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SITE FIDELITY, MOVEMENT, AND VISIBILITY FOLLOWING TRANSLOCATION OF ORNATE BOX TURTLES (*TERRAPENE ORNATA ORNATA*) FROM A WILDLIFE REHABILITATION CENTER IN THE HIGH PLAINS OF TEXAS

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***Abstract.*—Both injured and uninjured box turtles (*Terrapene* spp.) are admitted to wildlife rehabilitation centers where they are treated and/or released. However, nothing is known of their movements, activity, and site fidelity following release. Studies of other reptiles suggest site fidelity and survival following release may be poor. We translocated 17 adult, two juvenile, and 20 hatchling Ornate Box Turtles (*Terrapene ornata ornata*) from a wildlife rehabilitation center in Lubbock, Texas to four sites varying in degree of urbanization. Forty percent of hatchlings remained at the original release sites, but only 24% of adults (all females) did so. Adults and hatchlings displayed roughly similar bimodal activity patterns related to time of day, and activity related to median ambient temperature range during the study period. Hatchlings were significantly more active than adults over a wider range of relative humidity and at higher relative humidity, however. Translocated hatchling home range size did not differ significantly between urban and natural release sites. Translocation of hatchling turtles may be a viable conservation strategy, though mortality of these age cohorts (25%) should be considered when planning translocations. Our data suggest translocations of adults are not likely to be successful in most cases.**

Key Words.—dispersal; home range; restoration ecology; urban ecology

INTRODUCTION

Urbanization generally has an adverse effect on wildlife, leading to predictions of increased extinction levels in urban environments (Novacek and Cleland 2001; McKinney 2002; Misfud and Misfud 2008; Perry et al. 2008). As a result of habitat degradation and fragmentation, extirpations of native species from urbanized environments are fairly common (Maglea et al. 2010). Wildlife remaining in urban fragments face injury and mortality from domestic pets, automobiles, and lawn care equipment, to name just a few threats. Injured individuals are sometimes delivered to wildlife rehabilitation centers (WRC), which also receive and release uninjured animals brought in by the general public and officials (McGaughey et al. 2011). Historically, WRCs have focused on birds and mammals, but recent trends show an increase in the admission and treatment of both injured and uninjured reptiles (Hartup 1996; Brown and Sleeman 2002; McGaughey et al. 2011).

Box turtles, like many reptiles, can be negatively affected by urbanization (Dodd 2001). Habitat loss and fragmentation result in both local extirpations and the encapsulation of populations within urban areas (Bowen et al. 2004; Budischak et al. 2006). Both injured and uninjured box turtles are admitted to WRCs and are usually later released (Gould 1998; Brown and Sleeman 2002; McGoughey et al. 2011). The ultimate goal of WRCs is usually release into the wild, though origin and release locations typically differ.

The fate of most reptiles translocated from wildlife rehabilitation centers is currently unknown. The success of translocating reptiles is limited, and reviews report translocation success rates at 19 and 41% respectively (Dodd and Seigel 1991; Germano and Bishop 2009). For example, the reintroduction of *Mauremys leprosa* in Catalonia, Spain failed, despite considerable effort (Bertolero and Oro, 2009), and translocation of *Geochelone gigantea* in the Seychelles was also not considered a success (Hambler 1994). Many of the Ornate Box Turtles (*Terrapene ornata ornata*) admitted to the South Plains Wildlife Rehabilitation Center (SPWRC; Lubbock County, Texas) in the past have been translocated to a variety of sites, but nothing is known of their post-translocation behavior and ultimate fate. In this study, we translocated rehabilitated and uninjured Ornate Box Turtles admitted to the SPWRC and monitored them for at least one activity season. We translocated turtles to one of four locations representative of those commonly used in the Lubbock vicinity: suburban yards within the Lubbock city limits, two exurban sites within the Lubbock city limits, and an exurban site outside the Lubbock city limits.

