TRANSACTIONS OF THE KANSAS ACADEMY OF SCIENCES
83(4), 1980, pp. 239–246

Nesting Habits of Diamondback Terrapins (*Malaclemys terrapin*) on the Atlantic Coast of Florida

RICHARD A. SEIGEL[1]
Department of Biological Sciences
University of Central Florida, Box 25000
Orlando, Florida 32816

ABSTRACT

The reproductive habits of the Florida east coast terrapin, *Malaclemys terrapin tequesta* were studied from 1977 to 1979 at the Merritt Island National Wildlife Refuge, Brevard County, Florida. Nesting occurred only on dike roads, in contrast to other subspecies of *Malaclemys* which normally nest on sand dunes. Nesting occurred from April to July, during daylight hours, and reached a peak during periods of high air temperatures and clear skies. Mean clutch size was 6.7, and up to three clutches may be laid each year. The clutch size of *M. t. tequesta* is considerably smaller than that of northern populations of *Malaclemys*. Small clutch size is apparently correlated with an increase in egg and hatchling size, which may result in higher survivorship of offspring in southern populations.

The diamondback terrapin, *Malaclemys terrapin* is one of the most widely distributed species of turtles in North America, extending from Cape Cod southward to the Florida Keys, and as far west as the Gulf coast of Texas. Such a wide-ranging species might be expected to show considerable variation in its reproductive biology. Unfortunately, field studies of the reproductive habits of *Malaclemys* have been limited to the northern subspecies, *M. t. terrapin* (Finneran, 1948; Reid, 1955; Burger and Montevecchi, 1975; Montevecchi and Burger, 1975; Burger, 1976a,b, 1977). Information regarding reproduction in other subspecies is confined to captive specimens (Hildebrand, 1929, 1932; Burns and Williams, 1972); the usefulness of this information is limited (Carr, 1952; Burnley, 1969).

The Florida east coast terrapin, *M. t. tequesta* has the southernmost distribution of any *Malaclemys* with the exception of *M. t. rhizophorarum*. Recent papers have dealt with mortality (Seigel, 1978), predation (Seigel,

---

[1] Present address: Museum of Natural History, University of Kansas, Lawrence, Kansas 66045.

