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Effects of different attractants and human scent on mesocarnivore detection at camera traps

Bracy W. Heinlein[A], *Rachael E. Urbanek*[A,C], *Colleen Olfenbuttel*[B] and *Casey G. Dukes*[B]

[A]University of North Carolina Wilmington, Department of Environmental Sciences, 601 S. College Road, Wilmington, NC 28403, USA.
[B]North Carolina Wildlife Resources Commission, North Carolina State University Centennial Campus, 1751 Varsity Drive, Raleigh, NC 27606, USA.
[C]Corresponding author. Email: urbanekr@uncw.edu

Abstract

Context. Camera traps paired with baits and scented lures can be used to monitor mesocarnivore populations, but not all attractants are equally effective. Several studies have investigated the efficacy of different attractants on the success of luring mesocarnivores to camera traps; fewer studies have examined the effect of human scent at camera traps.

Aims. We sought to determine the effects of human scent, four attractants and the interaction between attractants and human scent in luring mesocarnivores to camera traps.

Methods. We compared the success of synthetic fermented egg (SFE), fatty acid scent (FAS) tablets, castor oil, and sardines against a control of no attractant in luring mesocarnivores to camera traps. We deployed each attractant and the control with either no regard to masking human scent or attempting to restrict human scent for a total of 10 treatments, and replicated treatments eight to nine times in two different phases. We investigated whether: (1) any attractants increased the probability of capturing a mesocarnivore at a camera trap; (2) not masking human scent affected the probability of capturing a mesocarnivore at a camera trap; and (3) any attractants increased the probability of repeat detections at a given camera trap. We also analysed the behaviour (i.e. speed and distance to attractant) of each mesocarnivore in relation to the attractants.

Key results. Sardines improved capture success compared with the control treatments, whereas SFE, castor oil, and FAS tablets had no effect when all mesocarnivores were included in the analyses. Masking human scent did not affect detection rates in the multispecies analyses. Individually, the detection of some species depended on the interactions between masking (or not masking) human scent and some attractants.

Conclusions. Sardines were the most effective as a broad-based attractant for mesocarnivores. Mesocarnivores approached traps baited with sardines at slower rates, which allows for a higher success of capturing an image of the animal.

Implications. Human scent may not need to be masked when deploying camera traps for multispecies mesocarnivore studies, but researchers should be aware that individual species respond differently to attractants and may have higher capture success with species-specific attractants.

Additional keywords: bobcat, *Canis latrans*, castor oil, coyote, *Didelphis virginiana*, fatty-acid scent tablet, grey fox, *Lynx rufus*, opossum, *Procyon lotor*, raccoon, red fox, sardine, synthetic fermented egg, *Urocyon cinereoargenteus*, *Vulpes vulpes*.

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Introduction

Camera trap data can be analysed to estimate relative abundance (Silver *et al.* 2004) and species richness (Rowcliffe and Carbone 2008), as well as occupancy rates of photographed species (Carbone *et al.* 2001). Camera traps are relatively unobtrusive, can take photographs in quick succession when triggered by the passive infrared motion sensor, run for long periods of time, can be coupled with baits and lures and can cover a wide habitat range (Gese 2004; O'Connell *et al.* 2011). The images taken in camera trap studies allow for easy identification of species and, unlike other non-invasive methods that require some subjective identification (e.g. tracks) or the use of cost-prohibitive and challenging low-copy DNA samples (e.g. hair), images from camera traps can provide unambiguous evidence that a species is present. Typical retail costs for trail cameras, such as Bushnell's Aggressor Trophy Cam HD Cameras (Bushnell Corporation, Overland Park, KS, USA), can cost around US$220 per camera. However, this one-time cost can result in an overall more cost-effective technique. Other methods, such as scat collection paired with DNA analyses, have higher accuracy in identifying individuals but require larger sample collection for a single species compared with camera trap data. Camera traps are one of the few non-invasive methods that provide adequate results in terms of species identification and parameter estimates across multiple species and large areas (Gompper *et al.* 2006; Vine *et al.* 2009). Camera traps are also resilient against varying weather conditions and are labour and cost efficient compared with other methods (Gompper *et al.* 2006; Vine *et al.* 2009; O'Connell *et al.* 2011; Nielsen and Cooper 2012).

