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THE INFLUENCE OF WEATHER ON ANNUAL CLUTCH FREQUENCY FOR THE YELLOW MUD TURTLE (*KINOSTERNON FLAVESCENS*) IN WESTERN NEBRASKA, USA

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***Abstract.*—Clutch frequency (CF) is one of the most difficult life-history traits to quantify in turtles. Although the range of clutch frequency has been reported for many turtle species, quantification of that trait in the wild is much less well known, and environmental correlates of its annual variation have been poorly detailed. I monitored the nesting season for 15 y between 1988 to 2017 for Yellow Mud Turtles (*Kinosternon flavescens*) in the Sandhills of Nebraska. Females produced a maximum of one clutch per year at this site. Clutch frequency averaged 94.1 ± 3.6% per year (range of values, 85.5 to 100%), varied significantly among years, and was positively correlated to the warmth of the previous summer, and rainfall in August, but not to weather in the spring of nesting. This suggests that the primary physiological threshold for *K. flavescens* to nest is crossed during follicular development in the previous summer.**

Key Words.—Kinosternidae; reproduction; reproductive output; senescence

INTRODUCTION

Clutch frequency (CF) been identified as one of the most elusive and critical life-history traits for turtles (Gibbons 1982; Gibbons and Greene 1990; Iverson and Smith 1993), and intra-annual CF variation has been reported for at least 115 species (Iverson et al. 2025). Significant variation in CF across years has also been commonly reported (e.g., Tucker 2001; Broderick et al. 2002; Bertolero et al. 2007; Hatase et al. 2013; Tucker et al. 2018), but correlates of that variation remain elusive and few studies follow individual females across years (but see Rose and Mali 2023, for example). Many authors that reported interannual CF variation speculated that it was because of fluctuations in resource availability or energy acquisition, but most did not explicitly test that hypothesis (e.g., Frazer and Richardson 1985; Dodd 1997; Wallis et al. 1999; Leuteritz and Hofmeyr 2007; Hatase and Omuta 2020; among others).

A few published studies, however, are relevant to the impact of resources on interannual CF variation in turtles. For example, marine turtle studies by Broderick et al. (2001) and Hatase and Omuta (2020) suggested that interannual variability in CF was affected by the trophic level of the turtle, although they did not speculate on what specific environmental conditions might impact that variability. In contrast, Rollinson and Brooks (2007) examined variation in clutch frequency over 8 y for Painted Turtles (*Chrysemys picta*) in Canada, and found CF was not related to May temperatures prior to nesting but was positively correlated with July to October temperatures in the prior year. Similarly, Turner et al (1986) found that clutch frequency varied annually in Desert Tortoises (*Gopherus agassizii*) and may be related to rainfall over the previous year (primarily in the winter), which drove the net production of the annual plants on which they feed in the coming year (see also Lovich et al. 1999 and Wallis et al. 1999; but see Lovich et al. 2015).

I (Iverson 1991) observed variation in CF for the Yellow Mud Turtle (*Kinosternon flavescens*) in Nebraska, USA, and my preliminary correlation analyses identified temperatures during May-June of the previous year and June of the current year as the strongest correlates. My study spanned only 4 y (two of which exhibited unusually hot or dry spring conditions), however, and the gravidity of females was verified by radiography only in the last year of the study (see Discussion below). I continued that field study (Iverson 1991) through 2019 and included intensive monitoring of 15 nesting seasons. I radiographed every female that left the wetland during each monitored nesting season, from 1988 onward. The CF data set is finally robust enough to test for environmental correlates of annual variation, and that forms the basis of this report.

MATERIALS AND METHODS

Capture methods.—I used an extensive drift fence array to monitor female Yellow Mud Turtles as they emerged from the Gimlet Lake wetland complex (41°45.24’N, 102°26.12’W) on the Crescent Lake National Wildlife Refuge, Garden County, Nebraska, USA, during each nesting season for 15 y between 1988 and 2017 (see Iverson 1991; Iverson and Smith 1993; and Iverson and Greene 2025 for detailed study site descriptions and drift fence construction methods). Because Yellow Mud Turtles exhibit high migration path fidelity between the wetland and the uplands at this site (Iverson 1991; Iverson et al. 2009; Iverson and Christiansen 2023; see also Tuma 2006), relatively few turtles at the Gimlet complex had migration paths beyond our fences. Each year, two fences were constructed parallel to the entire northwest (300 m) and northeast (900 m) shores of Gimlet Lake, blocking access to the uplands used by females for nesting, estivation, or brumation. This allowed me to reliably capture virtually every female that entered or left the wetland while the fences were deployed. I never encountered a female that changed its migration path to a different fence. Furthermore, at this site, even subadult females leave the wetland in June and July to move to estivate. Hence, I could also monitor non-reproductive females (as confirmed by x-ray; see females #330 and 1080 in the Appendix as examples).

