Review of Radio Transmitter Attachment Techniques for Turtle Research and Recommendations for Improvement

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Abstract-*How* a radio, sonic, or satellite transmitter is attached to a turtle or tortoise may affect the transmitter's transmission range and the animal's behavior, survival, and reproductive success. We reviewed 113 scientific papers, reports, and semi-technical articles reporting on radio-tracking projects with turtles and conclude that little information is avail- able in the literature to evaluate the effects of transmitters on the study animals. We also provide step-by-step directions on a successful method we used to attach transmitters to desert tortoises *(Gopherus agassizii)* that minirnizes potential of affecting the animal's behavior, physiology, reproduction, or survival while maximizing distance of transmission. We believe this method can be used on many other species of turtles and tortoises.

Biotelemetry has become indispensable for studying turtle migration, dispersal, home range, habitat use, physiology, and the effectiveness of relocation efforts. The most common types of telemeters used on turtles are radio, sonic, and satellite transmitters, which each have advantages depending on the specific applications. An important consideration for using radio transn-dtters and D marking techniques is assuring they do not affect significantly the behavior, physiology, reproductive success, and survival of the animals (Anonymous 1987; Brander and Cochran 1969; Ireland and Kanwisher 1978; Kaufmann 1992a; Renaud et al. 1993b; Schubauer 1981; Schwartzman and Ohmart 1977). Therefore, non-invasive methods of transmitter attachment must be developed and tested (Anonymous 1987). Furthermore, as there are tradeoffs between transmitter weight, transmitter longevity, and transmission range (Brander and Cochran 1969; MacDonald and Amlaner 1980), transmitter attachment methods should be developed to optimize performance to meet study objectives.

We reviewed 113 published and unpublished accounts of the use of radio, sonic, and satellite tracking of turtles to determine the attachment methods used and to identify problems for the study animals caused by the transmitters. We also outline the method we have used for five years to attach transmitters to desert tor- toises *(Gopherus agassizii)* without causing physical harm to the study animals, while maxin-dzing transn-dtter longevity and range. This method can be used for multi-year applications with other species of turtles.

Review of Transmitter Attachment Methods and Their Problems.-*In* the 113 publications, articles, and reports we reviewed, radio transmitters, which consist of three major components (body of transmitter, battery, and antenna), were attached externally to the carapace of turtles by several means: cemented on with epoxy, silicone sealant, dental acrylic, or some other adhesive; strapped on with harnesses; or attached via bolts, wire, cable or nylon ties, or monofilament line passed through holes drilled in the carapace, usually through the posterior carapace or marginal scutes (Table 1). These methods were used to attach either the transmitter and battery directly to the carapace or to allow the transmitter to trail loosely behind the animal.

Some less conventional modes of attachment were used. In one instance, transmitters were sewn onto the carapace of soft-shelled turtles (Plummer and Shirer 1975). Transmitters also were attached with some success using black plastic electrical tape (Eckler et al. 1990; Moll and Legler 1971). Whereas implantation is the norm in snakes (Fitch and Shirer 197 1; but see Ikeda et al. 1979), it has been rarely employed in turtles (Table 1). Many authors (23%) did not mention how or where transmitters were attached, mak- ing it difficult to evaluate the potential effect of the transmitter on the animals, and hence the possible limitations on interpreting study results.

Problems caused by transmitters are well documented for birds and mammals (Kenward 1987; White and Garrott 1990), but are poorly known for turtles. We know of only three limited studies designed in part to test the effects of different transmitters or attachment methods on turtles. Tirnko and Kolz (1982) estimated that a satellite transmitter caused a captive loggerhead turtle to spend twice as much time on the water surface, but concluded the transmitter caused no "radical" change in behavior. However, their sample size was one, and no control was reported. Kenunerer et al. (1983) found that after equipping 20 loggerhead turtles with transmitters, the turtles spent more time on the surface during the first 3 days than the following 17 days of study. Beavers et al. (1992) found three different adhesive attachment methods had no effect on loggerhead turtle behavior, but their sample size was one per method and they made no mention of methods or criteria.

We located six papers reporting problems observed during the course of field studies with turtles. Keinath and Musick (1993) reported the transmitter and harness cemented to a leatherback *turtle (Dermochelys coriacea)* were bitten by a tiger shark *(Galeocerdo cuvieri),* the resultant damage causing the harness to chafe the turtle's skin. Equipment poorly attached to harnesses slapped against and severely damaged the carapaces of leatherback turtles (Eckert and Eckert 1986). Implanting transmitters into the oviducts of northern long-necked turtles *(Chelodina rugosa)* caused oviducal adhesion in at least two turtles, reducing reproductive output in the year studied, and the surgical procedure resulted in the death of one turtle (Kennett et al. 1993). The act of attaching transmitters may have caused up to 55% of fernale yellow mud turtles *(Kinosternonflavescens)* to move to new nesting locations (Iverson 1990); the transmitter attachment method was not noted, however. Brill et al. (1995) found submergence behavior of green turtles *(Chelonia mydas)* was affected for up to three hours after they attached transmitters to the rear marginals of the carapace by inserting nylon straps (tie-wraps) through drilled holes. Some shell deformation occurred in hatchling gopher tortoises *(Gopherus Polyphemus)* because epoxy holding on the transmitters encroached growth areas between scutes (Butler et al. 1995). On the other hand, Hopkins and Murphy (I 98 1) reported no damage to carapace or flippers from transmit- ters on 37 loggerhead turtles.

Although not published, other problems have occurred. For instance, J. Congdon (pers. comm.) found transmitters placed on the carapaces of painted turtles *(Chrysemys picta)* became entangled in filamentous algae preventing the turtles from diving. C. K. Dodd, Jr. (pers. comm.), has made similar observations on common mud turtles *(Kinosternon subrubrum).* H. Avery (pers. comm.) observed female desert tortoises impeded by transmit- ters, which were mounted on the anterior carapace, that got hooked by stems of desert shrubs. We found one desert tortoise shell that became deformed because normal shell growth was inhibited by a transmitter antenna that was attached improperly for one year. Similar results from desert tortoises were reported by K. Berry (pers. comm.) and A. Karl (pers. comm.). Such deformation is most likely to occur in animals that experience relatively rapid growth during the course of study (e.g., juveniles or animals equipped for several years). Although unreported, drilling holes into the shell and underlying bone may lead to potentially harin- ful infection, and this effect may not be observable until some- time after the transmitters have been removed (B. Homer, pers. comm.). Bertram (1979) did comment on the absence of any wounds after removing a transmitter that had been bolted onto the carapace of a hingeback tortoise *(Kinixys belliana)* two years earlier.

