05-10

Sonoran Mud Turtles and Surface Water Availability At Saguaro National Park, Pima County, Arizona

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Eric W. Stitt
Rincon Institute, Tucson, Arizona
and
Don E. Swann
Saguaro National Park, Tucson, Arizona

INTRODUCTION AND OVERVIEW

The National Park Service is charged with preserving and protecting native biota at designated National Parks and Monuments in perpetuity. As part of this responsibility, Saguaro National Park in Tucson, Arizona has been conducting studies to support an application for flow maintenance rights in the middle reach of Rincon Creek, at the base of the Rincon Mountains. The goals of this study were to determine whether demographic or behavioral differences occurred between populations of Sonoran Mud Turtles at two study sites at Saguaro with different hydrologic regimes. We hypothesized that differences in water availability would lead to quantifiable differences in population traits. We compared abundance, recruitment, mortality and movement of turtles in the different populations with the aim of determining how fluctuations in timing and amount of standing water might affect those parameters.

General Description of Study Site

Rincon Creek occurs in the Santa Cruz River watershed in Tucson, Pima County, Arizona, and drains the western-facing slopes of the Rincon Mountains (Briggs 1996). The study reach runs from private land to the west, through the southern boundary of Saguaro National Park, and reenters private property approximately 1.5 miles to the east. Rincon Creek is an ephemeral stream that serves as the approximate boundary line between Saguaro Park to the north and the private properties of X-9 Ranch to the south. Vegetation throughout the reach is dominated by velvet mesquite (*Prosopis velutina*) – desert hackberry (*Celtis pallida*) bosques, particularly to the south, and remnants of Fremont cottonwood (*Populus fremontii*) – Arizona sycamore (*Platanus wrightii*) gallery forest occur in places.

Chimenea Creek, a small stream draining into Rincon Creek, was used as a comparison site. Steeper in slope, Chimenea features several perennial tinajas (deep bedrock pools), and most of the study section flows over bedrock. The study section is generally open, with a sparse canopy of Arizona sycamore, willow (*Salix* sp.), Arizona walnut (*Juglans major*), velvet mesquite, and oaks (*Quercus* spp.). Based on past records, we believed that standing water at this site would be available to Sonoran Mud Turtles generally year-round, as opposed to at Rincon Creek where water is sometimes unavailable for large proportions of the year.

This study was conducted during a significant drought period. Poor summer rains in summer 2004 in the Rincon Valley were followed by average winter rains in 2004-2005. Summer 2005 was characterized by meager rainfall, and almost no rain fell during the winter and spring of 2005-2006. Surface waters in Rincon Creek dropped between winter 2004-05 and summer 2005, when the area received below average rainfall. Rincon Creek went completely dry during the summer of 2005 and did not flow or contain standing water July of 2006, an entire year later (Perger, in prep.). In contrast, water remained in tinajas at Chimenea Creek throughout the entire study period. In summer 2006, an extreme flood event occurred throughout the Rincon Mountains watershed, significantly rearranging the streambeds of Chimenea and Rincon Creeks, flushing out tons of accumulated woody debris, and overflowing the banks of Rincon Creek. Representative photographs of both sites are shown in Figures 1 and 2.

Sonoran Mud Turtle (*Kinosternon sonoriense*)

Sonoran Mud Turtles are relatively small turtles (to 17.5 cm) found in all types of waters in Arizona, most commonly in creeks and streams (Stebbins 2003). Like most turtles, they are long-lived, probably living to 30 years of age or older (Ernst et al. 1994). Courtship and copulation occur in April through late July, with both behaviors taking place in water. Eggs are laid in late May through September depending on geographic location. Eggs incubate for up to a full year before hatching, which is timed to occur with the summer monsoon. In spring, adults forage and male Sonoran Mud Turtles search for mates. Adult males and females are highly territorial, with the largest turtles of each sex excluding smaller turtles from the best habitat (Hall pers. comm). Thus, as water contracts during the arid pre-monsoon, density-dependent interactions start becoming more acute, with smaller turtles excluded from aquatic habitat, in

effect forcing them into early summer aestivation. Some movement of individuals occurs within a population throughout the winter, particularly during warmer conditions.

METHODOLOGY

Surveys

Surveys were conducted by walking Rincon or Chimenea Creeks for known periods of time while looking for Sonoran Mud Turtles. Turtles were captured by hand or trap (below), measured, weighed, and individually marked.