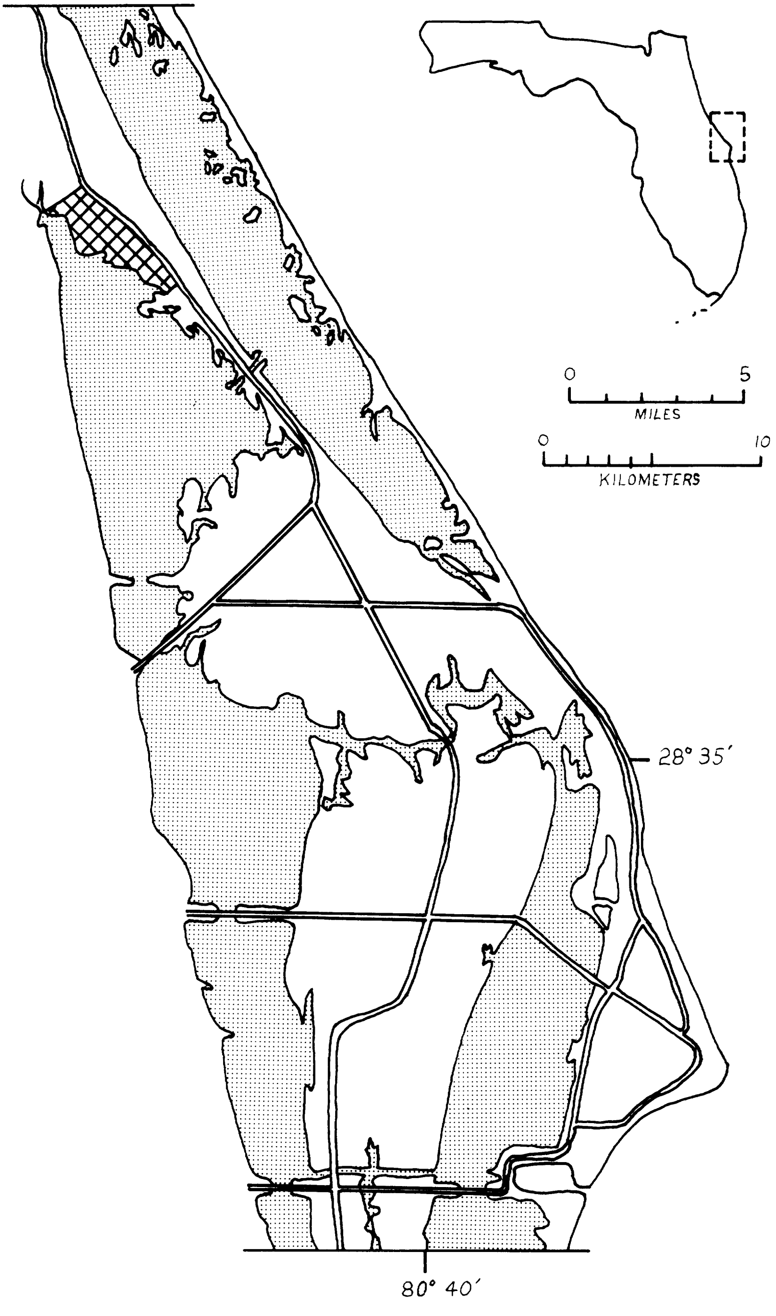

Fig. 1. Merritt Island National Wildlife Refuge. Shaded areas represent lagoonal waters. Study area for nesting habits is shown by cross-hatching.

1980a), and mating behavior (Seigel, 1980b), but nothing has been published concerning reproduction in this subspecies. The purpose of this paper is to compare the nesting habits, clutch size, and reproductive potential of *M. t. tequesta* to those of other subspecies.

Materials and Methods

My investigations were conducted from January 1977 to April 1979 at the Merritt Island National Wildlife Refuge, Brevard County, Florida (Fig. 1). The refuge consists of three large brackish water lagoons, each surrounded by a series of dikes and brackish water impoundments, built in the late 1950's. The construction of these dikes resulted in the elimination of virtually all of the salt marsh on the refuge, so *Malaclemys* at Merritt Island are confined to the lagoons, or to the brackish water impoundments which surround them. A more detailed description of the study site is given elsewhere (Seigel, 1979).

Information concerning nesting habits was collected by walking two standardized 1.6 km census routes along a dike road on the northern boundary of the refuge (Fig. 1). Each route was checked 3–5 times daily during April–July, from 0700–0100. Turtles were collected by hand as they nested along the sides of the dike. Additional specimens were collected from a narrow canal bordering the study area. Straight-line carapace and plastron lengths (to the nearest 0.1 cm), and body weights (to the nearest 10 g) were recorded for each individual. Cloacal, substrate and shaded air temperatures were measured to the nearest 0.1 C with a Schultheis quick-reading thermometer. All turtles were marked and released at point of capture. Clutch size was determined by direct counts in natural nests, examination of corpora lutea, enlarged follicles and oviducal eggs, and by X-ray examination of gravid females (Gibbons and Greene, 1979). Eggs were incubated on moist soil in an open house trailer on the refuge. Eggs and hatchlings were measured to the nearest 0.1 cm with dial calipers, and weighed to the nearest 0.1 g on a Mettler balance.

All means are followed by ± one standard deviation. Student's t-tests were used to compare sample means.

Results and Discussion

Nesting habits. Although numerous areas, including sand dunes, spoil islands, and the borders of the lagoons were surveyed for signs of nesting activity, nesting was observed only on dike roads. In contrast, other subspecies of *Malaclemys* nest almost exclusively on sand dunes, or in areas where sand dunes were historically present (Carr, 1952; Reid, 1955; Burger and Montevecchi, 1975; R. Wood, pers. comm.). Why Merritt Island terrapins do not nest on sand dunes is unknown. Distance from the water is not an important barrier, since at least one lagoon (Fig. 1) is bordered quite closely by sand dunes. Conceivably, the soil of the dunes on the refuge is unsuitable for nesting. The only suitable nesting areas before the construction of the dikes in the late 1950's would have been the sandy borders of the lagoons. Although no nesting occurred in those areas during my study, it is likely that nesting was confined to those areas prior to 1960.

Gravid females were found from 6 May to 1 July in 1977 (57 days), and from 28 April to 18 June in 1978 (52 days). *Malaclemys t. terrapin* from New Jersey had a 44 day nesting season, extending from early June to late July (Burger and Montevecchi, 1975). All nesting in Florida occurred during daylight hours, from 1040 to 1610. Although air temperatures during surveys ranged from 24.4 to 36.2 C, nesting occurred only at temperatures of 28.0 to 36.0 C ($\bar{x}$ = 31.0 ± 1.9), and 83% of all nesting occurred between 29.0 and 33.0 C. Turtles also showed a significant preference for nesting during fair weather, rather than during periods of cloudy or overcast skies (χ^2 = 5.11, d.f. = 1, $P < .05$). Other turtles, including *M. t. terrapin* (Burger and Montevecchi, 1975) and *Trionyx muticus* (Plummer, 1976) also have been found to nest primarily during fair weather.