Materials and Methods

In 2008 and 2009, we worked with the SPWRC to rehabilitate and translocate Ornate Box Turtles that arrived as part of regular center operations (2008: n = 21; 2009: n = 18). We initially evaluated each turtle for potential injuries which were treated by local veterinarians if needed. Only individuals deemed healthy, either on admittance or following treatment, were used in this study. Box turtles admitted after being disturbed in their hibernacula were overwintered and not translocated until we observed naturally active turtles at our study sites. Before translocation, we housed turtles in 37.85 L terraria filled with topsoil and fed a mixture of fruits, vegetables, and invertebrates (crickets and mealworms). In addition, each turtle was also provided with 200ml of water in a saucer.

We weighed each turtle with a top-loading balance (Scout Pro 600 g; Ohaus, Pine Brook, New Jersey, USA) to the nearest 0.1g and we measured carapace length, plastron length and width, and shell height to the nearest 1 mm with calipers. We estimated age based on growth ring count and presence of secondary sexual characteristics (Germano and Bury 1998; Wilson et al. 2003): hatchlings had two growth rings or fewer, juveniles had more than two growth rings but no sign of secondary sexual characteristics, and adults had secondary sexual characteristics present. We differentiated males and females based on hind leg structure and coloration of the eye, head, and foreleg (Legler 1960). Prior to release we used industrial-strength epoxy to attach radio transmitters (SOPR 2070 and 2038, Wildlife Materials, Inc., Murphysboro, Illinois, USA; BD-2, Holohil Systems Ltd., Carp, Ontario, Canada) to the first pleural scute of all turtles. Transmitters were < 5% of adult and 10% of the total weight of juvenile and hatchling turtles.

We translocated turtles (n = 39) to four sites: (1) The Beach Ranch is a 3,636 ha private ranch 21km east of Post (Garza County, Texas). Soils are primarily clay and fine sandy loams (Richardson et al. 1975). Areas of dense mesquite (*Prosopsis* spp.) and rolling grasslands (Buffalo Grass, *Bouteloua dactyloides*; various gramas, *Bouteloua* spp.; ragweed, *Ambrosia* spp.) are interspersed with rocky outcroppings and artificial watering ponds. The land is leased for cattle grazing, and the owners attempt to control noxious vegetation. Six adults (two males and four females), three hatchlings, and one juvenile were translocated here. (2) The Texas Tech University Native Rangeland (TTUNR), a 65 ha protected area used solely for research, is located within the city limits of Lubbock (Lubbock County, Texas). The vegetative community consists mainly of Mesquite scrub and the soils are primarily Amarillo-Urban land complex (Natural Resources Conservation Service. 2009. Available from http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx [Accessed 2 September 2009]). Six adults (four males and two females), and eight hatchlings were translocated here. (3) The Juvenile Justice Alternative Education Program Nature Area (JJAEPNA) is a 0.6 ha area owned by Lubbock County. It is adjacent to the Juvenile Justice Alternative Education Program within the Lubbock city limits. A nature walk bisects the area but is seldom used (Sosa et al. 2010). The JJAEPNA is similar to the TTUNR in regards to vegetation cover and soil type but has greater topographical relief. Four hatchlings were translocated here. (4) We released turtles into private backyards throughout the city of Lubbock. These varied in vegetation (native and introduced), yard maintenance, and presence of domestic animals. Five adults (three males and two females), five hatchlings, and one juvenile were translocated here. We categorized the Beach Ranch, TTUNR, and JJAEPNA as natural sites, whereas the private backyards were categorized as urban sites.

