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Detection Rates of Eastern Spotted Skunks (Spilogale putorius) in Missouri and Arkansas Using Live-capture and Non-invasive Techniques

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Abstract.—The eastern spotted skunk (*Spilogale putorius*) is a rare species of conservation concern throughout much of its range, but effective management is hampered by a lack of information on appropriate survey strategies. We validated three commonly used techniques to identify the presence of eastern spotted skunks at four sites in Missouri and Arkansas where the species was known to occur. Live-capture with box-traps revealed a strong seasonal pattern in capture success in both states, with virtually all captures occurring between late Sept. and early May. This pattern of detection also occurred when surveys were conducted using non-invasive camera-traps and enclosed track-plates in Missouri. Track-plates were more efficient than camera-traps at detecting eastern spotted skunks, with a lower latency to initial detection (LTD) and higher probability of detection (POD). Our results indicate that the use of enclosed track-plates is a powerful non-invasive technique for detecting eastern spotted skunks when surveys are conducted between late Sept. and early May. Surveys conducted during late spring and summers are inappropriate given the high likelihood of not detecting the species despite its presence.

Introduction

The eastern spotted skunk (*Spilogale putorius*) is a small mephitid that was once common throughout much of the Midwestern United States. Historically the species was harvested in significant numbers (*e.g.*, 55,000 in Missouri in 1940), but beginning in the 1940s precipitous declines in harvests occurred throughout its range (DeSanty, 2001; Gompper and Hackett, 2005; Sasse and Gompper, *in press*). This decline was not an artifact of altered harvest pressures or pelt demands, but rather reflected a range-wide decline in abundance (Gompper and Hackett, 2005). Currently the species is listed as endangered, threatened or 'of concern' in virtually every state in the Midwestern portion of its range and in multiple states in the eastern portion of its range. In Missouri the species was listed as Endangered (S1) in 1991 and in Arkansas the species was listed as an Animal of Special Concern (S2/S3) in 2006.

Reliable survey and monitoring protocols must be developed before designing management and conservation efforts focused on the eastern spotted skunk. Once such protocols are developed, fundamental information such as presence/absence data and habitat-use patterns could be identified and used to make informed management decisions relevant to the species. Designing such protocols initially requires: (1) information on seasonal variability of the likelihood of detection and (2) information on the appropriateness of the technique being used for the survey. Most researchers recognize that seasonal variability in detection probability exists for many species (*e.g.*, Moore and Kennedy, 1985; Gehrt and Fritzell, 1996; Baker *et al.*, 2001), but such information is often unavailable for rare species. Yet an understanding of this variability is particularly relevant when novel survey techniques are being considered. Non-invasive techniques are increasingly used by researchers to identify the presence of carnivores in specific habitat types. For small and mid-sized carnivores, the two primary methods used are camera-traps and track-plates, both of which usually use a bait or scent to attract the target species to a census station which then records the visit by photograph or track imprint (Zielinski and Kucera, 1995; Foresman and Pearson, 1998; Gese, 2001, 2004; Wilson and Delahay, 2001). Importantly, these techniques vary in their utility for identifying the presence of particular species. For reasons that are not entirely clear, some species avoid certain types of survey apparatus or hesitate to approach a census station, increasing the likelihood of a false negative being recorded for a particular site (Gompper *et al.*, 2006; Vanak and Gompper, *in press*). Thus, researchers should validate that the technique in question efficiently identifies the presence of the species at sites where the species is known, *a priori*, to exist.

We surveyed for eastern spotted sites at three sites in southeastern Missouri and one site in west-central Arkansas where populations were known to be present. Our approach in Missouri was to periodically trap the sites to reconfirm eastern spotted skunk presence, and to resurvey the sites using both cameras and track-plate apparatus between capture sessions. In Arkansas, we conducted a year-long study of capture success using traps but without additional surveying. Our objectives were: (1) to assess if camera-traps and track-plates are appropriate techniques for identifying the presence of eastern spotted skunks; (2) to compare the relative merits of the two non-invasive techniques for discerning the presence of eastern spotted skunks; and (3) to examine seasonal variation in detection rates. Together, the Missouri and Arkansas datasets allowed us to discern whether any patterns of variability in detection occurred at localized or broad spatial scales.