Clutch size and reproductive potential. The mean size of 14 clutches, taken from natural nests, oviducal eggs, and X-ray examination, was 6.7 ± 1.4 (range 5–10). There was a significant positive correlation between female plastron length and clutch size (r = .53, $P < .05$). Montevecchi and Burger (1975) found a similar correlation for *M. t. terrapin*. Of eight Florida females examined for corpora lutea, two showed evidence of having laid two clutches, and one probably laid three. Multiple clutches have also been noted for *M. t. terrapin* (Hildebrand, 1932; R. Wood, pers. comm.) and *M. t. macrospilota* (D. Jackson, pers. comm.).

Eggs and hatchlings. Measurements of eggs and hatchlings are presented in Table 1. No significant correlations were found between clutch size and egg size, nor between female size and egg size. Montevecchi and Burger (1975) also found no correlation between these parameters.

Mean incubation time for five clutches incubated under temperatures of 20.0–34.0 C was 65.6 ± 5.3 days (range 60–73). Burger (1977) reported a mean incubation time of 76.2 days for *M. t. terrapin* eggs incubated under natural conditions. The lack of adequate temperature controls in this study make meaningful comparisons of these figures impossible. Of 31 eggs incubated, 29 (93.5%) hatched successfully.

Geographic variation in reproduction. Montevecchi and Burger (1975) suggested that *Malaclemys* showed considerable geographic variation in clutch size, and my data support that speculation. Available information concerning clutch size in *Malaclemys* is presented in Table 2. Clutch size varies from 9.7 eggs/clutch in New Jersey terrapins, to 6.7 eggs/clutch in *M. t. tequesta*. Similar reduction in clutch size in southern populations of

Table 1. Statistical data for 31 eggs and 29 hatchlings of *Malaclemys terrapin tequesta*. Length in cm, weight in g.

Parameter	$\bar{x} \pm$ SD	Range
Egg length	3.90 ± .13	3.61–4.08
Egg width	2.23 ± .12	1.90–2.40
Egg weight	12.48 ± .73	11.20–13.20
Carapace length	3.19 ± .15	2.88–3.40
Plastron length	2.79 ± .14	2.42–3.02
Hatchling weight	8.83 ± .15	6.00–10.80

turtles has been reported for *Sternotherus odoratus* (Tinkle, 1961), and *Chrysemys picta* (Powell, 1967; Christiansen and Moll, 1973; Moll, 1973). The significance of this trend in *Malaclemys* is in part reduced by the small number of populations examined, and by the fact that considerable variation in clutch size can occur between local populations of some species (Gibbons and Tinkle, 1969). More populations of *Malaclemys* need to be studied to confirm this trend.

Perhaps a more significant geographic trend is that for egg size (Table 3). Eggs of Florida terrapins are significantly larger in both length and weight than eggs of *M. t. terrapin* or *M. t. pileata* (t-test, $P < .01$). Florida hatchlings were also significantly larger than their northern counterparts, but since these measurements may be affected by soil moisture during incubation (Marion et al., 1979; Packard and Packard, 1980), they are not compared here. Although it is conceivable that egg size could vary as greatly between populations as does clutch size, no such variation has been reported, and in general, mean egg size appears to be fairly uniform within a subspecies (Christiansen and Moll, 1973; Iverson, 1979), although individual egg size may vary widely (Ewert, 1979).

Table 2. Comparison of clutch size and reproductive potential in various subspecies of *Malaclemys*.

Subspecies	Locality	Authority	$\bar{x}$ clutch size (range)	# of clutches	N
terrapin	New Jersey	Montevecchi and Burger (1975)	9.7 (4–18)	1	40
terrapin	Virginia	Reid (1955)	7.0 (—)	1	1
terrapin × *centrata**	N. Carolina	Hildebrand (1932)	8.0 (—)	1–5	—
*pileata**	Louisiana	Burns and Williams (1972)	8.5 (5–12)	1	11
tequesta	Florida	This study	6.7 (5–10)	1–3	14

* Captive specimens.

