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Survival in Common Snapping Turtles, Chelydra serpentina (Testudines: Chelydridae), in western Nebraska

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Survival in Common Snapping Turtles, *Chelydra serpentina* (Testudines: Chelydridae), in western Nebraska

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Abstract. Annual estimates of survival for Common Snapping Turtles (*Chelydra serpentina*) in western Nebraska USA were generated from mark-recapture data from nesting females encountered in 2005–2017. Our population models suggested no annual variation in either adult annual survival (0.947 ± 0.017 SE) or annual capture probability (0.294 ± 0.027 SE). However, there was a tendency toward higher survival in larger females. High annual survival (e.g. > 90%) characterises populations of *Chelydra* from Ontario to Texas.

Key words: *Chelydra serpentina*, Chelydridae, Nebraska, survival

Introduction

The Common Snapping Turtle, *Chelydra serpentina* (Linnaeus 1758), is the most widely distributed turtle species in North America and the fourth most widely distributed in the world, even excluding introduced populations (Turtle Taxonomy Working Group, 2021). It is also one of the most frequently encountered turtles in its range (Ernst and Lovich, 2009), and one of the world's best-studied turtle species (among the top five; Lovich and Ennen, 2013).

One of the well-studied populations of *C. serpentina* is that on the Crescent Lake National Wildlife Refuge (CLNWR) in Nebraska USA, where our research was on-going from 1981 through 2018. We have studied the reproductive ecology of this species (Iverson et al., 1997), including correlates of its reproductive output (Hedrick et al., 2018; Iverson and Hedrick, 2018), examined climate effects on its nesting phenology (Hedrick et al., 2021), quantified sex ratio and density (Iverson and Smith, 2010), growth and longevity (Iverson and Lewis, 2019), and diet (Lewis and Iverson, 2018). However, we have not previously reported on survival of adult females, perhaps the most important determinant of long-term population viability in turtles (e.g., Heppell, 1998). Here we add that survival information, examine the effect of body size on survival, and compare our survival data with those published by others.

Materials and Methods

Our field site was located in the western Sandhills region of Nebraska on the CLNWR, Garden County, adjacent to the Gimlet Lake wetland complex (41.7651°N, 102.4367°W). Our field methods were described in Iverson et al. (1997). We restricted our survival analysis to females captured during nesting forays in the years 2005–2017 (excluding 2016, when we did not sample), during which we consistently and rigorously surveyed potential nesting areas on Gimlet Lake, rather than sporadic surveying prior to 2005. During this period we captured 94 adult nesting females 200 times. All turtles were measured (e.g., maximum carapace length [CL] in mm), weighed, marked, and released immediately.

We used Program MARK to estimate annualised survival estimates and capture probabilities (White and Burnham, 1999). In addition, to test for a body size effect on survival and capture probability, we conducted separate MARK analyses with 42 smaller females (<300 mm CL; estimated age 11–17 years; Iverson and Lewis, 2019), and 52 larger females (> 300 mm CL). Only six females passed 300 mm CL during their recapture history. One was initially 293 mm but was over 300 for her four subsequent recaptures, and was considered a large female. Five others were 307 to 312 mm CL at their last capture, but had spent most of their capture history below 300 mm, and hence were considered small females for this analysis.

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Results

The best population model for our full 2005–2017 sample, based on the lowest Akaike Information Criterion value (598) and model weight (97%, Table 1), suggested no annual variation in either adult annual survival (0.947 ± 0.017 SE) or annual capture probability (0.294 ± 0.027 SE). Estimated population sizes from the fully parameterised model (i.e., including annual estimates of survival and capture probability) suggested a stable population of about 59 ± 14 (SD) females (excluding first and last year estimates; Table 2).

For only those Nebraska females < 300 mm CL, the best model (AICc = 182; weight = 99.9%) again suggested no annual variation in survival (0.878 ± 0.043 SE; 95% Confidence Interval, 0.77 – 0.94) or capture probability (0.363 ± 0.061 SE), as did the best model for females > 300 mm CL (AICc = 395; weight = 99.3%; survival = 0.954 ± 0.019 SE, 95% CI 0.90 – 0.98; capture probability = 0.285 ± 0.033 SE). These restricted data sets suggest that small (younger) females are more reliably captured each year, but may suffer higher mortality than larger females.

Table 1. Model comparison for mark-recapture data for *Chelydra serpentina* in western Nebraska, analysing the effects of time (t, in years) on annual survival (phi) and capture probability (p). The first model (no annual variation in either adult survival or capture probability) is by far the most strongly supported (Akaike weight = 0.97).

