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FLUORESCENT POWDER IS ONLY PARTIALLY SUCCESSFUL IN TRACKING MOVEMENTS OF THE SIX-LINED RACERUNNER (*CNEMIDOPHORUS SEXLINEATUS*)

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Abstract.—I tracked 21 male and 19 female six-lined racerunners, *Cnemidophorus sexlineatus*, in north-central Florida using a fluorescent powder-ultraviolet light technique. Lizards traveled approximately 15 m after release, and from 16 to 18 m from point of capture; there was no difference between the sexes in the distance traveled. Trails could be followed easily but generally only for short distances until the lizard went to a cover site or the powder wore off. Short-distance movements to cover sites suggest handling may have influenced behavior. Tracking racerunners with fluorescent powder provided information on habitat use and cover sites, but had negative side-effects that limited its usefulness.

One of the most important behavioral aspects of an animal is its movement patterns, especially the specific routes it takes as it goes about daily activity. A knowledge of precise routes is important so that the areal extent of microhabitat use can be mapped, and to give an indication of the types of resources and predators that might be encountered. Both mark-recapture and direct visual observation have been used to discover movement patterns of small lizards. These techniques can define an activity area or home range but neither can elucidate the routes traveled. These methods may also influence an animal's behavior because of the physical proximity of an observer.

The development of non-interruptive tracking techniques that allow an observer to follow the movements of a small animal are not new. For instance, fluorescent powder was used to track site visits of bees (Johansson 1959) and monitor the movements of insects and mice (Frantz 1972, Lemen and Freeman 1985, review in Mullican 1988). Only recently, however, has fluorescent powder been used to study the movements of reptiles (Blankenship et al. 1990, Fellers and Drost 1989, 1991).

The six-lined racerunner, *Cnemidophorus sexlineatus*, is a common small heliophilic ground-dwelling lizard of open sandy habitats throughout the southern United States and the eastern Great Plains (Conant and Collins 1991, Smith 1946). Although home ranges have been measured for this species (Fitch 1958, Clark 1976) and observers have provided accounts of movements and activities of individuals in the field (Carpenter 1960, Hardy 1962, Paulissen 1987), precise trails have never been mapped for this or any other small lizard even over short distances,

except for *Xantusia riversiana* (Fellers and Drost 1991) and *Leiocephalus carinatus* (Franz and Dodd, unpublished data).

In this paper, I report the results of using fluorescent powder to follow the trails of six-lined racerunners in north-central Florida. My objectives were to determine if and how long powder remained on lizards, whether and how far trails could be followed, and to determine the racerunners' microhabitat use in the vicinity of a small ephemeral pond (Dodd and Charest 1988).

METHODS

I recorded the movements of 40 *C. sexlineatus* captured on the Katharine Ordway Preserve-Swisher Memorial Sanctuary, Putnam Co., Florida. Most lizards (30) were captured in pitfall traps (19 liter buckets) located on the outside of a drift fence encircling Breezeway Pond, a depression marsh (Florida Natural Areas Inventory 1990) located at an ecotone adjacent to a "high pine" community and a xeric oak hammock (Dodd and Charest 1988). Additional lizards were secured from screen mesh funnel traps at four other uplands sites located within 5 km of Breezeway Pond. All habitats were open and sandy providing ideal conditions for six-lined racerunners.

I measured each lizard (snout-vent length) and determined its sex by checking for hemipenes. The lizards were coated with yellowish-green fluorescent powder (Fellers and Drost 1989) over the entire body, limbs, and tail; I attempted to keep powder away from the lizard's eyes. I released the lizards generally within 3-5 m of capture within 48 h of capture; 34 were released between 0930-1215 (17 July to 23 August 1989; 14 April to 27 July 1990) whereas the remainder were released from 1630-1710 (only on 12 July 1989). Lizards were not followed after release to avoid influencing their behavior.

I marked the release site with a survey flag. After sunset, I followed the lizard's trail using a Raytech Industries Model R-4 ultraviolet 12-volt lamp. Survey flags were used to mark the trail and notes were recorded on presumed activity, movements, and habitat. The next morning, I mapped the trails and measured distances between survey flags.