Transmitters may attract the attention of predators (Keinath and Musick 1993; cf. Renaud et al. 1993b) or people (Stoneburner 1982). To reduce the potential for such effects, transmitters should be camouflaged in some way. For instance, Dizon and Balazs (1982) covered their transmitters with roofing tar and sand be- fore attaching to Hawaiian green turtles *(Chelonia mydas).* Schwartzman and Ohmart (I 977) mixed neutral color compounds to the epoxy or painted the dried epoxy after attachment to desert tortoises. Satellite transmitters placed on sea turtles are routinely painted black (C. K. Dodd, Jr., pers. comm.).

Authors occasionally mention transmitter failures, problems, or malfunctions (Table 1), but rarely are the causes known, mentioned, or hypothesized. We found several accounts in the lit6rature of the loss of transmitters. Stonebumer (1982) laments the theft of seven out of eight buoy transmitters attached to logger- head turtles *(Caretta caretta).* Timko and DeBlanc (I 98 1) lost 4 of 22 transmitters and Tiniko and Kolz (I 982) lost their only trans- mitter when the linen lanyard used to attach floating transmitters to Kemp's ridley turtles and a loggerhead turtle became abrade and parted (see also Renaud et al. 1992; Renaud et al. 1993b; Renaud and Carpenter 1994; Schubauer 198 1). After being in place for five months, the verticahy-protruding antenna broke off a transmitter attached to a hingeback tortoise *(Kinixys belliana,* Bertram 1979). In one study of the desert tortoise, 9% of transmitters (10 of I I 1) fell off the animals over four years (EG&G 1993).

Attaching Transmitters to Desert Tortoises.-For nearly two decades, researchers have been attaching transmitters to the carapaces of desert and gopher tortoises with epoxy cement (for example, see Schwartzman and Ohmart 1977). We modified the methods used by Schwartzman and Ohmart (1977), Mike Cor- nish (pers. comm.), Charles Peterson (pers. comm.), and others to attach radio transmitters securely to desert tortoises apparently without causing shell deformation, predator attraction, mating disruption, or transmitter loss, while also yielding greater trans- mitter range. We present the following step-by-step description of the protocol we used so that the method can be adapted to other species of turtles and tortoises.

We used three different types of transmitters depending on the size of the tortoise. Two-stage battery-powered transmitters (AVM Instruments SB-2*), weighing 35 g, were attached 108 times to 43 tortoises (171-296 mm midline carapace length [MCL], 1075- 5200 g). One-stage battery-powered transmitters (AVM Instru- ments SM- I H), which are smaller (26 g) and weaker, were attached 24 times to 14 tortoises between 146 and 239 mm MCL (800-3150 g).

One-stage solar-assisted transmitters (AVM Instruments SM-1H-solar), weighing 4.2 g, were attached 41 times to 21 immature and subadult tortoises between 97 and 207 nun MCL (220-1800 g). Whip antennas on the larger two transn-dtters ranged from 280 to 320 mm in length and were made of 20 gauge, insulated, stranded wire. The whip antennas for the solar transmitters were 150 mm long and made of single 24 gauge, insulated, stranded wire.

We used the following step-wise procedure to attach the non-solar assisted transmitters to 57 desert tortoises (Fig. la):

1. We tested the transmitter to confirm that it worked.
2. All dirt was brushed off of the carapace.
3. We pre-positioned the transmitters to the first left or first right costal scute of the tortoise's carapace, as flush to the carapace as possible.
4. To position the antenna, we cut short sections of flexible 3 mm plastic tubing, and epoxied each section to the first four vertebral scutes (see also Butler et al. 1995). Each section was cut slightly shorter than its associated scute. Super glue was used to hold each section of tubing in place while we applied a quick drying, pli- able putty epoxy (Power Poxy Adhesives, Inc., Power Poxy® #40001 *) over each section of tubing in a continuous layer from the scute surface on one side of the tube to the scute surface on the opposite side of the tube. We were cautious not to get any epoxy on the scute sutures or on neighboring scutes.
5. We ran the antenna through the tube sections leaving approximately 50-120 mm of antenna hanging loose beyond the posterior of the animal.
6. The transmitter was then attached with putty epoxy, using care not to bridge the scute margins. Spaces between the transmitter and carapace were filled in with epoxy to prevent the transmitter from getting caught in vegetation.
7. Both the transmitter and the putty epoxy were painted with a flat colored, lead-free paint to reduce reflectivity and contrast.
8. Finally, the transmitter was checked again for proper operation and the tortoise was released immediately.

The entire procedure takes approximately 15 min. The transmitters were removed about every two years for battery replacement by cutting through the epoxy with a pocket knife, a simple process that took less than 10 min.

Using similar procedures, solar-assisted transmitters were attached to the fifth vertebral scutes of 21 tortoises using putty ep- oxy, but the antenna was left loose. We did not use any tubing to attach the antenna to the tortoise. Some transmitters were attached with the antenna oriented vertically and others horizontally.

To simplify and expedite transmitter removal during future scheduled battery replacement, we initially attached a brass base plate with Devcon® Five-Minute Epoxy®* to the carapace, then attached the transmitter to a metal post on the plate. Transmitters attached in this manner became detached 22 times between day 1 and 26 months later. No additional losses were experienced after eliminating use of the brass plate (i.e., using the methods described above).

For the first two years, we attached the antenna to the marginals, partially encircling the animal. Later, we began attaching the trans- mitter to the first right or left costal, as described above, which facilitated placement of the antenna over the vertebral scutes and letting the distal 50-120 mm of antenna trail behind the tortoise. This improvement increased transmission range by approximately 2O% (pers. obs.). Diverting the antenna down to the last one or two costal scutes on females would keep it from possibly inter- fering with copulation, although we have observed unimpeded copulations with the antenna attached to all vertebral scutes. Leaving antennas loose on solar-assisted transmitters caused antennas to break 19 times, but was necessary to maximize the range of these weaker transmitters. Vertical orientation of antennas also resulted in greater range compared to horizontal orientation, but made the antenna more vulnerable to breakage. To reduce the breakage problem, a smaller, more resilient gauge antenna was used and the base of each antenna was enclosed in a small spring.