The combination of the striking migration path fidelity of this turtle, and the effectiveness of the fences at capturing the turtles, offered a unique study system, and allowed me to census (rather than sample) the population. In addition, because I and my students did not disturb females (e.g., by trapping) while they were in Gimlet Lake, we did not risk disrupting their ovarian cycles due to stress. Rather, both reproductive and non-reproductive females were systematically and reliably captured when they emerged to nest or estivate in late May to early July. Other techniques (e.g., palpation, ultrasound, radiography, etc.) applied to aquatic or terrestrial turtle captures earlier in the spring could have compromised the accuracy of our clutch frequency counts.

Although fieldwork at this site was ongoing from 1981 through 2019, I (and my students) monitored the nesting seasons intensively in 1988, 1990, 1993–1994, 1998–2000, 2004–2006, 2010, 2013–2015, and 2017. Monitoring began in late May prior to the first emergence of a female on a nesting foray, and continued at least until early July, after the last gravid turtle emerged. Once erected, one to four persons walked the fences continuously during all periods of potential turtle activity (generally 0800–1200 and 1600–2100). All fences were removed at the end of each nesting season.

I measured the maximum carapace length (CL in mm) and maximum plastron length (PL in mm) of each turtle (± 0.5 mm) with dial calipers in a plane parallel to the plastral midlobe (following Cagle 1946; see Iverson and Lewis 2018) and weighed each turtle (± 1 g) with spring scales. I individually marked turtles with marginal scute notches following Cagle (1939) and/or notches along the margin of the plastral scutes. I determined the age of juveniles at first capture by counts of abdominal scute annuli (see Iverson 1991 and 2022 for details). I determined the sex of turtles ≥ 80 mm CL based on external dimorphic characters, e.g., elongate tails and clasping organs in males (Ernst and Lovich 2009), and the smallest of 4,984 gravid females in this study were 84.0, 84.5, and 85.0 mm CL. Hence, I radiographed at least every female > 84 mm CL leaving the wetland during each nesting season on site to determine gravidity, and clutch and egg size (Iverson 1991).

I estimated CF in two ways. First, over the 15 y of full nesting season monitoring, I scored each female > 84 mm CL, and known to be alive in a given year, as having nested (eggs visible on x-ray) or having skipped reproduction that year (no eggs on radiographs or not captured on a nesting foray). I included only females with migration paths near the center of the fences to avoid the possibility that they might wander around the fences and thus erroneously be assumed not to have nested. By restricting my data analysis only to those females whose migration paths always centered along the fences, I ensured the quality of the data analyzed, and reduced the bias associated with most mark-recapture studies. Thus, I restricted the data set to 287 females (4,406 total turtle-years) with age ≥ 10 winters, and body mass (BM) ≥ 150 g (i.e., potentially sexually mature; Iverson 1991; unpubl. data), and with at least six sequential nest season records (Appendix Table 1). Second, I tallied the nesting history of a restricted set of those 287 females (n = 58) that I radiographed during at least 11 of the years with full nest season monitoring (i.e., those females most reliably captured each sample year).

Weather data.—Weather data were recorded at a National Oceanographic and Atmospheric Administration (NOAA) weather station north of

Gimlet Lake, between 120–1,000 m from the ends of the drift fences. I explored the relationship of clutch frequency to weather data in the year prior to, and the spring prior to, each nesting season. Weather variables included monthly mean minimum and maximum temperatures, and monthly rain for April through September in the previous year and April and May of the current year. I examined these relationships using Least Squares Regression Analyses (both with raw and arc-sin square root-transformed data), and I made frequency comparisons (using raw proportions rather than percentages) using Chi-Square Contingency Tests. I analyzed all data with Statview software (Abacus Concepts; Piscataway, New Jersey, USA). Means are followed by ± 1 standard deviation.

Results

For all 4,406 female-years, 275 skipped reproduction (6.24%), and the annual skipping rate varied from 0 to 14.52% (Table 1). Frequency of skipping (SF) for 287 females with more than six sequential years of nest season monitoring (n = 2,431 total female-year records) averaged 6.1 ± 8.6% (range of values, 0–50%). For the subset of 58 females with sequential nesting season records of at least 11 y, SF was 6.3 ± 8.2% (range for individual females was 0 to 28.6%). Only a few females regularly skipped nesting (Fig. 1; e.g., see female #128 in Appendix Table 1).

