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Efficacy of attractants for detecting eastern spotted skunks: an experimental approach

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Estimates of abundance and occupancy are essential for wildlife management, particularly for species of conservation concern such as eastern spotted skunks *Spilogale putorius*. Most studies of eastern spotted skunks rely on limited evidence for best monitoring practices, and while many studies use attractants to increase detections, previous studies have not tested attractants against a control of no attractant to determine their effectiveness. We tested two common attractants (sardines and fatty acid tablets) and one uncommon attractant (wild boar carcasses) against a control of no attractant to determine if any attractant increased detections of eastern spotted skunks or changed their temporal activity. Based on our model, sardines and wild boar carcasses improved detections by three and eight times that of the control, respectively. Further, for every 100 trap nights, we detected eastern spotted skunks 10.67 times with wild boar carcasses, 1.02 times with sardines, 0.53 times with fatty acid tablets and 0.44 times with no attractant. Wild boar carcasses also substantially decreased latency to detection, with skunks detected two times faster than at other attractants and almost three times faster than at the control. Eastern spotted skunks were most active in the early morning before sunrise, and their temporal activity did not vary significantly by attractant. This study is the first to use an experimental framework to test attractants for eastern spotted skunks, and our results showed that choice of attractant matters. Large animal carcasses, although rarely used, may be most effective for detecting eastern spotted skunks, while fatty acid tablets were no different than the control, and we recommend against their use in future studies. Monitoring plans should incorporate our results as increasing detections is essential to understanding the abundance, range and demographics of eastern spotted skunks.

Keywords: bait, camera trap, carrion, detection, experimental framework, fatty acid tablet, large animal carcass, lure, sardines, *Spilogale putorius*

Estimates of population abundance and occupancy are essential for the management and conservation of wildlife species (Skalski et al. 2005, Allen et al. 2020). Accurate estimates are especially important for species of conservation concern, but many of these species are difficult to document due to their cryptic nature or low density (Gompper and Hackett 2005, Allen et al. 2020). In many cases, species-specific monitoring plans must be developed to increase detections and accuracy of studies (Zielinski and Stauffer 1996), often including the use of attractants (any device or material used to attract a target species including edible baits and inedible or inaccessible lures, Schlexer 2008). These species-specific plans are most rigorous when developed using experimental methods to compare different approaches, rather than generalizing an approach based on successes that may be context-dependent or anecdotal.

Eastern spotted skunks *Spilogale putorius* are thought to have been abundant in the central and southeastern United States of America before dramatic declines in abundance beginning in the 1940s (Gompper and Hackett 2005). Reasons for this decline are not fully understood but may include habitat loss (Gompper and Hackett 2005), disease (Thorne et al. 2017) or increased use of pesticides (Gompper and Hackett 2005). As a result, eastern spotted skunks are a species of concern in many of the states where they occur (Gompper and Hackett 2005) and are considered vulnerable by the International Union for Conservation of Nature (IUCN, Gompper and Jachowski 2016). Records of harvest and pelt sales inform our understanding of historical range (Gompper and Hackett 2005), but the use of track plates and camera traps with attractants has been the basis of field-intensive studies in the last two decades (Hackett et al. 2007).

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While developing best monitoring practices for eastern spotted skunks is essential to understanding their abundance, distribution and demographics, most techniques currently used are not based on results from rigorous experimental studies (ESSCSG 2020). For example, despite the widespread use of camera traps and track plates for eastern spotted skunks, few studies have compared the effectiveness of these and other trapping strategies (Hackett et al. 2007, ESSCSG 2020). Similarly, few other noninvasive monitoring techniques are used for eastern spotted skunks, though many – such as scat surveys and snow tracking – are effective for other carnivores (Gompper et al. 2006). Further, trapping during colder months is thought to increase detections of eastern spotted skunks, but that is based solely on one study (conducted over one year in two states) that did not detect any skunks in summer months (Hackett et al. 2007). It is possible that this observed seasonal pattern would not hold true across time or over the entire range of eastern spotted skunks, as evidenced by one study incidentally capturing 18 eastern spotted skunks during summer in Arkansas (Perry et al. 2018). Finally, attractants (e.g. bait or lure) are frequently used to increase detections (Hackett et al. 2007, Lesmeister et al. 2009), but studies often lack a rigorous experimental design to determine their effectiveness. Only one study has compared eastern spotted skunk detections between different attractants (Eng and Jachowski 2019a), and no studies have compared the efficacy of attractants to a control of no attractant. Without control, the effects of the attractant cannot be separated from random variation (Dytham 2011), limiting the utility of results and implementation of effective monitoring techniques.

Past studies frequently used attractants to increase detections of eastern spotted skunks, despite the lack of evidence on their efficacy, with varying degrees of success. Sardines and other canned fish are the most commonly used attractant in eastern spotted skunk studies (Table 1). The fish is often placed on the ground as a bait where the skunk can access it (Lesmeister et al. 2013, Sprayberry and Edelman 2018), but the can may also be nailed to a tree as a lure (Hackett et al. 2007, Higdon and Gompper 2020). Studies have also used other scent lures, such as Caven's Gusto (Minnesota Trapline Products, Pennock, MN, USA) and fruit oils, and other baits, such as wet cat food, fruit pastes and large animal carcasses (Table 1). One study reported incidental captures of eastern spotted skunks in live herpetofauna traps (Perry et al. 2018), which they are known to prey on (Sprayberry and Edelman 2016, Thorne and Waggy 2017), and another reported captures in flying squirrel traps baited with bacon grease, molasses, peanut butter, oatmeal and apple (Diggins et al. 2015) suggesting potentially effective baits. Given the number of possible attractants and the lack of knowledge on their comparative efficacy for eastern spotted skunks, future studies would benefit from experimental tests of the effectiveness of attractants against a control.

