SURVEY AND MONITORING OF THE EASTERN INDIGO SNAKE IN GEORGIA

Dirk J. Stevenson[1,*], Karen J. Dyer[1,2], and Beth A. Willis-Stevenson[1,3]

ABSTRACT – We studied the federally threatened eastern indigo snake (*Drymarchon couperi*) from 1992 to 2002 in southeastern Georgia, including a 4-year mark-recapture study conducted on the Fort Stewart Military Reservation. Indigo snakes in this region are sexually dimorphic in size, with males attaining greater maximum lengths. Subadult and small adult snakes grow more rapidly than larger adults. Georgia specimens prey on a variety of vertebrates, including juvenile gopher tortoises (*Gopherus polyphemus*). The return of adult indigo snakes to the same sandhills in multiple years has conservation and management significance. Long-term population monitoring of indigo snakes is feasible and may yield valuable information.

INTRODUCTION

The eastern indigo snake (*Drymarchon couperi* Holbrook) is native to the Coastal Plain of the southeastern United States (Conant and Collins 1991). Today, the species occurs throughout most of Florida and much of southeastern Georgia (Diemer and Speake 1983, Moler 1985a). Historically, the eastern indigo snake also ranged to South Carolina, Alabama, and Mississippi, but natural populations are now rare or extirpated from these states (Moler 1992, U.S. Fish and Wildlife Service 1982).

During the warmer months, indigo snakes have large home ranges (up to 101 ha) and use a variety of habitat types (Moler 1992, Speake et al. 1978). The species is susceptible to desiccation (Bogert and Cowles 1947) and frequently shelters in animal burrows or similar humid retreats to avoid temperature extremes. In Georgia and northern Florida, indigo snake populations are restricted to the vicinity of xeric pine-oak sandhills inhabited by gopher tortoises (*Gopherus polyphemus* Daudin) (Diemer and Speake 1983, Lawler 1977). In this region, adult indigo snakes rely on tortoise burrows for winter dens (Diemer and Speake 1981, 1983). They also use tortoise burrows during the warm months of the year for nesting, foraging, or refuges prior to shedding (Landers and Speake 1980, Smith 1987).

[1]DPW, ENRD Fort Stewart Fish and Wildlife Branch, 1557 Frank Cochran Drive, Building 1145, Fort Stewart, GA 31314. [2]Present address - University of Central Florida, Department of Biology, 4000 Central Florida Boulevard, Orlando, FL 32816-2368. [3]Present address - DPW, Environmental Branch, 1550 Frank Cochran Drive, Building 1137, Fort Stewart, GA 31314. [*]Corresponding author - stevensond@stewart.army.mil.

The eastern indigo snake was federally listed as Threatened in 1978 because of population declines in the 1960s–70s due to habitat loss, killing by vehicles and persons, diminishing tortoise numbers, overcollection for the pet trade, and gassing of tortoise burrows by eastern diamondback rattlesnake (*Crotalus adamanteus* Palisot de Beauvois) hunters (U.S. Fish and Wildlife Service 1982). Recent studies of the indigo snake have addressed distribution (Diemer and Speake 1983, Moler 1985a), habitat use by juveniles (Smith 1987), and adult home range and habitat use (Layne and Steiner 1996, Moler 1985b, Speake et al. 1978). Layne and Steiner (1996) studied the demography, morphology, and ecology of a southern Florida indigo snake population. However, many aspects of life history and ecology have yet to be investigated. Knowledge regarding current population trends is lacking because reliable survey methods or population monitoring techniques have not been developed. Because of secretive, cryptic, or fossorial habits, snake species like the indigo snake are difficult to study in the field, and attempts to census them are often unsatisfactory (Fitch 1987).

Eastern indigo snakes are long-lived, attaining 25 years in captivity (Bowler 1977). Thus, if individuals were to return to the same sandhills every year and could be effectively sampled, a mark-recapture population study could be conducted. Herein, we summarize 10 years of field observations of the indigo snake in southeastern Georgia, including a 4-year mark-recapture study, and present new information on size, growth rates, and winter den site fidelity. We also provide prey records for Georgia specimens and discuss survey and monitoring techniques.

