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INDIGO SNAKE CAPTURE METHODS: EFFECTIVENESS OF TWO SURVEY TECHNIQUES FOR *DRYMARCHON COUPERI* IN GEORGIA

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Abstract: Drymarchon couperi *(Eastern Indigo Snake), a federally threatened species of the southeastern Coastal Plain, has presented challenges for surveyors, with few reliable methods developed for its detection or monitoring. Surveys for* D. couperi *at potential underground shelters conducted in late fall through early spring have been relatively successful when performed by experienced surveyors, especially in the northern portions of the range. However, trapping efforts for* D. couperi *conducted throughout the range have met with limited success. To further evaluate detection methods, we completed trapping and surveying from December 2002 to April 2004 in areas known to support* D. couperi *in southeastern Georgia. We captured 18* D. couperi *through surveys of potential underground shelters from December 2002 to March 2003 (14 person-hours per capture) and six individuals through trapping (141 trap days or 27 in-field person-hours per capture). Trapping was most successful during early fall, a period when surveys are often less effective compared to those conducted in late fall through early spring. We recommend a combination of surveys from mid-fall through March in conjunction with trapping, especially from late-summer through fall in the northern portions of the snake's range. We also recommend further experimentation with alternative trap designs and survey methods for* D. couperi.

Key Words: Eastern Indigo Snake, *Drymarchon couperi*, *Gopherus polyphemus*, monitoring, sandhills, survey methods, trapping

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THE ability to accurately detect and monitor wildlife species across their geographic range is vital to conservation and management of imperiled species. Detection of rare and cryptic taxa often requires survey techniques specific to those species (McDonald, 2004); however, for many species natural history data are inadequate to identify appropriate sampling techniques. Without reliable means of detection, conservation and management decisions must rely on speculation regarding presence or absence of target species. In cases involving development decisions, failure to detect a threatened or endangered species is often interpreted as absence of that species, allowing development to proceed.

Drymarchon couperi (Eastern Indigo Snake), a federally threatened species of the southeastern Coastal Plain of the United States (USFWS, 1978), has presented challenges for biologists and surveyors, with few reliable survey and capture methods developed for the species (Diemer and Speake, 1981; Stevenson et al., 2003). Despite federal protective status since 1978, our understanding of the natural history and ecology of *D. couperi* has been limited, especially in the northern portions of the snake's range (northern Florida and the Coastal Plain of southern Georgia). Consequently, population trends for *D. couperi* are currently unknown, in large part due to lack of reliable survey methods (Stevenson et al., 2003).

Adult *D. couperi* in the northern part of the range primarily use xeric upland sandhill habitats during late fall through early spring (Lawler, 1977; Diemer and Speake, 1983; Hyslop, 2007). In these habitats, *D. couperi* often associate with *Gopherus polyphemus* (Gopher Tortoise) burrows, which are used as shelters from environmental extremes and predation (Lawler, 1977; Diemer and Speake, 1983; Stevenson et al., 2003; Hyslop, 2007). Development of survey methods has centered on this association. Stevenson and co-workers (2003) present pedestrian surveys conducted in late-fall through early-spring around tortoise burrows and other potential underground shelters as a reliable method of sampling for *D. couperi*; however, they noted that this method is time intensive and requires experienced and knowledgeable surveyors. Previous trapping efforts for *D. couperi*, including drift fence arrays with funnel traps and/or box traps, and traps placed at *G. polyphemus* burrow entrances, have met with limited success in the southern portion of the snake's range (1 capture in 86 trap-days to 1 capture in 2672 trap-days; Lips, 1991; Layne and Steiner, 1996; Enge and Wood, 2000; Smith and Dyer, 2003). Similarly, remote video camera surveys of *G. polyphemus* burrows are largely unsuccessful (Stevenson et al., 2003).