Our first objective was to test the effectiveness of multiple attractants for increasing detections of eastern spotted skunks using a rigorous experimental framework. We compared three different attractants to each other and to a control of no attractant to determine if any bait (accessible for consumption) or lure (not accessible for consumption) increased detections, decreased latency to first detection or changed the temporal activity of eastern spotted skunks. Our first attractant was a bait of wild boar *Sus scrofa* carcasses, based on a previous study's successful use of large animal carcasses to attract eastern spotted skunks (Thorne et al. 2017). The second was a lure of sardines as they are the most common attractant used for eastern spotted skunks (Hackett et al. 2007, Lesmeister et al. 2009, Table 1). The third was a lure of fatty acid tablets, which are often used to attract skunks and other mesocarnivores (Sprayberry and Edelman 2018, Heinlein et al. 2020). Based on the prevalent use of attractants in eastern spotted skunk studies, we expected all three attractants to significantly increase detections and reduce latency to detection compared to the control. We further predicted that sardines would improve both of these measures more than the other two attractants based on their frequent use in past studies. Our second objective was to examine monthly and daily activity patterns of eastern spotted skunks to determine if detections varied with season and if temporal activity differed between attractants. Based on previous work, we expected eastern spotted skunk detections to be highest during the winter months (Hackett et al. 2007). We further predicted that skunks would primarily exhibit nocturnal activity (Benson et al. 2019), but that temporal activity would vary by attractant because skunks would seek out preferred attractants earlier in their foraging compared to the control (Gerber et al. 2012).

Material and methods

Study area

Fort Hood is an 88 557 ha Army installation in central Texas (Fig. 1). The landscape is characterized by remnant mesas with canyons separated by wide valleys and rolling lowlands with elevations of 139–394 m (Hayden et al. 2000, Thornton and Pekins 2015). The vegetation consists of perennial grasslands and forests of several oak species (*Quercus buckleyi*, *Q. fusiformis* and *Q. sinuata*) and Ashe juniper (*Juniperus ashei*, Eckrich et al. 1999, Hayden et al. 2000). Summer lasts for about five months (May–September) with a mean monthly temperature of 35°C, and winter lasts for about three months (December–February) with a mean monthly temperature of 2°C. Annual rainfall averages 84 cm, falling mostly in May and September (NOAA weather station data, accessed 26 June 2020 from <https://www.noaa.gov>). The primary use of the land is military training with tracked and wheeled vehicles, rotary wing aviation and live fire of weapon systems, but recreation activities such as hiking, hunting and fishing occur as well (Hayden et al. 2000). The diverse ecosystems and protection from surrounding development provide sanctuary for many species (Hayden et al. 2000), including eastern spotted skunks.

Literature review methods

We performed a literature review of attractant use for eastern spotted skunks. On 18 January 2021, we searched Web of Science for 'eastern spotted skunk' and '*Spilogale putorius*' each with 'bait', 'lure' and 'attractant'. We then read each entry and removed mismatched entries and those from non-

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Table 1. Peer-reviewed studies that used an attractant for eastern spotted skunks and results on the efficacy of that attractant. No study compared attractants to a control of no attractant. Detection results are detections per 100 trap nights unless otherwise stated. Studies listed chronologically.

Study	Location	Trap nights	Number of sites	Traps per site	Attractant	Detection method	Bait or lure	Detection results	Latency result (days)
Reed and Kennedy 2000	Tennessee	5723	–	20	Cat food or sardines	Live traps	Bait	0.07	–
Hackett et al. 2007	Missouri	2268*	3	9	Sardines	Camera traps	Lure	0.49	7.2
		2268*	3	9	Sardines	Track plates	Bait	0.84	5
	Missouri and Arkansas	15 264	4	20–100	Sardines	Live traps	Bait	0.73	–
Lesmeister et al. 2009	Arkansas	12 970	–	25–100	Canned fish and fruit-scented paste	Live traps	Both	0.25	–
Lesmeister et al. 2013	Arkansas	5400*	50	9	Sardines	Track plates	Bait	2.33	–
Diggins et al. 2015	Virginia	2426	–	76	Bacon grease, molasses, peanut butter, oatmeal and apple	Live traps for flying squirrels†	Bait	1.07	2
Wilson et al. 2016	South Carolina	1326	56	1	Sardines	Camera traps	Lure	0.38	19.6
Boulerice and Zinke 2017	Wyoming	1512*	72	1	Wet cat food and Caven's Gusto or Tinctured Skunk Essence	Camera traps	Both	22% of sites	–
Lombardi et al. 2017	Virginia	1985	48	2	Gusto long-distance call lure and raw meat or sardines	Camera traps	Both	0.35	–
Thorne et al. 2017	Virginia	3522*	91	1	Deer carcass	Camera traps	Bait	21% of sites	–
Perry et al. 2018	Arkansas	864*	12	3	Unknown	Live drift fence traps for herpetofauna†	–	2.08	–
Sprayberry and Edelman 2018	Alabama	–	Through-out study area	1	Fatty acid tablets and sardines	Camera traps	Lure	–	–
		250	At successful cameras	–	Sardines	Live trap	Bait	4.00	–
Eng and Jachowski 2019a	Border of North/South Carolina and Georgia	4689 total	45	1	Sardines and Caven's Gusto	Camera traps	Lure	23% higher than sardines alone	28.3- all sites
			45	1	Sardines and Cherry Oil		Lure	23% lower than sardines alone	
			45	1	Sardines only		Lure	–	
Eng and Jachowski 2019b	South Carolina	382	–	–	Canned fish, peanut butter, cherry oil and Caven's gusto	Live traps	Both	15.45	–
Harris et al. 2020	Florida	–	–	–	Wet cat food	Live traps	Bait	59 captures	–
Higdon and Gompper 2020	Arkansas	8119	73	1	Tuna, Hawbaker's skunk/ opossum lure	Camera traps	Lure	0.07	–
		–	4	49–54	Cat food, Hawbaker's lure, Striped skunk urine, tuna, sardines or mackerel	Live traps	Both	3 captures	–

*Calculated based on length of deployment in methods, actual trap nights not reported.
†Incidental capture during study of another species.