METHODS

Study Areas

Our primary study sites were xeric sandhills near the Canoochee River (ca. 32°N, 81°W) on Fort Stewart Military Reservation (FSMR), Georgia. Fort Stewart (113,064 ha) is located in the Lower Atlantic Coastal Plain, 25 km west of Savannah. This installation has actively managed longleaf pine (*Pinus palustris* Miller)-wiregrass (*Aristida stricta* Michaux) habitats with prescribed fire for several decades and supports significant populations of the indigo snake, gopher tortoise, red-cockaded woodpecker (*Picoides borealis* Vieillot), and flatwoods salamander (*Ambystoma cingulatum* Cope) (Carlile 1995, Gawin et al. 1995).

We used mark-recapture methods to monitor snake populations on FSMR from 1998 to 2001. We monitored snakes at 6 sandhill sites that ranged in size from 8 to 154 ha ($\overline{x}$ = 75 ha). We treated sites separated by > 4.8 km as different subpopulations; thus, these sites contained 4 snake subpopulations. At 1 study site, snakes inhabited 3 discrete sandhills (wetlands and other mesic habitats divide otherwise continuous sandhills) separated by < 400 m.

Dominant sandhill vegetation at our study sites consisted of an open canopy and subcanopy of longleaf pine, slash pine (*P. elliottii* Engelmann), turkey oak (*Quercus laevis* Walter), and sand post oak (*Q. margaretta* Ashe), with a scattered ground cover of saw palmetto (*Serenoa repens* Bartram) and wiregrass. The deep (to 9.1 m), coarse, and well-drained sands of these habitats support distinctive plant communities that typically have an open and barren aspect, which is maintained by occasional fires and nutrient-poor soils (Wharton 1978). Gopher tortoise burrows of various size classes were numerous at all sites.

Data Collection

We captured indigo snakes from mid-November through mid-March (hereafter referred to as "winter") by searching for individuals near gopher tortoise burrows and other potential refugia, such as nine-banded armadillo (*Dasypus novemcinctus* Linnaeus) burrows and stump holes. Study sites were visited 5–25 times per year. We searched a site, or a portion thereof, in a systematic fashion (i.e., we attempted to search near every burrow). Snakes were also incidentally found crossing roads during the warmer months (April–October). All indigo snakes captured were processed as described below and released at capture sites within 48 hours.

We recorded date, time, and air temperature for each capture. Snakes were sexed using a blunt probe. We measured snout-vent length (SVL) and tail length (TAIL) to the nearest mm with a tape measure. We measured larger specimens by having 2 persons hold opposite ends of the snake and carefully apply pressure until the snake relaxed along its full length (Fitch 1987). We added SVL and TAIL to obtain total length (TL). Because males and females mature at ca. 1500 mm TL (Speake et al. 1987, Layne and Steiner 1996), we regarded snakes < 1500 mm TL as subadults and snakes ≥ 1500 mm TL as adults. We weighed snakes to the nearest gram using a Pesola spring scale. Based on color intensity and opaqueness of the eyes, we recorded each snake as recently shed, midway through a shed cycle, or preparing to shed. Each snake was individually marked by subcutaneously implanting a 14 mm PIT (passive integrated transponder) tag on the side of the body ca. 20 scale rows anterior to the vent. We also marked each snake by clipping ventral (Brown and Parker 1976) or subcaudal scales.

Using a Global Positioning System (GPS), we recorded all snake capture locations. We took GPS readings at the gopher tortoise burrow entrance for snakes found within 8 m of a tortoise burrow because snake use of a nearby burrow was usually evident based on fresh tracks, and flushed snakes often crawled directly toward nearby burrows. For captures associated with tortoise burrows, we classified burrows as active/inactive or abandoned (Cox et al. 1987). We also described the burrow as juvenile, subadult, or adult (Cox et al. 1987).

Prey records for Georgia indigo snakes were compiled from our field observations, necropsies of DOR (dead-on-road) specimens, interviews with biologists, and a literature review.

Data Analyses

We determined distances between an individual's capture sites using Animal Movement Extension to Arcview, Version 1.1 (Hooge and Eichenlaub 1997). For an individual captured multiple times in the same winter, we measured distances from its first capture location that winter. If a snake was captured 3 times in the same winter, we calculated an average recapture distance from its first capture location. For an individual captured in ≥ 2 winters, we measured recapture distances from its initial winter capture location.