Placed on the vertebrals, the tubing allowed the antenna to be pulled through the tubes as the tortoise grew, thus preventing shell deformation. We have attached antennas in this manner to 57 tor-

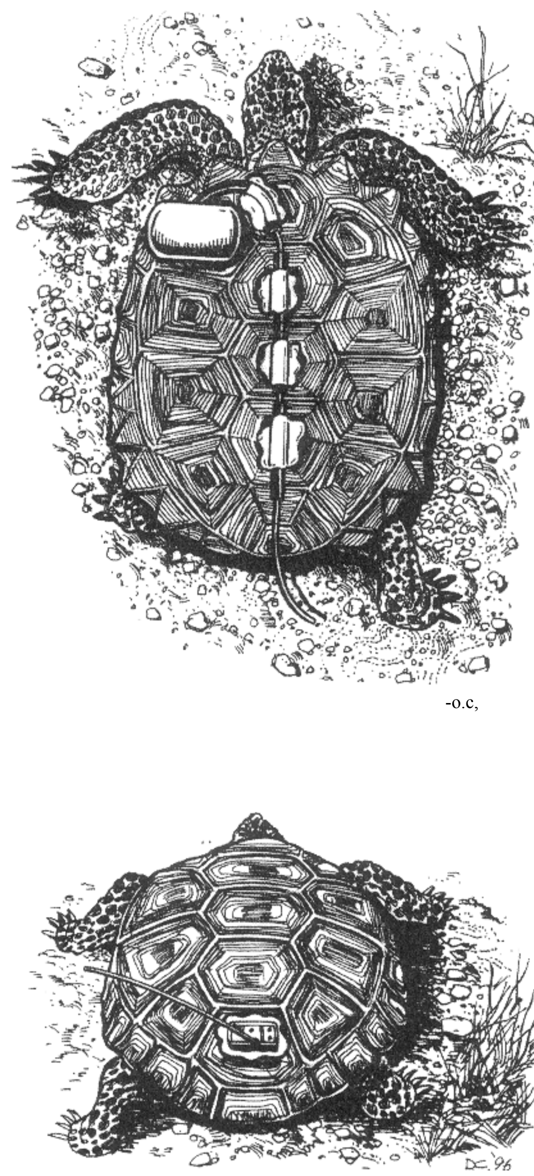

FIG. 1. Drawing showing how we attached radio transmitters to the carapaces of desert tortoises: (a) larger battery-powered transmitters were attached to tortoises larger than 146 mm (midline carapace length; 800 g) and (b) smaller solar-assisted transmitters were attached to immature and subadult tortoises between 97 and 207 *m*m (220-1 800 g).

TABLE 1. Methods of transmitter attachments in chelonians. Methods are categorized as one of the following classifications: "adhesive" (transmit- ter was attached to the shell of the turtle with glue, epoxy, dental acrylic, or fiberglass), "harness" (transmitter was strapped around the shell without otherwise disturbing the shell), "hole in shell" (holes were drilled, screwed, or punched through the shell, and bolts, string, wire or other filament was strung through the holefs] to attach the transmitter), "implantation" (transmitters were surgically implanted within the body), "tape" (transmitter was attached with electrical tape), "sewn" (the transmitter was sewn into the shell of a soft shell turtle), or "not mentioned" (method was not evident). Papers that reported on problems are indicated by superscripts. An "*" notes data on effect of the transmitter on the health, development, behavior, or ecology of the turtle. A "+" denotes problems with transmitters failing off or otherwise being lost from the turtle. A "t" notes a non-specified problem with transmitter use on a turtle.

Method	Species	Source
adhesive	*Caretta caretta*	Beavers et al. 1992; Hays et al. 1991; Renaud et al. 1992+; Renaud and Car- penter 1994
	Chelonia mydas	Renaud et al. 1992+; Renaud et al. 1993b+
	Chelydra serpentine	Ireland and Kanwisher 1978
	Clemmys guttata	Lovich 1990, pers. comm.
	Clemmys mar?norata	Rathbun et al. 1992
	Clemmys muhlenbergii	F-ckler et al. 1990t; Larson 1984; Lovich et al. 1992, pers. comm.
	Dermochelys coriacea	Standora et al. 1984t
	Gopherus agassizii	Barrett 1990; Bulova 1994; Burge 1977b-, Esque 1994; Goldsmith and Shaw 1994; Martin 1995; O'Connor et al. 1994a, b; Peterson 1993; Schwartzman and Ohmart 1977; Stewart 1993; Turner et al.
	Gopherus flavomarginatus	1984; Zimmerman et al. 1994 Tom 1994
	GopheruspPolyphemus	Butler et al. 1995*; Diemer and Moler 1982; Diemer 1992t; Smith 1995; Wilson et al. 1994
	Lepidochelys kempii	Renaud et al. 1993a
	L.epidochelys olivacea	Beavers and Cassano 1996; Plotkin et al. 1995, 1996
	Sternotherus depressus	Dodd et al. 1988
	Terrapene carolina	Madden 1975+
	Terrapene omata	Nieuwolt 1993
	Trachemys scripta	Moll 1994, pers. comm.
	Testudo kleinmanni	Geffen and Mendelsson 1988t, 1989
	generic	Belzer and Reese 1995
hamess	*Caretta caretta*	Stonebumer 1982+
	Chelonia mydas	Ireland 1980; Standora et al. 1982
	Dermochelys coriacea	Duron-Dufrenne 1987; Eckert and Eckert 1986*; Eckert et al. 1986; Keinath and Musick 1993*
hole in shell	*Lepidochelys kempii*	Byles 1989*+
	Caretta caretta	Byles and Dodd 1989+; Hopkins and Murphy 198 1 *; Keinath et al. 1989*+, Kemmerer et al. 1983; Standora et al. 1982; Renaud and Carpenter 1994; Wibbels et al. 1990t; Yano and Tanaka 199 It
	Chelonia mydas	Baldwin 1973; Brill et al. 1995*; Dizon and Balazs 1982; Mendonqa 1983; Ogden et al. 1983f
	Chelydra serpentine	Froese 1974; Galbraith et al. 1987t; Ireland and Kanwisher 1978; Brown and Brooks 1991; Brown et al. 1990; Obbard and Brooks
	Chrysemys picta	1981
	Clemmys insculpta	Taylor and Nol 1989; Christens and Bider 1987t
	Emydoidea blandingii	Kaufmann 1995, 1992a, b
	Gopherus pokvphernus	Ross and Anderson 1990; Rowe and Moll 1991 t
	Kinixys belliana	Diemer 1992t
	Lepidochelys kempt .i.	Bertram 1979+
	Macroclemys temminckii	Byles 1989*+; Tiniko and DeBlanc 198 1 +
	Pseudemys concinna	Harrel et al. 1996; Sloan and Taylor 1987
	Terrapene ornata	Buhimann and Vaughan 1991
	Trachemys scripta	Doroff and Keith 1990; Eliner and Karasov 1993; Legier 1971
	generic	Florence 1975t; Moll and Legier 197 It; Schubauer et al. 1990
implantation	*Chelonia rugosa*	Schubauer 1981
	Geochelone gigantea	Kennett et al. 1993*t
	Gopherusflavomarginatus	Swingland and Frazier 1980
sewn tape	*Apalone mutica*	Aguirre et al. 1984
	Clemmvs muhlenbergii	Plummer and Shirer 1975
	Trachemvs scri.pta	Eckler et al. 1990
not mentioned	*Batagur baska*	Moll and Legier 197 I t
	Caretta came	Moll 1980
	Clielonia mvdas	Soma and Ichihara 1977; Soma 1985; Timko and Kolz 1982+
	Chelydra serpentine	Ireland 1979; Carr 1967
		Ultsch and Lee 1983