When studies are directed towards mesocarnivores, attractants often improve capture success at camera traps (Gompper *et al.* 2006; Schlexer 2008). One of the most common lures used to target mesocarnivores is a fatty-acid scent (FAS) tablet (Gompper *et al.* 2006; Nielsen and Cooper 2012). These tablets are a synthetic attractant developed from seven volatile fatty acids found in fermented egg that have successfully lured coyotes (*Canis latrans*) to traps (Roughton 1982). Meat baits (e.g. raw chicken, pork, beef, liver and sardines) have been used to attract carnivores, either by burying the sample, hanging it from a tree or pole or securing the meat under wire, with varying detection rates (Gompper *et al.* 2006; Vine *et al.* 2009). Beaver (*Castor canadensis*) castor has also been used by many recreational and commercial trappers to lure furbearers to traps (Noonan 2013). Another lure that has been postulated to work as an effective attractant in resource-rich areas is synthetic fermented egg (SFE; Vine *et al.* 2009). SFE consists of a variety of fatty acids, amines, esters and sulfurous compounds (Bullard and Herendeen 1975) and has been used in numerous studies to attract wild canids and other mesocarnivores (Bullard *et al.* 1978; Roughton 1982; Travaini *et al.* 1996; Vine *et al.* 2009).

Human scent left by researchers during deployment may affect the detection of mesocarnivores by camera traps. It is common practice among licensed trappers to keep their clothing and boots free of unusual odours and to limit human scent at their trap sites (Association of Fish and Wildlife Agencies (AFWA) 2005). Larrucea *et al.* (2007) speculated that coyotes could detect the human scent left at camera sites during the first 10 days following camera deployment. They hypothesised that more coyotes may have been captured on camera only after the scent had dissipated or until the coyotes became accustomed to the cameras (Larrucea *et al.* 2007). Larrucea *et al.* (2007) also photographed more coyotes in areas with frequent human traffic, such as near roads or trails, and hypothesised that the regular human scent of the area masked the scent on the cameras. However, coyotes and other mesocarnivores often use roads and trails as walking paths, which could account for the greater number of photographs (Gese 2004; Larrucea *et al.* 2007; Nielsen and Cooper 2012).

Several studies have investigated the efficacy of different attractants on the success of luring mesocarnivores to camera traps (e.g. Vine *et al.* 2009; Ferreras *et al.* 2018). Fewer studies have examined the effect of human scent at camera traps (Muñoz *et al.* 2014). Examining both effects simultaneously may be necessary because human scent and attractant type have the possibility of interacting to influence mesocarnivore detection. The present study investigated the possible effects of human scent, four different attractants and the interaction between these attractants and human scent in luring five mesocarnivore species to infrared camera traps.

Materials and methods

Study area

Holly Shelter Game Land is located in Pender County (NC, USA) and covers 275 km^2 of land in the Cape Fear River Basin (Hamlett 2015). The area consists of multiple habitat types, the largest of which is pocosin (61%), a sandy peat soil wetland bog with woody shrubs (National Oceanic and Atmospheric Administration (NOAA) 2018). Small wetland habitats comprise 0.03 km^2 (0.01%), an annually flooded waterfowl impoundment comprises 0.83 km^2 (0.3%) and approximately 23.2 km^2 (8.4%) are loblolly pine (*Pinus taeda*) plantation. The other habitats include dry coniferous forest, dry longleaf pine (*Pinus palustris*)/scrub oak (*Quercus ilicifolia*) sandhill, early successional, floodplain forest, mesic mixed hardwood and wet pine savanna. The site has >161 km of public and administrative access roads (Hamlett 2015) and several kilometres of trails. During the study, the mean (±s.d.) wind speed was 8.8 ± 4.1 km h^{-1}, the mean daily precipitation was 0.32 ± 1.00 cm and the mean daily temperature was 10.5 ± 6.1°C.