Average SF (as a proportion) varied among years ($X^2 = 31.3$; df = 14, $P = 0.005$) but was not related to any spring variable (for all regressions, $P > 0.370$, n = 15). SF was inversely correlated with April to September temperatures in the previous year (Fig. 2), however, and positively correlated with August rainfall in the previous year (Fig. 2; Table 2). Across all full nesting season sample years, SF varied with female carapace length and age (Fig. 3). A relatively high percentage of older females (> 35 y, compared to middle-aged [20–35 y] females) also skipped reproduction in a given year (Fig. 3), although older age class sample sizes were small. These data support the conclusion that adult CF in this population typically is very high, averaging about 94%. Finally, the percentage of females that skipped oviposition in a given year declined over the course of this study (Fig. 4).

Table 1. Annual variation in the percentage of female Yellow Mud Turtles (*Kinosternon flavescens*) in Nebraska, USA, that skipped reproduction. Asterisks (*) indicate that the northwest fence was not operated in 1988, but was the only fence monitored in 2013. The error term in the Mean of means is the standard deviation, # = number, and % = percentage.

Year	# nested	# skipped	Total	% skipped
1988	195	9	204	4.41
1990	297	16	313	5.11
1993	259	44	303	14.52
1994	266	31	297	10.44
1998*	353	37	390	9.49
1999	356	27	383	7.05
2000	401	27	428	6.31
2004	283	14	297	4.71
2005	220	13	233	5.58
2006	247	18	265	6.79
2010	304	3	307	0.98
2013*	132	0	132	0.00
2014	303	11	314	3.50
2015	250	10	260	3.85
2017	265	15	280	5.36
Mean of means				5.87 (± 3.62)
Weighted mean		275	4,406	6.24

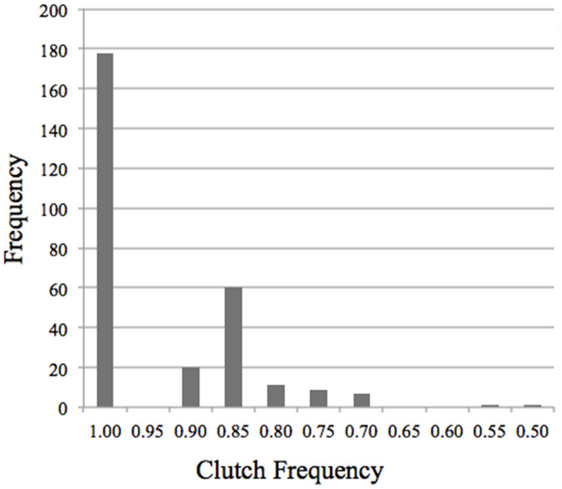

Figure 1. Clutch frequency for 287 female Yellow Mud Turtles (*Kinosternon flavescens*) in western Nebraska, USA, with at least six sequential years of nesting season data (total = 4,406 turtle years). Annual sample sizes are in Table 1.