To study the size of indigo snakes in southeastern Georgia, we combined measurements from our FSMR mark-recapture study of 39 snakes, 11 additional specimens found on FSMR and vicinity in 1992–2002, and 11 snakes from southeastern Georgia reported by Williamson and Moulis (1994). For FSMR mark-recapture study animals captured ≥ 2 times, we used size data from each snake's final capture. In this analysis, we used measurements of subadult and adult snakes from the following Georgia counties: Appling, Bryan, Coffee, Effingham, Emanuel, Evans, Liberty, Long, and Tattnall. These individuals were measured alive or soon after death (some were found DOR).

We performed t-tests and non-parametric Kruskal-Wallis tests for male/female comparisons of length and mass. We used chi-square tests to determine whether sex ratios differed from parity and to determine if male/female recapture rates were significantly different. Significance levels were set at $\alpha = 0.05$.

RESULTS AND DISCUSSION

Body Size

Length and mass data for indigo snakes from southeastern Georgia are summarized in Table 1. Males were significantly larger than females in SVL (Kruskal-Wallis: df = 58, H = 5.12, P = 0.0236), TL (Kruskal-Wallis: df = 59, H = 6.91, P = 0.0086), and TAIL (t-test: t = -4.21, df = 58, P < 0.0001). Tail length averaged 16.0% of TL (mean for both sexes combined), and there was no significant difference in relative tail length between males and females (Kruskal-Wallis: df = 58, H = 2.59, P = 0.1072). Mass did not differ significantly between sexes

(Kruskal-Wallis: df = 42, H = 2.21, P = 0.1371), but this is likely due to our small sample size of females, as 9 of the 10 heaviest (> 3000 g) snakes were males.

In a large sample of indigo snakes from the Lake Wales Ridge region of southern Florida, males were significantly longer and heavier than females (Layne and Steiner 1996). For snakes > 900 mm TL, percent tail length averaged 15.6% (n = 176, both sexes combined) (Layne and Steiner 1996). As in our study, they found no significant difference between the sexes in relative tail length. With respect to sexual size dimorphism in snakes, males tend to be larger than females in larger species (Shine 1993). The occurrence of male combat is correlated with sexual dimorphism in which the male is the larger sex, suggesting that large male size is an adaptation to intrasexual competition (Shine 1978). Male combat is known for the eastern indigo snake (Moler 1992).

We found that male indigo snakes in southern Georgia often reach > 1800 mm SVL (Fig. 1) and exceed 3250 g. The longest male examined by Layne and Steiner (1996) was 2180 mm SVL and the longest female was 1889 mm SVL. The maximum TL reported for the species is 2629 mm (Conant and Collins 1991). Interestingly, our heaviest male (4420 g) and female (3110 g) exceeded the maximum mass for each sex reported by Speake et al. (1987) and Layne and Steiner (1996).

Growth Rates

Twelve individuals recaptured 1–4 times at intervals of 10–37 months provided data on growth rates (Fig. 2). Our data indicate faster growth rates for subadult and small adult snakes than for large adults, as reported by Layne and Steiner (1996). A subadult male (initial SVL = 1156 mm) recaptured 10 months later had grown 32 mm/month. Three adult females (1384, 1461, 1524 mm SVL), although well below the maximum size (ca. 2000 mm SVL) known for females (Speake et al.

Table 1. Linear measurement (mm) and mass (g) data for eastern indigo snakes from southeastern Georgia.

Sex	Measurement	N	Mean ± S.D. (range)
Male	SVL	38	1527 ± 256.7 (1092-1956)
	TL	39	1829 ± 287.4 (1334-2286)
	TAIL	38	293 ± 36.9 (197-376)
	MASS	30	2089 ± 1178.3 (740-4420)
Female	SVL	22	1371 ± 168.7 (1088-1715)
	TL	22	1622 ± 196.8 (1221-2032)
	TAIL	22	251 ± 38.0 (133-317)
	MASS	14	1429 ± 647.4 (560-3110)
Combined	SVL	60	1470 ± 239.1 (1088-1956)
	TL	61	1754 ± 275.5 (1221-2286)
	TAIL	60	278 ± 42.3 (133-376)
	MASS	44	1879 ± 1076.9 (560-4420)

1987; pers. comm., D. Alessandrini, Cincinnati, OH), had not grown at all when recaptured 12–23 months later. These individuals may have put all available energy into maintenance and egg production rather than into bodily growth (Shine 1980).