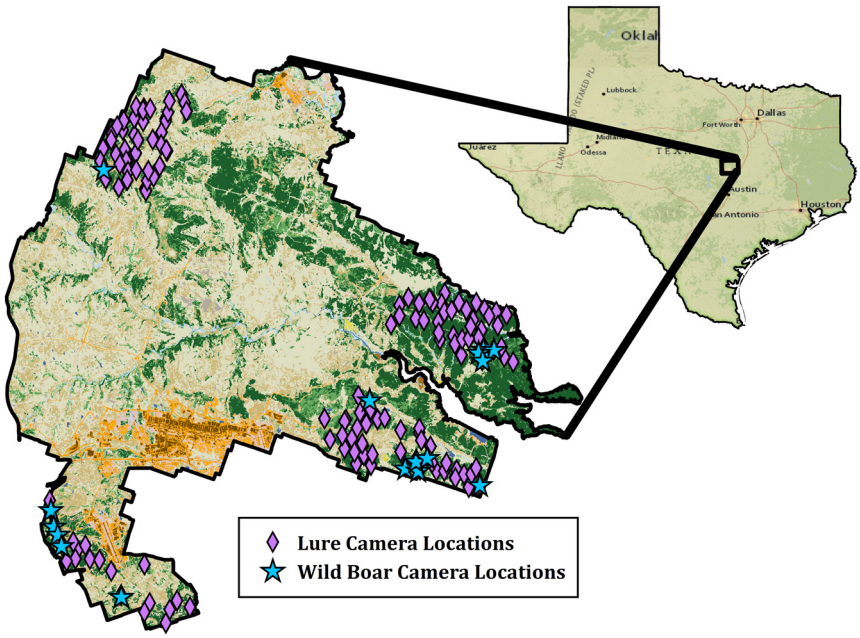


Figure 1. Map of study area (Fort Hood) and location within Texas, USA. Purple diamonds represent lure camera trap locations and blue stars represent boar carcass camera trap locations. Vegetation mapping from 2016 National Land Cover Database (accessed 26 June 2020 <www.mrlc.gov>) green = forest, tan = grassland, orange = urban.

peer-reviewed journals. We searched the remaining papers (n = 19) for attractant use descriptions and detection rates and summarized these results in Table 1.

Experimental design and field methods

We deployed camera traps over two years (year 1 = 13 November 2018 to 17 April 2019, year 2 = 19 December 2019 to 13 May 2020). We used systematic grids (year 1 = 6, year 2 = 7) each consisting of 20 camera traps spaced approximately 500 m apart with locations predetermined in ArcGIS (v. 10.0, ESRI 2011) by laying a grid over the forested portions of Fort Hood. We then placed cameras along the closest trail to the predetermined location (Thornton and Pekins 2015, Fig. 1). We placed camera traps in the same locations (stations, 140 total) each year and left them in place for an average 39 trap nights (range = 17–51) before moving them to the next grid. We randomly assigned placement of lures (sardines, fatty acid tablets and control) in equal proportions within each grid (n = 86 sardines, n = 86 fatty acid tablets, n = 85 controls total) with lure location within the grid varying between years. We placed lures in mesh bags approximately 1.5 m above the ground across the trail from the camera trap and refreshed the lure (replaced with a fresh version of the same lure) approximately every two weeks (mean = 15.55 ± 0.12 SE days). We considered this period, from the time we deployed or refreshed the lure to the time we visited again or stopped monitoring, as a session (2–3 sessions per camera deployment). We also placed 16 wild boar carcasses (obtained opportunistically from invasive species management at Fort Hood) within the boundaries of five of the grids (location within grid chosen randomly, Fig. 1) in January and February 2020, either after the lures had been removed or ≥6 weeks before the lures were deployed to avoid biasing the lure data. We placed carcasses ≥1 km apart on the ground secured to a tree with wire to prevent animals from removing them from camera view, with one camera trap monitoring each carcass. We left the carcasses in place for approximately two weeks (mean = 12.63 ± 0.63 SE days), did not refresh them, and considered their deployment one session. We programmed camera traps (Reconyx PC800 Hyperfire, XP9 Ultrafire and HC600 Hyperfire, Holmen, WI, USA) to take ten photographs each time they sensed motion for the lure camera traps and one min videos for the wild boar carcass camera traps with no refractory period.

Statistical analyses

We considered each trigger of a camera trap as one detection. To reduce pseudoreplication, we combined all detections of eastern spotted skunks at each camera trap that were <30 min apart into one independent event (Kelly and Holub 2008). We excluded three camera traps from our analysis that produced no trap nights due to malfunctions. All analyses were done in program R ver. 4.0.1 (<www.r-project.org>).

We used several methods to compare the effectiveness of the three attractants for increasing detections of eastern spotted skunks. We compared the average number of detections (over all sessions) per 100 trap nights between attractants and to the control using a Welch's t-test (for unequal variance). To evaluate the efficacy of each attractant, we assigned each camera trap session a 0 (not detected) or 1 (detected) and used a binomial generalized linear model to determine if the attractant significantly increased detections above the control. We included session length (in days) as a covariate to account for unequal deployments of attractants. We also included month (with December as the intercept because it had the lowest detection rate of the months with detections) in the model to examine seasonal differences in detec-

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tions of eastern spotted skunks. We assigned sessions that occurred over two months to the month with the most days represented for that session. To further explore differences in detections between attractants, we compared the mean detection rate for each attractant using the contrast function in package emmeans (ver. 1.5.2-1, Russel et al. 2020). To compare latency to detection (time from deployment to first eastern spotted skunk detection) between attractants, we used a t-test for each combination of attractants (e.g. sardines versus control, wild boar carcass versus fatty acid tablet, and so on).