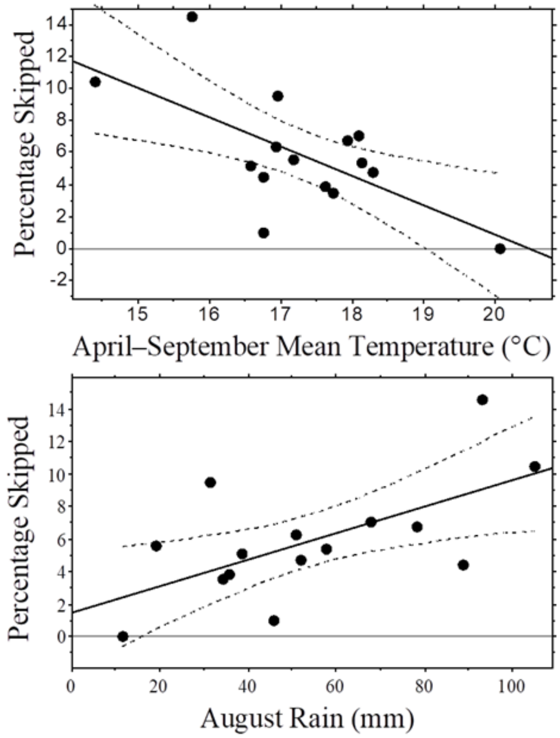

Figure 2. Relationship (with 95% confidence limits) between the annual percentage of skipped clutches in a nesting year and (Top) mean air temperature (°C) during the previous active season and (Bottom) August rain during the previous active season for female Yellow Mud Turtles (*Kinosternon flavescens*) in western Nebraska, USA. For temperature, the best fit equation is Percentage Skipped = -1.85 × April-September Mean Temperature + 37.76; $r^2 = 0.42$; $F_{1,13} = 9.41$; $P = 0.009$; n = 15 y; after arc-sin transformation, $r^2 = 0.46$; $F_{1,13} = 10.90$; $P = 0.006$; warmer conditions are followed in the next year by increased clutch frequency. For rain, the best fit equation is Percentage Skipped = 0.08 ×August Rain + 1.48; $r^2 = 0.38$; $F_{1,13} = 8.09$; $P = 0.014$; n = 15; after arc-sin transformation, $r^2 = 0.38$; $F_{1,13} = 8.01$; $P = 0.014$); wet conditions in August are followed in the next year by decreased clutch frequency. Annual sample sizes are in Table 1.

Table 2. Significant between annual percentage of female Yellow Mud Turtles (*Kinosternon flavescens*) in western Nebraska, USA, that skipped reproduction and climate variables from the previous year (negative correlations for temperature, positive correlations for rainfall; Figs 2 and 3, respectively). No current-year climate variable was correlated (see text).

Variable	r^2	P
April minimum	0.28	0.048
April maximum	--	0.750
May minimum	0.41	0.010
May maximum	--	0.980
June minimum	--	0.065
June maximum	0.28	0.043
July minimum	0.33	0.027
July maximum	0.41	0.010
August minimum	--	0.150
August maximum	0.33	0.025
September minimum	--	0.350
September maximum	--	0.500
April-September	0.42	0.009
April rain	--	0.600
May rain	--	0.560
June rain	--	0.410
July rain	--	0.870
August rain	0.38	0.010
September rain	--	0.590

DISCUSSION

Although CF was predicted to increase with body size (and/or age) in turtles (Moll 1979; Iverson 1992), the published data are equivocal. Many studies confirmed this relationship of CF to body size or age, whereas nearly as many authors have denied it (Appendix Table 2). No pattern in the relationship between size and CF is yet evident for turtles.

Clutch frequency in Yellow Mud Turtles increased with body size and age, primarily because smaller and younger adults frequently skipped reproduction in a given year. Larger adults rarely missed reproduction, but a few older females skipped during some years. Although sample sizes for older age classes were small, this pattern may be evidence of reproductive senescence (i.e., a decline in reproductive output with age); however, Bronikowski et al. (2023) provided evidence of immunological senescence in this species). Reduced CF in old female tortoises was also reported by Hailey and Loumbourdis (1988) for Hermann's Tortoises (*Testudo hermanni*) in Greece and by Díaz-Paniagua et al. (1996) for Spur-thighed Tortoises (*Testudo graeca*) in Spain. Unfortunately, other long-term studies of confidently aged turtles with multiple years of CF data are not available to detect a broader pattern of clutch frequency decline among turtles. Although each of the above studies provide evidence consistent with reproductive senescence in turtles, the evidence for senescence in turtles is generally considered to be negligible (whether reproductive, immunological, or mortality based; Congdon et al. 2001, 2003; Spencer and Thompson 2005; Schwanz et al. 2011; da Silva et al. 2022; Reinke et al. 2022). Other recent turtle studies provided data, however, suggesting that reproductive senescence (Warner et al. 2016), mortality senescence