TABLE 1. cont'd

Method	Species	Source
not mentioned	*Gopherus agassizii*	Berry 1974; Burge 1977a; Christopher et al. 1993; DeFalco 1995; EG&G 1993*+; Henen 1994; Jennings 1993; Turner et. al. 1987, 1986; Wallis et al. 1992
	Gopherus potyphei-nus	McRae et al. 1981
	Kinosternonflavescens	Iverson 1990*
	Kinosternon subrubum	Burke et al. 1994
	Mauremysjaponica	Yabe 1992
	Pseudemydura umbrina	Fullagarl967
	Terrapene carolina triunguis	Kiester et al. 1982; Schwartz et al. 1984
	Testudo hermanni	Swingland et al. 1986

toises for up to five years, and have observed only ond shell that became slightly deformed when the widened distal end of the antenna failed to slide through the tubing. We now use antennas with continuous surfaces rather than ones with additional insula- tion at their ends.

Attachment to the first right or left costal prevented the transmitter from interfering with mating when males mounted females. We did not measure the effect of transmitters on tortoise behav- ior, but did observe several instances of males mounting females unobstructed by the transmitter and two transmittered animals successfully righting themselves after falling on their carapace.

Attaching the transmitter to the first right or left costal scute generally resulted in a fairly flush alignment with the top of the carapace, thus minimizing problems that could occur when tortoises with transmitters turn around inside their burrows. Three of our transmittered animals were found stuck in collapsed burrows following an unusually rainy winter, but we were unable to determine if the transmitters contributed to burrow collapse or tortoise entombment. None of three known mortalities of our transmittered animals were attributed to the presence of the trans- mitter (one was a road kill, one probably died from a respiratory disease, and one died of unknown causes).

Discussion.-Based on five years of observation, the method described herein successfully reduced loss of transmitters, increased transmission range, and prevented deformation of the shells, while minimally altering the animals'behavior. However, experiments designed explicitly to measure transmitter effect were not conducted.

Transmitter design is a three-way compromise between battery size, longevity, and transmission range (Brander and Cochran 1969; Macdonald and Amlaner 1980; Mech 1983). We found an- tenna orientation to affect transmission range. We found that trans- mission range was increased by allowing the antenna to lie across the top of the carapace. This orientation likely reduced nulls in the transmission signal caused by an open loop and reduced slightly ground attenuation (Mech 1983).

Allowing the transmitter and/or antenna to bind together two or more scutes may cause deformation of the shell as the animal grows. If the antennas were attached directly to the shell with epoxy, they would connect several scutes together for as long as the transmitter was attached; which may be the life of the animal if the animal becomes lost with the transmitter still attached. This would be particularly critical in rapidly growing turtles (e.g., hatchlings and juveniles). Although undocumented, shell defor- mations could be hazardous if they impede normal behavior or damage underlying tissues (B. Homer, pers. comm.).

We found that our transmittered tortoises were still able to mate apparently unimpeded by the transmitter and were able to successfully right themselves if tipped over during mating or aggression. Eckler et al. (1990) also observed the behavioral effect of attaching transmitters to 45 bog turtles *(Clemmys muhlenbergii),* and reported seeing successful foraging, mating, and nesting. They epoxied the transmitters to the fourth costal scute and attached the antennae directly to the carapace.

The method chosen for attaching radio transn-titters depends on the size, behavior, potential future growth, and catchability of the species, as well as characteristics of the environment and the principal study objectives (e.g., length of study, type of data desired). It is essential that the transmitter not affect significantly the behavior, survival, or reproductive success of the study animals. Therefore, for relatively long-term applications (the length of time depends on the animal's growth rate, which depends in part on the animal's age), attachment should avoid causing shelf deformation. Studies should be conducted to evaluate the effect that transmitters and their attachment methods have on turtles and tortoises with the results reported in the literature. Furthermore, stud- ies usinc, radio transmitters should provide sufficient detail on attachment methods to allow readers to evaluate the potential ef- fect the transmitters may have on the animals and the study's re- sults.

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LITERATURE CITED

AGUIRRE, G., G. A. ADEST, AND D. J. MORAFKA. 1984. Home range and movement patterns of the bolson tortoise, *Gopherusfiavomarginatus.* Acta Zool. Mex. 1: 1-28.

ANONYMOUS. 1987. Guidelines for use of live amphibians and reptiles in field research. American Society of Ichthyologists and Herpetologists, The Herpetologists'League, and Society for the Study of Amphibians and Reptiles. 14 pp.

BALDWIN, H. A. 1973. Long-range radio tracking of sea turtles and polar bear-instmmentation and preliminary results. NASA Sp. 262:19-37,

BARRETT, S. L. 1990. Home range and habitat of the desert tortoise *(Xerobates agassizii)* in the Picacho Mountains of Arizona. Herpeto- logica 46:202-206.

BEAVERS, S. C., AND E. R. CASSANO. 1996. Movements and dive behavior of a male sea turtle *(Lepidochelys olivacea)* in the eastern tropical Pacific. J. Herpetol. 30:97-104.

——, ——, AND R. A. BYLES. 1992. Stuck on turtles: preliminary re,ul;s from adhesive studies with satellite transmitters. In M. Salmon and J. Wyneken (eds.), Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation, pp. 135-138. NOAA Tech- nical Memo. NMFS-SEFSC-302. National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, Florida.

BELZER, W. R., AND D. A. REESE. 1995. Radio transmitter attachment for turtle telemetry. Herpetol. Rev. 26:191-192.

BERRY, K. H. 1974. Desert tortoise relocation project: Status report for 1972. U.S. Department of the Interior, Bureau of Land Management, Ridgecrest, California. v + 104 pp.

BERTRAM, B. C. 1979. Home range of a hingeback tortoise in the Serengeti. Afr. J. Ecol. 17:241-244.