METHODS

We conducted the study at three sites in Missouri and one site in Arkansas. In Missouri, field work occurred on Mark Twain National Forest lands in Madison County approximately 40 km southwest of the town of Farmington: Gray Fox (37°31′38″N, −90°08′36″W), Cottoner Mountain (37°27′49″N, −90°13′03″W) and Turkey Ridge (37°24′42″N, −90°17′31″W). Habitat in all three sites is second-growth forest dominated by oak-hickory (*Quercus-Carya*) typical of southeastern Missouri. These sites were selected based on insights from a local trapper that skunks had been captured at these sites in previous years, and the presence of skunks at each site was confirmed in Dec. 2004–Jan. 2005 by live-capture with Tomahawk #103 box-traps. All captures of eastern spotted skunks were recorded followed by immediate release on site without any direct handling. Recapture efforts were thereafter carried out approximately every two months to confirm the continued presence of eastern spotted skunks at the sites.

Beginning in Feb. 2005 at each Missouri site, the presence of eastern spotted skunks was confirmed approximately every 6–8 wk by capturing animals with box traps, camera-traps and track-plates. Box traps (n = 20 per site) were placed along both sides of an unpaved road at about 200-m intervals and run daily with a goal of nine nights (180 trap-nights) per site each month. However, logistic concerns such as poor weather or theft of traps occasionally reduced the total number of trap-nights in any given month. Camera-traps and track-plates were placed on a 3 × 3 grid (0.25 km^2; internodal distance of ~250 m), the center of which overlapped the mid-point of the trap-line. One survey unit (a camera or track plate) was placed at each of the nine grid nodes and run for 14 d (126 survey-nights), before being switched to the other survey technique. This resulted in a total survey period of 4 wk at a given survey area (252 survey-nights). We altered the order of technique implementation during each survey event, allowing for the consideration that the initial 2-wk survey may influence the likelihood of detection during the second 2-week period if individual skunks became trap-shy or trap-happy. Following each 4-wk survey period, all survey apparatus were removed from the site and no visits were made to the site for 2 wk prior to live-trapping and subsequent resurvey efforts with non-invasive techniques.

Camera-trapping involved the use of a Deercam DC200 (Nontypical Inc., Park Falls, WI) camera which was secured on the bole of a tree, and pointed at another tree 2–3 m away upon which a can of sardines was secured ca 0.5 m above ground. Camera-traps were run for two weeks, with a single station check on day 7–8. Track-plate design followed Gompper *et al.* (2006) and involved a 1 mm aluminum plate (76 × 20 cm) coated on one half with a tracking medium (carbon toner), while the other half was covered with adhesive contact paper (sticky side exposed), leaving approximately 6 cm uncovered. Sardines were placed in this uncovered section as bait and the entire plate was then placed within an enclosure of corrugated plastic sheeting. Track plates were checked and rebaited every 2–3 d, depending on animal activity levels and weather.

In Arkansas, all field work was conducted in the Ouachita National Forest in Scott County (34°48′29″N, −90°20′54″W) approximately 25 km southwest of the town of Waldron at a site where incidental captures had occurred in the mid-1990s. The site is primarily shortleaf-pine (*Pinus echinata*) forest with a hardwood component and an understory dominated by native grasses and forbs. Because primary goals of the trapping were to capture eastern spotted skunks for a habitat ecology study, trapping localities shifted slightly from month-to-month, but maximum distance between all localities was about 13 km. Eastern spotted skunks were captured in Tomahawk #103 box traps, anesthetized, ear-tagged, radio collared and released at the capture site following recovery. Trap-lines of 25–100 traps were placed at 100–250 m intervals in grid patterns or along existing roads and trails. Trap-lines were run monthly beginning in Mar. 2005 for a minimum of 500 trap-nights or one week (both measures were exceeded in virtually all months). Camera traps and track plates were not used in Arkansas.

