenues of extrapulmonary oxygen uptake in Western Painted Turtles (*Chrysemys picta bellii*) at 10°C. *Comparative Biochemistry and Physiology A* 139:221-227.
- King, J. M., Kuchling, G., and Bradshaw, S. D. 1998. Thermal environment, behavior, and body condition of wild *Pseudemys umbrina* (Testudines:Chelidae) during late winter and early spring. *Herpetologica* 54:103-112.
- Koper, N. and Brooks, R. J. 2000. Environmental constraints on growth of Painted Turtles (*Chrysemys picta*) in northern climates. *Herpetologica* 56:421-432.

- Lardie, R. L. 1980. Winter activity of *Chrysemys scripta elegans* (Wied-Neuwied) in north-central Texas. *Bulletin of the Oklahoma Herpetological Society* 4:72-76.
- Lutterschmidt, D. I., LeMaster, M. P., and Mason, R. T. 2006. Minimal overwintering temperatures of Red-sided Garter Snakes (*Thamnophis sirtalis parietalis*): A possible cue for emergence? *Canadian Journal of Herpetology* 84:771-777.
- Munn, A. J., Barboza, P. S. and Dehn, J. 2009. Sensible heat loss from Musk oxen (*Ovibos moschatus*) feeding in winter: small calves are not at a thermal disadvantage compared with adult cows. *Physiological and Biochemical Zoology* 82:455-467.
- Peterson, C. C. 1987. Thermal relations of hibernating Painted Turtles, *Chrysemys picta*. *Journal of Herpetology* 21:16-20.
- Reese, S. A., Crocker, C. E., Carwile, M. E., Jackson, D. C., and Ultsch, D. R. 2001. The physiology of hibernation in Common Map Turtles (*Graptemys geographica*). *Comparative Biochemistry and Physiology A* 130:331-340.
- Reese, S. A., Jackson, D. C., and Ultsch, G. R. 2002. The physiology of overwintering in a turtle that occupies multiple habitats, the Common Snapping Turtle (*Chelydra serpentina*). *Physiological and Biochemical Zoology* 75:432-438.
- Rollinson, N., Tattersall, G. J., and Brooks, R. J. 2008. Overwintering habitats of a northern population of Painted Turtles (*Chrysemys picta*): winter temperature selection and dissolved oxygen concentrations. *Journal of Herpetology* 42:312-321.

- Rowe, J. W. and Dalgarn, S. F. 2010. Home range size and daily movements of Midland Painted Turtles (*Chrysemys picta marginata*) in relation to body size, sex, and weather patterns. *Herpetological Conservation and Biology* 5:461-473.
- Roznik, E. A. and Alford, R. A. 2012. Does waterproofing Thermochron iButton dataloggers influence temperature readings? *Journal of Thermal Biology* 37:260-264.
- St. Clair, R. C. and Gregory, P. T. 1990. Factors affecting the northern range limit of Painted Turtles (*Chrysemys picta*): Winter acidosis or freezing? *Copeia* 1990:1083-1089.
- Taylor, G. M. and Nol, E. 1989. Movements and hibernation sites of overwintering painted turtles in southern Ontario. *Canadian Journal of Zoology* 67:1877-1881.
- Thomas, R. B. 2006. *Trachemys scripta* – slider or yellow-bellied slider. *Chelonian Research Monographs* 3:296-312.
- Ultsch, G. R. 2006. The ecology of overwintering among turtles: Where turtles overwinter and its consequences. *Biological Reviews* 81:339-367.
- Wolaver, B. D. and Sharp, J. M. 2007. Thermochron iButton: Limitation of this inexpensive and small-diameter temperature logger. *Ground Water Monitoring & Remediation* 27:127-128.

CHAPTER 3

ESCAPE RATES OF SEMI-AQUATIC TURTLES FROM
BASKING TRAPS AND FUNNEL TRAPS

Animal researchers often use sampling methods to produce estimates of various population or community level parameters (e.g., sex ratio, relative abundance, etc.; Krebs 1999). Such estimates may help guide the development of management and conservation policies (Gelatt and Siniff 1999). However, biased sampling methods that produce inaccurate estimates of such parameters may negatively affect the efficacy of such policies. Therefore, it is important to investigate the potential biases associated with the methods used to sample animal populations or communities (Willson et al. 2008).