BRANDER, R. B., AND W. W. COCHRAN. 1969. Radio-location telemetry. In R. H. Giles (ed.), Wildlife Management Techniques, pp. 95-103. The Wildlife Society, Washington, D.C.

BRILL, R. W., G. H. BALAZS, K. N. HOLLAND, R. K. C. CHANG, S. SULLI-VAN, AND J. C. GEORGE. 1995. Daily movements, habitat use, and sub-mergence intervals of normal and tumor-bearing juvenile green turtles *(Chelonia mydas* L.) within a foraging area in the Hawaiian islands. J. Exp. Mar. Biol. Ecol. 185:203-218.

BROWN, G. P., AND R. J. BROOKS. 199 1. Thermal and behavioral responses to feeding in free-ranging turtles, *Chelydra serpentine.* J. Herpetol. 25:273-278.

——, ——, AND J. A. LAYFIELD. 1990. Radiotelemetry of body tem-peratures of free-ranging snapping turtles *(Chelydra serpentine) dur*- ing summer. Can. J. Zool. 68:1659-1663.

BUHLMANN, K. A., AND M. R. VAUCHAN. 1991.ECOlOgy Of the turtle Pseud*emys concinna* in the New River, West Virginia (USA). J. Herpetol. 25:72-78.

BULOVA, S. J. 1994. Patterns of burrow use by desert tortoises: gender differences and seasonal trends. Herp. Monogr. 8:133-143.

BURGE, B. L. 1977a. Daily and seasonal behavior, and areas utilized by the desert tortoise *Gopherus agassizii* in southern Nevada. Proc. Desert Tortoise Council Symp. 1977:59-94.

——. 1977b. Movements and behavior of the desert tortoise, *Gopherus agassizii.* Masters thesis, Univ. Nevada, Las Vegas, Nevada.

BURKE, V. J., J. W. GIBBONS, AND J. L. GREENE. 1994. Prolonged nesting forays by common mud turtles *(Kinosternon subrubrum).* Am. Midl. Nat. 131(l):190-195.

BUTLER, J. A., R. D. BOWMAN, T. W. HULL, AND S. SOWELL. 1995. Move-ments and home range of hatchling and yearling gopher tortoises, *Gopherus Polyphemus.* Chel. Conserv. Biol. 1(3):173-180.

BYLES, R. A. 1989. Satellite telemetry of Kemp's ridley turtle, *Lepido- chelys kempi,* in the Gulf of Mexico. In S. A. Eckert, K. L. Eckert, and T. H. Richardson (eds.), Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology, pp. 25-26. NOAA Technical Memorandum NMFS-SEFC-232.

——,, AND C. K. DODD. 1989. Satellite biotelemetry of a loggerhead sea turtle *(Caretta came)* from the east coast of Florida. In S. A. Eckert, K. L. Eckert, and T. H. Richardson (eds.), Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology, pp. 215-217. NOAA Technical Memorandum NMFS-SEFC-232.

CARR, A. 1967. Caribbean green turtle: imperiled gift of the sea. Nat. Geogr. Mag. 131:876-890.

CHRISTENS, E., AND J. R. BIDER. 1987. Nesting activity and hatching suc-cess of the painted turtle *(Chrysemys picta marginate)* in southwest- em Quebec (Canada). Herpetologica 43:55-65.

CHRISTOPHER, M. M., 1. WALLIS, K. A. NAGY, B. HENEN, C. C. PETER-SON, C. MEIENBERGER, 1. GIRARD, AND J. K. KLAASSEN. 1993. Laboratory health profiles of free-ranging desert tortoises in California: In-terpretation of physiologic and pathologic alterations (October 1990- October 1991). University of Florida, Gainesville, Florida. 137 pp. + app.

DEFALCO, L. A. 1995. Influence of cryptobiotic crusts on winter annuals and foraging movements of the desert tortoise. Masters thesis, Colo- rado State Univ., Fort Collins, Colorado.

DIEMER, J. E. 1992. Home range and movements of the tortoise *Gopherus Polyphemus* in northern Florida. S. Herpetol. 26:158-165.

——,, AND P. E. MOLER. 1982. Gopher tortoise response to site prepara- tion in northern Florida. Proc. Ann. Conf. Southeast. Assoc. Fish Wildl. Agencies 36:634-637.

DIZON, A. E., AND G. H. BALAZS. 1982. Radio telemetry of Hawaiian green turtles at their breeding colony. Mar. Fish. Rev. 44(5):13-20.

DODD, C. K., JR., K. M. ENGE, AND J. N. STUART. 1988. Aspects of the biology of the flattened musk turtle, *Sternotherus depressus,* in north- ern Alabama. Bull. Florida State Mus. Biol. Sci. 34(l):1-64.

DOROFF, A. M., AND L. B. KEITH. 1990. Demography and ecology of an omate box turtle *(Terrapene ornata)* population in south-central Wis- consin (USA). Copeia 1990:387-399.

DURON-DUFRENNE, M. 1987. Premier suivi par satellite en Atlantique d'une tortue Luth *Dermochelys coriacea.* Compt. Rend. Seanc. L:Academ. Scienc. 15:399-402.

ECKERT, S. A., AND K. L. ECKERT. 1986. Harnessing leatherbacks. Marine Turtle Newsl. 37:1-3.

——, D. W. NELLIS, K. L. ECKERT, AND G. L. KOOYMAN. 1986. Diving patterns of two leatherback sea turtles *(Dennochelys coriacea)* during interesting intervals at Sandy Point, St. Croix, U.S. Virgin Islands. Herpetologica 42:381-388.

ECKLER, J. T, A. R. BREISCH, AND J. L. BEHLER. 1990. Radio telemetry techniques applied to the bog turtle *(Clemmys muhlenbergii* Schoepff 1801). *In* R. S. Mitchell, C. J. Sheviak, and D. J. Leopold (eds.), Eco- system Management: Rare Species and Significant Habitats, pp. 69- 70. New York State Museum, Albany, New York.

EG&G. 1993. Yucca Mountain: biological resources monitoring program. Annual report FY92. EG&G Energy Measurements, Inc., Santa Bar- bara Operations, Goleta, California. viii + 77 pp.

ELLNER, L. R., AND W. H. KARAsov. 1993. Latitudinal variation in the thermal biology of omate box turtles. Copeia 1993:447-455.

ESQUE, T. C. 1994. Diet and diet selection of the desert tortoise (Go- *pherus agassizii)* in the northeast Mojave Desert. Masters thesis, Colo- rado State Univ., Fort Collins, Colorado. xx + 243 pp.