We also examined the temporal activity of eastern spotted skunks and compared daily activity patterns between attractants to determine if using attractants changes skunk activity. We converted the time stamp in the photograph of each detection to radian times and then created a probability density distribution of eastern spotted skunk activity using a kernel density estimation (Ridout and Linkie 2009) in the density plot function in package overlap (ver. 0.3.3, Meredith and Ridout 2020). We estimated the difference in activity patterns between each of the three attractants and the control using the compareAct function in package activity (ver. 1.3.1, Rowcliffe 2021).

Results

We found 19 papers in our literature review that used an attractant to detect eastern spotted skunks (n = 15), reported incidental captures of eastern spotted skunks while using an attractant (n = 2) or reported observations of eastern spotted skunk prey (n = 2). Of these studies, most used camera traps (n = 8), live traps (n = 6) or track plates (n = 2). Canned fish was the most common attractant used (n = 13), followed by commercial lures (n = 6) and cat food (n = 4). Most studies used a combination of two or more attractants (n = 11). Eastern spotted skunk detections ranged from 3 to 126 detections over 250–15 264 trap nights, with an average of 2.16 detections per 100 trap nights (Table 1) although this may be skewed by one study (Eng and Jachowski 2019b) that had much higher detections than any other.

We deployed camera traps at 156 stations (140 lure locations and 16 wild boar carcass locations) for 10 347 trap nights over two years resulting in 89 eastern spotted skunk detection events (Table 2). We averaged 10.67 detections/100 trap nights (± 5.51 SE) with wild boar carcasses, 1.02 detections/100 trap nights (± 0.23 SE) with sardines, 0.53 detections/100 trap nights (± 0.17 SE) with fatty acid tablets and 0.44 detections/100 trap nights (± 0.52 SE) with no attractant (Fig. 2). Detections at wild boar carcasses were significantly higher than at both lures and the control ($p < 0.001$ for all), and detections at sardines were significantly higher than at the control ($p = 0.03$).

Based on our binomial logistic regression model of eastern spotted skunk detection/non-detection per session, detections were significantly higher at sites with wild boar carcasses and sardines compared to control sites (Table 3), and wild boar carcasses were doubly as effective ($\beta = 2.18 \pm 0.71$ SE, $p = 0.002$) as sardines ($\beta = 0.93 \pm 0.39$ SE, $p = 0.02$). Fatty acid tablets did not significantly affect detections. Similarly, the estimated detection probability based on our model at wild boar carcasses (detection probability = 0.08) was more than double that of sardines (detection probability = 0.03) and eight times that of fatty acid tablets and the control (detection probability = 0.01 for both). When we compared mean detections between attractants, both wild boar carcasses and sardines had significantly higher detections than the control ($p = 0.002$ and $p = 0.02$ respectively) and fatty acid tablets ($p = 0.001$ and $p = 0.007$). Eastern spotted skunk detections also significantly increased with longer sessions ($\beta = 0.52 \pm 0.17$ SE, $p = 0.002$) and when monitoring occurred in February ($\beta = 2.04 \pm 0.79$ SE, $p = 0.01$), March ($\beta = 1.82 \pm 0.79$ SE, $p = 0.02$) and April ($\beta = 1.94 \pm 0.80$ SE, $p = 0.01$, Table 3). When we compared mean detections between months, February, March and April had significantly higher detections than December ($p = 0.01$, 0.01 and 0.02 respectively, Fig. 3), but no other comparisons were significant. We did not detect any eastern spotted skunks in May, although this month had the fewest trap nights.

Table 2. Summary of eastern spotted skunk detections by attractant type. Total detections based on independent events (≥30 min apart).

Attractant	Total cameras	Cameras detected at	Total trap nights	Total detections
Wild boar carcass	16	4	202	20
Sardines	86	20	3358	35
Fatty acid tablet	86	9	3428	19
Control	85	9	3359	15
Total	273	42	10347	89

In our analysis of latency to detection, wild boar carcass had the shortest latency to detection (6.50 days ± 0.65 SE) and was significantly shorter than both lures (sardines = 13.67 days ± 2.10 SE, $p = 0.003$, fatty acid tablets = 16.22 days ± 3.56 SE, $p = 0.03$) and the control (17.56 days ± 3.30 SE, $p = 0.02$). No other comparisons between attractants and/or the control were significantly different (Fig. 4).

Based on the probability density distribution of temporal activity (Fig. 5), eastern spotted skunks were most active in the early morning, prior to sunrise. Their activity was entirely contained between 18:30 and 6:29 h, which roughly

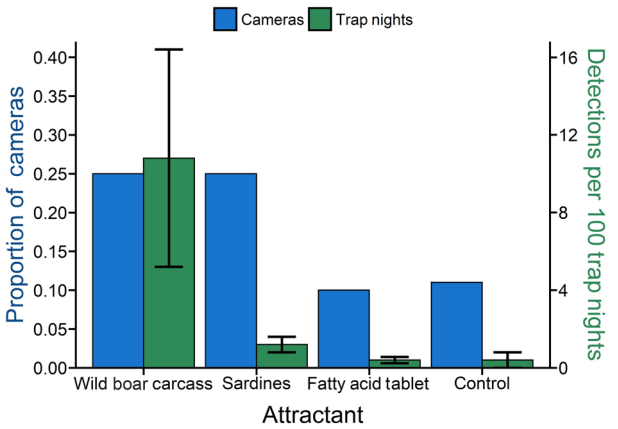


Figure 2. Proportion of camera traps where eastern spotted skunks were detected (blue–left axis) and average number of eastern spotted skunk detections per 100 trap nights (green–right axis) with standard error bars. Total number of camera traps per attractant: wild boar carcass = 16, sardines = 86, control = 85, fatty acid tablet = 86.