This study was conducted during a protracted drought (rainfall totals for our study sites were ca. 130 cm below normal for 1998–2001), which may have affected snake growth. Although some water sources remained, large swamps and seepage-fed wetlands close to sandhills used by snakes were dry throughout most of our study. We suspect the drought caused a decline in herpetofaunal populations inhabiting these wetlands, including frogs (*Rana* spp.), small turtles, and snakes (*Nerodia*, *Elaphe*, and *Agkistrodon*) that are potential prey for indigo snakes.

Food Habits

The eastern indigo snake, which is near the top of the sandhill ecosystem food chain, is a powerful, indiscriminant predator known to feed on birds, small mammals, frogs, toads, lizards, turtles, and snakes, including venomous species (Ernst and Barbour 1989).

We compiled 25 prey records for the indigo snake in Georgia (Table 2). Fifteen snakes yielded 2 amphibian, 8 reptile, and 3 mammal species (Table 2). A specimen reported by Mount (1975) that disgorged a southern toad (*Bufo terrestris* Bonnaterre), gopher tortoise, southern hognose snake (*Heterodon simus* Linnaeus), and pigmy rattlesnake (*Sistrurus miliarius* Linnaeus) was collected on FSMR (pers. comm., R. Mount, Auburn, AL). Apparently, the eastern indigo snake frequently

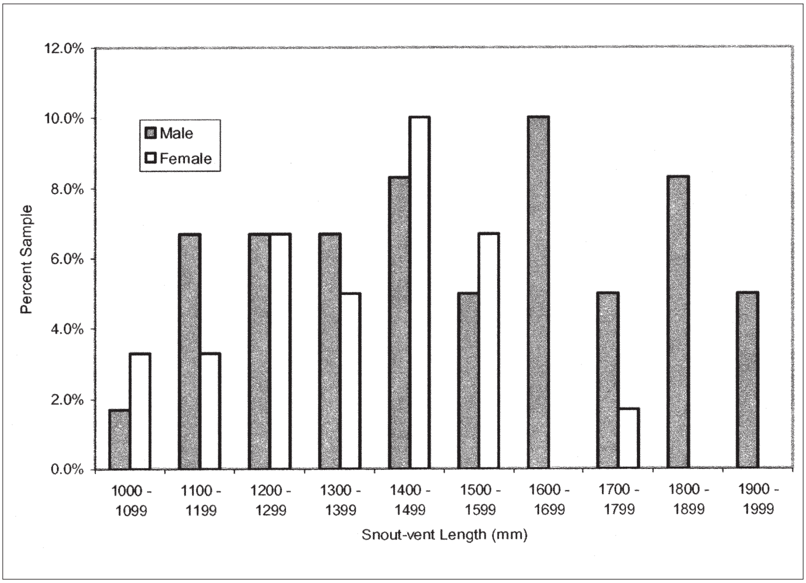

Figure 1. Size distribution of 60 eastern indigo snakes from southeastern Georgia.

eats hatchling and juvenile gopher tortoises (Layne and Steiner 1996). In addition to the records we provide (Table 2), we recovered scutes of juvenile tortoises in putative indigo snake feces (found on the ground in association with shed skins) on 3 occasions.

Fort Stewart Capture Data

From 1998 through 2001, we captured and marked 27 male and 12 female indigo snakes, and recorded 32 recaptures. Twelve males were recaptured 22 times and 7 females 10 times. Snakes were recaptured 1–4 times at intervals of 1–37 months. Although we did not calculate a population estimate, during the winter of 2000 a minimum of 8 adult males and 6 adult females inhabited 2 sandhill sites (51 ha and 129 ha) that were located 400 m apart. This figure includes snakes that were not captured in winter 2000 but were captured during winter surveys both before and after 2000.