	AICc	delta AICc	Weight	Likelihood	# parameters
Phi(.) p(.)	597.76	0.00	0.97	1.00	2.00
Phi(.) p(t)	604.91	7.16	0.03	0.08	12.00
Phi(t) p(.)	614.80	17.04	0.00	0.00	12.00
Phi(t) p(t)	623.37	25.61	0.00	0.00	21.00

Discussion

Despite the extensive distribution of *Chelydra*, there is apparently little geographic variation in annual adult female survival, although there are still large areas of the species' range that lack data (Table 3). However, despite differences in sample sizes, population body sizes, sample periods, season lengths, and capture probabilities among studies, survival is consistently very high (average from Table 3 = 94%), which no doubt explains the success of this species when so many others are in decline. Only two studies have reported survival estimates for both males and females (Eskew et al., 2010; Rose and Small, 2014), both of which suggest higher survival in males than females. Additional studies are needed to confirm this possible pattern.

Our ability to detect younger females more easily may also apply to their predators. In the only other study to examine the effect of body size on survival, Armstrong et al. (2017) also found annual survival to increase with body size.

It is perhaps not surprising that such a large, dangerous turtle would have high rates of adult survival. Nevertheless, despite those high rates across its range (Table 3), snapping turtle populations apparently have great difficulty recovering from catastrophic mortality events. Brooks et al. (1991) documented the loss of approximately 40% of the adults to River Otters (*Lutra*

Table 2. Fully parameterised model by year based on mark-recapture data for *Chelydra serpentina* in western Nebraska, analysing the effects of time (t, in years) on annual survival (phi) and capture probability (p). N = number of captures; N estimate = female population size estimate; SE = standard error.

Data year	N	phi estimate	SE	p estimate	SE	N estimate
2005-2006	6	0.882	0.176	0.200	0.109	30.0
2006-2007	14	0.912	0.172	0.365	0.123	38.4
2007-2008	18	1.000	0.000	0.205	0.083	87.8
2008-2009	24	0.963	0.105	0.416	0.091	57.7
2009-2010	21	0.869	0.110	0.400	0.084	52.5
2010-2011	10	1.000	0.000	0.130	0.051	46.9
2011-2012	21	0.948	0.115	0.337	0.076	62.3
2012-2013	19	1.000	0.000	0.299	0.068	63.5
2013-2014	18	1.000	0.000	0.301	0.066	59.8
2014-2015	24	0.740	0.241	0.364	0.133	65.9
2015-2017	25	0.648	0.000	0.596	0.000	41.9

Table 3. Annual survival estimates for Snapping Turtles (*Chelydra serpentina*) from the literature arranged in order of declining latitude. Sample restrictions are indicated; abbreviations include males (M), females (F), and carapace length (CL in cm). Note that the first five studies refer to the same population.

State	Latitude	Sample	Survival	Source
Ontario	45.5	F	0.97	Galbraith and Brooks, 1987
Ontario	45.5	F	0.93	Galbraith and Brooks, 1987
Ontario	45.5	F	0.966	Cunnington and Brooks, 1996
Ontario	45.5	25 cm CL F	0.935	Armstrong et al., 2017
Ontario	45.5	30 cm CL F	0.962	Armstrong et al., 2017
Ontario	45.5	35 cm CL F	0.976	Armstrong et al., 2017
Wisconsin	43.7	M, F	0.963	Paisley et al., 2009
Minnesota	43.7	M, F	0.939	Paisley et al., 2009
Michigan	42.5	F	0.88	Congdon et al., 1994
Nebraska	41.8	<30 cm CL F	0.878	This paper
Nebraska	41.8	>30 cm CL F	0.954	This paper
W Virginia	39.1	M, F	0.97	Flaherty et al., 2008
Virginia	37.6	M, F	0.91	Colteaux and Johnson, in Colteaux, 2017
N Carolina	35.2	M	0.994	Eskew et al., 2010
N Carolina	35.2	F	0.914	Eskew et al., 2010
Texas	29.9	M	0.94	Rose and Small, 2014
Texas	29.9	F	0.93	Rose and Small, 2014

canadensis) in 1986-1989 at the northern limit of the range in Ontario, Canada. However, despite high annual survival (97%) since that event, the population had not recovered after 23 years (Keevil et al., 2018), and females remained at only ca. 60% of pre-catastrophe numbers. Whether more southern populations (with more benign climates) would recover more quickly is unknown. In any case, the high annual adult survival rates known for this species no doubt contributes to their abundance in diverse habitats across the largest range of any North American turtle.

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