The endpoint of the track was classified as follows: trail ends at a burrow with a distinct opening (b), trail ends in loose sandy soil (s), trail ends in leaf litter (l), trail ends in pitfall trap (t), ability to follow track terminated by rain (r), and trail became impossible to follow because it gradually disappeared (u). I initially used categories b, s, and l as endpoints to compare distances moved between sexes because these tracks terminated at a distinct location either at a burrow or at the presumed location of a hidden burrow.

RESULTS AND DISCUSSION

I tracked 21 males ($\bar{x}$ = 57.4 mm snout-vent length [SVL], range 44-65 mm) and 19 females ($\bar{x}$ = 58.2 mm SVL, range 50-70 mm, 1 not measured); there was no significant difference in snout-vent length between sexes (t = –0.431, 37 df, p = 0.67). These lizards are within the size range of adults reported elsewhere in Florida (Mushinsky 1985) but include juveniles.

There was no significant difference between sexes in the total distance traveled (males: N = 14, $\bar{x}$ = 14.74 m, range 1.0-51.5 m, SD = 13.57; females: N = 14, $\bar{x}$ = 14.99 m, range 1.8-43.4 m, SD = 13.02) (t = −0.050, 26 df, p = 0.96). Also, there was no difference between the

sexes in the total distance traveled if the type of the end of the track was disregarded (males: $N = 21$, $\bar{x} = 18.12$ m, range 1.0-70.8 m, SD = 17.88; females: $N = 19$, $\bar{x} = 17.0$ m, range 1.8-62.6 m, SD = 16.39) ($t = 0.220$, 38 df, $P = 0.83$).

The maximum straight-line distance traveled from point of initial capture to where the track ended averaged 18.2 m for males (range 3.0-49.8 m, SD = 12.42) and 15.8 m for females (range 4.0-40.7 m, SD = 12.31). There was no significant difference between males and females ($t = 0.603$, 38 df, $p = 0.55$).

Female *C. sexlineatus* have a smaller home range than males (Fitch 1958, Clark 1976) although there was no difference in trail lengths in this study. The similarity in distances traveled probably reflects a similarity in the amount of time powder stays on a lizard and the distance to the nearest cover site rather than a similarity in home ranges between sexes of Florida animals.

Lizards went to a cover site to rest, usually under a bush or grass clump, immediately after release. All *Cnemidophorus* traveled in relatively straight lines across open ground, often going from grass clump to grass clump, while skirting the bases of small trees and bushes when available (Fig. 1). When abrupt changes in vegetation structure occurred, the lizards walked along the base of the bushes until the habitat changed or some other factors caused the lizard to change direction. When thick stands of oak leaves or pine needles covered the ground leaving no patches of bare sand, the lizards walked directly up, over, or through them.

Most lizard trails seemed directed, that is, going from one location to another. However, certain areas experienced concentrated use where a trail looped back across itself or where powder was scattered heavily within a small area. Loops and trail backcrossing occurred in open areas, whereas areas with concentrated powder were in the shade under grass clumps and bushes. Resting palettes were easily discerned.

Obstacles such as logs, pine bark, and Spanish moss (*Tillandsia* sp.) clumps often were climbed and, by the convoluted trails, appeared to have been searched (Fig. 1). Seven lizards climbed well above the ground into small (i.e., stems < approximately 1 m in total height) longleaf pine trees, *Pinus palustris* ($N=3$), a rosemary bush, *Ceratiola ericoides* ($N=1$), lichens ($N=2$), and unidentified small bushes ($N=5$). Such lizards left well-defined trails as if searching for prey among the long needles and branches. Above-surface trails extended to 30 cm above the ground. Lizards also left the ground surface as they crawled over large grass clumps and through clumps of gopher apple, *Licania michauxii*. Climbing through small bushes and grass clumps has been observed in other *C. sexlineatus* populations (Carpenter 1960, Hardy 1962, Paulissen 1987).

Seven lizard trails ended in distinct burrows, and four lizards also were tracked to burrows that they entered and then left (Fig. 1). Ten trails ended in thick surface litter; three lizards were found asleep under pine needles or leaf litter. Eleven trails ended in loose sand where the lizard presumably was buried (one lizard was recovered by lightly raking away the sand until the burrow was revealed). Seven trails ended as the powder came off, four trails were only partially followed because of rainfall, and one lizard fell into a pitfall trap.

Only one intraspecific interaction between marked lizards can be inferred from tracks. On 25 June 1990, two female racerunners (50, 54 mm SVL) crossed tracks near a rosemary bush in open bare sand. From the large amount of powder scattered over an area nearly 1 m^2, it appears that the lizards met and engaged in some form of interaction. Aggressive encounters between female racerunners are common in this species (Carpenter 1960).