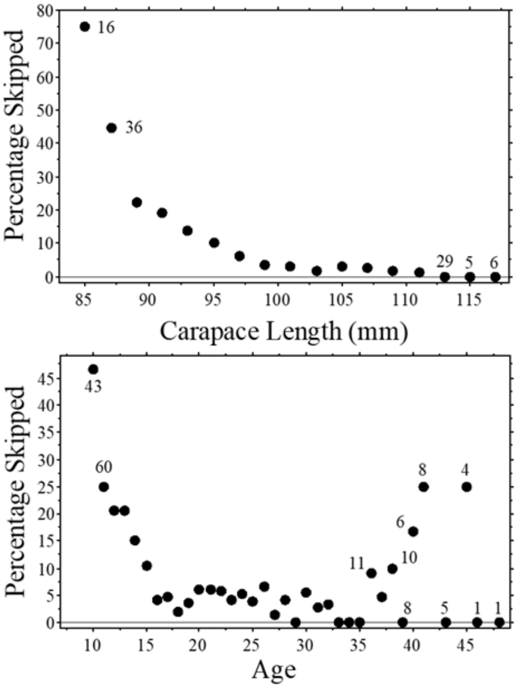

Figure 3. Relationship between skipped clutch percentage (SF) and carapace length (CL, in 2 mm bins; top) and age (bottom in years) for female Yellow Mud Turtles (*Kinosternon flavescens*) in western Nebraska, USA. For CL, sample included 287 females over 4,406 turtle years (sample sizes < 90 are indicated; for all others, n = 90–587). For age, sample included 2,940 total turtle-years, including only those reliably aged (selected sample sizes and all those < 19 are indicated; others ranged from 19–241). Increased SF in older turtles may indicate reproductive senescence (see text).

(Miller et al. 2014; Warner et al. 2016; Cayuela et al. 2019; Reinke et al. 2020), and/or immunological senescence (Bronikowski et al. 2023) are perhaps more common in turtles than generally believed. Understanding the prevalence and importance of senescence in turtle populations will require many more labor-intensive, long-term, individual-based field studies than are currently available (Clutton-Brock and Sheldon 2010).

In an early paper based on this population (Iverson 1991), I estimated much lower values of CF, which must be considered highly suspect based on the more recent data presented here. I earlier assumed that all females leaving the wetland in June were on nesting forays. Once I began radiographing all females leaving the wetland in 1988 (and following more females with telemetry), however, I realized that many subadults (i.e., immature) and adult, non-gravid females left the water and moved directly to estivation without reproducing, especially during multi-year droughts. Second, I did not restrict the early CF data to those females whose migration paths were near the center of the fences. Hence, I likely missed many gravid females that walked along and around my fences.

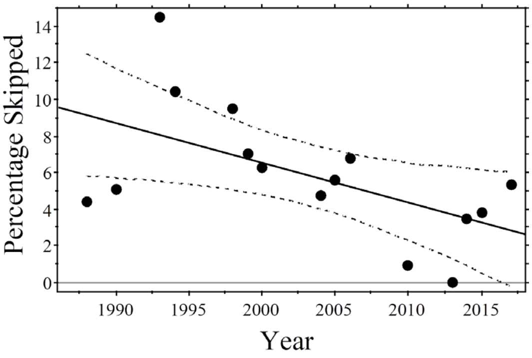

Figure 4. Relationship between skipped clutch frequency (SF; in %) and year of study for 287 female Yellow Mud Turtles (*Kinosternon flavescens*) in western Nebraska, USA (line of best fit is Percentage Skipped = -0.22 × Year + 437.6; $r^2 = 0.32$; $F_{1,13} = 6.01$; $P = 0.029$; 4,406 total turtle-years; after arc-sin transformation, $r^2 = 0.31$; $F_{1,13} = 5.73$; $P = 0.006$), indicating an increase in clutch frequency over the study period. Sample sizes are in Table 1.

Based on the more rigorous data collection presented here, CF was high (though never more than 1.0), and varied across years, apparently reflecting temperatures during the activity season (April-September) of the previous year. It is likely the higher temperatures positively impacted the acquisition of resources (whether through increased prey productivity, increased food intake, or improved processing of food). These effects may drive CF via their positive impact on the ovarian cycle.

The ovarian cycle of *K. flavescens* differs from that of most other North American freshwater turtles that have been studied (see below) in that it is more continuous than cyclical (Kuchling 1999; Ernst and Lovich 2009). In April and May, adult females already have a set of ovulatory-sized follicles for the clutch of that year, and a second set of enlarged follicles that presumably represent the clutch destined to be ovulated in the following year (Christiansen and Dunham 1972; Long 1986; Iverson 1991). By nesting season in late May to early July, that second set of follicles has enlarged to 9–14 mm diameter (Long 1986; unpubl. data) and continues to enlarge to ovulatory size by the following spring (Christiansen and Dunham 1972; Long 1986; Iverson 1991).

My own dissections of females from late May to July from a nearby (7.3 km) population in a similar permanent wetland confirmed this sequence (unpubl. data). Hence, vitellogenesis is much more protracted in this species, requiring at least two years for follicles to be developed to ovulatory size. This unusual protracted ovarian cycle seems to be an adaptation to extreme environments (Kuchling and Bradshaw 1993; Kuchling 1999; Hofmeyr et al. 2018) and might explain why warmer temperatures during the previous activity season might result in an increased frequency of reproduction in the following year (see also Wallis et al. 1999, among others). In addition, environmental conditions in a given year may be the best predictor of conditions for reproduction in the following year for this species. Water is always available in the spring at this site, and because this turtle is aquatic in the spring, reproduction in a given year is not much impacted by spring rainfall or temperatures, except in their effect on the timing of departure from the wetland to nest or estivate (the subject of a separate paper). In any case, temperatures experienced by females are likely never high enough to impede vitellogenesis, as reported for several other turtle species (including another kinosternid, the Eastern Musk Turtle, *Sternotherus odoratus*; Mendonca 1987).