Table 3. Mean sizes of *Malaclemys terrapin* eggs from various parts of the range. Measurement ranges are given in parentheses.

	terrapin (I)	*terrapin* (II)	*pileata*	*tequesta*
Locality	New Jersey	Maryland	Louisiana	Florida
Authority	Montevecchi and Burger (1975)	McCauley (1945)	Burns and Williams (1972)	This study
Egg length	3.16 (2.60–3.65)	3.11 (2.85–3.50)	3.73 (3.40–4.01)	3.90 (3.61–4.08)
Egg width	1.97 (1.59–2.19)	2.12 (2.00–2.25)	2.39 (2.19–2.70)	2.23 (1.90–2.40)
Egg weight	7.7 (5.0–11.0)	—	—	12.48 (11.20–13.20)
N	336	12	95	31

It has been suggested (Tinkle, 1961; Tinkle et al., 1970; Pianka, 1970) that because of high abiotic mortality in northern climates, selection there might favor increased fecundity. In southern or tropical areas, where abiotic mortality may be less important and populations may approach the carrying capacity, selection might favor increased survivorship and competitive ability among offspring, while reducing fecundity. The apparent shift in *Malaclemys* from large clutch size/small egg size in the north, to small clutch size/large egg size in the south, appears to conform to these ideas. Moll and Legler (1971) reported similar trends in egg size in *Kinosternon*. Large egg size may result in higher offspring survivorship by providing greater food reserves during development (Moll and Legler, 1971), by decreasing incubation time and thus increasing the amount of time available for hatchling growth (Burger, 1977), and by producing a larger hatchling which may be less vulnerable to some predators (Moll and Legler, 1971). Higher survivorship among larger offspring has been reported for some lizards (Derickson, 1976; Ferguson and Bohler, 1978) and for one turtle (Swingland and Coe, 1979).

Moll (1979) suggested that reproductive strategies in turtles may be divided into two types: Type I—large clutches of small eggs laid in a well-defined area and nesting season; Type II—small clutches of large eggs laid continuously and apparently at random. Type I is characteristic of temperate species, while Type II is more characteristic of tropical areas. Considerable overlap may occur however, so the above dichotomy is not complete. Moll also suggested that the Type II pattern may result in increased survivorship of offspring while sacrificing fecundity, the opposite of the Type I pattern. Florida *Malaclemys* may be intermediate between the two types, laying small clutches of relatively large eggs in a well-defined area, and in a definite, if elongated nesting season. It is possible that this strategy represents an adaptation to the subtropical environment of *M. t. tequesta*.

ACKNOWLEDGMENTS

For help with the fieldwork, I thank E. Scott Clark, Timothy R. Claybaugh, John D. Galluzzo, Mary T. Mendonca, and Sherry E. Wiliams. Dale Jackson discussed the use of oxytocin, and helped examine specimens for corpora lutea. I thank J. Whitfield Gibbons for advice on the use of X-rays, and Jo Guren and Alan Bosemany for use of hospital equipment. Jeffrey D. Wetherington helped with the statistical analysis. The U.S. Fish and Wildlife Service made field sites available, and provided logistical support. Various drafts of this manuscript were improved by the critical reviews of William E. Duellman, Henry S. Fitch, Mary T. Mendonca, Peter C. H. Pritchard, Michael Ryan, I. Jack Stout, and Roger C. Wood. My wife, Nadia, was a constant help, both in the field and during preparation of the manuscript. I particularly thank the late James D. Anderson for advice and encouragement. This research was supported by NASA Contract NAS10-8986, to L. M. Ehrhart, who made financial support available.

LITERATURE CITED

Burger, J. 1976a. Behavior of hatchling diamondback terrapins (*Malaclemys terrapin*) in the field. Copeia 1976:742–748.

Burger, J. 1976b. Temperature relationships in nests of the diamondback terrapin, *Malaclemys terrapin terrapin*. Herpetologica 32:412–418.

Burger, J. 1977. Determinants of hatching success in diamondback terrapin, *Malaclemys terrapin*. Amer. Midl. Natur. 97:444–464.

Burger, J., and W. A. Montevecchi. 1975. Nest site selection in the terrapin *Malaclemys terrapin*. Copeia 1975:113–119.

Burnley, J. M. 1969. Diamondback terrapin. Int. Turtle and Tortoise Soc. J. 3:32–34.

Burns, T., and K. Williams. 1972. Notes on the reproductive habits of *Malaclemys terrapin pileata*. J. Herpetol. 6:238–239.

Carr, A. F. 1952. Handbook of turtles. Comstock Publ. Assoc. Ithaca, New York.

Christiansen, J. L., and E. O. Moll. 1973. Latitudinal reproductive variation within a single subspecies of painted turtle, *Chrysemys picta bellii*. Herpetologica 29:152–163.

