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Reproductive Parameters of *Trachemys scripta* *venusta* in Southern Mexico

Abstract

The female reproductive cycle and other life history parameters of *Trachemys scripta venusta* were studied in southern Veracruz and Chiapas, Mexico, over a five-year period. Females are reproductively mature at a carapace length of 19.4 cm. Vitellogenesis begins in mid-September, coinciding with a decrease in temperature, and continues until ovulation in late January. The nesting season coincides with the dry season, late January through May, when one to four clutches of 5 to 22 ($\bar{x} = 12$) eggs are laid. Female body size and egg size are larger than those found in northern populations but smaller than those in Panama. Incubation periods, hatchling sizes, adult sex ratios, and effect of incubation temperature on sex determination are also reported.

Introduction

Neotropical freshwater cryptodires are a diverse assemblage in southern Veracruz and Chiapas, Mexico. Although reproduction in *Trachemys scripta* has been well studied in temperate zone populations (Cagle, 1944c, 1950; Gibbons, 1970b; Gibbons et al., 1981, 1982; Congdon and Gibbons, 1983), little published information other than anecdotal accounts exists concerning the reproduction of any turtle species in the Neotropics, with the exception of the study by Moll and Legler (1971) in Panama. The purpose of this paper is to provide comparative data from a geographically intermediate population near the northern edge of the Neotropics.

Methods

This study was conducted from 1981 to 1986 in southern Veracruz and Chiapas, Mexico (lat. 18 N). Turtles were

collected from natural populations in Chiapas (the Río Lacantún and its tributaries in the Reserve of Montes Azules and Laguna de Catazaja) and in Veracruz (lagunas and rivers in or near the Estación de Biología Tropical "Los Tuxtlas" near Catemaco and from the Río Papaloapan and its tributaries near Lerdo de Tejada and Alvarado).

Turtles were collected by fyke nets or trammel nets (Vogt, 1980a) or obtained from local fishermen who used baited hoop traps. Females were palpated for the presence of shelled eggs to determine reproductive conditions. The turtles were injected with oxytocin (Ewert and Legler, 1978) for collection of eggs and released where captured, held in the holding facilities of Los Tuxtlas, or euthanized with Nembutal for dissection. The gonads of all dissected turtles were fixed in neutral buffered 10% formalin and are in the collection at Los Tuxtlas. All data regarding incubation times are from experimental incubations of eggs in incubators ($\pm 0.5^\circ\text{C}$) or under ambient conditions. All eggs were incubated in vermiculite:water, at a 1:1 proportion by weight. Incubation times were calculated from laying date to pipping date (defined as when the first opening occurs in the eggshell). Hatchling sex was determined by gross inspection of dissected gonads under a dissecting microscope (Bull and Vogt, 1979). Egg weights and measurements were taken immediately after laying or dissection to avoid changes due to water absorption. Hatchlings were weighed and measured within four days after hatching, usually within 24 hours. Clutch sizes were based only on oviductal eggs; those obtained by oxytocin injection were not included, because of the potential error of underestimating clutch size (Congdon and Gibbons, 1985). The number of clutches per year was determined by oviductal eggs, corpora lutea, and enlarged follicles. Follicles were placed in four size classes (Moll and Legler, 1971): Class I, 6 mm or smaller; Class II, 7–13 mm; Class III, 14–20 mm; Class IV, 21 mm or larger.

Results

SIZE AT SEXUAL MATURITY

Those females for which clutch data are available measured 19.4–31.1 mm in carapace length ($\bar{x} = 23.6$ mm, $SD = 3.09$, $N = 31$) and weighed 963–4,100 g ($\bar{x} = 1,813$ mm, $SD = 690.6$, $N = 31$). Smaller females may be reproductively mature in some instances, but none were encountered in this study. No dissected female smaller than 19.4 cm in carapace length ($N = 84$) showed evidence of enlarged follicles or expanded oviducts.