In support of this mechanism, Mueller et al. (1998) found that body condition (presumably a reflection of stored resources, including water) during July to October may determine egg production the following spring in the Desert Tortoise. In addition, Hammer (2015) reported substantially increased clutch frequency in captive female Radiated Tortoises (*Astrochelys radiata*) compared to wild females. Captives were provided with ample access to food and water, but temperature regimes were not reported. Finally, Rollinson and Brooks (2007) demonstrated that warm temperatures in the fall (during maximum vitellogenesis) were followed by increased CF the next spring for *Chrysemys picta*.

My analysis also suggested that August rainfall in the previous year was positively correlated with SF in the following year for Yellow Mud Turtles, but this is likely because of the inverse correlation between August rainfall and mean maximum August temperatures at my site over this study (r = -0.34; $F_{1,35}$ = 4.70, P = 0.037; n = 37 y, 1981–2017). A wet August apparently suppresses temperatures that month, perhaps slowing the rate of vitellogenesis. Because Gimlet Lake is an extremely productive (McCarraher 1977), spring-fed, fish-less, permanent impoundment with a water control structure (i.e., constant surface area; Gosselin et al. 2000), and Yellow Mud Turtles are a top predator and feed primarily on snails in the system (unpubl. data), rainfall is unlikely to significantly alter aquatic productivity. Although there are other possible explanations why an individual female might skip reproduction in a given year (e.g., disease, parasite load, stress, and suboptimal food intake), temperature is likely the most important driver of overall CF variation in this population.

Based on this study, the age and size-class distributions in a given turtle population have the potential to affect the overall CF in that population. Thus, the demography of adults may contribute to variation within or across turtle populations. Finally, in retrospect, the increase in CF over time that I identified is not surprising given that mean April-September temperatures also increased over the course of the study (1981–2017) at a rate of 1° C over 15.1 y (r = 0.66; $F_{1,35}$ = 27.6, P < 0.001; n = 37 y, 1981–2017). This trend indicates the potential impact of climate change on population growth in this species, via its effect on CF, but this potential has not been studied among other turtle populations.

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John B. Iverson holds a Ph.D. in Zoology from the University of Florida, Gainesville, USA, and is Biology Research Professor at Earlham College in Richmond, Indiana, USA. Because of his interests in the natural history, ecology, and evolution of iguanas and turtles, he is currently on the steering committees (and founding member) of the IUCN/SSC Iguana Specialist Group, and the Tortoise and Freshwater Turtle Specialist Group. He has been involved with the Turtle Survival Alliance since its inception in 2001 (currently a Board member) and serves on the Board of the Turtle Conservation Fund. He has been active in several herp societies, serving as Editor and President of the Herpetologists League. He has maintained long-term field research sites from 1980–2024 for rock iguanas (*Cyclura*) in the Exumas in the Bahamas, and 1981–2019 for turtles at the Crescent Lake National Wildlife Refuge in western Nebraska, USA. His hobby is restoring a 31 ha (76 ac) woodlot/cornfield (now in a Conservation Easement) to a mature hardwood forest. (Photographer unknown).

APPENDICES

Appendix Table 1. Examples of variation in nesting histories for six females with high to low clutch frequencies. Est. age is estimated age (in post-hatching winters), Date is day-month-year (six digits), Site is location along fence (see Iverson and Greene 2025), CL is carapace length in mm, CS is clutch size (? indicates confirmed clutch but uncertain number of eggs), and BM is body mass in grams. Captures in April and May (with site terminating in E or H) are females emerging from brumation and moving to the wetland). Dates in late May to early July (with site terminating with W or L) are captures of females leaving the wetland on nesting forays. Numeric sequences under Comments are date-site-BM for recaptures within the same year. For example, in 1986 female #281 emerged from brumation on 24 April (BM = 271 g), and on 12 June she left the wetland nest (BM = 309 g) and was radiographed (6 eggs). On 20 June she returned to the wetland post-nesting (BM = 262 g). Clutch frequencies (CF) for each female across all survey years are indicated to the right (shaded green). Note that the history for female 913B was so aberrant that she was excluded from the analyses reported in this paper. Note the abrupt termination of captures (prior to 2017) for some females, which was assumed to indicate their death.