Derickson, W. K. 1976. Ecological and physiological aspects of reproductive strategies in two lizards. Ecology 57:445–458.

Ewert, M. A. 1979. The embryo and its egg: development and natural history. *in* Turtles, Perspectives and Research, M. Harless and H. Morlock, eds. p. 333–413.

Ferguson, G. W., and C. H. Bohlen. 1978. Demographic analysis: a tool for the study of natural selection of behavioral traits. *in* Behavior and Neurobiology of Lizards, N. Greenburg and P. D. MacLean, eds. p. 227–243.

Finneran, L. C. 1948. Diamondback terrapin in Connecticut. Copeia 1948:138.

Gibbons, J. W., and D. W. Tinkle. 1969. Reproductive variation between turtle populations in a single geographic area. Ecology 50:340–341.

Gibbons, J. W., and J. L. Greene. 1979. X-ray photography: a mechanism to determine reproductive patterns in freshwater turtles. Herpetologica 35:86–89.

Hildebrand, S. F. 1929. Review of experiments on artificial culture of diamondback terrapin. Bull. U.S. Bur. Fish. 45:25–70.

Hildebrand, S. F. 1932. Growth of diamondback terrapins: size attained, sex ratio and longevity. Zoologica 9:551–563.

Iverson, J. B. 1979. Reproduction and growth of the mud turtle, *Kinosternon subrubrum* (Reptilia: Testudines: Kinosternidae), in Arkansas. J. Herpetol. 13:105–111.

Marion, K. R., J. B. Bizer, and O. J. Sexton. 1979. A between-clutch comparison of hatchling weights of the lizard *Sceloporus undulatus* (Reptilia: Squamata: Lacertilia). Herpetologica 35:111–114.

McCauley, R. H. 1945. The reptiles of Maryland and the District of Columbia. Privately printed, Hagerstown, Maryland.

Moll, E. O. 1973. Latitudinal and interspecific variation in reproduction of the painted turtle, *Chrysemys picta*. Herpetologica 29:307–318.

Moll, E. O. 1979. Reproductive cycles and adaptations. *in* Turtles, Perspectives and Research, M. Harless and H. Morlock, eds., p. 305–331.

Moll, E. O., and J. M. Legler. 1971. The life history of a neotropical slider, *Pseudemys scripta* (Schoepff), in Panama. Bull. Los Angeles Co. Mus. Nat. Hist. Sci. 11:1–102.

Montevecchi, W. A., and J. Burger. 1975. Aspects of the reproductive biology of the northern diamondback terrapin *Malaclemys terrapin terrapin*. Amer. Midl. Natur. 104:592–597.

Packard, G. C., and M. J. Packard. 1980. Evolution of the cleidoic egg among reptilian antecedents of birds. Amer. Zool. 20:351–362.

Pianka, E. R. 1970. On r and K selection. Amer. Natur. 104:592–597.

Plummer, M. V. 1976. Some aspects of the nesting success in the turtle, *Trionyx muticus*. Herpetologica 32:353–359.

Powell, C. B. 1967. Female sexual cycles of *Chrysemys picta* and *Clemmys insculpta* in Nova Scotia. Can. Field. Natur. 81:134–140.

Reid, G. K. 1955. Reproduction and development in the diamondback terrapin, *Malaclemys terrapin terrapin*. Copeia 1955:310–311.

Seigel, R. A. 1978. Simultaneous mortality in the diamondback terrapin, *Malaclemys terrapin tequesta* (Schwartz). Bull. N.Y. Herpetol. Soc. 14:31–32.

Seigel, R. A. 1979. The reproductive biology of the diamondback terrapin, *Malaclemys terrapin tequesta*. Master's thesis, University of Central Florida, Orlando. 40 pp.

Seigel, R. A. 1980a. Predation by raccoons on diamondback terrapins, *Malaclemys terrapin tequesta*. J. Herpetol. 14:87–89.

Seigel, R. A. 1980b. Courtship and mating behavior of the diamondback terrapin, *Malaclemys terrapin tequesta*. J. Herpetol. in press.

Swingland, I. R., and M. J. Coe. 1979. The natural regulation of giant tortoise populations on Aldabra Atoll: Recruitment. Philos. Trans. R. Soc. London Ser. B 286:177–188.

Tinkle, D. W. 1961. Geographic variation in reproduction, size, sex ratio, and maturity of *Sternothaerus odoratus* (Testudinata, Chelydridae). Ecology 42:68–76.

Tinkle, D. W., H. M. Wilbur, and S. G. Tilley. 1970. Evolutionary strategies in lizard reproduction. Evolution 24:55–74.