Sonoran Mud Turtles were trapped at regular intervals with 76.2 cm diameter hoop traps baited with canned cat food. Mesh size was 3.8 cm, thus smaller turtles were probably able to come and go at will from traps. Trapping was by necessity restricted to deeper parts of the streams in water deeper than ca. 40 cm. Traps were checked in the morning daily, and occasionally every two days.

Telemetry

A subset of turtles at Rincon (six individuals) and Chimenea Creeks (10 individuals) were fitted with radio-transmitters (Holohil SB-2FT, 6.0 g) and followed with a receiver and directional antenna (Communications Specialists R-1000 and Telonics RM-14 respectively) at regular intervals during August 2005-October 2006. During the active season turtles were tracked up to twice per week. During the winter they were tracked once every 1 – 3 weeks.

At each location, data collected included whether a turtle was in water or on dry ground. Comparisons of habitat and movement parameters were made between Rincon and Chimenea Creeks. For movements, we compared total and mean distances moved between telemetry locations on successive sessions, and the size of the physical area used (MCP home range) by turtles. All movement parameters were calculated with the Animal Movements extension in ARCview (Hooge and Eisenlaub 1997). All other statistical tests were conducted with JMP, vers. 5.0 (SAS Institute, 2003).

RESULTS

A total of 132 Sonoran Mud Turtles were captured, marked, and released in Rincon Creek from April 2004 through October 2006, totaling 267 captures. The ratio of females to males was 1 to 1. There was no difference in body length between males and females (t-test, $p>0.05$) but females were heavier than males (t-test, $p = 0.0076$). Forty-six turtles were captured at Chimenea Creek from July 2004 through October 2006 for a total of 175 captures. The ratio of females to males was 1.6:1, but did not differ from the expected 1:1 ratio (chi-square, $p>005$). There was no difference in body length between males and females (t-test, $p>005$) and no difference in mass between females and males (t-test, $p>0.05$).

Mortality

Starting in late May, 2006, dead turtles were found in the Rincon Creek streambed with frequency (Table 1). Compared with 17 mortalities at Rincon Creek, only two turtles were found dead at Chimenea in the same spring-summer timeframe. Additionally, four of six turtles (66%) in our telemetry study (below) died between June 10 and June 25, 2006, compared to none of 10 turtles in Chimenea Creek. Tracked turtles that died went without standing water for approximately 305 days before succumbing.

One turtle's transmitter malfunctioned prematurely (after 8 April, 2006) and could not be relocated. One turtle survived to July 1, 2006 but was lost during the July 2006 flood event. During the flood, several turtles at the Chimenea Creek control site may have also been displaced or killed, as they could not be located after the flood.

Telemetry

For radio telemetry of mud turtles in Rincon and Chimenea Creeks (Table 2), there was no difference in sample size between sites (t-test, $p>0.05$). We located turtles 267 times at the Rincon Creek site, and 438 times at Chimenea Creek.

Over the course of the study, transmittered turtles were in water 61% of the time at Chimenea Creek (269 of 447 locations), whereas turtles at Rincon Creek were in water only 0.75% of the time (2 of 267 locations) (Figure 3). Of those times when turtles were not found in water, water was unavailable at Rincon Creek in 250 of 268 instances (95.1% of the time), compared to 68 instances when water was unavailable at Chimenea Creek (n = 171, 39.7%). At Chimenea Creek, 60% (103) of non-aquatic locations were near water (38 locations within 100 m of water, 65 locations with water >100 m). There was no statistical difference in total or mean distances moved by turtles between sites (t-test, $p>0.05$ for all; Figures 4 and 5). There was no statistical difference between the home range size of turtles at either site (t-test, $p>0.05$).

DISCUSSION

Clearly, a healthy population of Sonoran Mud Turtles exists in the Rincon Creek/Chimenea Creek system. Apparently, no differential mortality exists between males and females, as sex ratios were even at the two sites. Also, recruitment of juveniles has been occurring, although probably at much lower levels in 2005 and 2006 relative to wetter years (see Table 1).

Among the variables that we measured during telemetry, the most simple and easiest to interpret was whether a turtle was in water. From July of 2005 to July 2006, turtles at Rincon Creek were high and dry, without standing water virtually the entire time. In contrast, turtles at Chimenea were in water for most of the telemetry locations. For an organism that has most of its life history centered around and within an aquatic medium, the lack of a full year's use of habitat can be profound and we can infer that turtles that spent their time inactive on land had lower reproductive potential, reduced growth rates, and increased mortality.