FITCH, H. S., AND H. W. SHIRER. 1971. A radiotelemetric study of spatial relationships in some common snakes. Copeia 1971:118-128.

FLORENCE, T. H., JR. 1975. A telemetric study of the activity of the red- eared turtle, *Chrysemys scripta elegans.* Masters thesis, Middle Ten- nessee State Univ., Tennessee.

FROESE, A. D. 1974. Aspects of space use in the common snapping turtle, *Chelydra s. serpentine.* Ph.D. dissertation. University of Tennessee, Knoxville, Tennessee.

FULLAGER, P. J. 1967. The use of radio telemetry in Australian biological research. Proc. Ecol. Soc. Australia. 2:16-26.

GALBRAITH, D. A., M. W. CHANDLER, AND R. J. BROOKS. 1987. The fine structure of home ranges of male *Chelydra serpentine:* are snapping turtles territorial? Can. J. Zool. 65:2623-2629.

GEFFEN, E., AND H. MENDELSSOHN. 1988. Home range use and seasonal movements of the Egyptian tortoise *(Testudo kleinmanni)* in the north-western Negev, Israel. Herpetologica 44:354-359.

——, AND ——. 1989. Activity patterns and thermoregulatory be- havior of the Egyptian tortoise *Testudo kleinmanni* in Israel. J. Herpe- tol. 23:404-409.

GOLDSMITH, A. E., AND W. W. SHAW. 1994. A preliminary report of home range and use of cover sites by desert tortoises in Saguaro National Monument, 1988. Proceedings of the 1987-1991 Desert Tortoise Coun- cil Symposium 1994:174-179.

HARREL, J. B., C. M. ALLEN, AND S. J. HEBERT. 1996. Movements and habitat use of subadult alligator snapping turtles *(Macroclemys tem- minckii)* in Louisiana. Am. Midl. Nat. 135:60-67.

IFAYS, G. C., P. 1. WEBB, J. P. HAYES, 1. G. PRIEDE, AND J. FRENCH. 1991. Satellite tracking of a loggerhead turtle *(Caretta caretta).* J. Mar. Biol. Assoc. U.K. 71:743-746.

HENEN, B. T. 1994. Seasonal and annual energy and water budget of fe- male desert tortoises *(Xerobates agassizii)* at Goffs, California. Ph.D. dissertation, Univ. California, Los Angeles.

HOPKINS, S. R., AND T. M. MURPHY. 198 1. Reproductive ecology of *Careua caretta* in South Carolina. Study completion report E-1, Study No. VI-A-1. South Carolina Wildlife and Marine Resources Department, Charleston, South Carolina. iv + 97 pp.

IKEDA, K., N. IWAI, Y. WADA, AND Y. HAYASHI. 1979. Technical develop- mentoftheradiotrackingsystemforstudiesofhabumovernent. Snake 11:29-31,

IRELAND, L. C. 1979. Homing behavior of immature green turtles *(Che- Ionia mydas)* [abstract]. Am. Zool. 19:952.

——,. 1980. Homing behavior ofjuvenile green turtles, *Chelonia my- das. In* C. J. Amlaner, and D. W. MacDonald (eds.), A Handbook on Biotelemetry and Radio Tracking, pp. 761-764. Pergamon Press, Ox- ford.

——, AND J. W. KANWISHER. 1978. Underwater acoustic biotelemetry: Procedures for obtaining information on the behavior and physiology of free-swimming aquatic animals in their natural environments. In D. 1. Mostofsky (ed.), The Behavior of Fish and Other Aquatic Animals, pp. 341-379. Academic Press, New York, New York.

IVERSON, J. 1990. Nesting and parental care in the mud turtle, *Kinoster-nonflavescens.* Can. J. Zool. 68:230-233.

JENNINGS, W. B. 1993. Foraging ecology of the desert tortoise *(Gopherus agassizii)* in the western Mojave Desert. Masters thesis, Univ. Texas, Arlington. xvii + 89 pp.

KAUFMANN, J. H. 1992a. Habitat use by wood turtles in central Pennsyl- vania. J. Herpetol. 26:315-321.

——,. 1992b. The social behavior of wood turtles, *Clemmys insculpta,* in central Pennsylvania. Herp. Monogr. 6:1-25.

——,. 1995. Home ranges and movements of wood turtles, *Clemmys insculpta,* in central Pennsylvania. Copeia 1995:22-27.

KEINATH, J. A., R. A. BYLES, AND J. A. MUSICK. 1989. Satellite telemetry of loggerhead turtles in the western North Atlantic. In S. A. Eckert, K. L. Eckert, and T. H. Richardson (eds.), Proceedings of the Ninth An- nual Workshop on Sea Turtle Conservation and Biology, pp. 75-76. NOAA Technical Memorandum NMFS-SEFC-232.

——, AND J. A. MUSICK. 1993. Movements and diving behavior of a leatherback turtle, *Dennochelys coriacea.* Copeia 1993:1010-1017.

KEMMERER, A. J., R. E. TIMKO, AND S. B. BURKETT. 1983. Movement and surfacing behavior patterns of loggerhead sea turtles in and near Canav- eral Channel, Florida (September and October 1981). U.S. Dept. Com- merce, National Oceanic and Atmospheric Administration, National Space Technology Laboratories, NSTL Station, Mississippi. 43 pp.

KENNETR, R., K. CHRISTIAN, AND D. PPDTCHARD. 1993. Underwater nesting by the tropical freshwater turtle, *Chelodina rugosa* (Testudinata: Chelidae). Aust. J. Zool. 41:47-52.

KENWARD, R. E. 1987. Wildlife Radio Tagging. Academic Press, Lon- don.

KIESTER, A. R., C. W. SCHWARTZ, AND E. R. SCHWARTZ. 1982. Promotion of gene flow by transient individuals in an otherwise sedentary popu- lation of box turtles *(Terrapene carolina triunguis).* Evolution 36:617-619.

LARSON, M. A. 1984. A simple method for transmitter attachment in che- lonians. Bull. Maryland Herpetol. Soc. 20:54-57.

LEGLER, W. K. 197 1. Radiotelemetric observations of cardiac rates in the omate box turtle. Copeia 1971:760-761.

Lovicii, J. 1990. Spring movement patterns of two radio-tagged male spotted turtles. Brimleyana 16:67-71.

——, D. W. HERMAN, AND K. M. FAHEY. 1992. Seasonal activity and movements of bog turtles *(Clemmys muhlenbergii)* in North Carolina. Copeia 1992:1107-11 1 1.