Data on effectiveness of different detection and survey techniques will facilitate regulatory decisions regarding survey methods, ensuring the most effective techniques are employed. To further evaluate detection methods, and to capture snakes for a radiotelemetry study, we examined the effectiveness of two survey methods for *D. couperi*. Here, we present results from trapping and burrow surveys at sites in areas known to support *D. couperi* in southeastern Georgia.

TABLE 1. Trapping and survey efforts for *Drymarchon couperi* on sandhill habitats, 2002–2004, Georgia. Surveys were conducted on foot by individual surveyors. We activated traps (n = 18) in groups of six. Two trap designs were used during the study; the first from December 2002–February 2003. The second design, in which a horizontal shelf was added above each funnel trap entrance, was used from March 2003–May 2004.

					Hours/capture	
	Days	Field hours[1,2]	Total hours[3]	*D. couperi* captures	Field activity[2]	Total activity[3]
Burrow surveys						
12/2002–03/2003	43	249	249	18	14	14
Trapping						
12/2002–03/2003	306	61	367	0	-	-
04/2003–08/2003	108	23	131	0	-	-
09/2003–11/2003	363	70	433	6	12	72
12/2003–04/2004	70	12	82	0	-	-
Trapping total	847	166	1013	6	27	87

[1] Person-hours in the field conducting surveys or checking traps.
[2] Person-hours exclude trap construction, installation, and maintenance hours.
[3] Person-hours include trap construction, installation, and maintenance hours.

MATERIALS AND METHODS—Study areas were located on approximately 4,870 ha of Fort Stewart Military Reservation (FSMR, ca. 111,600 ha total) and on tracts of adjacent private lands (ca. 3,150 ha) in southeastern Georgia. We systematically searched for *D. couperi* during late-fall and winter 2002–2003 on seven sandhills known to support overwintering *D. couperi*. Searches were conducted near active/inactive and abandoned *G. polyphemus* burrows (Cox et al., 1987; Smith et al., 2005); *Dasypus novemcinctus* (nine-banded armadillo) burrows; stump and root channels; and other potential shelters (hereafter referred to as burrow surveys). We conducted burrow surveys for *D. couperi* from 1 December 2002 through 12 March 2003 on days with air temperatures >10.6°C (Table 1). We also searched for shed skins and snake tracks near underground shelters to identify areas with recent snake activity. For more extensive treatment of pedestrian surveys of *G. polyphemus* burrows and other underground shelter to detect *D. couperi* see Stevenson and co-workers (2003). We recorded field search effort (person-hours per day) to capture 18 *D. couperi* (12 males, 6 females).

Concurrent to burrow surveys, we constructed and installed 18 drift fences at FSMR (12) and adjacent private lands (6) on the same seven sandhills where surveys were conducted (Table 1). Each trap consisted of a 1.2 m × 1.2 m × 0.3 m plywood and hardware cloth (6.4 mm mesh) box trap with one funnel entrance, also constructed of hardware cloth, on each side of the box (Fig. 1). Fifteen-meter sections of 1-m high silt fence, with the base buried approximately 0.15 m below the surface, radiated perpendicularly from each funnel midpoint. This design was adapted from traps used to survey *Pituophis ruthveni* (Louisiana Pine Snake) in Louisiana and Texas (Rudolph et al., 1999; Burgdorf et al., 2005) and *Pituophis melanoleucus* (Northern Pine Snake) in Tennessee and southern Alabama (Bailey, 2002; Gerald et al., 2006). Details of this design, including diagrams, are available in Burgdorf and co-workers (2005). Our modification to this design included a wider funnel apex (ca. 7.5 cm min. diameter) to accommodate larger *D. couperi* and a reduced trap height of 0.30 m from 0.45 m used by Burgdorf and co-workers (2005). This reduced trap height design was used successfully in Tennessee and Alabama to capture adult *P. melanoleucus* (Bailey, 2002). We also added a side door (0.3 × 0.3 m) that, in addition to the top door, allowed animals to exit traps when not in use (Bailey, 2002).