We used two metrics to compare technique efficacy that take advantage of data from resampling a site multiple times: latency to initial detection (LTD; Gompper *et al.*, 2006) and probability of detection (POD; Mackenzie *et al.*, 2002). The LTD was defined as the time (in days) until initial detection of a species at a survey site, and was calculated for camera from photo stamps and for track plates based on checking intervals. Because track plates were not checked daily, estimates of LTD may be slightly biased upwards. Probability of detection was the likelihood that a species was detected with a given technique when present at a survey site. The program PRESENCE (Mackenzie *et al.*, 2002) was used to calculate POD per site for cameras (~14 daily intervals) and track plates (~4–5·3-d intervals). This method uses a maximum likelihood approach to estimate the probability that a species will be detected at least once when it is present at a site and assumes that the likelihood of detection does not change over the course of the survey effort. Estimates of LTD and POD were only carried out at the site level (*i.e.*, combining data from all nine nodes). To convert survey length POD to a per-check POD, we used the formula

$$POD_{check} = 1 - \left(1 - POD_{survey}\right)^{n}$$

where n represents a conversion metric of 1/# survey intervals (for camera traps, n = 1/14 = 0.0714; for track plates which were checked 4 times over the course of a survey, n = 1/4 = 0.25).

RESULTS

Eastern spotted skunks were live-trapped at each site beginning in Mar. 2005. In Missouri, on average, 159 trap-nights per site (range 112–180) were run during each survey effort (n

TABLE 1.—Capture rates of eastern spotted skunks at Gray Fox (GF), Cottoner Mountain (CM) and Turkey Ridge (TR) in southeastern Missouri based on number of live captures (N), which combined new captures and recaptures, in Tomahawk box-traps between Feb. and Dec. 2005

Site	Month	Total trap-nights	N	Captures/100 trap-nights
CM	Mar.	144	4	2.8
GF	Mar.	160	0	0
TR	Mar.	152	1	0.7
All	Mar.	456	5	1.1
CM	May	175	0	0
GF	May	154	0	0
TR	May	180	2	1.1
All	May	509	2	0.4
CM	Jul.	176	0	0
GF	Jul.	161	0	0
TR	Jul.	175	0	0
All	Jul.	512	0	0
CM	Aug.	180	0	0
GF	Aug.	160	0	0
TR	Aug.	180	0	0
All	Aug.	520	0	0
CM	Oct.	112	1	0.9
GF	Oct.	160	1	0.6
TR	Oct.	160	1	0.6
All	Oct.	432	3	0.7
CM	Dec.	136	0	0
GF	Dec.	157	0	0
TR	Dec.	138	1	0.7
All	Dec.	431	1	0.2

= 2860 trap nights), and 9 eastern spotted skunks were captured 11 times over all three sites (capture success = 0.38%). Capture rates were higher at Cottoner Mountain (n = 923 trap-nights; n = 5 captures; capture rate = 0.54%) and Turkey Ridge (n = 985 trap-nights; n = 5 captures; capture rate = 0.51%) than at Gray Fox (n = 952 trap-nights; n = 1 capture; capture rate = 0.11%). Capture rates were highest in Oct.–May, with peak capture rates of 1.1% in Mar. In contrast, capture success was zero during the summer months (Table 1).

In Arkansas, we captured 23 eastern spotted skunks 101 times during 179 d and 12,404 trap-nights between Mar. 2005 and Mar. 2006, for a total capture rate of 0.19% for new captures and 0.81% for all captures. As in Missouri, however, there was a strong seasonal pattern in capture success (Fig. 1), with the lowest success occurring from May–Sept. (5182 trap nights; 2 new captures, 6 total captures). Excluding these months, capture success was 0.29% for new captures and 1.31% for all captures (n = 7222 trap nights).

Eastern spotted skunks were detected by either camera or track plates on 30 occasions in Missouri (Cottoner Mountain = 13; Gray Fox = 8; Turkey Ridge = 9). Similar to the live-trapping data, there was a distinct seasonal component to the variability in detections, with detections absent in late spring and summer (Fig. 2). Skunks were more likely to be detected by track plates than by cameras; 63% of detections were at track plates, and at one site (Turkey Ridge) eastern spotted skunks were only detected with track plates. The