OVARIAN CYCLE

Follicular enlargement begins in late September ($N = 3$), coinciding with the beginning of the period of highest

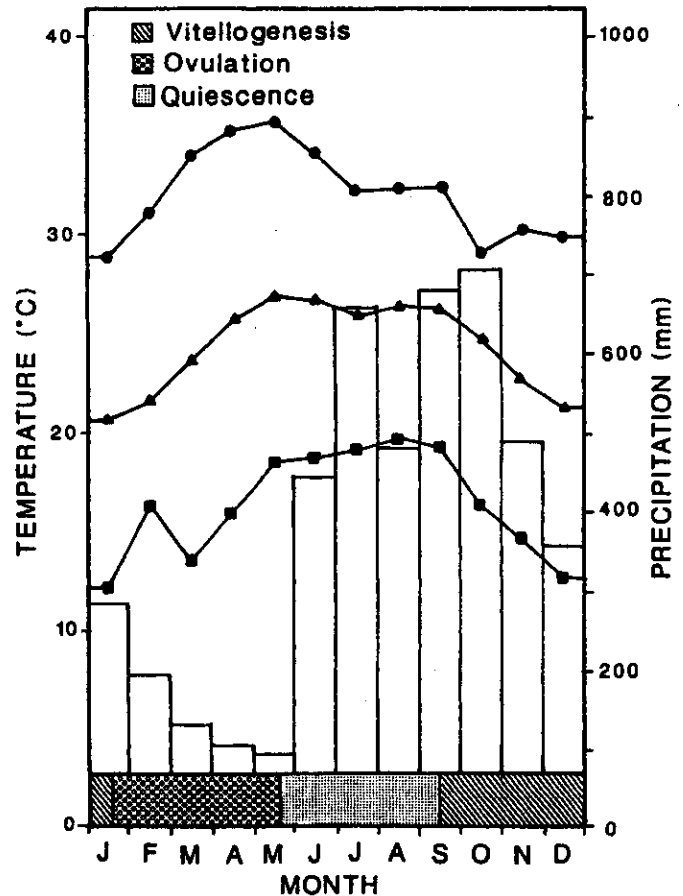


FIGURE 13.1. Ovarian cycle and monthly mean precipitation (bars) and temperature (circles = mean daily highs, triangles = means, squares = lows). Temperature and precipitation data are from Los Tuxtlas at the Coyame meteorological station (means from 1953 to 1981).

rainfall and lower temperatures (Fig. 13.1). By mid-October ($N = 6$), individuals have developed Class II follicles and are beginning to produce Class III follicles. By January ($N = 8$), reproductive females have Class IV follicles and do not produce oviductal eggs until the cold rainy season ends and temperatures begin to rise. The earliest collection date of a female with oviductal eggs was 15 January in the Río Tsendales, Chiapas. During the period of 15 January to 15 February, only 20% of the females examined ($N = 200$) contained oviductal eggs. From 15 February to 1 March, 30% contained oviductal eggs. Females have been found with oviductal eggs until 23 May. Variation in the beginning of the dry season appears to influence the beginning of the nesting season from year to year as much as three weeks. The nesting season coincides with the dry season (February–May), when daytime temperatures reach 35°C . However, even in the dry season, monthly mean rainfall is at least 100 mm. The onset of the summer rainy season, with lower temperatures and more than 400 mm of monthly

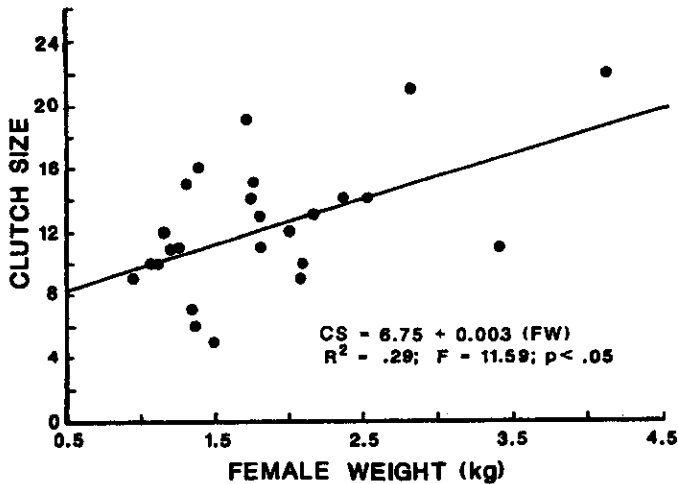


FIGURE 13.2. Relationship of clutch size (CS) with female weight (FW) in kg.