In March 2003, we modified our trap design with the addition of horizontal panels (0.75 m × 0.75 m) placed on top of traps and extending, parallel to the ground, approximately 0.60 m out from each funnel entrance (Fig. 1). These additions were intended to reduce the apparent exposure

FIG. 1. Trap design used for *Drymarchon couperi*, March 2003–April 2004, Georgia. Photo highlights the four horizontal panels (0.75 m × 0.75 m) extending over each funnel entrance to the box trap which were added after the first three months of trapping. Although these traps (0.3 m tall) captured six *D. couperi*, vertical extension of the box trap may have facilitated additional captures. Photo by D. J. Stevenson.

of funnel trap entrances and to limit opportunities for snakes to crawl over the box traps. We activated traps, in groups of six, only when overnight temperatures were >5°C and maximum daily temperatures were <33°C (Table 1). We checked traps daily when activated.

RESULTS—Between December 2002 and March 2003, we searched for snakes on 43 days totaling 249 person-hours. We found 13 *D. couperi* sheds (19 person-hours/shed) and 18 *D. couperi* adults (12 males, 6 females; 14 person-hours/snake). Captures occurred between 1050 and 1500 h, at 14.1–25.6°C ambient air temperature ($\bar{x}$ = 20.0°C), and within 15 m of a *G. polyphemus* burrow ($\bar{x}$ = 4 m). Four captures were at abandoned *G. polyphemus* burrows and 14 at active/inactive burrows.

Construction, installation, and maintenance of traps required approximately 367 person-hours from fall 2002 until we ceased trapping (Table 1). On each trapping day, we spent about one person-hour activating and checking traps, totaling approximately 166 person-hours from December 2002 through April 2004. From December 2002 to April 2004, we opened traps for 847 trap-days and captured six individual *D. couperi*. Traps also captured several small mammal species, one bird (Bachman's Sparrow, *Aimophila aestivalis*), seven amphibian species, and nine reptile species, including six snake species: *Coluber constrictor* (Black Racer), *Crotalus adamanteus* (Eastern Diamondback

Rattlesnake), *Heterodon platirhinos* (Eastern Hognose Snake), *Masticophis flagellum* (Coachwhip), and *Micrurus fulvius* (Coral Snake). Overall trapping efficiency for *D. couperi*, including time spent on construction, installation, maintenance, and checking traps was approximately 87 person-hours per *D. couperi* capture and 27 person-hours (141 trap days) per capture with time spent on construction, installation, and maintenance excluded (Table 1).

From December 2002 through March 2003 we activated traps (first design, December–February; second design, March) for 306 trap-days with no *D. couperi* captures. We activated traps only sporadically through most of spring and summer 2003, primarily because of high temperatures. From September 2003 through November 2003, we activated traps (second design) for 363 trap-days, and captured six *D. couperi* (5 males, 1 female). Two captures were adult males (SVL = 145 and 150 cm), four were subadults or small adults (107–120 cm SVL), and one was a recent hatchling (SVL = 59 cm). Trapping efficiency in this period was approximately 60 trap days or 72 person-hours per *D. couperi* captured, including trap construction, installation, and maintenance, and 12 person-hours per capture excluding these activities (Table 1).

Using burrow surveys we captured *D. couperi* on six of seven sandhills where we installed traps and where *D. couperi* were known to occur. Traps captured *D. couperi* on four of these seven sandhills, although not on the sandhill lacking captures by burrow surveys. Thirteen of 18 traps did not catch *D. couperi*.

Discussion—Our burrow survey capture efficiency was similar to that of a previous *D. couperi* study conducted on some of the same sites, which recorded 88 captures during eight consecutive years and averaged approximately one snake capture per 10 person-hours (Stevenson et al,. 2003; D. Stevenson, unpublished data). Efficiency of burrow surveys for capturing *D. couperi* relates to the experience of the individual surveyor, their ability to discern snake sign, familiarity with tortoise burrow locations, and life history knowledge of the species (Stevenson et al., 2003). Where small populations occur, it may take weeks or months of searching in appropriate conditions to capture *D. couperi* (N. Hyslop, unpublished data; D. Stevenson, unpublished data).