Traps used to sample animal populations or communities may be biased with respect to the probability of capturing particular subsets of species or individuals (Willson et al. 2008). For example, capture probabilities may differ between the sexes for specific trap types or during different portions of the active season (Noyce et al. 2001). Likewise, the efficacy of some traps may vary across different habitats (Lambert et al. 2005; Ryberg and Cathey 2004).

Some turtle traps are more likely to capture certain species, sexes, or sizes (Bluett et al., 2011; Brown and Hecnar 2005; Cagle and Cheney 1950; Fidenci 2005; Ream and Ream 1966; Sterret et al. 2010). Basking traps take advantage of the basking habit of some turtle species (Boyer 1965) and usually consist of a basking platform (sometimes with treadles) mounted over a net or holding pen (Plummer 1979). Turtles are captured after diving or falling off of the basking platform. Basking traps are used to successfully capture species that commonly exhibit aerial-basking behaviors (e.g., *Trachemys scripta*; Gamble 2006; Thomas et al. 1999), but are unlikely to catch species that do not commonly engage in such behaviors (e.g., *Macrochelys temminckii*; Lagler 1943). In addition, some basking traps are more likely to catch large females than other individuals

within a population (Ream and Ream 1966). However, the sexual biases of basking trap captures may vary seasonally (Thomas et al. 1999). The design of some basking traps may allow some turtles to escape from the holding pen (R. B. Thomas, personal observation). Gamble (2006) mentioned the possibility that escape rates from basking traps may vary for turtles of different sizes. However, no published studies have compared escape rates of turtles from basking traps.

Baited funnel traps are commonly used to sample freshwater turtle populations and communities (Gibbons and Greene 1990; Plummer 1979; Ream and Ream 1966). Bait (usually food) is used to motivate turtles to enter these traps through an inverted-funnel entrance. The ability of some turtles to escape from funnel traps has been documented (Brown et al. 2011; Frazer et al. 1990). Frazer et al. (1990) found that female *Chrysemys picta* often escaped from funnel traps, with 16 of 20 escaping during a 24 hr period. In contrast, Brown et al. (2011) investigated the escape rates of *T. scripta* from funnel traps and found a negligible rate of escape (only 5 out of 139 *T. scripta* escaped within 34 hr). Possible explanations for the disparity between the results of these two studies have not been explored. Differential escape rates between sexes or sizes could bias a sample and negatively impact estimates of population level parameters. I examined the escape frequency of *C. picta* and *T. scripta* from basking traps and funnel traps. Specifically, I compared escape rates among males, females, and juveniles and examined the influence of body size on escape rates for both species.

Methods and Materials.—Turtles were captured using funnel traps and basking traps from nine ponds in Lyon County, Kansas from 8 June to 26 September 2010. Funnel traps

were constructed with three rectangular 65 x 90 cm frames covered in 3.8 cm treated nylon mesh (Nichols Net and Twine, Inc., Granite City, Illinois). Each funnel trap was baited with canned mackerel held in a perforated PVC tube to prevent bait consumption (Nall and Thomas 2009). The basking traps (brand: Solar Turtle Trap) consisted of a 60 x 60 cm wood and styrofoam frame with a 90 cm deep net basket underneath (Memphis Net and Twine, Memphis, Tennessee). The frame supported a board set on a treadle suspended above a net. Long nails (~ 10 cm) were driven through additional pieces of PVC tubing were then snapped onto the sides of the trap at ~20 cm intervals with the sharp end of the nails protruded over the inside of the trap at a 45° angle from the water surface.

All turtles were uniquely marked for identification (Cagle 1939) and sex, species, and plastron length (PL) were recorded. Both Painted Turtles (*Chrysemys picta*) and Pond Sliders (*Trachemys scripta*) were used in this study. Sex was determined using a combination of PL and the presence or absence of male secondary sexual characteristics. Turtles with elongated foreclaws, a cloaca positioned posterior to the rear carapace margin, and a PL greater than 110 mm for *T. scripta* and 90 mm for *C. picta* were considered adult males; turtles with relatively short foreclaws, a cloaca positioned near or anterior to the rear carapace margin, and a PL greater than 160 mm for *T. scripta* and 120 mm for *C. picta* were considered adult females (Gibbons and Greene 1990; House et al. 2010). Individuals smaller than these specified sizes that lacked these secondary sex characters were categorized as juveniles.