Trails of six-lined racerunners were not discernible after one day of tracking. In several instances, powder wore off before the lizards sought shelter for the evening. Powder trailing can only be used to follow relatively short-term movements of this species. Based upon a single recapture, small amounts of powder remain in areas between scales for at least 4 days after initial powdering.

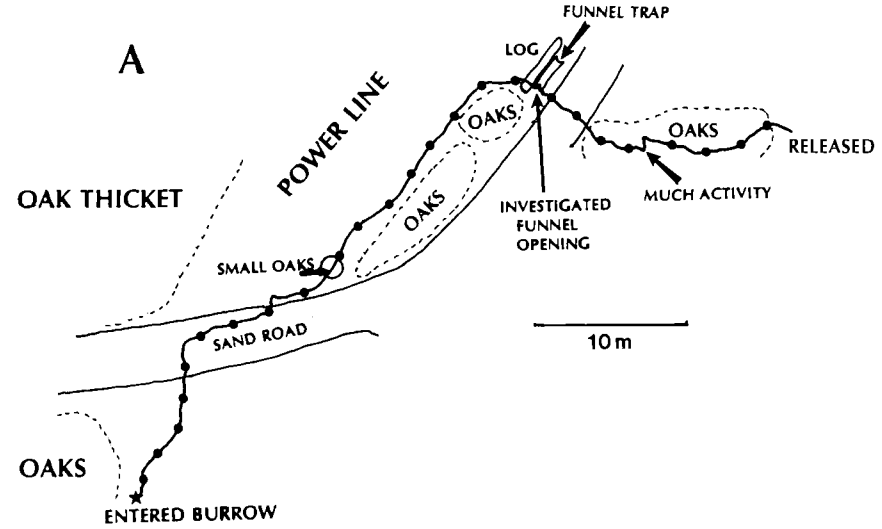
Fluorescent powder has the potential to allow one to track a lizard's exact trail without an observer's presence directly influencing behavior. However, Smith (1946) noted that six-lined racerunners exhibited what appeared to be normal activity as long as an observer stayed 4-5 m away, and Paulissen (1987) recorded foraging behavior over a mean duration of 21.2 min by following lizards at a distance of 2-3 m. Exact routes over long periods are difficult to map from direct observation, however.

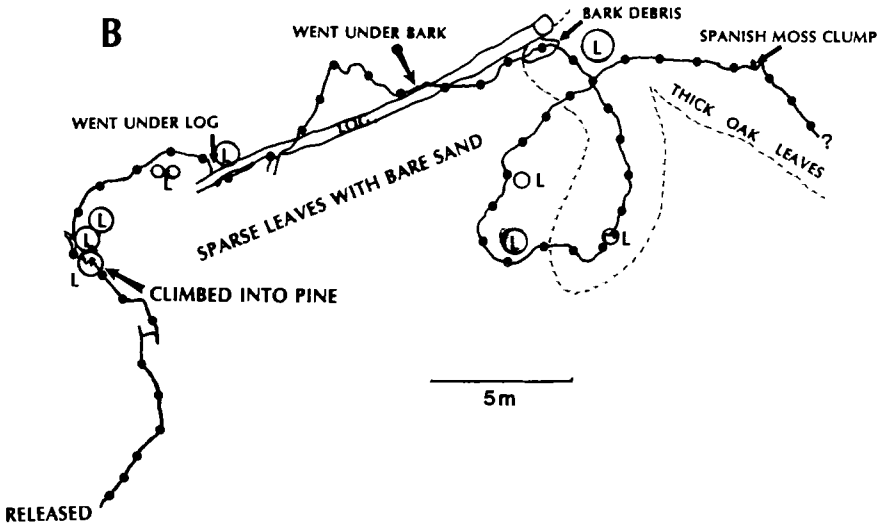
Rainfall quickly obliterated trails. At least 5 lizards were powdered early in the day only to have subsequent thundershowers preclude tracking. Another 4 lizard trails could only partially be followed after a light shower of about 5-10 min duration. If possible, tracking should be planned to ensure that adverse weather does not interfere with observations.