We re-located each radio-transmitted turtle 3–6 times per week after translocation with a Yagi antenna and a handheld receiver (R1000, Communications Specialists Inc., Orange, California, USA). At each encounter, we recorded date, time, location (UTM coordinates; Garmin 76 GPS, Olathe, Kansas, USA), and weather data (air temperature at 2 m and relative humidity at 2 m; model Kestrel 4000, Nielsen-Kellerman, Boothwyn, Pennsylvania, USA). We also scored turtles as visible (suggesting activity) or concealed (suggesting inactivity). A turtle was considered concealed if more than 50% of the carapace was not visible when located. It is conceivable that turtles could conceal themselves before being located and scored by the observer, but we do not think this happened often. Additionally, younger turtles are less conspicuous because of their smaller size, but attempts were made to be thorough and find every turtle as quickly as possible. We monitored each translocated turtle until the end of the activity season, death, or loss of transmitter signal. Turtles were scored as one of the following: (1) remained at release site until end of active season; (2) left release site but were able to be tracked beyond original release site until end of active season; (3) left release site and lost signal (turtle moved beyond the boundary of the original release site); (4) documented mortality; (5) unknown (turtle was monitored successfully at release site and signal was lost within the boundary of the release site); or (6) radio transmitter fell off at release site. If transmitter signal was lost either within or beyond the boundaries of the release site, we searched the area around the last known location for at least 10 days. We calculated 95% minimum convex polygons with Home Range Tools extension in ArcGIS 9.3 for 13 hatchlings that were monitored for at least 45 days including hatchlings that remained at the original release site, hatchlings that were monitored after leaving the original release site, hatchlings that died after being monitored at least 45 days, and hatchlings that had radio transmitters fall off after being monitored at least 45 days. We compared the home ranges of hatchlings released into natural and urban environments with an independent samples t-test. We tested visibility with Chi-square analysis for bins that had at least one turtle visible. We conducted analyses in SPSS 17 (IBM, Inc., Armonk, New York, USA) with $\alpha = 0.05$.

RESULTS

***Factors affecting visibility*.**—Translocated adult turtles were mostly visible, and hence considered active, in the mornings and evenings, and hatchlings were more visible throughout the day however these differences were not significant ($\chi^2 = 7.3$; df = 5; $P > 0.05$; Fig. 1 A, B). Similarly, translocated adult and hatchling visibility was not significantly different across the temperature regime recorded during their activity periods ($\chi^2 = 6.7$, df = 11; $P > 0.05$), although hatchlings were observed more frequently at lower temperatures than adults (Fig.1 C, D). However, hatchlings were significantly more visible across a greater range of relative humidity, and especially at higher humidity, than adults ($\chi^2 = 14.2$; df = 4; $P > 0.05$; Fig. 1 E, F).

***Site fidelity and movements*.**—All three adult males translocated to urban Lubbock habitats left their translocation yards and their radio transmitter signals were lost (18, 26, and 35 days post translocation; Table 1). All four adult males translocated to the TTUNR dispersed beyond the fence. In three cases, evidence suggests that passing motorists may have removed them, as signal was lost and no signs of mortality were found (14, 15, and 25 d post translocation). Road mortality of the fourth was documented (11 d post translocation). One adult male and one adult female translocated to the Beach Ranch moved onto adjacent property and radio transmitter signals were lost (52 and 50 d post translocation, respectively); an additional adult female remained on the property; and we lost the transmitter signal of another adult female on the property for unknown reasons (Table 1). Radio transmitters fell off one male and one female at the Beach Ranch site. The two adult females translocated to urban Lubbock sites also left the initial translocation yard, but were able to be monitored. A neighbor returned one female to the original translocation yard where it remained, whereas the other female was collected by a neighbor and remained in the yard of a neighbor. The two adult females translocated to the TTUNR remained within the TTUNR. Overall, only 24% of translocated adults remained within the boundaries of their release sites until the end of the active season, including the urban female that was returned to the original release site.