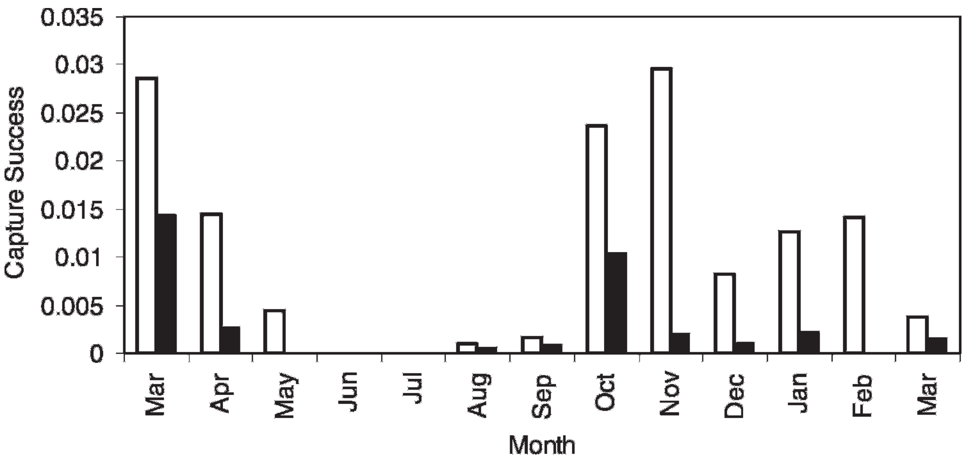


FIG. 1.—Live-trapping capture success (number of captures per trap-night) of eastern spotted skunks in The Ouachita National Forest, Arkansas between Mar. 2005 and Mar. 2006. Filled bars represent new captures, open bars represent both new captures and recaptures

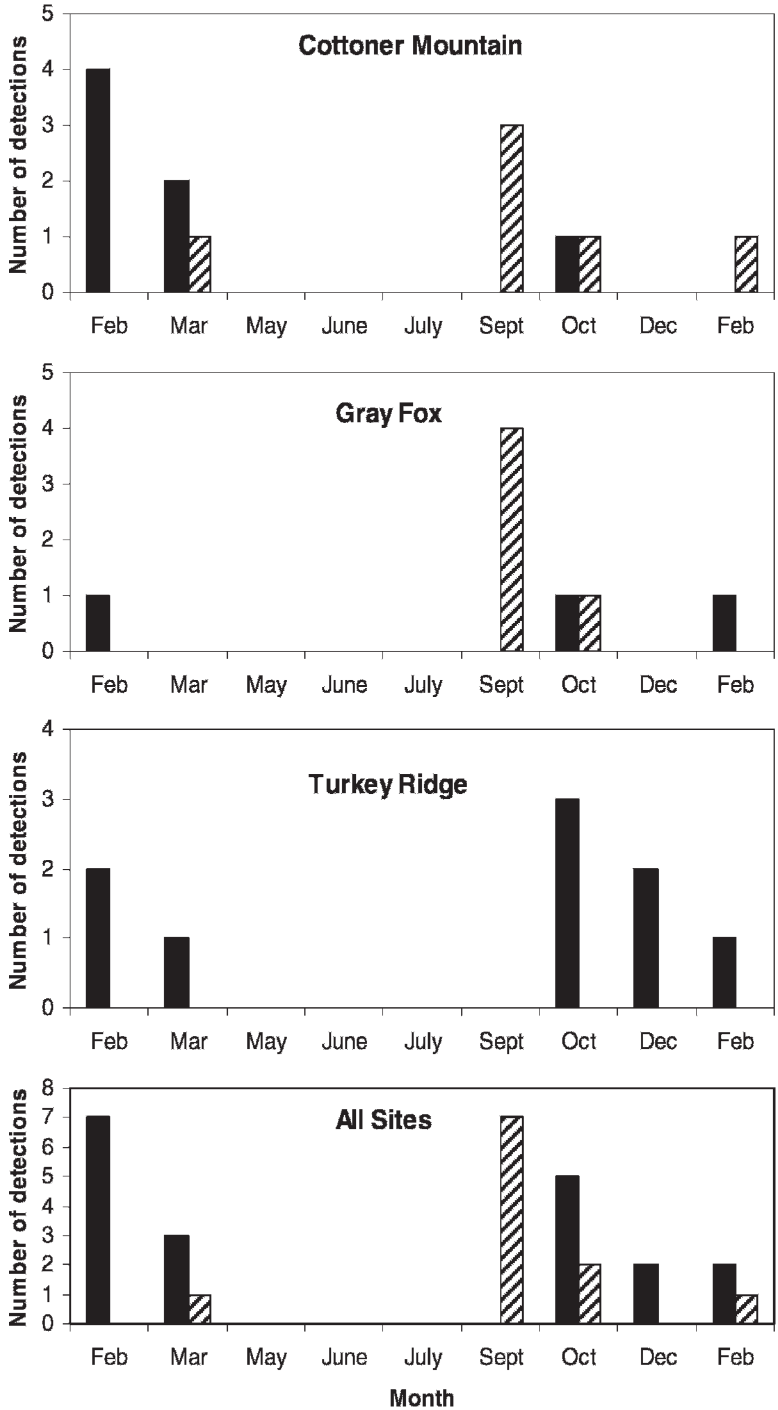
exception to this result was during Sept., when all detections were by cameras. Combining all sites, monthly capture rates (number of nights with eastern spotted skunk captures/total number of survey nights) for cameras were 0–1.6%. For track plates, across all sites, monthly capture rates were 0–1.9%. However, because track plates were only checked every 2–3 d, capture rates also may be estimated as the rate of positive identifications divided by the number of track-plate checking intervals (n = 36 per month per site). Across all sites, monthly capture rates for track plates were 0–6.5% per sampling interval (n = 108).