Dehydration is probably the most immediate consequence of drought. The water requirements for Sonoran Mud Turtles are incompletely known. However, conclusions reached based on indirect evidence have lead to speculation that they are highly aquatic and greatly affected by dehydration (Wygoda and Chmura 1990, Ernst et al. 1994). This suggestion is contrary to what might otherwise be suspected given the ephemeral nature of waters in much of the range occupied by these turtles. Indeed, recent investigations have shown that 1) individuals in some populations have the physiological capacity to undergo aestivation when artificially induced (Peterson and Stone 2000), and 2) some free-living Sonoran Mud Turtles occasionally aestivate when water is unavailable (Ligon and Stone 2003).

Unreported in the literature are any reports of Sonoran Mud Turtles having undergone aestivation for as long as turtles in our study were forced to due to the 2005-2006 drought. Turtles at Rincon Creek in our study went without water for almost four times that reported in a laboratory study (Peterson and Stone 2000). In the only other study to show terrestrial aestivation in a wild population of Sonoran Mud Turtles, turtles in southwest New Mexico went without water for 11 to 34 days, an even smaller fraction of time than ours (Ligon and Stone 2003).

In contrast with Rincon Creek, turtles in Chimenea were located in water for the majority of telemetry locations. When turtles were not found directly in water, water was usually located in the near vicinity. At the population level, Sonoran Mud Turtles at Chimenea were clearly better hydrated and had more opportunities available to replace body fluids. Evidence of a highly aquatic existence was also evidenced by the presence of dense growths of algae on some turtles at Chimenea (Figure 6). Obviously, Sonoran Mud Turtles face a range of environmental extremes between these two connected streams.

Implications for Water Management

The question driving this research for Saguaro National Park is: how much surface water flow is required for the continued health of the Sonoran Mud Turtle population in the middle stretch of Rincon Creek? As demand for water increases in Tucson, and as groundwater withdrawal increases in the vicinity of the park, could reduced amounts of surface water in

Rincon Creek and other streams in the park result in declines and loss of populations of mud turtles and other aquatic animals?

A long period of no flow in Rincon Creek during this study certainly affected the turtles' ability in that area to reproduce and survive. The death of the majority of the radioed turtles in Rincon Creek in spring of 2006, in contrast with the survival of all of the Chimenea turtles, coupled with the evidence of a number of other turtle shells found along Rincon Creek, suggests that extremely long periods with no surface water can lead to mortality in this species. Indeed, this has long been suspected, as populations of Sonoran Mud Turtles have been lost in the desert southwest concurrent with the draining of groundwater and other degradation of surface waters (Jennings and Hayes 1994 and references therein). Data from our study suggest that if surface water in streams in Saguaro National Park becomes less reliable – that is, if ephemeral streams remain dry for longer periods each year – due to climatic changes, groundwater-withdrawal, or other reasons, populations of Sonoran mud turtles are likely to be impacted.

Timing of stream flow is probably a factor for healthy populations of mud turtles as well, with sustained flow during the months of April and May being most important. Flow during these months helps determines the amount of pooled water in the creek, which is critical for April-June activity including feeding, hydration, and mating. Water flow during August and September may be most important for survivorship of hatchling turtles just emerging in the summer.

ACKNOWLEDGEMENTS

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APPENDIX: Figures and Tables

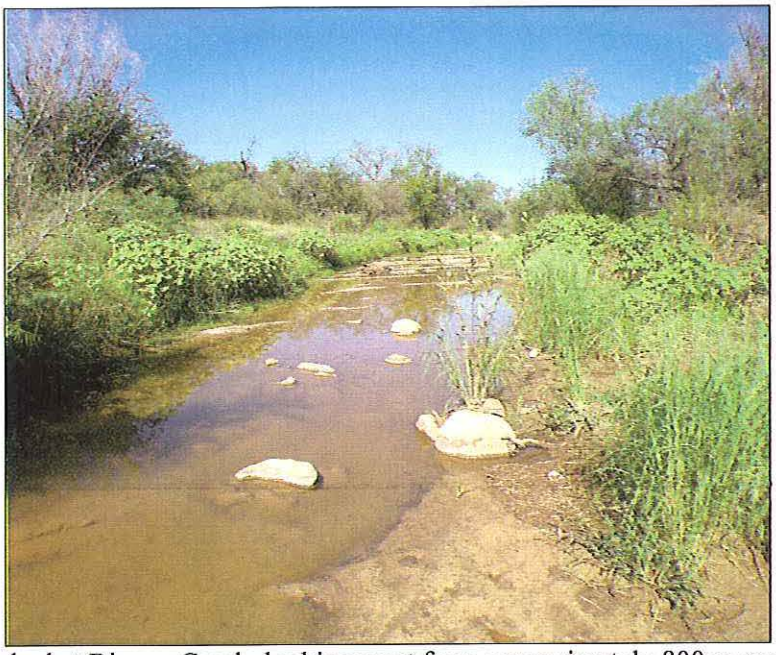

Figure 1. Streambed at Rincon Creek, looking west from approximately 800 m east of existing USGS stream gage and western boundary of the study site, showing flush of new vegetation after summer 2004 rains. This portion of Rincon Creek was completely dry during most of 2005-2006.