One juvenile (Beach Ranch) and 40% of hatchlings (eight of 20) remained at the original release site until the end of the active season: five at the TTUNR, two in urban Lubbock, and one at JJAEP (Table 2). In addition, one urban juvenile and two urban hatchlings dispersed beyond the initial release site but were monitored until the end of the active season. An urban hatchling and a JJAEPNA hatchling moved beyond the release site and signal was lost. Five translocated hatchlings of the 20 (25%) perished while being monitored (one to snake predation at the Beach Ranch, one to a small mammalian predator at the Beach Ranch, and three to unknown causes at the TTUNR). Radio transmitters fell off two JJAEPNA hatchlings and one Beach Ranch hatchling. We included in the home range analysis 13 hatchlings that we monitored for at least 45 d (Table 2). There was no significant difference in mean home range size between the urban and natural translocated hatchlings (natural, n = 9, mean 825.1 m^2; urban, n = 4, mean 548.8 m^2; $t = -0.701$; df= 11; $P > 0.05$). All three hatchlings translocated to one urban yard moved to neighboring yards with thicker ground cover, whereas the two hatchlings translocated to a yard with thick, mostly native vegetation remained within that yard. One translocated Beach Ranch juvenile remained at the release site, and one translocated urban juvenile left the release site but was able to be monitored.

DISCUSSION

Activity patterns (as suggested by visibility patterns) of translocated Ornate Box Turtles varied slightly among age groups but were relatively similar, suggesting that detectability of younger age cohorts was not a problem. Translocated adults and hatchlings were active principally in the morning and early evening (although a few hatchlings were observed at mid-day), a bimodal pattern that is common in box turtles which allows them to avoid high temperatures during the middle of the day (Legler 1960). Adults and juveniles also were generally similar in maintaining activity patterns over a similar temperature regime, although hatchlings sometimes were visible at lower temperatures. In our study, hatchlings were often more active over a wider range of relative humidity, and especially at higher humidities than adults. The reasons for the difference between adults and hatchlings' responses to humidity levels are not known. Jennings (2003) found that the activity of resident juvenile *T. carolina bauri* peaked during a narrower time interval compared to adults, however.

Site fidelity of our translocated turtles is relatively low, particularly for adult turtles. Other studies have documented similarly low site fidelities for translocated adult box turtles into natural habitats (i.e., *T. ornata*:

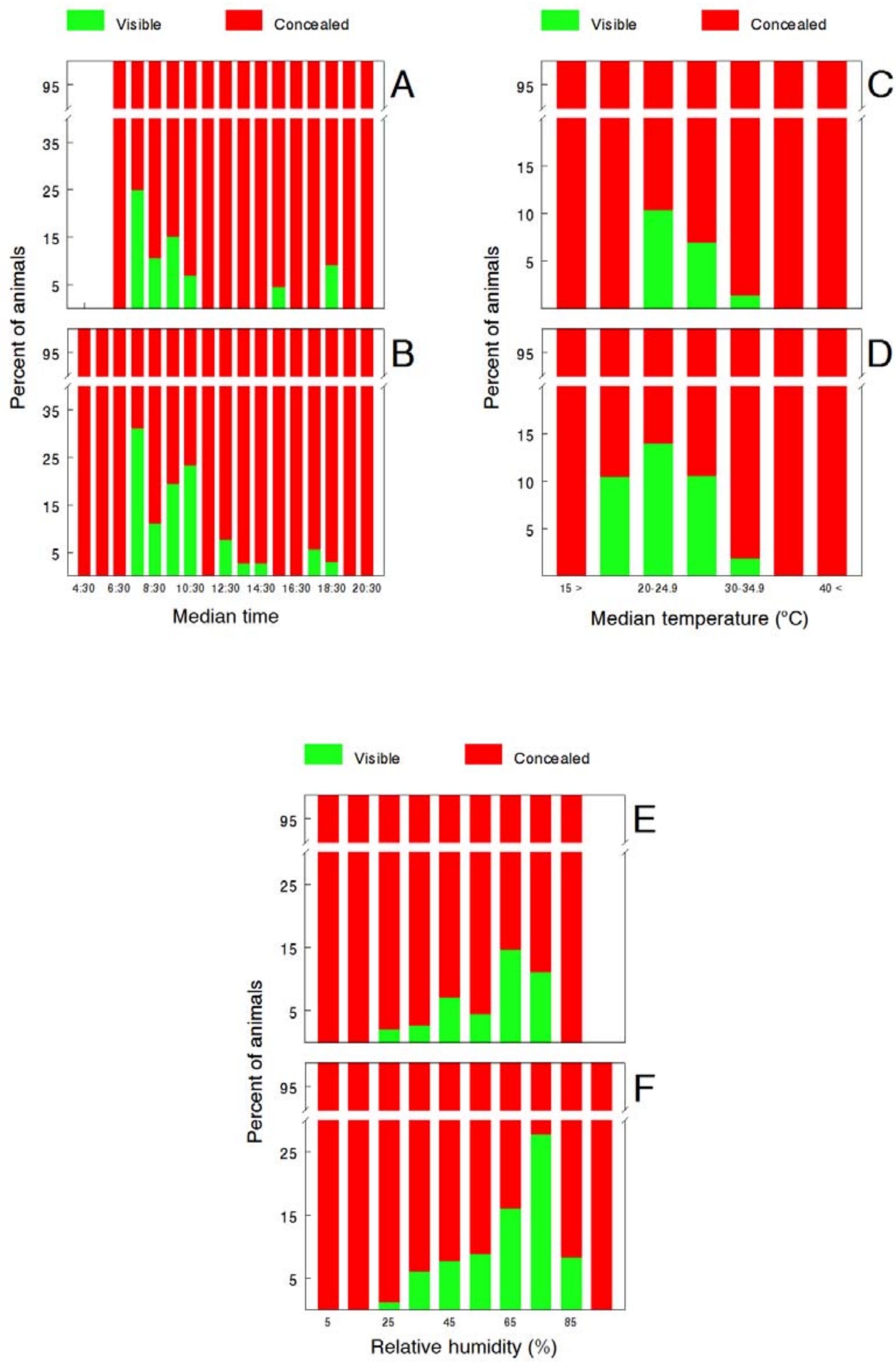

FIGURE 1. Visibility patterns of translocated adult (A, C, E) and hatchling (B, D, F) Ornate Box Turtles, *T. o. ornata* based on time of day, ambient temperature, and ambient relative humidity. Data from all study areas combined in the vicinity of Lubbock, Texas, USA.

Doroff and Keith 1990; *T. carolina*: Cook 2004; Hester et al. 2008). Most adult box turtles establish home ranges that are used across years and return to favored forms and resources within the home range (Dodd 2001). As is the case with translocated *T. c. triunguis*, which select habitats similar to their original location (Rittenhouse et al. 2008), translocated Ornate Box Turtles may have left our release sites in search of familiar locales. Box turtles are capable of homing from considerable distances (e.g., 9 km *T. o. luteola:* Germano and Nieuwolt-Decanay 1999) and long straight-line distance movements have been reported (e.g., 8 km *T. o. ornata:* Doroff and Keith 1990). The origin of our turtles delivered to SPWRC may have introduced an additional bias towards moving. A portion of box turtle populations is comprised of transients that apparently never establish a home range (Kiester et al. 1982; Schwartz 2000). Although box turtles tend to avoid roads (Shepard et al. 2008), turtles in highly urbanized areas may be unable to avoid roads. As a result of extensive habitat fragmentation (Kautz et al 1993; Samson and Knopf 1994), transient box turtles may be more likely to be collected and admitted to WRCs as they cross roads and move around urban areas. When translocated, these turtles may be unlikely to establish home ranges.