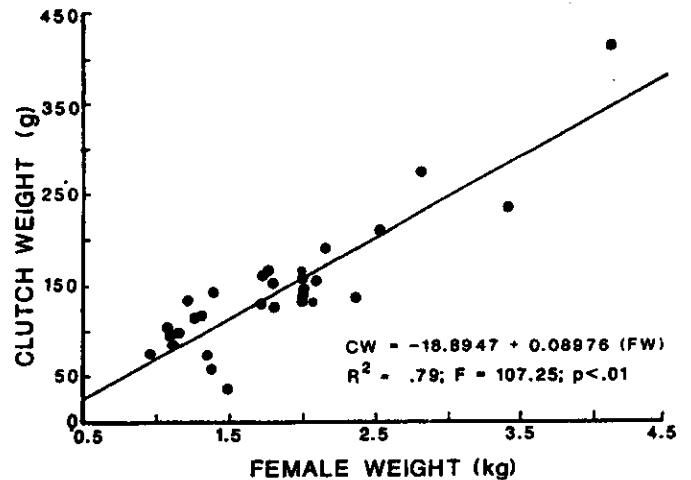


FIGURE 13.3. Relationship of clutch weight (CW) in g with female weight (FW) in kg.

precipitation, marks the end of the nesting season and the initiation of a quiescent period of four months. Vitellogenesis is apparently stimulated by the cooler temperatures in late September (Ganzhorn and Licht, 1983).

CLUTCH AND EGG SIZE

Because atretic follicles were found in three females collected in September and October, enlarged follicles were not used to estimate clutch size. However, a count of enlarged follicles, corpora lutea, and oviductal eggs was used to estimate the number of clutches per year at a maximum of four ($\bar{x} = 3.5$, range = 2–4, $N = 23$). Clutch size varied from 5 to 22 ($\bar{x} = 12.03$, $SD = 3.75$, $N = 31$). The number of eggs per clutch was significantly corre-

lated with both carapace length ($p < .05$, $r^2 = .15$) and female weight ($p < .05$, $r^2 = .29$, Fig. 13.2). Clutch mass varied from 33.7 to 417.0 g ($\bar{x} = 143.8$, $SD = 69.86$, $N = 31$). Both carapace length ($r^2 = .54$) and female weight ($r^2 = .79$, Fig. 13.3) were significantly correlated with clutch mass.

Eggs measured 2.80–4.88 cm ($\bar{x} = 3.81$, $SD = 0.33$) in length and 1.86–2.93 cm ($\bar{x} = 2.26$, $SD = 0.23$) in width ($N = 373$). Egg weight ranged from 6.4 to 22.7 g ($\bar{x} = 11.78$, $SD = 3.33$, $N = 373$). Egg size was not highly correlated with clutch size ($r^2 = .015$). Both carapace length and female weight were significantly positively correlated with egg length, width, and mass ($p < .01$, Figs. 13.4–13.6). Female weight in all cases, however, had a higher correlation than did carapace length or clutch size.