MACDONALD, D. W., AND C. J. AMLANER, JR. 1980. A practical guide to radio tracking. In C. J. Amlaner, Jr. and D. W. MacDonald (eds.), A Handbook on Biotelemetry and Radiotracking, pp. 143-160. Pergamon Press, Oxford.

MADDEN, R. C. 1975. Home range, movements, and orientation in the eastern box turtle, *Terrapene carolina carolina.* Ph.D. dissertation. City Univ. of New York, New York, New York. xii + 217 pp.

MARTIN, B. E. 1995. Ecology of the desert tortoise *(Gopherus agassizii)* in a desert-grassland community in southern Arizona. Masters thesis, Univ. Arizona, Tucson, Arizona. 11 2 pp.

McRAE, W. A., J. L. LANDERS, AND J. A. GARNER. 198 1. Movement pat- terns and home range of the gopher tortoise. Am. Midl. Nat. 106(l):165-179.

MECH, L. D. 1983. Handbook of Animal Radio Tracking. University of Minnesota Press, Minneapolis, Minnesota. xii + 108 pp.

MENDONCA, M. T. 1983. Movements and feeding ecology of immature green turtles *(Chelonia mydas)* in a Florida lagoon. Copeia 1983:1013- 1023.

MOLL, D. 1994. The ecology of sea beach nesting in slider turtles (Tra- *chemys scripta venusta)* from Caribbean Costa Rica. Chel. Conserv. Biol. 1(2):107-116.

MOLL, E. 0. 1980. Natural history of the river terrapin, *Batagur baska* (Gray) in Malaysia (Testudines: Emydidae). Malaysian J. Sci. 6(A):23- 62.

——, AND J. M. LEGLER. 1971. The life history of a neotropical slider *turtle, Pseudemys Script* (Schoepff), in Panama. Bull. Los Angeles Co. Mus. Nat. Hist. 11: 1-102.

NIEUWOLT, M. C. 1993. The ecology of movement and reproduction in the western box turtle in central New Mexico. Ph.D. dissert. Univ. of New Mexico, Albuquerque, New Mexico. xiii + 84 pp.

O'CONNOR, M. P., J. S. GRUMBLES, R. H. GEORGE, L. C. ZIMMERMAN AND J. R. SPOTILA. 1994a. Potential hematological and biochemical indica- tors of stress in free-ranging desert tortoises and captive tortoises ex- posed to a hydric stress gradient. Herp. Monogr. 8:5-26.

——, L. C. ZIMMERMAN, D. E. RUBY, S. J. BULOVA, AND J. R. SPOTILA. 1994b. Home range size and movements by desert tortoises, *Gopherus agassizii,* in the eastern Mojave Desert.. Herp. Monogr. 8:60-71.

OBBARD, M. E., AND R. J. BROOKS. 1981. A radio-telemetry and mark-recapture study of activity in the common snapping turtle, *Chelydra serpentine.* Copeia 1981:630-637.

OGDEN, J. C., L. ROBINSON, K. WHITLOCK, ff. DAGANHARDT, AND R. CHBULA. 1983. Diel foraging patterns injuvenile green turtles *(Chelonia mydas* L.) in St. Croix United States Virgin Islands. J. Exp. Mar. Biol. Ecol. 66:199-205.

PETERSON, C. C. 1993. Physiological ecology of two Mojave Desert popu- lations of the desert tortoise *Xerobates agassizii:* effects of seasonal rainfall pattern and drought. Ph.D. Dissert. Univ. California, Los An- geles, California.

PLOTKIN, P. T., R. A. BYLES, D. C., D. ROSTAL, AND D. W. OwENs. 1995. Independent versus socially facilitated oceanic migrations of the olive *ridley, Lepidochelys olivacea.* Mar. Biol. 122:137-143.

——, D. W. OWENs, R. A. BYLES, AND R. PATTERSON. 1996. Departure of male olive ridley turtles *(Lepidochelys olivacea)* from a nearshore breeding ground. ff erpetologica 52:1-7.

PLUMMER, M. V., AND H. W. SHIRER. 1975. Movement patterns in a river population of the softshell turtle, *Trionyx muticus.* Occas. Pap. Univ. Kansas Mus. Nat. Hist. 43:1-26.

RATHBUN, G. B., N. SIEPEL, AND D. HOLLAND. 1992. Nesting behavior and movements of western pond turtles, *Clemmys marmorata.* Southwest. Nat. 37:319-324.

RENAUD, M. L., AND J. A. CARPENTER. 1994. Movements and submer- gence patterns of loggerhead turtles *(Caretta came* in the Gulf of Mexico determined through satellite telemetry. Bull. Mar. Sci. 55(l): 1- 15.

——, ——, E. KLIMA, S. MANZELLA, AND J. WILLIAMS. 1993a. Tele- metric tracking of green sea turtles *(Chelonia mydas)* in relation to dredged channels at South Padre Island, Texas. July-September 1992. Final report to U.S. Army Corps. of Engineers (Galveston and New Orleans District), Galveston, Texas.

——, G. R. GITSCHLAG, AND J. K. HALE. 1993b. Retention of imitation satellite transmitters fiberglassed to the carapace of sea turtles. Herpetol. Rev. 24:94-95, 98-99.

——, ——, E. KLIMA, S. MANZELLA, AND J. WILLIAMS. 1992. Tracking of green *(Chelonia mydas)* and loggerhead *(Caretta caretta) sea* turtles using radio and sonic telemetry at South Padre Island, Texas. June-September 199 1. Final report to U.S. Army Corps. of Engineers (Galveston and New Orleans District), Galveston, Texas.

ROSS, D. A., AND R. K. ANDERSON. 1990. Habitat use, movements, and nesting of *Emydoidea blandingi* in central Wisconsin. J. Herpetol. 24:6- 12.

ROWE, J. W., AND E. 0. MOLL. 199 1. A radiotelemetric study of activity and movements of the Blanding's turtle *(Emydoidea blandingi) in* northeastern Illinois (USA). J. Herpetol. 25:178-185.

SCHUBAUER, J. P. 198 1. A reliable radio-telemetry system suitable for studies of chelonians. J. Herpetol. 15:117-120.

——, J. W. GIBBONS, AND J. R. SPOTILA. 1990. Home range and movement patterns of slider turtles inhabiting Par Pond. In J. W. Gibbons (ed.), Life History and Ecology of the Slider Turtle, pp. 223-232. Smithsonian Institution Press, Washington, D.C.

SCHWARTZ, E. R., C. W. SCHWARTZ, AND A. R. KIESTER. 1984. The three- toed box turtle in Central Missouri, Part 11: A nineteen-year study of home range, movements and population. Missouri Dept. of Conserva- tion, Jefferson City, Missouri. 29 pp.