Camera deployment

From 13 January to 30 March 2018, cameras were deployed along game land roads given the propensity of mesocarnivores to use roads as travel corridors (Gese 2004; Larrucea *et al.* 2007; Nielsen and Cooper 2012). Using ArcMap 10.3.1 (ESRI, Redlands, CA, USA), we overlaid road line files onto a shapefile of Holly Shelter Game Land and then created a grid of 2.6-km^2 blocks, the average home range of foxes, over the study area (Nielsen and Cooper 2012; Lesmeister *et al.* 2015; Urbanek *et al.* 2019). Only blocks that had accessible roads (by truck or bicycle) were used in the present study. Thirty Bushnell Aggressor Trophy Cam HD (Model 19774c) cameras were deployed simultaneously for seven nights before they were moved to a new set of blocks. All cameras were set ≥250 m apart and ≤50 m off the road (Fig. 1).

Cameras were anchored to a tree 42 cm above the ground. Attractants were placed in a film canister 42 cm from the ground and/or level with the camera based on topography and attached to a stake 200 cm from the camera (Urbanek *et al.* 2019). For the control, the stake and film canister were used but did not include any attractant inside the canister. If there was underbrush affecting the camera between the lens and the film canister, it was cleared during camera deployment. The cameras were set with the following parameters: camera mode; 14 million pixels; wide-screen image format; three photographs per trigger; low light-emitting diode (LED) control; 1-s interval between triggers; high sensor level; medium night vision shutter speed; night camera mode; time stamp on; field scan off; and coordinate input off.

SFE, FAS tablets, castor oil and commercially purchased sardines in olive oil were compared against a control of no attractant. Each attractant and the control was deployed with either no regard to masking human scent or attempting to restrict human scent for a total of 10 treatments. Blocks were randomly