number	est age	Date	Year	Fence	Site	CL	CS	BM	Comments	
281	21	180681	1981	Main	C10W	106.2	?	304	270681 D2E 250 at least 20 yrs; nested based on BM loss	
281	22	040682	1982	Main	C4W	105.9	?	286	220682 C6E 268 250682 C7W 282; nested based on BM loss	
281	23	050583	1983	Main	C1E	105.7	–	243	Nesting not monitored	
281	26	240486	1986	Main	C6E	107.7	6	271	120686 C9W 309 200686 C9E 262	17 of 18
281	28	280488	1988	Main	D1E	108.4	6	275	100688 C10W 321 120688 C9E 264	
281	30	230490	1990	Main	C10E	108.3	7	253	210690 D2W 321 250690 D1E 275	
281	33	040593	1993	Main	C7E	107.8	6	300	090693 C8W 322 010793 C10E 268	
281	34	240494	1994	Main	C7E	109.2	6	295	060694 C6W 322 210694 C7E 284	
281	38	–	1998	Main	–	–	0	–	not captured this year	
281	39	270699	1999	Main	C7W	110.0	6	313	290699 C8E 276	
281	40	020500	2000	Main	B3E	109.5	7	293	030600 C6W 345	
281	44	140604	2004	Main	C5W	110.6	6	319		
281	45	210605	2005	Main	C9W	109.9	8	328	010705 C9E 279	
281	46	160506	2006	Main	D1E	108.9	6	310	090606 C4W 318 140606 C2E 273 ca 45 y	
281	47	280407	2007	Main	C10E	108.2	7	298	110607 C8W 330 nesting incompletely monitored	

Appendix Table 1, continued

number	est age	Date	Year	Fence	Site	CL	CS	BM	Comments	
281	50	260610	2010	Main	B5W	109.4	6	330		
281	54	090614	2014	Main	C8W	109.5	6	340		
281	55	130615	2015	Main	C7W	110.8	8	342	55+y	
281	57	200617	2017	Main	C5W	110.5	6	332		
281	58	080518	2018	Main	C5E	109.2	–	322	Nesting not monitored; age~58+ y	
27B	21	220490	1990	Dike	M7H	107.6	8	262	140690 M7L 297 180690 M7H 253 est 20+ y	
27B	24	250493	1993	Dike	M6H	108.1	6	265	200693 M5L 292 260693 M7H 255	
27B	25	170494	1994	Dike	M8H	107.6	6	275	060694 M8L 307 110694 M7H 258	
27B	29	060698	1998	Dike	M6L	109.2	7	290	180698 M7H 230	10 of 11
27B	30	130699	1999	Dike	M7L	110.0	8	315		
27B	31	230400	2000	Dike	M6H	108.1	9	292	020600 M7L 335 120600 M5H 258	
27B	35	150604	2004	Dike	M7L	110.2	8	307		
27B	36	–	2005	Dike	–	–	0	–	Not captured this year	
27B	37	160606	2006	Dike	M8L	108.9	7	296	160606 M8L 296	
27B	38	150407	2007	Dike	M8H	108.7	–	238	Nesting incompletely monitored	
27B	41	220610	2010	Dike	M7L	110.0	7	308	240610 M6H 253	
27B	44	190613	2013	Dike	M9L	109.5	5	305	220613 M6H 263; at least 44 y old	
128		160681	1981	Main	D7W	97.4	?	220	Probably nested based on date of foray	
128		060583	1983	Main	D1E	96.1	–	195	Nesting not monitored	
128		230486	1986	Main	D6E	98.4	?	205	210686 D3W 253 240686 D9E 221; nested based on BM loss	
128		300488	1988	Main	D1E	100.4	0	222	NO NEST	
128		070590	1990	Main	D1E	102.2	7	217	260690 E3W 257	5 of 8
128		050593	1993	Main	D6E	101.5	6	208	010793 D6W 265	
128		220494	1994	Main	C8E	101.8	0	222	NO NEST	
128		100598	1998	Main	B5E	103.1	6	237	1206D1W266 1306D2E265 1306D1W260	