Captured individuals (both *C. picta* and *T. scripta*) were returned (at random) to either funnel traps or basking traps in their pond of capture. Traps were checked the next

day and any of these animals found in the trap ~24 h later were recorded as “non-escapees”, and those missing were assumed to have “escaped”. Individuals were used as a test animal only once during these trials.

I tested escape frequency from basking traps with 77 turtles: 49 *C. picta* (22 males, 14 females, and 13 juveniles) and 28 *T. scripta* (11 males, 12 females, and 5 juveniles). I tested escape frequency from funnel traps with 88 turtles: 49 *C. picta* (23 males, 16 females, and 10 juveniles) and 39 *T. scripta* (11 males, 18 females, and 10 juveniles).

Male, female, and juvenile escape rates were compared using a Fisher exact test (Zar 2009). The likelihood-of-escape correlation with plastron length was analyzed using a Wilcoxon signed-rank test (Zar 2009). Level of significance was set at 0.05 for all statistical tests.

Results.—Overall, 73.6% of all turtles escaped from basking traps or funnel traps within 24 hrs. *Chrysemys picta* escaped from basking traps in 56.1 % of trials (54.5% of males, 85.7% of females, and 30.8% of juveniles; Table 1). I observed significant differences among the escape rates of males, females, and juveniles ($\chi^2 = 9.0770$; d.f. = 2; $p = 0.0107$). Juvenile *C. picta* escaped from the basking traps significantly less frequently than adult males or females. Mean PL of escapees and non-escapees were 133.9 mm and 106.0 mm, respectively. I found a significant difference ($Z = -3.2124$; d.f. = 1; $P=0.0013$) in PL of escapee and non-escapee turtles. Smaller *C. picta* were less likely to escape from the basking traps.

Table 3-1. Escape rates of *Chrysemys picta* and *Trachemys scripta* from basking traps over 24 hr period, 8 June to 26 September 2010 in Lyon County, Kansas.

| | <i>C. picta</i> | | | | <i>T. scripta</i> | | | |
|--------------|-----------------|--------|----------|-------|-------------------|--------|----------|-------|
| | Male | Female | Juvenile | Total | Male | Female | Juvenile | Total |
| Escapees | 12 | 12 | 4 | 28 | 9 | 12 | 3 | 24 |
| Non-escapees | 10 | 2 | 9 | 21 | 2 | 0 | 2 | 4 |
| % Escaped | 54.5 | 85.7 | 30.8 | 56.1 | 81.8 | 100 | 60.0 | 85.7 |

Trachemys scripta escaped from basking traps in 85.7% of trials (81.8% of males, 100% of females, and 60% of juveniles; Table 1). I did not observe a significant difference among the escape rates of these groups ($\chi^2 = 5.8053$; d.f. = 2; $p=0.0549$). However, the sparsity of certain cells may have diminished the accuracy of these test results (Zar 2009). Juvenile *T. scripta* were 40% less likely to escape than adult females. The result of the Wilcoxon signed rank test of escapee PL vs. non-escapee PL reflected this difference ($Z = -2.7918$; d.f. = 1; $p = 0.0052$). Mean PL of escapees and non-escapees were 185.10 mm and 107.04 mm, respectively. Smaller *T. scripta* were less likely to escape from basking traps.

Chrysemys picta escaped funnel traps in 73.5% of trials; 69.6% of males, 65% of females, and 90% of juveniles escaped within 24 h (Table 2). Significant differences in the escape rates among the groups were not observed ($\chi^2 = 2.0528$; d.f. = 2; $p = 0.3583$). The Wilcoxon signed-rank test of escapee vs. non-escapee PL showed no significant difference in escape rates by body size for *C. picta* ($Z = 1.4380$; d.f. = 1; $p = 0.1504$). Mean PLs of escapees and non-escapees were 116.71 mm and 133.31 mm, respectively.