Figure 2. Looking south from largest perennial tinajas at Chimenea Creek, September 1, 2005. Even at the height of the 2005-2006 drought water remained here, although at much reduced levels.

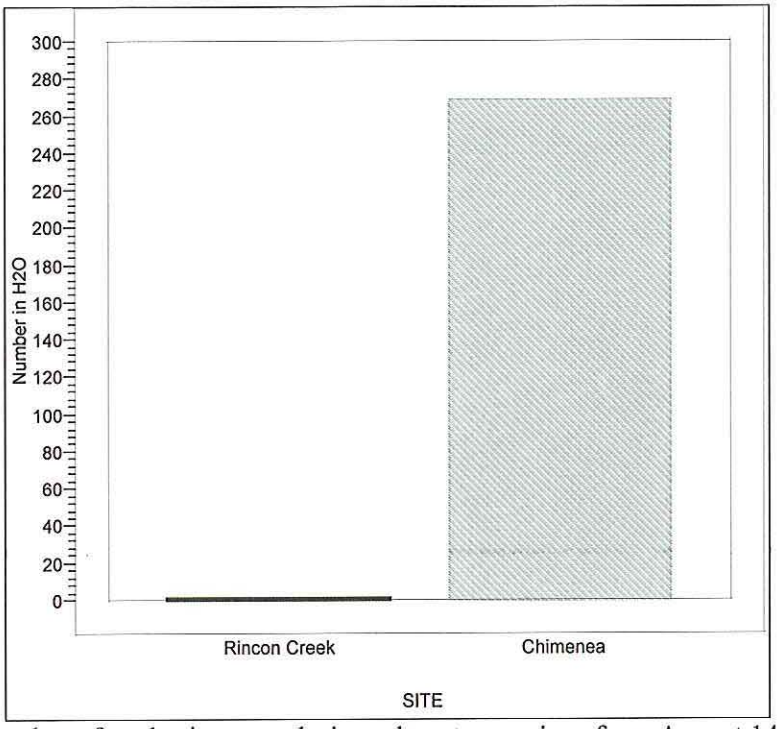

Figure 3. The number of turtles in water during telemetry sessions from August 14, 2005 to July 1, 2006. In all but two locations (0.75%, n = 267) for Rincon Creek, turtles were on dry land with no access to standing water. At Chimenea, 61% (269 of 447 locations) of telemetry fixes found the turtle to be in water.

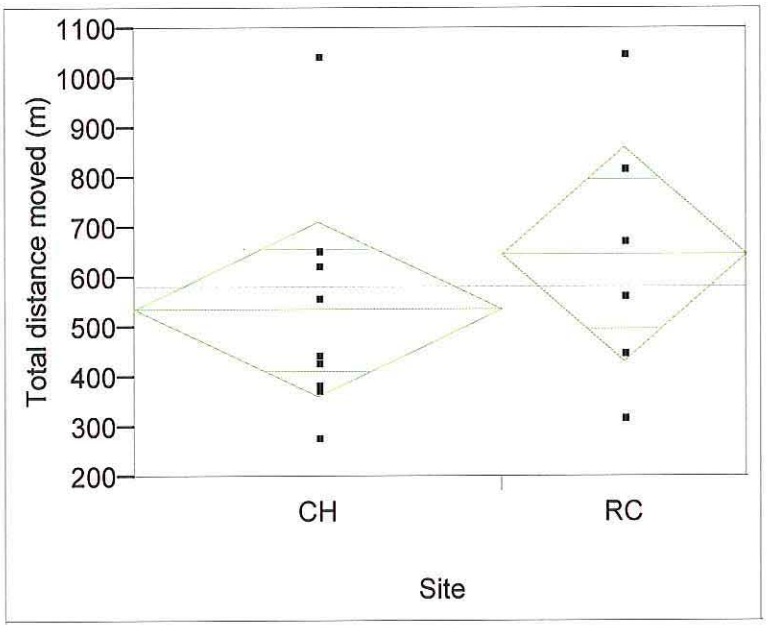

Figure 4. Comparison of total distance moved by turtles at Rincon and Chimenea Creeks. There was no difference in total distance moved between sites (t-test, $p>0.05$).