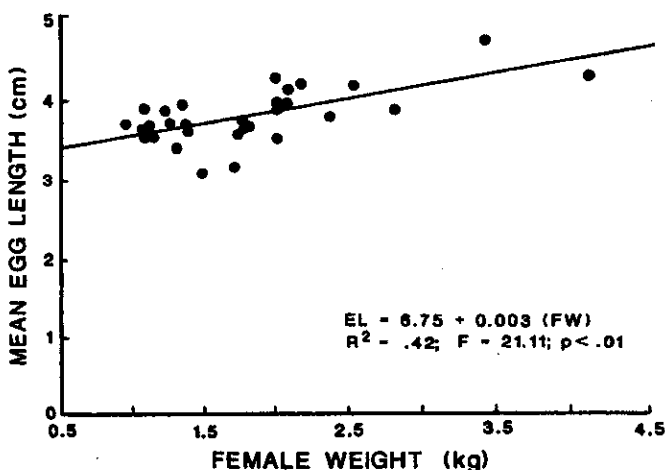


FIGURE 13.4. Relationship of mean egg length (EL) in cm with female weight (FW) in kg.

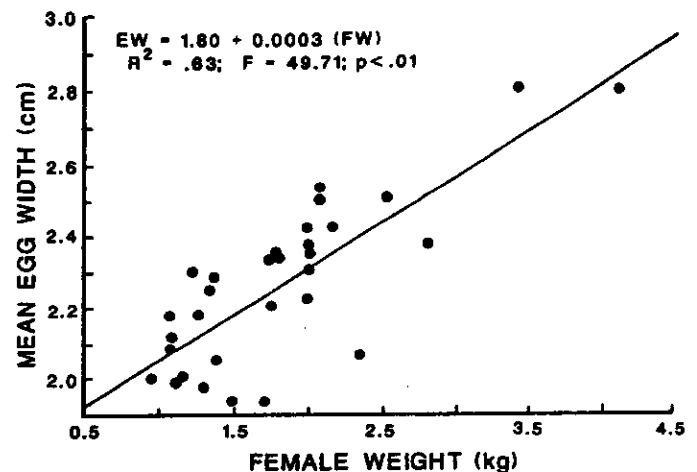


FIGURE 13.5. Relationship of mean egg width (EW) in cm with female weight (FW) in kg.

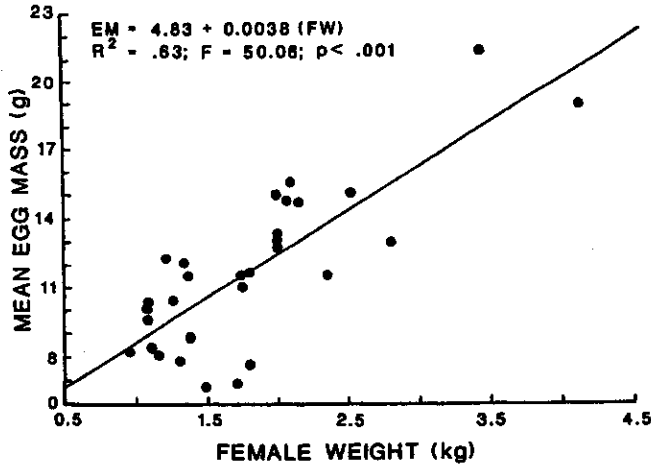


FIGURE 13.6. Relationship of mean egg mass (EM) in g with female weight (FW) in g.

INCUBATION PERIODS AND HATCHLINGS

Natural nests were not monitored, but eggs incubated at ambient temperature (26°–28° C) hatched in 63 to 74 days. Eggs in the laboratory hatched after 42 to 74 days when incubated under the following temperatures: 27.5°–28.5° C (62–74 days); 28.5°–29.5° C (50–62 days); 29.5°–30.5° C (42–57 days). Only females were produced at temperatures above 29° C. At 28.5° C the sex ratio was 4.2 females:1 male, and at 27.5° C the sex ratio was 1:1 (Table 13.1). Hatchlings varied from 2.5 to 3.78 cm (\bar{x} = 3.18, SD = 0.27, N = 154 from 18 clutches) in carapace length and weighed from 3.5 to 10.7 g (\bar{x} = 7.24, SD = 1.68, N = 154 from 18 clutches).