Our data suggest that even long-distance translocations of adult box turtles to large natural sites (the Beach Ranch is located approximately 90 km from Lubbock) are ineffective at establishing individuals at particular sites because adults (particularly males) moved beyond the translocation site. Thus, overall adult translocation success is low as observed in previous studies (i.e., Reinert and Rupert 1999; Fischer and Lindenmayer 2000; Plummer and Mills 2000; Sullivan et al. 2004). Moreover, the potential for disease transmission during translocation and disruption of residents has not been evaluated (Berry 1986; Cunningham 1996). We recommend educating the public against collecting uninjured turtles to decrease the number of unnecessary translocations. In particular, we agree with Hartup (1996) that emphasis at WRCs should be placed on prevention of unwarranted collection and education rather than on numbers of box turtles released.

The majority of hatchling and juvenile box turtles remained at or near the release site as might be expected, because box turtle home range establishment and movements increase with age (Schwartz et al. 1984). Nichols (1939) found that relatively few smaller *T. carolina* attempted to home. Thus, our younger turtles may have been more likely to remain close to the release site, simply because they have not established home ranges prior to collection. Nevertheless, hatchlings translocated to yards with less vegetation moved to and remained in adjacent yards with more and thicker vegetation. Similarly, hatchlings translocated to exurban sites with native vegetation and structure remained near the release point.

Based on the site fidelity and usage areas of hatchling and juvenile Ornate Box Turtles, head-starting or release of young animals may be a viable option for increasing populations in both urban and exurban areas (although the relatively high mortality we observed in hatchlings [25%] should be considered when planning translocations of younger individuals). Because habitat structure is apparently assessed by hatchlings in selecting suitable habitat (Garden et al. 2007; present study), we recommend translocating hatchling turtles to sites with areas that include diverse, and preferably native vegetation. However, we do not recommend release of adult box turtles brought in to WRCs, particularly males. An alternative disposition method should be found for adult animals that would have a low chance of surviving if released following admittance to a

TABLE 1. Site fidelity data for adult Ornate Box Turtles, *Terrapene o. ornata*, translocated from the South Plains Wildlife Rehabilitation Center. A single asterisk (*) indicates an urban female that left original release site but was returned by a neighbor and remained. A double asterisk (**) indicates an urban female that left original release site and was collected by a neighbor and remained in second urban yard.

Site	Sex	Total	Remained at Release Site	Left Release Site But Maintained Tracking	Left Release Site and Lost Signal	Mortality Beyond Release Site	Unknown	Transmitter Fell off at Release Site
Urban	Male	3	0	0	3	0	0	0
	Female	2	1*	1**	0	0	0	0
Beach	Male	2	0	0	1	0	0	1
Ranch	Female	4	1	0	1	0	1	1
TTUNR	Male	4	0	0	3	1	0	0
	Female	2	2	0	0	0	0	0
Total	Male	9	0	0	7	1	0	1
	Female	8	4	1	1	0	1	1

TABLE 2. Site fidelity data for juvenile and hatchling Ornate Box Turtles, *Terrapene o. ornata*, translocated from the South Plains Wildlife Rehabilitation Center. The numbers in parentheses indicates the number of hatchlings used in home range analysis for each category (total n = 13).

Site	Sex	Total	Remained at Release Site	Left Release Site But Maintained Tracking	Left Release Site and Lost Signal	Mortality At Release Site	Transmitter Fell off at Release Site
Urban	Hatchling	5	2 (2)	2 (2)	1	0	0
	Juvenile	1	0	1	0	0	0
JJAEPNA	Hatchling	4	1 (1)	0	1	0	2
	Juvenile	0	0	0	0	0	0
Beach	Hatchling	3	0	0	0	2 (1)	1 (1)
Ranch	Juvenile	1	1	0	0	0	0
TTUNR	Hatchling	8	5 (5)	0	0	3 (1)	0
	Juvenile	0	0	0	0	0	0
Total	Hatchling	20	8	2	2	5	3
	Juvenile	2	1	1	0	0	0

WRC. We suggest using aforementioned turtles as educational ambassadors at schools, pet stores, etc. to increase box turtle awareness and conservation. Additional research should investigate soft release strategies for adults, such a penning, which has been successful in creating site fidelity for other chelonians (Tuberville et al. 2005).

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