SCHWARTZMAN, J. L., AND R. D. OHMART. 1977. Radiolocating free-rang- ing desert tortoises *(Gopherus agassizii):* maximizing transmitter range and longevity. Proceedings of the 1977 Desert Tortoise Council Sym- posium 1977:57-58.

SLOAN, K. N., AND D. TAYLOR. 1987. Habitats and movements of adult alligator snapping turtles in northeast Louisiana. Proc. Ann. Conf. Southeast. Assoc. Fish Wildi. Agencies 41:343-348.

SMITH, L. L. 1995. Nesting ecology, female home range and activity, and population size-class structure of the gopher tortoise, *Gopherus Polyphemus,* on the Katharine Ordway Preserve, Putnam County, Florida. Bull. Florida Mus. Nat. Hist. 37, Pt. 1:97-126.

SOMA, M. 1985. Radio biotelemetry system applied to migratory study of turtle. J. Fac. Mar. Sci. Tech. Tokai Univ. 21:47-56.

——, AND T. ICHIHARA. 1977. The study on swimming behavior of sea turtles utilizing radio telemetry system. In F. M. Long (ed.), Proceed- ings First International Conference on Wildlife Biotelemetry, pp. 15 *I*- 159. International Conference on Wildlife Biotelemetry, Laramie, Wyoming.

STANDORA, E. A., J. R. SPOTILA, AND R. E. FOLEY. 1982. Regional endot- hermy in the sea turtle, *Chelonia mydas*. J. Therin. Biol. 7:159-165.

——, ——, J. A. KEINATH, AND C. R. SHOOP. 1984. Body tempera- tures, diving cycles, and movement of a subadult leatherback turtle, *Dermochelys coriacea.* Herpetologica 40:169-176.

STEWART, G. R. 1993. Movements and survival of desert tortoises (Go- *pherus agassizii)* following relocation from the Luz Solar Electric Plant at Kramer Junction. Proceedings of the 1992 Desert Tortoise Council Symposium 1993:234-261.

STONEBURNER, D. L. 1982. Satellite telemetry of loggerhead sea turtle movement in the Georgia Bight. Copeia 1982:400-408.

SWINGLAND, 1. R., AND J. 0. FRAZIER. 1980. The conflict between feeding and overheating in the Aldabran giant tortoise. In C. J. Amianer, Jr. and D. W. MacDonald (eds.), A Handbook on Biotelemetry and Radio Tracking, pp. 611-615. Pergamon Press, Oxford.

——, D. STUBBS, M. NEWDICK, AND B. WORTON. 1986. Movement pat- tems in *Testudo hermanni* and implications for management. In Z. Rocek (ed.), Studies in Herpetology. Proceedings of the European Herpetological Meeting, pp. 573-578. Prague.

TAYLOR, G. M., AND E. NOL. 1989. Movements and hibernation sites of overwintering painted turtles in southern Ontario (Canada). Can. J. Zool. 67:1877-1881.

TIMKO, R. E., AND D. DEBLANC. 198 1. Radio tracking juvenile marine turtles. Mar. Fish. Rev. 43(3):20-24.

——, AND A. L. KOLZ. 1982. Satellite sea turtle tracking. Mar. Fish. Rev. 4(4):19-24.

TOM, J. 1994. Microhabitats and use of burrows of bolson tortoise hatchlings. In R. B. Bury and D. J. Germano (eds.), Biology of North American Tortoises, pp. 139-146. Fish and Wildlife Research Publi- cation No. 13. National Biological Service, Washington, D. C.

TURNER, F. B., K. H. BERRY, D. C. RANDALL, AND G. C. WHITE. 1987. Population ecology of the desert tortoise at Goffs, California, 1983- 1986. United States Department of the Interior, Bureau of Land Management. Riverside, California. 101 pp.

——, P. HAYDEN, B. L. BURGE, AND J. B ROBERSON. 1986. Egg produc- tion by the desert tortoise *(Gopherus agassizii)* in California. Herpe- tologica 42(l):93-104.

——, P. A. MEDICA, AND C. L. LYONS. 1984. Reproduction and sur- vival of the desert tortoise *(Scaptochelys agassizii)* in Ivanpah 'v7alley, California. Copeia 1984:811-820.

ULTSCH, G. R., AND D. LEE. 1983. Radiotelemetric observations of win- tering snapping turtles *(Chelydra serpentine)* in Rhode Island. J. Ala- bama Acad. Sci. 54(4):200-206.

WALLIS, 1. R., K. A. NAGY, B. S. WILSON, B. T. HENFN, C. C. PETERSON, C.MEINBERC,ER, 1. A. GIRARD. 1992. Mortality and upper respiratory tract disease (URTD) in wild desert tortoises: Hematological, biochemical, and physiological correlates during two drought years in the Mojave Desert in California. Draft Report. United States Department of the Interior, Bureau of Land Management.

WHITE, G. C., AND R. A. GARROTT. 1990. Analysis of Wildlife Radio-tracking Data. Academic Press, San Diego, California.

WIBBELS, T., D. W. OWENS, C. J. Limpus, P. C. REED, AND M. S. Amos. 1990. Seasonal changes in serum gonadal steroids associated with migration, mating, and nesting in the loggerhead sea turtle *(Caretta came.* Gen. Comp. Endocrinol. 79:154-164.

WILSON, D. S., H. R. MUSHINSKY, AND E. D. McCoy. 1994. Home range, activity, and use of burrows of juvenile gopher tortoises in central Florida. In R. B. Bury and D. J. Gerynano (eds.), Biology of North American Tortoises, pp. 147-160. National Biological Service, Washington, D.C.

YABE, T. 1992. Sexual difference in annual activity and home range of the Japanese pond turtle, *Mauremys japonica,* assessed by mark-re- capture and radio-tracking methods. Jap. J. Herpetol. 14(4):191-197.

YANO, K., AND S. TANAKA. 1991. Diurnal swimming patterns of logger-head turtles during their breeding period as observed by ultrasonic telemetry. Nippon Suisan Gakkaishi 57(9):1669-1678.

ZIMMERMAN, L. C., M. P. O'CONNOR, S. J. BULOVA, J. R. SPONLA, S. J. KEMP, AND C. J. SALICE. 1994. Thermal ecology of desert tortoises in the Eastern Mojave Desert: seasonal patterns of operative and body temperatures, and microhabitat utilization. Herp. Monogr. 8:45-59.

Bufo terrestris (Southern Toad). USA: Georgia: Chatham Co. Illustration by Michael G. Frick.