ADULT SIZE AND SEX RATIO

From October 1984 through February 1986, 112 *Trachemys* were captured in unbaited fyke nets in 840 trap nights in the Río Lacantún and its tributaries. The adult sex ratio was highly skewed toward males (1.91 males:1 female). The 34 adult females weighed 1,100–5,050 g (\bar{x} = 3,350, SD = 974.4), with a carapace length of 188–330 mm (\bar{x} = 284, SD = 32.3) and a plastron length of

188–318 mm (\bar{x} = 266, SD = 34.0). The 65 adult males weighed 900–4,400 g (\bar{x} = 1,896, SD = 668.4), with a carapace length of 187–331 mm (\bar{x} = 241, SD = 28.1) and a plastron length of 172–305 mm (\bar{x} = 222, SD = 32.5). The 13 males that were considered subadults did not have greatly enlarged tails and ranged in weight from 300 to 900 g (\bar{x} = 621, SD = 223.6), from 128 to 179 mm in carapace length (\bar{x} = 162, SD = 20.2), and from 125 to 178 mm in plastron length (\bar{x} = 153, SD = 16.2). No subadult females or hatchlings were seen or captured during the trapping periods.

Discussion

SIZE AT SEXUAL MATURITY

Gibbons (1982) and Thornhill (1982) have both shown that growth and size at sexual maturity in populations of sliders are directly affected by water temperatures. Tropical waters are presumably warmer than those in temperate zones, so it is not surprising to find that the mean size of reproductive females is larger in Mexico and Panama than in the temperate regions. Cagle (1950) found that reproductive females in Illinois ranged from 15 to 19.5 cm in plastron length. Mexican *Trachemys* began maturing at a larger size (around 19 cm) and females in the Panamanian study were even larger (24 cm) before maturity was reached (Moll and Legler, 1971). Although it has been stated that turtles need to reach a minimum size before becoming reproductive and that size rather than age determines when female turtles begin laying eggs (Cagle, 1950; Bury, 1979), the results of both field studies (Moll and Legler, 1971; Gibbons et al., 1982) and lab studies (Vogt, n.d.) support the opposing viewpoint, that age rather than size determines the onset of reproduction. This is apparent from the studies of thermally altered areas as well as the latitudinal variation within this species.

OVARIAN CYCLE

The ovarian cycle of Veracruz sliders varies little from that reported in northern or more southern latitudes; only

Table 13.1. Sex ratio of hatchlings produced in the laboratory under constant incubation temperatures

Locality	Temperature (° C)						
	27.5	28.0	28.5	29.0	29.5	30.0	30.6
Alabama	100 (21)			37 (16)		0 (17)	
Tennessee		92 (36)			30 (40)		5 (42)
Mexico	53 (34)		20 (45)		0 (44)		0 (41)

Source: Alabama and Tennessee data from Bull et al., 1982.
 Note: Ratios are presented as percent male, with sample size in parentheses.

the dates corresponding to the local temperatures are slightly shifted (Fig. 13.1). Vitellogenesis begins at a later date than in the north, most likely because of higher temperatures, as found in *Chrysemys* (Ganzhorn and Licht, 1983) and coincides to what was reported for Panama (Moll and Legler, 1971). Ovulation is shifted three months earlier than in northern latitudes, where nesting does not begin until late April (Cagle, 1950). This coincides with the beginning of nesting in Panama, where the earliest nest found was on 13 January, even though nesting is presumed to occur one month earlier in Panama. Nesting in Veracruz begins in the dry season, as in Panama, with the majority of the females laying in March and April and fewer laying in January-February or May. An important factor, both in Mexico and in Panama, is that the dry season also coincides with a rise in temperature after a distinct cool period. It was demonstrated in *Chrysemys picta* (Ganzhorn and Licht, 1983) that high temperatures inhibit vitellogenesis. In addition, temperate zone species have been shown to need a cool period to induce ovulation (Vogt, 1980a). Wisconsin *Graptemys* brought directly from brumation in the Mississippi River in November and maintained under warm conditions in the laboratory failed to develop oviductal eggs and began reabsorbing the yolked follicles. However, individuals in the sample that were kept under cold conditions (5° C for six weeks) developed oviductal eggs after two weeks under temperatures of 28°–30° C. Thus, it is more likely that the lowering of temperatures in September stimulates vitellogenesis and that the even lower temperatures of December and January inhibit ovulation. Warmer temperatures in February and March stimulate ovulation, and the even warmer temperatures of April and May inhibit vitellogenesis, resulting in fewer clutches in Mexico (four), than in Panama (six). This is an increase, however, over temperate zone populations, where a maximum of three clutches is laid (Gibbons et al., 1982).