Trachemys scripta escaped funnel traps in 82.1 % of trials (90.9% of males, 72.2% of females, and 80% of juveniles; Table 2). Significant differences in escape rates among groups were not observed ($\chi^2 = 0.9285$; d. f. = 2; $p = 0.6286$). I observed no significant difference between the mean PL of *T. scripta* categorized as escapees and non-escapees ($Z = -0.4940$; d.f. = 1; $p = 0.621$). The mean PLs of escapees and non-escapees were 171.2 mm and 159.7 mm, respectively.

Table 3-2. Escape rates of *Chrysemys picta* and *Trachemys scripta* from funnel traps over 24 hr period, 8 June to 26 September 2010 in Lyon County, Kansas.

| | <i>C. picta</i> | | | | <i>T. scripta</i> | | | |
|--------------|-----------------|--------|----------|-------|-------------------|--------|----------|-------|
| | Male | Female | Juvenile | Total | Male | Female | Juvenile | Total |
| Escapees | 16 | 11 | 9 | 36 | 10 | 14 | 8 | 32 |
| Non-escapees | 7 | 5 | 1 | 13 | 1 | 4 | 2 | 7 |
| % escaped | 69.6 | 65.0 | 90.0 | 73.5 | 90.9 | 72.2 | 80.0 | 82.1 |

Discussion. – Overall, escape rates of turtles were greater than expected. Smaller *C. picta* were significantly less likely to escape from basking traps. Although the escape rates for female, male, and juvenile *T. scripta* from basking traps were not significantly different, the p-value approached significance and the overall pattern of a greater female escape rate was similar to that of *C. picta*. Large females of both species frequently escaped from the basking traps. Therefore, the use of basking traps to sample populations of these two species may result in an underrepresentation of large adults (particularly females).

Though the funnel traps had a high rate of escape, they had a lower escape sampling bias by sex of both trap types; male, female, and juvenile escape rates did not differ significantly. My results for *C. picta* escape from funnel traps were very similar to those reported by Frazer et al. (1990; 73.5 vs. 75%). In contrast, Brown et al. (2011) reported a negligible escape rate (3.6%) of *T. scripta* from funnel traps, versus my 82.1%. It is possible that differences in trapping methods or trap types could be responsible for the disparity among these studies. My traps were constructed with rectangular 60 X 90 cm frames, while Brown et al. (2011) used circular 76.2 cm diameter frames. The specific design and dimensions of the traps used by Frazer et al. (1990) were not reported. Perhaps different shapes and sizes of these traps were relevant to the different rates of escape. Frazer et al. (1990) also used *C. picta* from a long-term study population of turtles, and some of their study animals may have had extensive prior experience in funnel traps; conversely, Brown et al. (2011) used *T. scripta* that were unmarked and presumably had not been trapped before. My study used a combination of both “new” turtles and turtles that had been caught and marked previously. Frazer et al. (1990) reported results similar to ours: a 75% escape rate for female *C. picta* in 24 hr. These

studies also involved two species from three widely spaced study sites (Michigan, Kansas, and Texas), which could have impacted results due to species differences or geographic variation.

Future research should examine possible differences in turtle escape frequency between variations of funnel trap design (one-throated vs. two-throated, round vs. rectangular, etc.). In addition, the value of checking turtle traps in various time increments has not been investigated. Some researchers believe that checking traps more often than once per 48 h disturbs the site and reduces trap yield; others prefer to check their traps every 6-12 h. However, there is no published evidence to support or negate the efficacy of these practices.

The trap types used for this research were only two of a variety of different trap designs (Cagle and Cheney 1950; Fratto et al. 2008; Kennett 1992; Lagler 1943; Ream and Ream 1966) that may yield different results with similar testing. However, I can conclude that *T. scripta* and *C. picta* have a great potential for escape from some forms of basking and funnel traps, and escape from these basking traps was biased by size. Of the two traps compared in this study, funnel traps yielded lesser biased samples of *C. picta* and *T. scripta* in these Kansas ponds.