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Table 3. Results from binomial generalized linear model of eastern spotted skunk detections for each session (time from lure deployment to refreshment or collection) with attractant type, month deployed and session length (in days) as covariates. Intercept represents no attractant in December (month with lowest detections) and mean session length. Table includes beta estimates (β), standard errors (SE), p-values where * indicates significant results and detection rates based on the model.

	β	SE	p-value	Estimated detection rate
(Intercept)	−4.59	0.80	<0.001*	0.01
Wild boar carcass	2.18	0.71	0.002*	0.08
Sardines	0.93	0.39	0.02*	0.03
Fatty acid tablet	−0.14	0.46	0.77	0.01
November	1.64	1.07	0.13	0.05
January	1.07	0.89	0.23	0.03
February	2.04	0.79	0.01*	0.07
March	1.82	0.79	0.02*	0.06
April	1.94	0.80	0.01*	0.07
May	−13.83	891.43	0.99	< 0.001
Session length	0.52	0.17	0.002*	0.02

corresponds to sunset and sunrise in central Texas in winter (NOAA sunrise/sunset calculator, accessed 15 January 2021 from <https://www.esrl.noaa.gov>). Temporal activity did show minor variation by attractant type, although activity peaked in the early morning for all attractants. No activity patterns at attractants were significantly different from activity patterns at the control (p = 0.24–0.79). Activity at the wild boar carcasses was the most similar to activity at the control (difference = 0.02 ± 0.08 SE), followed by sardines and the control (difference = 0.07 ± 0.08 SE), and fatty acid tablets and the control (difference = 0.11 ± 0.09 SE).

Discussion

The most effective monitoring techniques for eastern spotted skunks are still unknown, but camera traps are often paired with attractants to increase detections (ESSCSG 2020) and appear to be effective. There is ambiguity in results from previous studies that evaluated monitoring techniques (Hackett et al. 2007, Eng and Jachowski 2019a) because they did

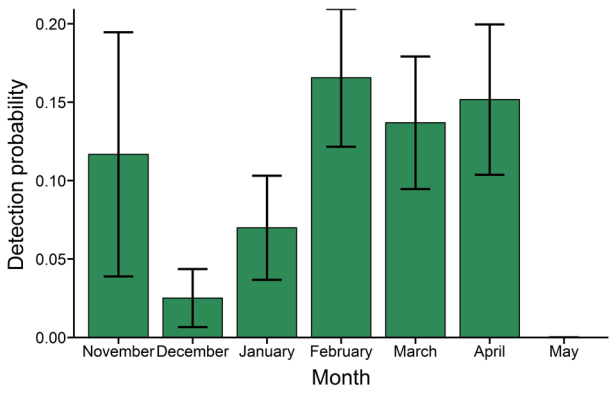


Figure 3. Estimated detection probability of eastern spotted skunks by month based on binomial regression model with standard error bars. Lure held as sardines and session length held at mean. May had the fewest trap nights so the detection probability of 0 may not represent reality.

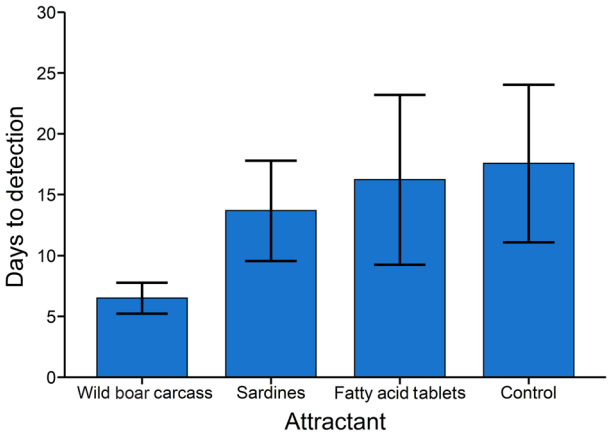


Figure 4. Latency to first detection (in days) of eastern spotted skunk by attractant type. Bars represent 95% confidence interval.

not use a rigorous experimental framework that included a control of no attractant. We used a rigorous experimental framework to determine if two common attractants (sardines and fatty acid tablets) and one uncommon attractant (wild boar carcasses) were more effective for detecting eastern spotted skunks than camera traps with no attractant. Our experiment showed that sardines and wild boar carcasses increase the effectiveness of camera traps for detecting eastern spotted skunks, but fatty acid tablets do not. This study is the first to use an experimental framework to compare attractants for monitoring eastern spotted skunks and also one of the most robust with 646 trials over 10 347 trap nights (Table 1).

We found that wild boar carcasses were the most effective of the three attractants we tested for detecting eastern spotted skunks, as it had substantially higher detection rates than with the other attractants (Table 3) and was the only attractant to significantly decrease latency to detection. While sardines are easier to deploy, our results suggest large animal carcasses may be the most effective attractant for eastern spotted skunks when logistically feasible. In fact, our detection rate (per 100 trap nights) at wild boar carcasses was higher than all but one previous study (Eng and Jachowski 2019b) that used attractants. Two studies reported similar detection rates to ours but one of those also used large animal carcasses (Boulerice and Zinke 2017, Thorne et al. 2017, Table 1). Of the four past studies that reported latency to detection (Hackett et al. 2007, Diggins et al. 2015, Wilson et al. 2016, Eng and Jachowski 2019a), our results with wild boar carcasses were similar or lower, and in our study, carcasses reduced latency to detection by half or more compared to the other attractants. Despite evidence of the effectiveness of large animal carcasses for eastern spotted skunks (Thorne et al. 2017), they are under-utilized as an attractant in studies. Most carnivores, including eastern spotted skunks, are scavengers (Allen et al. 2015, Sebastián-González 2020), and the use of carrion resources appears to be an effective method of detecting eastern spotted skunks.