Although some populations show no relationship between body size and the incidence of multiple clutches (Gibbons et al., 1982), there seems to be a latitudinal variation coinciding with both an increase in the number of clutches and the mean size of females in southern populations (Table 13.2). This increase in body size may explain, in part, why Panamanian turtles lay up to six clutches annually, although Mexican turtles deposit only four clutches annually. The laying season is also longer in Mexico and Panama than in Illinois (Cagle, 1950) or South Carolina (Gibbons et al., 1982), allowing for the production of more nests. However, no evidence exists that individual turtles have an extended laying season. I would predict that the season of an individual turtle is shorter but the range of variation found is greater because of population and microhabitat differences.

Comparison of the female reproductive cycle of *Trachemys* with that of Neotropical endemic species (*Kinostemon*

Table 13.2. Clutch size variation in populations of *Trachemys scripta*

Locality	Mean	Range	N	Reference
Illinois	9.5	4-18	217	2
Tennessee	10.5	5-22	47	2
South Carolina	7.7	2-17	121	2
Oklahoma	8.8	1-12	6	2
Louisiana	7.2	4-11	188	2
Southern Mexico	12.03	5-22	31	3
Panama	17.4	9-25	38	1

References: 1, Moll and Legler, 1971; 2, Fitch, 1985; 3, this study.

acutum, *K. leucostomum*, *Claudius angustatus*, *Staurotypus triporcatus*, and *Dermatemys mawii*) suggests that *Trachemys* is "stranded" in its present reproductive cycle because of phylogenetic constraints. The other species are capable of vitellogenesis during the warm summer months, begin an extended egg-laying season with the onset of the cold rainy season, from September to November, and continue laying eggs until April or May (Vogt, n.d.).

CLUTCH AND EGG SIZE

Clutch size is a variable related to the size, age, and energetic state of the female, as well as the date of oviposition. Clutch size has been shown to be highly variable among populations within a single geographic area (Congdon and Gibbons, 1983) and among years. Because my samples are from various populations over a span of several years and taken from throughout the nesting season, they are not readily comparable with the studies of discrete populations. These data are, however, comparable with the means compiled by Fitch (1985) to show regional trends in clutch sizes (Table 13.2). It is interesting to note that the range of variation between Mexico and Tennessee is the same, but the mean clutch size is larger in Mexico. This does not follow the trend for smaller clutches as one moves farther south, as stated by Fitch (1985), especially considering that the mean clutch size in Panama is 17.4. Studies of a long-term nature need to be conducted on discrete populations in southern Mexico before conclusions can be made concerning trends in clutch size.

Clutch size in this study was positively correlated with two measures of body size: carapace length and female weight. Clutch mass, a better estimate of the amount of energy a female expends on a particular clutch, was significantly correlated with female weight ($r^2 = .79, p < .001$). Female weight was more important than plastron or carapace length in estimating clutch size. There was no significant difference in the variability of egg size (weight, length, or width) in relation to weight, carapace length, or plastron length of the female. Clutch size, however, was negatively correlated with variability of egg length ($r^2 =$