LITERATURE CITED

- BLUETT, R. D., E. M. SCHAUBER, C. K. BLOOMQUIST, AND D. A. BROWN. 2011. Sampling assemblages of turtles in central Illinois: A case study of capture efficiency and species coverage. *Tran. Illinois Acad. Sci.* 104:127-136.
- BOYER, D. R. 1965. Ecology of the basking habit in turtles. *Ecology* 46:99-118.
- BROWN, C. L. AND S. J. HECNAR. 2005. Capture success of Northern Map Turtles (*Graptemys geographica*) and other turtle species in basking vs. baited hoop traps. *Herpetol. Rev.* 36:145-147.
- BROWN, C. L. AND S. J. HECNAR. 2005. Capture success of Northern Map Turtles (*Graptemys geographica*) and other turtle species in basking vs. baited hoop traps. *Herpetol. Rev.* 36:145-147.
- BROWN, D. J., B. DEVOLLD, AND M. R. J. FORSTNER. 2011. Escapes from hoop nets by Red-Eared Sliders (*Trachemys scripta*). *Southwest. Nat.* 56:124-127.
- CAGLE, F. R. 1939. A system of marking turtles for future identification. *Copeia* 1939:170-173.
- CAGLE, F. R. AND A. H. CHENEY. 1950. Turtle populations in Louisiana. *Am. Midl. Nat.* 43:383-388.
- FIDENCI, P. 2005. A new technique for capturing Pacific Pond Turtles (*Actinemys marmorata*) and a comparison with traditional trapping methods. *Herpetol. Rev.* 36:266-267.
- FRATTO, Z. W., V. A. BARKO, P. R. PITTS, S. L. SHERIFF, J. T. BRIGGLER, K. P. SULLIVAN, B. L. MCKEAGE, AND T. R. JOHNSON. 2008. Evaluation of turtle exclusion and escapement devices for hoop nets. *J. Wildl. Man.* 72:1628-1633.

- FRAZER, N. B., J. W. GIBBONS, AND T. J. OWENS. 1990. Turtle trapping: Preliminary tests of conventional wisdom. *Copeia* 1990:1150-1152.
- GAMBLE, T. 2006. The relative efficiency of basking and hoop traps for Painted Turtles (*Chrysemys picta*). *Herpetol. Rev.* 37:308-312.
- GELATT, T. S. AND D. B. SINIFF. 1999. Line transect survey of crabeater seals in the Amundsen-Bellingshausen Seas, 1994. *Wildl. Soc. Bull.* 27:330-336.
- GIBBONS, J. W. AND J. L. GREENE. 1990. Reproduction in the slider and other species of turtles. In J. W. Gibbons (ed.), *Life History and Ecology of the Slider*, pp. 124-134. Smithsonian University Press, Washington, D. C.
- HOUSE, W. J., I. M. NALL, AND R. B. THOMAS. 2010. Interpond movements of Western Painted Turtles (*Chrysemys picta*) in east-central Kansas. *Southwest. Nat.* 55:403-410.
- KENNET, R. 1992. A new trap design for catching freshwater turtles. *Wildl. Res.* 19:443-445.
- KREBS, C. J. 1999. *Ecological Methodology* (2nd edition). Addison Wesley Longman. Menlo Park, California.
- LAGLER, K. F. 1943. Methods of collecting freshwater turtles. *Copeia* 1943:21-25.
- LAMBERT, T. D., J. R. MALCOLM, AND B. L. ZIMMERMAN. 2005. Variation in small mammal species richness by trap height and trap type in southeastern Amazonia. *J. Mammal.* 86:982-990.
- NOYCE, K. V., D. L. GARSHELIS, AND P. L. COY. 2001. Differential vulnerability of black bears to trap and camera sampling and resulting biases in mark-recapture estimates. *Ursus* 12:211-225.