Contrary to our expectations, not all the attractants we tested improved detections of eastern spotted skunks, highlighting the importance of experimentally testing attractants before using them in a study. While eastern spotted skunk detections increased significantly compared to the control when we used sardines, they were not as effective as wild boar

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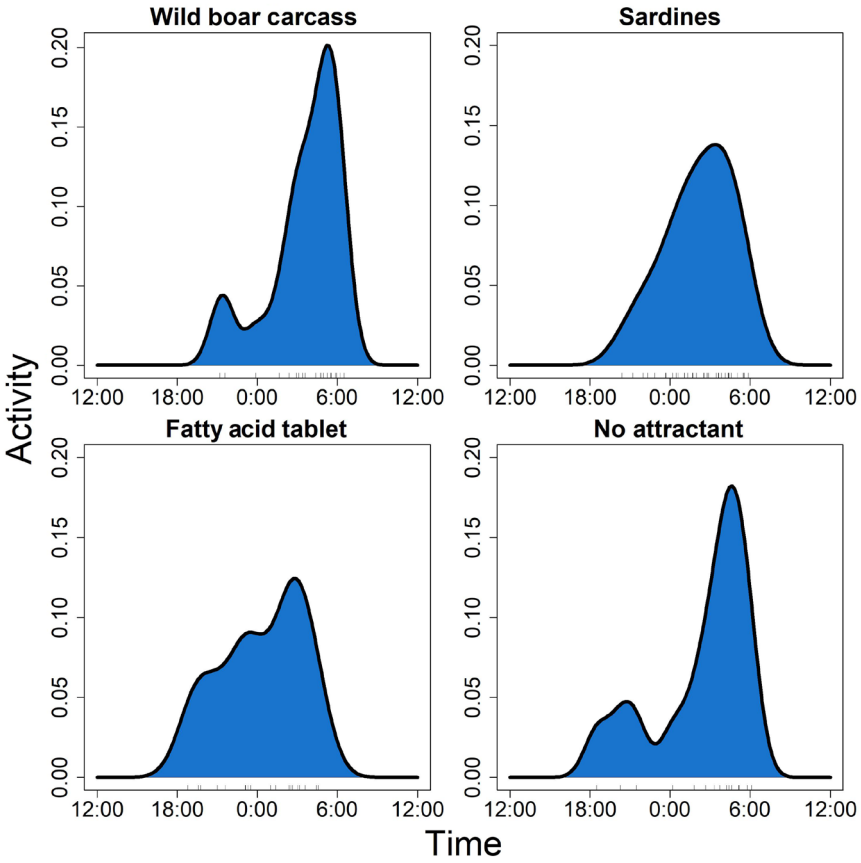


Figure 5. Probability density distribution of temporal activity (0:00 = midnight, 12:00 = noon) of eastern spotted skunks by attractant type based on camera trap time stamp.

carcasses, although this could be because we used them as a lure and not as a bait. Most previous studies placed sardines in traps or on track plates as a bait (Hackett et al. 2007, Lesmeister et al. 2009, 2013, Sprayberry and Edelman 2018, Eng and Jachowski 2019a, b) and appeared to have higher detection rates than those that nailed them to a tree as a lure (Hackett et al. 2007, Wilson et al. 2016, Higdon and Gompper 2020, Table 1). This may also be due to the detection method as sardines were most often used as a lure with camera traps, however, our study does not fit this pattern. Our detection rate (per 100 trap nights) at camera traps with sardines as a lure were similar to or higher than most previous studies that used canned fish (Hackett et al. 2007, Lesmeister et al. 2009, Table 1), although a few studies had much higher detection rates (Sprayberry and Edelman 2018, Eng and Jachowski 2019b). Our latency to detection with sardines was similar to other studies (Table 1), but sardines did not significantly improve latency to detection when compared to the control as we had expected. Surprisingly, fatty acid tablets did not improve any measure of eastern spotted skunk detection, despite commonly being used to increase detection of mesocarnivores and occasionally skunks (Sprayberry and Edelman 2018, ESSCSG 2020, Heinlein et al. 2020), likely because of their low cost and longevity. Overall, our results support the continued use of sardines to increase detections of eastern spotted skunks, but suggest fatty acid tablets should be avoided in future studies due to their ineffectiveness. However, further testing of fatty acid tablets for eastern spotted skunks may find conditions where they are effective.

Using an attractant, especially a large animal carcass, may complicate other aspects of study design, which should be considered during study development. The use of carrion by spotted skunks can result in competition with other carnivores at the carcass, which could have unintended consequences, including injury, disease from the carcass or other animals, or death (Briffa and Sneddon 2007, Rasambainarivo et al. 2017, but see Allen et al. 2013). Carcasses are also more logistically challenging than other attractants as they may not be widely available and can be difficult to move. On the other hand, the availability of the carcass provides a food resource, in contrast to lures, which provide no benefit to the focal species. This food resource also likely increases repeat visits by individuals, as demonstrated by the large observed difference in detection rates between sardines and wild boar carcass but the same proportion of camera traps that detected an eastern spotted skunk (Fig. 2). Feeding at carcasses also increases the amount of time an individual spends in front of the camera trap (Gerber et al. 2012), which can improve the accuracy of individual identifications for demography and population estimation studies. While the larger size and stronger smell of carrion may draw skunks from a larger area than the lures would, previous work suggests meat baits do not change the large-scale movements of animals (Gerber et al. 2012). Whether these factors bias results should be determined by the goals of a study. We encourage further experimentation with the effects and potential risks (e.g. death or disease) of large animal carcasses for detecting eastern spotted skunks, especially in areas where detection is less likely.