Trapping was most successful during early fall, a period when burrow surveys are often less effective compared to surveys conducted in late fall through early spring (Diemer and Speake, 1981; Stevenson et al., 2003). This higher capture success may have been attributable to seasonal behavioral changes in the snakes (Gibbons and Semlitsch, 1981; Speake et al., 1987; Hyslop, 2007). In fall, *D. couperi* at our sites made large, frequent movements with repeated visits to sandhill habitats. Comparatively, in winter, we recorded the smallest movement distances and frequencies of the year (Hyslop, 2007), potentially resulting in reduced encounters with traps. We also cannot discount that the 0.3 m height of our traps may have negatively affected capture success.

Developing successful trapping methods for *D. couperi* has been challenging and most studies have experienced low capture success throughout the southern portion of the range. On a military installation in central Florida, 15 box traps arranged in 3 arrays, similar to those used by Rudolph and co-workers (1999) and Burgdorf and co-workers (2005), captured seven *D. couperi* in 2001 (Legare, 2001). Three *D. couperi* were captured in central Florida (Smith and Dyer, 2003) using 24 box traps of the type described in Rudolph and co-workers (1999). Traps were modified with only two funnel trap entrances into the box trap and a single large funnel trap made of hardware cloth at the distal ends of the each fence (2,580 trap nights per capture; Smith and Dyer, 2003). Another study in Florida captured five *D. couperi* during 1,638 trap-days using linear drift fences with two funnel traps at the end of the fences (378 trap-days per capture; Layne and Steiner, 1996). A second trap design employed consisted of four 7.6 m drift fences radiating perpendicularly from a center, with funnel traps placed midway on each side of the fences. This design captured one *D. couperi* in 2,672 trap-days (1984–1996; Layne and Steiner, 1996). At Archbold Biological Station in south-central Florida, wire funnel traps without drift fencing were placed at the entrances of 80 *G. polyphemus* burrows captured two *D. couperi* during 240 trap-days (120 trap days per capture; Lips, 1991). Herpetofaunal surveys on a wildlife management area near the central Gulf Coast of peninsular Florida captured four *D. couperi* during 6,000 trap-days (1,500 trap days per capture; Enge and Wood, 2000). Their trap design used 30 drift arrays comprised of three, 10-m silt fence arms radiating from a center point at 120 degree angles with 12 funnel traps (86×25 cm) per array (Enge and Wood, 2000). Our trapping efficiency at FSMR and adjacent private lands was 141 trap-days per *D. couperi* capture; however, likely differences in population densities, among other factors, preclude objective comparisons.

Although our traps captured *D. couperi*, this method detected *D. couperi* at fewer sandhills than did burrow surveys. Low sample sizes, however, prevented conclusions on capture differences for burrow surveys and trapping at these locations. The high costs of building and maintaining traps, especially in areas with prescribed burning, where silt fences are susceptible to loss from fire, may make trapping practical only in conjunction with sampling for other upland fauna, including other snake species (Gibbons and Semlitsch, 1981), although the use of wire hardware cloth instead of silt fence may be more cost effective in areas with prescribed burning. Trapping is likely an effective complement to burrow surveys, especially during the fall and in studies where surveyors change frequently or experienced biologists familiar with locating *D. couperi* are not available. In the northern portion of *D. couperi*'s range, where the species is associated with xeric pine-oak sandhills and *G. polyphemus* populations (Lawler, 1977; Diemer and Speake, 1983; Hyslop, 2007), we recommend a combination of burrow surveys (from mid-fall through March) and trapping, especially in the late summer through fall, to most effectively detect and monitor *D. couperi* populations. We also recommend further experimentation with alternative trap designs and methods for detecting and surveying *D. couperi*.

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