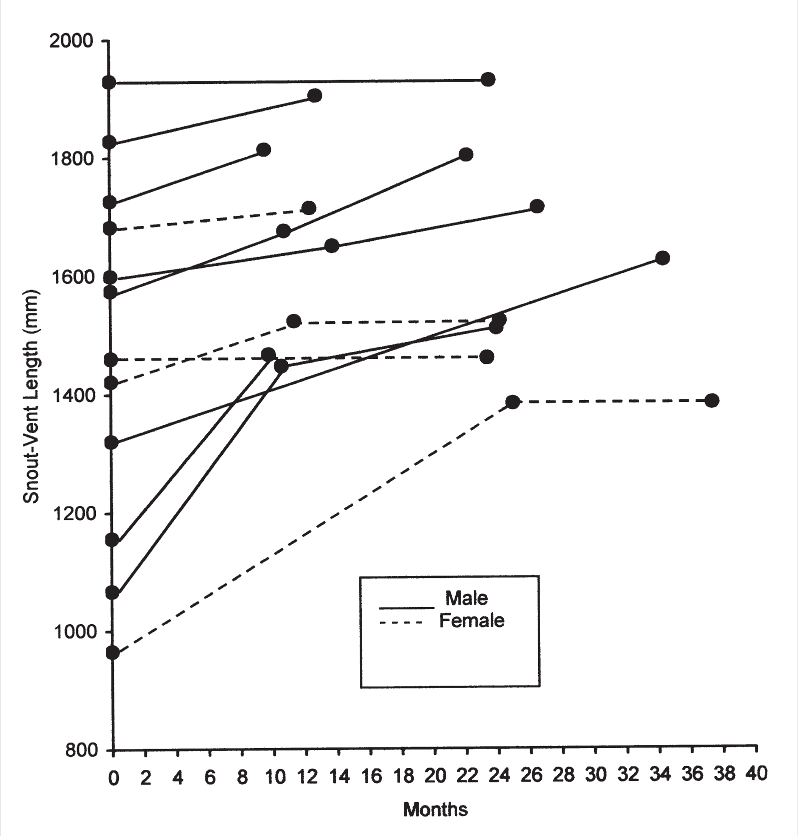

Figure 2. Growth data for 12 eastern indigo snakes captured on Fort Stewart, Georgia (1998–2001). Snout-vent length when first captured is plotted at 0 months.

Nine males and 5 females were subadults, and 18 males and 7 females were adults when initially captured. Most subadults were close to 1500 mm TL and thus nearing sexual maturity. We recorded 96% (n = 68) of our captures during winter surveys; 88% (n = 60) of these captures were snakes found on the surface near gopher tortoise burrows. The remaining 3 snakes (4%) were captured crossing roads in April–October. Most captures of males (n = 30, 61%) and females (n = 15, 68%) occurred in December–January. Twelve males and 5 females were captured and marked during the first 2 years of winter surveys. Five of these males and 4 females were recaptured during the final 2 years of the study.

The overall sex ratio for all six sandhill sites was 2.25:1 (males:females) and significantly male-biased ($x^2 = 5.92$, df = 1, $P < 0.05$). Larger winter home ranges (Layne and Steiner 1996) and greater surface activity may explain why we captured more male snakes. Recapture rates of marked snakes did not differ significantly between sexes ($x^2 = 0.0459$, df = 1, $P = 0.83$). Eighty-six percent of 71 captures were snakes that had recently shed or were midway through a shed cycle; 14% of captured snakes were preparing to shed.

Den Site Fidelity - We recaptured individuals in different winters at 4 of the 5 sites where we marked snakes in 1998–2001. Of 20 males and 11

Table 2. Prey items recorded for 15 eastern indigo snakes from Georgia. Codes for observation types are F = field observation, N = necropsied specimen, and R = regurgitated by captured animal. Source codes (in parentheses) are 1 = observation by authors; 2 = pers. comm., J. Waldon Fitzgerald, GA; 3 = Landers and Speake (1980); 4 = pers. comm., R. Moulis, Savannah, GA; 5 = Mount (1975); 6 = pers. comm., F. Snow, Douglas, GA; 7 = Hopkins (2001).