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The temporal activity of eastern spotted skunks is not well known (ESSCSG 2020) but they are thought to be nocturnal (Benson et al. 2019), which our data support (Fig. 5). While there was some variation between attractants, our hypothesis that skunks would shift their timing to access preferred attractants earlier was not supported. In fact, temporal activity at wild boar carcasses and sardines (presumably preferred attractants based on their efficacy for attracting skunks) had the smallest and second smallest difference from activity at control camera traps and no differences in activity patterns were significant, suggesting eastern spotted skunks do not alter their activity at preferred attractants. Although our small sample size at control camera traps hindered our ability to draw definitive conclusions, it appears that using an attractant does not substantially alter eastern spotted skunk temporal activity and suggests they can be used in temporal studies without concern of bias. We encourage further testing of the effects of attractants on eastern spotted skunk activity patterns with larger sample sizes to confirm our results.

The first study to test detection methods for eastern spotted skunks had low or no detections during the summer and concluded that detection may be better in colder months (Hackett et al. 2007). This pattern could be due to the increased food availability in summer making baits less desirable, as has been seen with other skunks (Bailey 1971, ESSCSG 2020). Although we primarily sampled during cold months, we found detections were highest in February, March and April (Table 3), which overlap with spring in central Texas and is counter to the belief that monitoring in colder months is more effective. Our results could reflect mating patterns as skunks are more active during mating season (March–April, Kinlaw 1995) and home ranges – particularly those of males – grow substantially in spring (Lesmeister et al. 2009). Without also sampling during the summer, however, it is difficult to comment on larger seasonal detection patterns. The effectiveness of attractants may also vary depending on the season as scents travel farther in warmer, wetter air (Rocha et al. 2016, Suárez-Tangil and Rodríguez 2017), but they may also decay faster under these conditions (Schlexer 2008).

Our study was the first to test the efficacy of attractants for eastern spotted skunks against a control of no attractant and provides a framework for future studies. While previous monitoring at Fort Hood has detected eastern spotted skunks without an attractant (Charles E. Pekins, observation, 2014), our results suggest that large animal carcasses and sardines increase detections of eastern spotted skunks, while fatty acid tablets do not. These attractants should also be tested in other areas to see if these results hold across their range and habitat quality classifications. Studies have also observed herpetofauna and sweet/savory baits attracting eastern spotted skunks (Diggins et al. 2015, Sprayberry and Edelman 2016), and Caven's Gusto, fruit pastes/oils and cat food are commonly used lures to attract eastern spotted skunks (Lesmeister et al. 2013, Boulerice and Zinke 2017, Eng and Jachowski 2019a). Further experimentation should be used to test these and other attractants in a rigorous experimental framework to determine their efficacy. Robust comparisons of attractant effectiveness will improve eastern spotted skunk monitoring, delineation of potential habitat and help develop effective and efficient monitoring plans.

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Data availability statement

No data are available from this study.

References

Allen, M. L. et al. 2013. Encounter competition between a cougar, *Puma concolor* and a western spotted skunk, *Spilogale gracilis*. – Can. Field Nat. 127: 64–66.

Allen, M. L. et al. 2015. The comparative effects of large carnivores on the acquisition of carrion by scavengers. – Am. Nat. 185: 822–833.

Allen, M. L. et al. 2020. Counting cats for conservation: seasonal estimates of leopard density and drivers of distribution in the Serengeti. – Biodivers. Conserv. 29: 3591–3608.

Bailey, T. N. 1971. Biology of striped skunks on a southwestern Lake Erie marsh. – Am. Midl. Nat. 85: 196–207.

Benson, I. W. et al. 2019. Rest-site activity patterns of eastern spotted skunks in Alabama. – Southeast Nat. 18: 165–172.

Boulerice, J. T. and Zinke, B. M. 2017. Winter habitat associations for spotted skunks (*Spilogale* spp.) in south-central Wyoming. – Am. Midl. Nat. 178: 17–28.

Briffa, M. and Sneddon, L. U. 2007. Physiological constraints on contest behaviour. – Funct. Ecol. 21: 627–637.

Diggins, C. A. et al. 2015. Incidental captures of eastern spotted skunk in a high-elevation red spruce forest in Virginia. – Northeast. Nat. 22: 6–10.

Dytham, C. 2011. Choosing and using statistics: a biologist's guide, 3rd ed. – Wiley.

Eckrich, G. H. et al. 1999. Effective landscape management of brown-headed cowbirds at Fort Hood, Texas. – Stud. Avian Biol. 18: 267–274.

Eng, R. Y. and Jachowski, D. S. 2019a. Evaluating detection and occupancy probabilities of eastern spotted skunks. – J. Wildl. Manage. 83: 1244–1253.

Eng, R. Y. and Jachowski, D. S. 2019b. Summer rest site selection by Appalachian eastern spotted skunks. – J. Mammal. 100: 1295–1304.

ESRI 2011. ArcGIS desktop: release 10. – Environmental Systems Research Inst., Redlands, CA.

ESSCSG (Eastern Spotted Skunk Cooperative Study Group) 2020. Eastern spotted skunk conservation plan. – <https://easternspottedskunk.weebly.com>, accessed 20 January 2021.

Gerber, B. D. et al. 2012. Evaluation the potential biases in carnivore capture–recapture studies associated with the use of lure and varying density estimation techniques using photographic-sampling data of Malagasy civet. – Popul. Ecol. 54: 43–54.