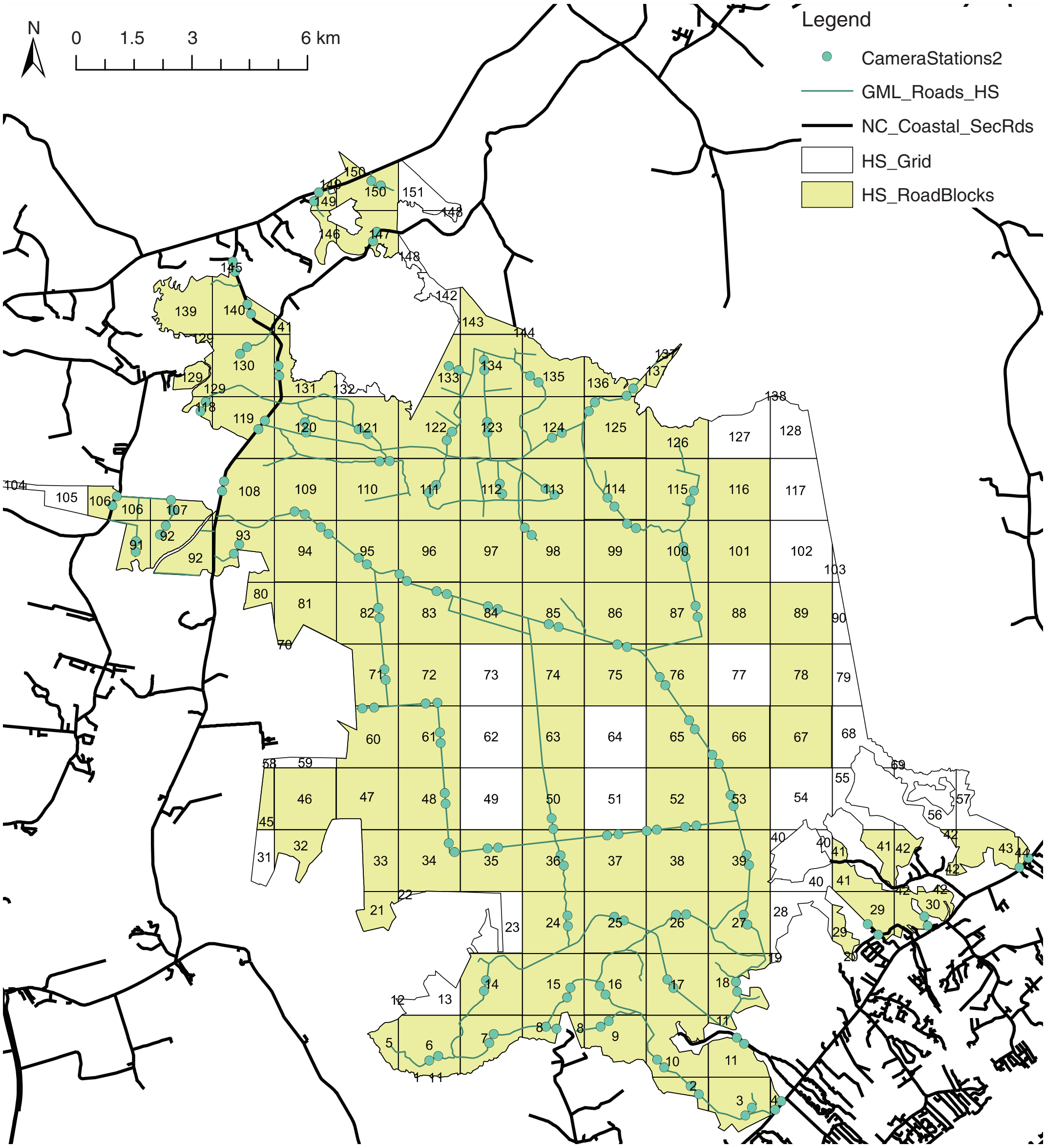

Fig. 1. Camera station placement in Phase 2 (CameraStations2) of assessing the effectiveness of different attractants and human scent on mesocarnivores in Holly Shelter Game Land, Pender County (NC, USA), 2018. Phase 1 used one camera per block and included blocks 5, 30, 43, 75, 129, 139, 141 and 146. GML_Roads_HS, Gameland Roads in Holly Shelter; NC_Coastal_SecRds, NC Coastal Secondary Roads; HS_Grid, Holly Shelter Grid; HS_RoadBlocks, Holly Shelter Road Blocks.

assigned treatments, although we ensured no adjacent blocks had the same treatment. In Phase 1, one camera trap was set on the main road closest to the centre of each of the 88 blocks, resulting in eight to nine replications per treatment over the duration of 4 weeks. In Phase 2, two cameras (≥250 m apart) were deployed using the same treatment within 80 blocks; data from the paired cameras were pooled, resulting in eight replications per treatment over the duration of 6 weeks.

One month before the study, half the equipment was cleaned using gloves and odour-eliminating detergent and then the container of this equipment was left undisturbed in a wooded area. Equipment that was used for the treatments that did not restrict human scent was treated normally with no special precautions and was kept separate from the scent-restricted container throughout the study. Deploying masked and not-masked scent treatments took place on two separate days. When deploying camera traps that did not mask human scent, normal fieldwork clothes and boots were worn and no gloves were used. For the camera traps that masked human scent, the procedure described by Muñoz *et al.* (2014) was followed closely. We showered with scent-obscuring soaps before heading to the study site and applied scent-masking deodorant. Non-specialised clothing was washed in odour-eliminating detergent as a transition outfit while travelling. Outer clothing was also

Fig. 2. Photograph of a mesocarnivore overlaid by a grid to determine the distance from the attractant canister (horizontal = 1, vertical = 2, depth = 2) to assess the effectiveness of different attractants and human scent on mesocarnivores, Holly Shelter Game Land, Pender County (NC, USA), 2018.

washed in odour-eliminating detergent and was placed over the travel clothing when first getting out of the vehicle and removed before getting back into the vehicle at each camera location. The outer clothing consisted of rubber boots, pants, socks, shirt, jacket and latex gloves. Scent-blocking spray was applied to the gloves and outerwear before handling the cameras and equipment designated for restricting human scent.