- PLUMMER, M. V. 1979. Collecting and marking. In M. Harless and H. Morlock (eds.),
Turtles: Perspectives and Research, pp. 45-60. Robert E. Krieger Publishing
Company, Malabar, Florida.
- REAM, C. AND R. REAM. 1966. The influence of sampling methods on the estimation of
population structure in Painted Turtles. *Am. Midl. Nat.* 75:325-338.
- RYBERG, W. A. AND J. C. CATHEY. 2004. A box-trap design to capture alligators in
forested wetland habitats. *Wildl. Soc. Bull.* 32:183-187.
- STERRET, S. C., L. L. SMITH, S. H. SCHWEITZER, AND J. C. MAERZ. 2010. An assessment
of two methods for sampling river turtle assemblages. *Herpetol. Cons. Biol.*
5:490-497.
- THOMAS, R. B., N. VOGRIN, AND R. ALTIG. 1999. Sexual and seasonal differences in
behavior of *Trachemys scripta* (Testudines: Emydidae). *J. Herpetol.* 33:511-515.
- WILLSON, J. D., C. T. WINNE, AND M. B. KECK. 2008. Empirical tests of biased body size
distributions in aquatic snake captures. *Copeia* 2008:401-408.
- ZAR, J. H. 2009. *Biostatistical Analysis: Fifth edition.* Pearson Prentice Hall. Upper
Saddle River, New Jersey.

CHAPTER 4

CONCLUSIONS

Chrysemys picta body temperatures ranged from 0.5 to 14.0 °C between 5 December 2010 and 21 March 2011 within the study pond. Turtle shell temperatures were close to the minimum recorded water temperatures from early December to mid-February and then steadily increased to temperatures that matched or exceeded maximum recorded water temperature for the final month of winter. Turtles began basking on 23 February 2011. The 2010-2011 winter was not ideal for basking research, as conditions were not conducive to basking for much of the season (Auth 1975). Future research should examine possible winter basking tendencies in different segments of the population (Auth 1975; Grayson and Dorcas 2004; Coleman and Gutberlet 2008).

Trachemys scripta and *C. picta* escaped from funnel traps and basking traps in 73.6% of trials. *Chrysemys picta* juveniles were significantly less likely to escape from basking traps, as were individuals with a shorter plastron length. Smaller *T. scripta* were also less likely to escape from basking traps. Though *T. scripta* and *C. picta* escaped from funnel traps 82.1% and 73.5% of the time respectively, no specific group or size in either species was significantly more likely to escape. My results for funnel traps were comparable to those of Frazer et al. (1990), but Brown et al. (2011) reported that *T. scripta* rarely (only 3.6%) escaped from funnel traps (3.6%). Differences in trap construction, geographic variation, or novelty of traps to study animals (i.e., amount of prior experience with traps) may influence escape rate of these animals and might explain the disparate results among these studies. However, of the two trap types compared, I concluded that the funnel trap produced the least biased samples of *T. scripta* and *C. picta* in Kansas ponds with respect to differential escape rate among animals related to body size and sex.

LITERATURE CITED

- Auth, D. L. 1975. Behavioral ecology of basking in the yellow-bellied turtle, *Chrysemys scripta scripta*. Bulletin of the Florida State Museum, Biological Sciences 20:1-45.
- Brown, D. J., DeVold, B. and Forstner, M. R. J. 2011. Escapes from hoop nets by Red-eared Sliders (*Trachemys scripta*). Southwestern Naturalist 56:124-127.
- Coleman, J. L. and Gutberlet, R. L. 2008. Seasonal variation in basking in two syntopic species of map turtles (Emydidae: *Graptemys*). Chelonian Conservation and Biology 7:276-281.
- Frazer, N. B., Gibbons, J. W. and Owens, T. J. 1990. Turtle trapping: Preliminary tests of conventional wisdom. Copeia 1990:1150-1152.
- Grayson, K. L., and Dorcas, M. E. 2004. Seasonal temperature variation in the Painted Turtle (*Chrysemys picta*). Herpetologica 60:325-336.

I, Jennifer Singelton, hereby submit this thesis/report to Emporia State University as partial fulfillment of the requirements for an advanced degree. I agree that the Library of the University may make it available to use in accordance with its regulations governing materials of this type. I further agree that quoting, photocopying, digitizing or other reproduction of this document is allowed for private study, scholarship (including teaching) and research purposes of a nonprofit nature. No copying which involves potential financial gain will be allowed without written permission of the author.

Signature of Author

Date

Selected Aspects of the Biology of
Freshwater Turtles in East-central Kansas:
Winter Thermal Profiles and Escape
Behavior

Title of Thesis

Signature of Graduate School Staff

Date Received