Gompper, M. and Jachowski, D. 2016. *Spilogale putorius*. – IUCN Red List of threatened species 2016: e.T41636A45211474, accessed 20 January 2021. <https://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T41636A45211474.en>

Gompper, M. E. and Hackett, H. M. 2005. The long-term, range-wide decline of a once common carnivore: the eastern spotted skunk *Spilogale putorius*. – Anim. Conserv. 8: 195–201.

Gompper, M. E. et al. 2006. A comparison of noninvasive techniques to survey carnivore communities in northeastern North America. – Wildl. Soc. B 34: 1142–1151.

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Hackett, M. H. et al. 2007. Detection rates of eastern spotted skunks *Spilogale putorius* in Missouri and Arkansas using live-capture and non-invasive techniques. – Am. Midl. Nat. 158: 123–131.
Harris, S. N. et al. 2020. Den sites by the Florida spotted skunk. – J. Wildl. Manage. 84: 127–137.
Hayden, T. J. et al. 2000. Cowbird control program at Fort Hood, Texas: lessons for mitigation of cowbird parasitism on a landscape scale. – In: Smith, J. N. M. (ed.), Ecology and management of cowbirds and their hosts. Univ. Texas Press, pp. 357–370.
Heinlein, B. W. et al. 2020. Effects of different attractants and human scent on mesocarnivore detection at camera traps. – Wildl. Res. 47: 338–348.
Higdon, S. D. and Gompper, M. E. 2020. Rest-site use and the apparent rarity of an Ozark population of plains spotted skunk *Spilogale putorius interrupta*. – Southeast. Nat. 19: 74–89.
Kelly, M. J. and Holub, E. L. 2008. Camera trapping of carnivores: trap success among camera types and across species, and habitat selection by species on Salt Pond Mountain, Giles County, Virginia. – Northeast. Nat. 15: 249–262.
Kinlaw, A. 1995. *Spilogale putorius*. – Mamm. Species 511: 1–7.
Lesmeister, D. B. et al. 2009. Habitat selection and home range dynamics of eastern spotted skunks in the Ouachita Mountains, Arkansas, USA. – J. Wildl. Manage. 73: 18–25.
Lesmeister, D. B. et al. 2013. Landscape ecology of eastern spotted skunks in habitats restored for red-cockaded woodpeckers. – Restor. Ecol. 21: 267–275.
Lombardi, J. V. et al. 2017. Mammal occurrence in rock outcrops in Shenandoah National Park: ecological and anthropogenic factors influencing trap success and co-occurrence. – Nat. Areas J. 37: 507–514.
Meredith, M. and Ridout, M. 2020. Overlap: estimates of coefficient of overlapping for animal activity patterns. – CRAN. <https://cran.r-project.org/web/packages/overlap/overlap.pdf>
Perry, R. W. et al. 2018. Capture-site characteristics for eastern spotted skunks in mature forests during summer. – Southeast. Nat. 17: 298–308.
Rasambainarivo, F. et al. 2017. Interactions between carnivores in Madagascar and the risk of disease transmission. – Ecohealth 14: 691–703.
Reed, A. W. and Kennedy, M. L. 2000. Conservation status of the eastern spotted skunk *Spilogale putorius* in the Appalachian Mountains of Tennessee. – Am. Midl. Nat. 144: 133–138.
Ridout, M. and Linkie, M. 2009. Estimating overlap of daily activity patterns from camera trap data. – J. Agric. Biol. Environ. Stat. 14: 322–337.
Rocha, D. G. et al. 2016. Baiting for carnivores might negatively affect capture rates of prey species in camera-trap studies. – J. Zool. 300: 205–212.
Rowcliffe, M. 2021. Activity: animal activity statistics. – CRAN. <https://cran.r-project.org/web/packages/activity/activity.pdf>
Russel, L. et al. 2020. Emmeans: estimated marginal means, aka least-squares means. – CRAN. <https://cran.r-project.org/web/packages/emmeans/emmeans.pdf>
Schlexer, F. V. 2008. Attracting animals to detection devices. – In: Long, R. A. et al. (eds), Noninvasive survey methods for carnivores. Island Press, pp. 264–292.
Sebastián-González, E. et al. 2020. Network structure of vertebrate scavenger assemblages is driven by ecosystem productivity and human impact at a global scale. – Ecography 43: 1143–1155.
Skalski, J. R. et al. 2005. Wildlife demography: analysis of sex, age and count data. – Elsevier Academic Press.
Sprayberry, T. R. and Edelman, A. J. 2016. Food provisioning of kits by a female eastern spotted skunk. – Southeast. Nat. 15: 53–56.
Sprayberry, T. R. and Edelman, A. J. 2018. Den-site selection of eastern spotted skunks in the southern Appalachian Mountains. – J. Mammal. 99: 242–251.
Suárez-Tangil, B. D. and Rodríguez, A. 2017. Detection of Iberian terrestrial mammals employing olfactory, visual and auditory attractants. – Eur. J. Wildl. Res. 63: 93.
Thorne, E. D. and Waggy, C. 2017. First reported observation of food provisioning to offspring by an eastern spotted skunk, a small carnivore. – Northeast. Nat. 24: 1–4.
Thorne, E. D. et al. 2017. Winter habitat associations of eastern spotted skunks in Virginia. – J. Wildl. Manage. 81: 1042–1050.
Thornton, D. H. and Pekins, C. E. 2015. Spatially explicit capture–recapture analysis of bobcat density: implications for mesocarnivore monitoring. – Wildl. Res. 42: 394–404.
Wilson, S. B. et al. 2016. Recent detections of *Spilogale putorius* (eastern spotted skunk) in South Carolina. – Southeast. Nat. 15: 269–274.
Zielinski, W. J. and Stauffer, H. B. 1996. Monitoring *Martes* populations in California: survey design and power analysis. – Ecol. Appl. 6: 1254–1267.

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