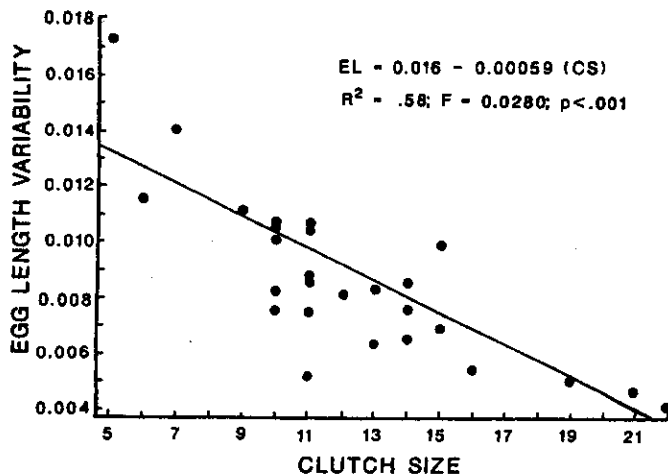


FIGURE 13.7. Relationship of egg length variability (standard deviation divided by mean egg length) with clutch size (CS).

.58, $p < .001$, Fig. 13.7). An increase in clutch size resulted in a decrease in the variability of egg length. Within-clutch variability of both egg weight ($r^2 = .11$, $p < .001$) and width ($r^2 = .14$, $p < .05$) increased significantly with an increase in clutch size. This suggests that females are selecting for an optimum egg length and the independent variable of egg weight; how much energy a female devotes to a single egg is expressed by an increase in egg width. As has been shown in northern populations (Congdon and Gibbons, 1983, 1985), egg width and egg mass increase proportionally with the size of the female, but egg length does not (Figs. 13.4–13.6). Although the range of variation of egg size is great, there appears to be a trend to produce larger, heavier eggs in tropical localities as opposed to northern latitudes (Table 13.3). This trend could be emphasized by larger sample sizes from Neotropical populations.

INCUBATION

The incubation period was shorter than that reported for northern populations under controlled laboratory conditions (Ewert, 1985): 57–65 days at 29°–30° C for northern populations versus 50–62 days at 28.5°–29.5° C in this

study, and a mean of 58 days at 30° C for northern populations versus 42–57 days at 29.5°–30.5° C in this study. One would expect to find shorter incubation periods in northern latitudes at the same temperature if there is a premium on leaving the egg at a faster rate. As was reported for several populations of *Chelydra* (Ewert, 1985), faster incubation rates in northern populations of *Trachemys* do not appear to be selected for. Perhaps because winter temperatures even in the northern edge of the range of this species are not sufficiently low to increase the mortality of unhatched embryos, there is no strong selective advantage for early hatching as in other species.

SEX DETERMINATION

One would predict that threshold temperatures for sex determination would be higher in the tropics or in the southern United States than in more northerly latitudes (Bull et al., 1982). Table 13.1 shows distinctly that the threshold temperature is 1° C lower in Neotropical Mexico than in the southern United States. Nesting sites appear similar in the areas studied. Along the Río Lacantún, slider nests have been found on sandbars 3 to 6 m from the water, both in shaded and open areas. Nests near Lerdo, Veracruz, are found on higher mounds of sand or clay at the edge of marshes, sites that are often overgrown by vegetation. In order to interpret the significance of these results, natural nests must be monitored by recording detailed temperature data. Only with such data can we begin discussing the selective advantage of a lower threshold temperature. It seems highly probable that the eggs of *Trachemys* in Veracruz and Chiapas are actually experiencing lower temperatures, making it advantageous to produce females at a lower temperature. Sex ratios of adults in Chiapas (this study) and Panama (Moll and Legler, 1971) were skewed 2 : 1 in favor of males. If in fact these data are not artifacts of sampling error, then they would suggest that there is an overabundance of males, and selection would favor those females that either placed their eggs in warmer sites or had a lower threshold temperature. Cagle (1950) found a 1 : 1 sex ratio in a sample of 825 adults from Illinois, suggesting that in northern popu-

Table 13.3. Geographic variation in egg size of *Trachemys scripta*

Locality	Length (mm)	Width (mm)	Mass (g)	N	Reference
Illinois	36.2 (30.9-43.0)	21.6 (19.4-24.8)	9.71 (6-15.4)	221	1
South Carolina	36.39	22.17	19.52	489	3
Southern Mexico	38.1 (28.0-48.8)	22.6 (19.6-29.3)	11.78 (6.4-22.7)	373	4
Panama	42.2 (37.1-47.6)	28.2 (25.5-41.3)	20.66 (16.4-25.6)	87	2

Note: Mean and range (in parentheses) of measurements are shown.