Probability of detecting eastern spotted skunks was higher for track plates than for camera traps, with the exception of Sept. (Fig. 3). During Sept.–Mar., mean POD_{survey} varied from 0–61% (mean POD_{survey} = 35.4%) for track-plates, and from 0–21% (mean POD_{survey} = 8.0%) for camera-traps. Transforming these survey-length values to a per-check value results in a mean POD_{check} of 0.006 for camera traps and a mean POD_{check} of 0.103 for track plates. Thus despite less frequent checking intervals, track plates were more likely to detect eastern spotted skunks.

Latency to initial detection was calculated for five site-months at two sites (Cottoner Mountain and Turkey Ridge) for camera traps and for nine site-months from all three sites for track plates (Table 2). Across all sites, mean LTD was lower for track plates (LTD = 5 d) than for camera traps (LTD = 7.2 d). The differences in LTD between the two techniques are not significant (*t*-test assuming unequal variance; df = 6; t = −1.07; P = 0.324), but this test may be confounded by small sample sizes of site-months where skunks were detected by cameras, as well as because LTD estimates for track plates are biased upwards (over-estimating LTD). Thus track plates recorded the presence of eastern spotted skunks more rapidly than did camera traps.

DISCUSSION

This study validates the use of two non-invasive techniques, camera traps and track plates, for the detection of eastern spotted skunks. Indeed, monthly capture success of eastern spotted skunks by non-invasive techniques tended to be comparable or higher than


Cottoner Mountain
Gray Fox
Turkey Ridge
All Sites
Number of detections
Feb
Mar
May
June
July
Sept
Oct
Dec
Feb
Month

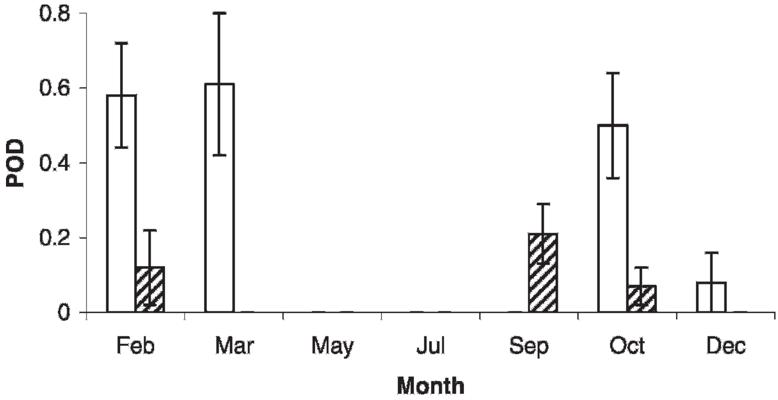


FIG. 3.—Probability of detection (POD_{survey}) ± SE for eastern spotted skunks using track-plates (open bars) and camera-traps (hatched bars). Data are subdivided by month of detection; eastern spotted skunks were not detected by either technique during the months of May and Jul.

measures derived from live-trapping with box-traps. In Missouri, the peak live-trapping capture rate was exceeded by track-plate detection rates in 3 mo and by camera-trap detection rates in 1 mo. Furthermore, given that track plates were only checked twice per week, detections per sampling interval (approximately 3–4 d) were considerably higher, ranging from 0.93% in Dec. to 6.5% in Feb. In the latter context, track plates could be considered superior to live traps for detecting eastern spotted skunks.