Appendix Table 1, continued

number	est age	Date	Year	Fence	Site	CL	CS	BM	Comments	
128		260699	1999	Main	E4W	103.0	0	250	NO NEST	
128		230400	2000	Main	C2E	102.3	6	235	160600 D4W 269	
330	4	270681	1981	MA	B6W	60.1	–	45	IMMATURE	
330	5	250582	1982	MA	A1E	59.3	–	42	IMMATURE	
330	6	220583	1983	MA	A1E	60.1	–	46.3	IMMATURE	3 of 6
330	8	010785	1985	MA	B1W	76.9	–	96	IMMATURE	
330	9	150586	1986	MA	B1E	75.5	–	85	120786 A3W IMMATURE	
330	11	090588	1988	MA	A1E	91.0	–	168	NO NEST; probably immature	
330	13	190590	1990	MA	A2E	96.7	0	183	NO NEST; immature?	
330	16	040593	1993	MA	A2E	100.0	0	200	NO NEST	
330	17	100594	1994	MA	A2E	100.2	7	225	130694 A1W 256 130694 A2E 235 150694 Z4W 252 180694 Z7E 244	
330	21	130598	1998	MA	A3E	103.1	0	220	NO NEST	
330	22	080599	1999	MA	A1E	103.6	5	220	150699 A4W 255	
330	23	240400	2000	MA	A5E	103.3	6	223	100600 Z3W 263	
913B	14	140588	1988	Dike	M?H	90.4	0	162	NO NEST; immature?	
913B	16	220490	1990	Dike	M7H	92.0	4	159	200690 M5L 199	2 of 7
913B	19	250493	1993	Dike	M8H	94.2	0	172	230693 M7L 200	
913B	20	180494	1994	Dike	M11H	93.7	5	182	270594 M6L 218 080694 M8H 200 110694 M9L 212	
913B	24	120598	1998	Dike	M8H	97.5	0	184	NO NEST	
913B	25	290599	1999	Dike	M7H	97.0	0	162	NO NEST	
913B	26	210500	2000	Dike	M6L	97.6	0	228	NO NEST	
1080	9	250583	1983	Main	B6E	59.4	–	43.5	IMMATURE	
1080	11	270685	1985	Main	C8W	74.3	–	101	IMMATURE	
1080	12	100586	1986	Main	C4E	74.6	–	98	IMMATURE	

Appendix Table 1, continued

number	est age	Date	Year	Fence	Site	CL	CS	BM	Comments	
1080	14	040588	1988	Main	C9E	91.7	0	180	300588 C9W 201 NO EGGS; possibly immature?	
1080	16	150590	1990	Main	B3E	93.3	?	192	180690 C9W 219 x-ray error but gravid	
1080	19	300493	1993	Main	C7E	94.1	0	182	NO NEST	
1080	20	230494	1994	Main	C8E	93.8	6	202	060694 C6W 232	10 of 14
1080	24	130598	1998	Main	B2E	98.6	0	233	NO NEST	
1080	25	170699	1999	Main	C8W	100.4	5	253	200699 D1E 228	
1080	26	240400	2000	Main	C3E	99.8	6	228	010600 C9W 258	
1080	30	–	2004	Main	–	–	0		Not captured this year	
1080	31	020605	2005	Main	C8W	101.0	6	267	240605 C9E 212	
1080	32	230506	2006	Main	D2E	100.1	7	242	040606 C7W 262, 080606 C10E 218	
1080	33	260407	2007	Main	D1E	100.0	–	232	Nesting incompletely monitored	
1080	36	170610	2010	Main	C7W	103.2	6	280		
1080	40	220614	2014	Main	C9W	103.5	5	300		
1080	41	130615	2015	Main	C8W	103.3	7	305		
1080	43	170617	2017	Main	C6W	103.7	6	295		
1080	44	060518	2018	Main	E4E	103.8	–	275	Nesting not monitored	

Appendix Table 2. Turtle studies that examined the relationship between clutch frequency and body size or age.

Studies supporting that relationship:

Christens and Bider 1986; Turner et al. 1986; Hailey and Loumbourdis 1988; Tucker and Frazer 1991; Litzgus and Brooks 1998; Zuffi and Odetti 1998; Wallis et al. 1999; McLuckie and Fridell 2002; Rollinson and Brooks 2007; McGuire et al. 2011; Lovich et al. 2015; Tucker et al. 2018; this study.

Studies denying that relationship:

Gibbons et al. 1982; Frazer and Richardson 1985, 1986; Iverson 1991; Díaz-Paniagua et al. 1996, 2001; Johnson and Ehrhart 1996; Mueller et al. 1998; Chen and Lue 1999; Leuteritz and Hofmeyr 2007; Rose 2011.