Prey Species	No. of occurrences	Observation type (source)
AMPHIBIANS		
Toad *(Bufo* spp.*)*	1	R(5)
Southern Toad *(Bufo terrestris)*	1	N(1)
Bullfrog *(Rana catesbeiana)*	1	F(6)
REPTILES		
Gopher tortoise *(Gopherus polyphemus)*	7	4R(3),R(5),N(1),F(6)
Southern hognose snake *(Heterodon simus)*	1	R(5)
Eastern coachwhip *(Masticophis flagellum)*	2	2R(7)
Corn snake *(Elaphe guttata)*	1	F(4)
Copperhead *(Agkistrodon contortrix)*	1	N(1)
Cottonmouth *(Agkistrodon piscivorus)*	1	R(3)
Pigmy rattlesnake *(Sistrurus miliarius)*	1	R(5)
Eastern diamondback rattlesnake *(Crotalus adamanteus)*	5	3R(3),N(4),F(2)
MAMMALS		
House mouse *(Mus musculus)*	1	R(3)
Eastern harvest mouse *(Reithrodontomys humilis)*	1	R(3)
Hispid cotton rat *(Sigmodon hispidus)*	1	N(1)

females captured during winter surveys in 1998–2000, 7 males and 4 females were recaptured in at least 1 subsequent winter. Four males and 2 females were captured in 2 different winters, and 3 males and 2 females were captured in 3 different winters. Ten snakes were captured multiple times in the same winter. Mean distances (m) for same-winter recaptures were 410 ± 196 (n = 8, range = 84–720) for 6 males and 239 ± 190 (n = 4, range = 32–470) for 4 females. Distances for between-winter captures ranged from 164 to 948 m for males and 11 to 622 m for females. A male (SVL = 1784 mm) captured at 1 of our study sites in September 2001 was recaptured in December 2001 at another sandhill area located 5.1 km away (pers. comm., R. Moulis, Savannah, GA).

Den site fidelity has been documented for several North American snakes including colubrid species (Parker and Brown 1980) and 2 viperid species (Fitch 1960, Martin 1992). Unlike these species, indigo snakes do not brumate and may bask on the surface or move between burrow refugia (dens) throughout the winter. However, during the winter indigo snakes do not wander far from favored dens and have limited home ranges (4.8 – 10 ha) (Speake et al. 1978, Moler 1985b). Many of our marked snakes (n = 11) returned to the same sandhills in multiple winters. Winter captures for 2 snake subpopulations are shown in Figure 3. Twice we found snakes at the same dens (tortoise burrows) used in previous winters (Fig. 3). Three female snakes were recaptured at or near previous dens 2–3 years later (Fig. 3). Other individuals that we were simply unable to find may have wintered repeatedly in the same sandhills. Marked snakes for which we did not document winter den site fidelity may have died, or may have wintered elsewhere. However, we did not document movement of snakes between different sandhills as part of winter den use. Biologists conducting an eastern indigo snake study (1999–present) on a sandhill located 3–7 km north of 3 of our study sites did not find (during the winter) any of the same individuals for which we recorded winter captures (pers. comm., R. Moulis, Savannah, GA).

We do not know what cues indigo snakes use to find the same tortoise burrows year-after-year, but olfactory cues (i.e., scent-trailing) might be involved, because they also mate at this time (Speake et al. 1987). Snake species that migrate long distances to and from specific dens may have a persistent site memory (Wharton 1969). Because tortoise burrows may persist for many decades (Guyer and Hermann 1997), indigo snakes may use many of the same tortoise burrows throughout their adult lives.

Recommendations

Potential survey methods for the eastern indigo snake include searching near gopher tortoise burrows (Diemer and Speake 1981, 1983, this study), road cruising (Diemer and Speake 1981), funnel trapping tortoise burrow entrances (Lips 1991), and using drift fences with funnel traps (Steiner et al. 1983, Enge 1997). Conventional drift fence methods (i.e., fences of metal flashing ca. 40 cm high with funnel traps ca. 70 cm long x 20 cm wide) seldom capture adult indigo snakes (Enge 1997), and snakes are not predictably encountered road cruising (Diemer and Speake 1981, Rostal 1997, pers. obs.). Researchers are currently studying the effectiveness of a large box trap 1.2 m long x 1.2 m wide x 0.45 m high (Rudolph et al. 1999) placed along drift fences (pers. comm., R. Smith, Cape Canaveral, FL). Remote video camera systems are widely used to survey tortoise burrows for the presence of commensals, including the indigo snake.