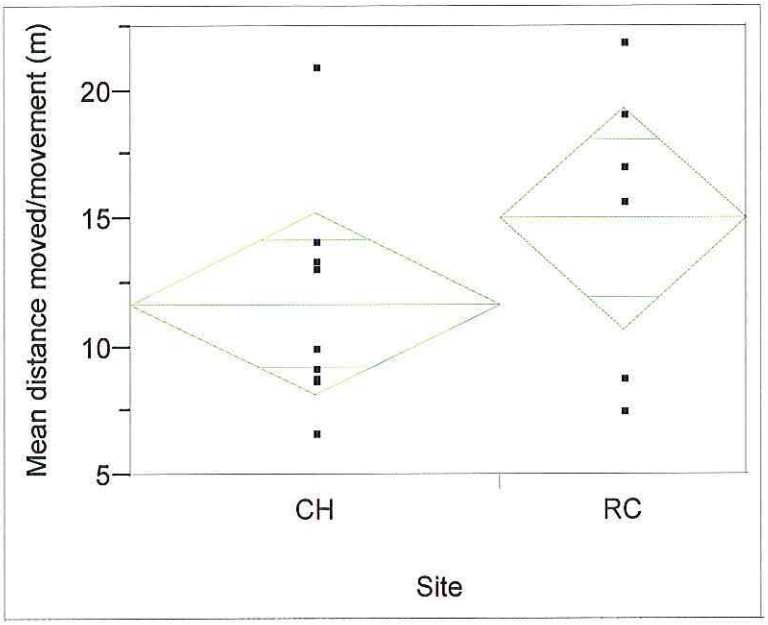

Figure 5. Comparison of mean distance moved at both streams. Here also, there was no difference in mean distance moved per movement between sites (t-test, $p>0.05$).

Figure 6. Variation in algae among turtles captured at Chimenea Creek. No turtles with extensive carpets of algae were documented at Rincon Creek. Notice the drying tinaja in the background.

Table 1. Summary of live and dead turtles observed per unit effort at Rincon Creek, by season, from 2004 through October 2006. Spring is defined as March-May, summer as June-August, and fall as September-November.

Season	Number of live turtles observed	Effort in hours	Number live turtles observed/Hr. effort	Number of dead turtles observed	Number of dead turtles observed/Hr. effort	Evidence of recruitment (# hatchlings observed[1])
Spring 04	15	31	0.48	1	0.03	--
Summer 04	35	54.5	0.64	0	0.00	64
Fall 04	15	33	0.45	0	0.00	--
Spring 05	4	30	0.13	0	0.00	--
Summer 05	20	35.5	0.56	0	0.00	13
Fall 05	0	32.5	0.00	0	0.00	--
Spring 06	5	38	0.13	4	0.11	--
Summer 06	13	60	0.22	13	0.22	0
Fall 06	8	39	0.21	0	0.00	--

[1]**Not counted as live turtles observed per unit effort**

Table 2. Sonoran Mud Turtles in the telemetry study by sex and site, and quantitative measures of movements.

Turtle #	Sex	Site[1]	Sample Size	Max Distance Moved (m)	Total Distance Moved (m)	Mean Distance Moved (m)	Home Range (MCP; ha)
4	♀	RC	49	160.30	1052.7	21.9	6337.0
5	♂	RC	44	1052.0	675.89	15.7	2045.0
9	♀	RC	44	196.04	822.43	19.1	6850.5
33	♀	RC	34	188.11	565.70	17.1	5735.0
50	♀	RC	44	30.806	323.76	7.53	594.50
54	♂	CH	45	52.000	385.32	8.76	1370.0
55	♂	CH	51	140.81	1049.3 0	21.0	5715.0
65	♀	RC	52	51.478	450.18	8.83	2846.0
76	♀	CH	50	41.146	433.54	8.85	1456.0
77	♀	CH	45	116.10	625.43	14.2	2250.5
79	♀	CH	43	95.635	562.07	13.4	1099.5
82	♀	CH	46	57.201	449.08	9.98	852.50
84	♀	CH	42	31.064	377.52	9.21	891.50
88	♀	CH	43	17.000	280.05	6.67	328.00
122	♀	CH	51	133.00	658.12	13.2	4497.5
Mean			**45.5**	**121.75**	**806.25**	**17.65**	**7375.9**
SD			**11.56**	**64.44**	**425.6**	**7.560**	**13719**

[1]RC = Rincon Creek, CH = Chimenea Creek