References: 1, Cagle, 1944c; 2, Moll and Legler, 1971; 3, Congdon and Gibbons, 1985; 4, this study.

lations an equilibrium has been reached between threshold temperature and nest site selection.

Mean hatchling weight (7.24 g, range = 3.5–10.7 g) and mean carapace length (31.8 mm, range = 25.0–38.0 mm) were lower in this study than in both northern studies: 8.07 g (5.4–10.0 g) and 32.46 mm (28.4–34.2 mm) in the study by Cagle (1950) and 36.5 mm (28.4–40.2 mm) in the Panamanian study. All of the hatchlings measured in this study were from eggs incubated under constant temperatures in the laboratory, many of which were from high temperatures. Smaller turtles hatch out at higher incubation temperatures (Ewert, 1985), explaining the conflicting results of larger eggs in Mexico producing smaller hatchlings. The range of the carapace length is greater in Mexico than in either Panama or Illinois, reflecting again the effects of incubation temperature.

ADULT SIZE AND SEX RATIO

The limited amount of data on the population of *Trachemys scripta venusta* from the Río Lacantún suggests that the population is skewed toward adults. Predation of both adults and juveniles is high in the region, *Crocodylus moreletii* being one of the most abundant predators. About 25% of the adult *Staurotypus triporcatus* from this area have holes in the carapace from attempted crocodile predation. *Trachemys* lack these holes and are also much less abundant, suggesting that when crocodiles bite *Trachemys*, they are able to eat them. Juveniles of *Staurotypus*, a bottom dweller, are abundant in the population, suggesting that it is not nest predation that is removing the juvenile *Trachemys* from the population. Although the skewed sex ratio may represent sampling error, it is also important to note that of the 13 subadults captured, all were males. This suggests that males are being overproduced and that these sex ratios are in fact real. A more intensified effort to locate juveniles and subadults and to monitor nest temperatures and hatchling sex ratios is needed before any statements

about the population biology of this species can be made in the Río Lacantún.

This chapter would not be complete without commenting that tropical Mexican sliders are very similar in every aspect of their biology to sliders in the southern United States and Panama. They do not seem to have changed in the least to adapt to life in the tropics and have not seemed to suffer for it. A slider is a slider is a slider.

Acknowledgments

This study would not have been possible without the assistance of numerous people in the field and laboratory. My sincere appreciation is given to my field assistants, who worked under the bites of *sancudos* and the biting words of El Maestro for paltry wages or the opportunity to learn more about turtles: Oscar Flores Villela, Mardocheo Palma Munoz, Chucho Ramirez Ramos, Paco D. Soberon, and Marcelo Paxtian Sinaca. My *lanchero* on the Río Lacantún, Augustin, was more of a biologist's caretaker than a *lanchero*. Funding for the Chiapas portion of this study was provided, in part, by the Secretaria de Desarrollo Urbano y Ecología through the guiding hands of Dr. Mario Ramos of the Instituto Nacional de Investigaciones sobre Recursos Bióticos and the assistance of Marco Lazcano. Some funding for other aspects of the study came from the Instituto de Biología de Universidad Nacional Autónoma de México. Miguel Martínez Ramos is thanked for helping me with data analysis. Finally, Rodolfo Dirzo, El Jefe de la Estación de Biología "Los Tuxtles," is appreciated for giving me the freedom to study turtles unhindered and directing all of the support he could my way. Manuscript preparation was aided by Miriam Stapleton at the Savannah River Ecology Laboratory under contract DE-AC09-76SROO-819 between the U.S. Department of Energy and the University of Georgia's Institute of Ecology. Whit Gibbons, Rich A. Seigel, James L. Knight, and Justin D. Congdon are thanked for their help in narrowing the focus of the chapter and clarifying the prose.