All techniques failed almost entirely to detect eastern spotted skunks during the summer months, and only live trapping detected the species in the late spring, albeit at a low rate. While this study was only carried out over approximately one year, and there could be variation among years, this finding was observed in both Arkansas and Missouri. Thus eastern spotted skunks cannot be reliably surveyed by any of the three techniques between mid-May and mid-Sept. The ecological underpinnings of this apparent lack of detectability are unclear, but similar patterns in capture success have been documented elsewhere. For instance, in Ohio, capture success of striped skunk (*Mephitis mephitis*) also declined to near zero in the spring and summer, a pattern attributed to resource availability, male sexual behavior and trap avoidance and reduced movement by pregnant and lactating females (Bailey, 1971). Many species of carnivores, including other skunk species, show dramatic seasonal shifts in home range size, habitat use, and foraging ecology (Bixler and Gittleman, 2000; Zapata *et al.*, 2001; Cantú-Salazar *et al.*, 2005; Doty and Dowler, 2006) and similar factors may underlie the patterns observed here. A concurrent telemetry-based study of Arkansas eastern spotted skunks has found greatly reduced home-range size during the late spring and summer (D. Lesmeister, pers. obs.)

Based on the data analyzed from southeastern Missouri, track plates outperformed camera traps for the detection of eastern spotted skunks. Relative to camera-traps, track plates recorded eastern spotted skunk presence at more sites, recorded more detections at any given site, had greater POD in most months and had a shorter LTD in most months.

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FIG. 2.—Number of detections of eastern spotted skunks (Feb. 2005–Feb. 2006) in southeastern Missouri at three sites plus all sites combined, with data subdivided by detection technique (track-plate = solid bars; camera-traps = hatched bars)

TABLE 2.—Mean (range; n) latency in days to initial detection (LTD) of eastern spotted skunks at three sites in southeastern Missouri subdivided by technique (camera-traps, track-plates), site (Gray Fox, GF; Cottoner Mountain, CM; Turkey Ridge, TR) and month of detection. Empty cells indicate no detection of eastern spotted skunks at the site or during the time interval. For track-plates, LTD is biased upwards, as survey apparatus were checked approximately every third day

	Camera-traps	Track-plates
Site		
All	7.2 (2–12; 5)	5 (3–9; 9)
CM	5.3 (2–10; 3)	3.75 (3–9; 3)
GF		4.5 (3–6; 4)
TR	10 (8–12; 2)	6 (2–9; 2)
Month		
Feb.	2 (2; 1)	4 (3–6; 3)
Mar.		6 (3–9; 2)
May		
Jul.		
Sep.	6 (4–8; 2)	
Oct.	11 (10–12; 2)	5 (3–9; 3)
Dec.		6 (6; 1)

Track-plates should therefore be considered the preferred non-invasive method for eastern spotted skunk surveys. Track-plates are less costly than camera-traps to purchase and issues pertaining to apparatus sensitivity and reliability are less of a concern (*e.g.*, Gompper *et al.*, 2006; Jackson *et al.*, 2006). Track plates do, however, require increased numbers of site visits relative to camera traps to periodically check for track imprints and make sure bait is still available at the survey apparatus. For this study, camera traps were only visited weekly following set-up, whereas track plates were visited four times following set-up. If such regular visitations are possible, track plates should be selected over camera traps for non-invasive surveys of eastern spotted skunks.

No single technique is ideal for surveying all species of carnivores (Gompper *et al.*, 2006). The differing value of various non-invasive techniques for accurate surveys has been recorded for other species. For instance, coyotes (*Canis latrans*) actively avoid camera traps, and Indian foxes (*Vulpes bengalensis*) avoid entering the types of enclosed track-plates used in this study (Sequin *et al.*, 2003; Gompper *et al.*, 2006; Vanak and Gompper, *in press*). Importantly in the context of this study, eastern spotted skunks are among the smallest of Carnivora, and it is possible that the sensors used in the cameras in this study are inappropriate for detecting small mammals such as eastern spotted skunks.

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