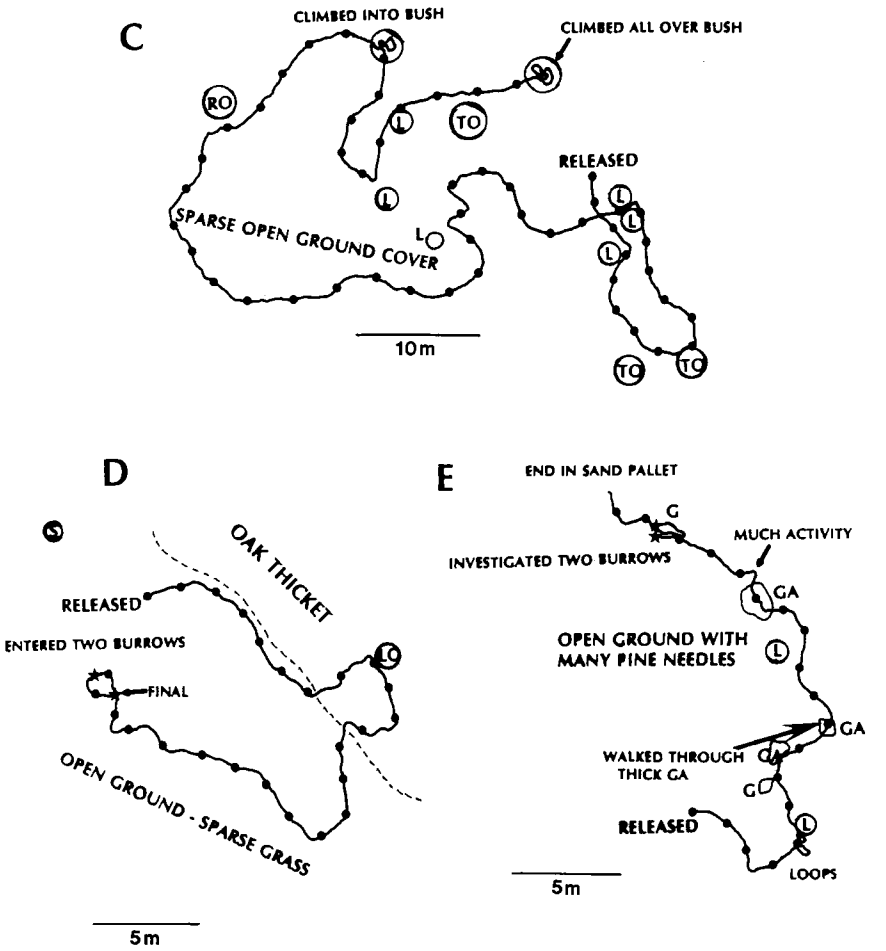
Fluorescent green powder made lizards quite visible to an observer at close ranges (1-2 m). However, at greater distances the animals often were not very obvious as they sat under vegetation or otherwise remained motionless. The extent to which powdering diurnally active lizards makes them prone to visually-oriented predators is unknown but should be considered. Powder in a lizard's eyes also may interfere with its ability to avoid predators.

The usefulness of fluorescent powder to track lizards varies inversely with the degree to which it influences behavior. Only 11 of 40 lizards traveled distances greater than 25 m, whereas the trails of 19 lizards could only be followed 10 m or less. Of those 19, five went directly to

Figure 1. Trails (solid lines with dots) of two male and three female *C. sexlineatus* illustrating movement patterns. A. Male, 65 mm SVL, released 14 April 1990; total length of trail is 51.5 m; B. Female, 59 mm SVL, released 27 June 1990; total length of trail is 62.6 m; C. Female, 59 mm SVL, released 23 August 1989; total length of trail is 39.6 m; D. Female, 70 mm SVL, released 14 April 1990; total length of trail is 18.4 m; E. Male, 62 mm SVL, released 13 June 1990; total length of trail is 23.7 m. G = grass clump, GA = clump of gopher apple, L = small longleaf pine, LO = laurel oak, RO = rosemary bush, S = stump, TO = turkey oak.







burrows and seven buried into the sand. These short distances indicate that handling the lizards affected their behavior after release, but the lack of long trails does not mean that powdering per se was the reason for quick retreats to cover sites or burrows. A few lizards traveled long distances after release and the complexity of their trails suggested that their behavior was not adversely affected by powdering. I suggest that it is stress from handling rather than the powder that limits the effectiveness of this technique.

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