Field studies in southern Georgia have documented that indigo snakes spend the cooler months in xeric sandhills, typically denning in gopher tortoise burrows (Landers and Speake 1980, Speake et al. 1978). Our field observations in southeastern Georgia during 1992–2002 (see Fig. 4) reflect this dependence on tortoise burrows and indicate that snakes can be found on the surface during the coldest months of the year

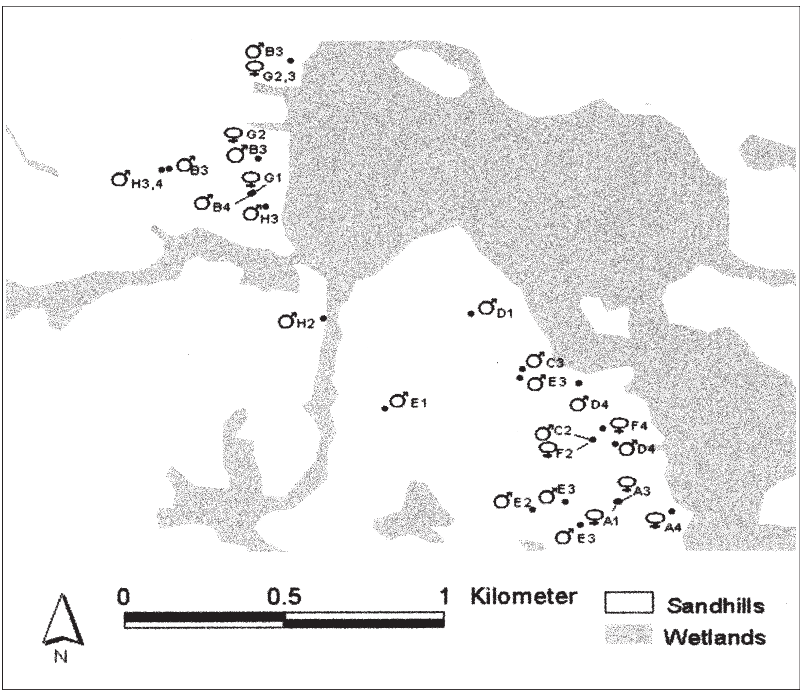

Figure 3. Eastern indigo snake capture sites (black dots) between 20 November and 22 March. Individual snakes are coded by letters; numbers 1–4 correspond to the four consecutive winters (1998-2001) of the Fort Stewart mark-recapture study.

(December–February). Of our 77 observations of snakes at tortoise burrows, 71% were of snakes at active/inactive burrows (occupied by or recently used by a tortoise) and 29% were of snakes at abandoned burrows (old, eroded burrows).

We successfully initiated a long-term monitoring study of the eastern indigo snake on FSMR by diurnal searching near tortoise burrows in sandhills from November through March. Over 4 consecutive years, we recaptured marked individuals of both sexes and obtained data on size, growth, movements, and survivorship. Because our snakes exhibit fidelity to the same sandhills and winter dens, future surveys should continue to yield data on marked individuals. Shortcomings of our survey methods include (1) finding snakes is time-intensive (we average 1 snake observation for every 2 days in the field) and a somewhat specialized skill (e.g., it helps to be familiar with tortoise burrow locations and able to recognize snake tracks), (2) the fate of individuals not recaptured is unknown, and (3) juvenile indigo snakes are not encountered, so data are lacking for smaller size classes. The smallest snakes we find (100–125 mm SVL) are estimated to be 1.5–2.5 years old (pers. comm., D. Alessandrini, Cincinnati, OH).

When surveying, we focus on looking for snakes, shed skins, and tracks near tortoise burrows. Indigo snakes may be active on the surface during the winter at air temperatures > 10.6 C (Landers and Speake 1980), during both cloudy and sunny weather (pers. obs.). Mirrors (10 x 15 cm) are used to reflect sunlight into burrows to look for snake tracks. Tracks cannot be identified to species, but tracks of large snakes may indicate the presence of an indigo snake. Indigo snakes shed their skins

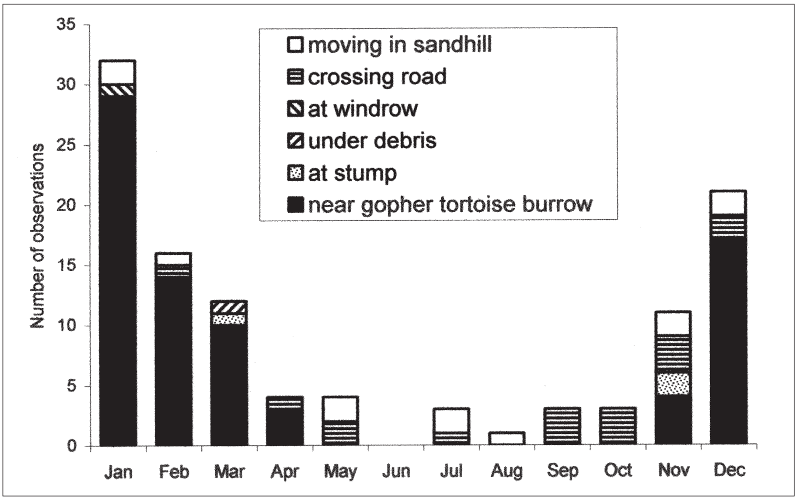

Figure 4. Observations of eastern indigo snakes in southeastern Georgia (1992–2002).

every 30–45 days (Moler 1992), and snakes often shed their skins on the ground within a few meters of tortoise burrow entrances (pers. obs.). Revisiting burrows where fresh shed skins were found sometimes resulted in capture of snakes. Between 1992 and 2002, we found 81 indigo snake shed skins in Georgia, almost all of which were found during the winter near tortoise burrows. It takes several months for newly shed skins to disintegrate (pers. obs.).

Because indigo snakes are federally protected, surveys (usually to determine presence/absence) are often required before large-scale development projects are initiated in areas of potential snake habitat. As part of indigo snake surveys, government agencies sometimes recommend remote video camera surveys of tortoise burrows (pers. comm., R. Brooks, Brunswick, GA; pers. comm., R. LeGere, Savannah, GA.). This type of system consists of a small closed circuit camera mounted on the end of flexible tubing that is inserted into the burrow; wiring within the tubing connects to a small monitor that is viewed by the investigator at the burrow entrance. These cameras allow identification of snakes and other animals encountered deep within the burrows (pers. obs.).

Although indigo snakes in tortoise burrows can be detected using camera systems, we question the reliability of this technique. Only 2 of 1,019 tortoise burrows surveyed with a camera at a northern Florida site revealed indigo snakes (Hipes and Jackson 1996). Camera surveys of 438 tortoise burrows (some burrows were surveyed multiple times) in southeastern Georgia, including surveys at known indigo snake sites, did not reveal any indigo snakes (Rostal 1997). Based on our observations, notable weaknesses of the camera system as a snake survey method of tortoise burrows are (1) openings of small or eroded abandoned burrows may be too small for a camera , (2) burrow curvature or obstacles (roots, plugs of pine straw or leaf litter, a tortoise blocking the burrow shaft) prevent manipulating the camera to the end of some burrows (ca. 10 % of adult-sized tortoise burrows), and (3) dozens or hundreds of potential burrow refugia may be present at sandhill sites occupied by indigo snakes; thus, the probability is typically small of scoping a particular tortoise burrow and finding a snake.

We recommend that persons surveying for indigo snakes in Georgia consider using a variety of search methods. If interested strictly in determining the presence of the species, we suggest that investigators focus on looking for snakes and shed skins near gopher tortoise burrows and similar refugia in November–April. Shed skins should be saved for positive identification by experienced herpetologists. Camera surveys or funnel trapping of tortoise burrows are more likely to produce snake observations or captures if practiced selectively (i.e., focus on burrows with snake sign). We do not recommend standard drift fences or road cruising as a survey technique, but current investigations on large box traps placed at drift fences may reveal this to be an effective snake survey method.

CONCLUSIONS

In southeastern Georgia, the ecology of the eastern indigo snake is tied intimately to its use of gopher tortoise burrows in xeric sandhill habitats. For winter dens, adult indigo snakes may return to the same sandhills in different years, even using the same tortoise burrows. This seasonal site fidelity underscores the importance of managing (e.g., prescribed fire) and conserving those intact xeric sandridge habitats remaining within the range of the indigo snake. Winter surveys for snakes at tortoise burrows are a viable method for monitoring populations. An ongoing radiotelemetry study of this snake population (pers. comm., N. Hyslop, Athens, GA) will provide detailed information on winter home range, movements between dens, habitat use, and social interactions.

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