Data analyses

All images of mesocarnivores were recorded with the location, date, time, treatment and behaviour (e.g. approached bait, passing through area). We focused on five mesocarnivores, namely coyote, fox (*Vulpes vulpes* and *Urocyon cinereoargenteus*), bobcat (*Lynx rufus*), opossum (*Didelphis virginiana*) and raccoon (*Procyon lotor*), because these were the most prevalent mesocarnivores within the study area. Analyses was conducted in two ways: all mesocarnivores combined and then independently by species. Chi-squared tests were used to determine whether: (1) any attractants increased the probability of capturing a mesocarnivore; (2) human scent affected the probability of capturing a mesocarnivore at a camera trap; and (3) any attractants increased the probability of repeat detections at a given camera trap. All statistical analyses ($\alpha = 0.05$) were completed in Microsoft (Bellevue, WA, USA) Excel using Real Statistics Resource Pack software (http://www.real-statistics.com/, accessed 12 March 2018; Zaiontz 2018).

We also analysed the behaviour of each mesocarnivore in relation to the attractants. Using Microsoft PowerPoint, each mesocarnivore image was overlaid with a 5×7 grid, with each grid block measuring 3.81 cm $\times$ 4.85 cm (Fig. 2). If the centre of gravity of the animal was within the same row as the film canister, it was marked with a '1' for vertical location, with each subsequent row away from the attractant increasing by 1 unit. If the individual was within the same column as the canister, it was marked with a '1' for horizontal location, with each subsequent column away from the attractant increasing by 1 unit. The individual was then marked with either a '1', '2', or '3' depending on depth, representing the foreground (between the attractant and camera), midground (in line with the attractant) and background (behind the attractant) respectively. If the centre of gravity was determined to be split between two or more columns or rows, the median value was used. We then calculated the Euclidean distance to each species from the film canister in each photograph. To maintain independence, photographs less than 1 h apart from the same camera were considered the same individual and the same event. Speed was calculated by taking the difference between the distance of the first photograph of an independent event and the photograph with the closest distance to the bait within an independent event and dividing it by the difference in time (seconds) between the two photographs. Two-way analysis of variance (ANOVA) was used to analyse the interaction between the species and the average distance the animals came to each attractant. One-way ANOVA was used to analyse the independent variables of attractant and species against the speed with which an animal approached the attractant. Only non-zero samples were used for speed, and we did not have sufficient sample sizes to use a two-way ANOVA for this analysis.

Results

Phase 1 had a total of 616 trap nights with 88 camera traps, resulting in 26 577 photographs. Phase 2 included 16 837 photographs from 560 trap nights and 160 camera traps.

Masked versus not-masked human scent

The effects of human scent on all mesocarnivores and individual species differed between phases (Table 1). In Phase 1, a higher proportion of cameras that were not masked of human scent detected more mesocarnivores than cameras that masked human scent. However, in Phase 2, the proportion of detections did not

Table 1. Percentage of cameras (Phase 1) and blocks (Phase 2) that detected mesocarnivore species, Holly Shelter Game Land, Pender County (NC, USA), 2018

Masked cameras and blocks indicate treatments where human scent was minimised. For all Chi-squared statistics, d.f. = 1

Species and phase	Statistics	% Cameras or blocks with detections	
		Masked	Not masked
All mesocarnivores			
Phase 1	$\chi^2 = 4.56, P = 0.03$	47	69
Phase 2	$\chi^2 = 0.00, P = 1.00$	72	72
Fox			
Phase 1	$\chi^2 = 1.30, P = 0.26$	5	11
Phase 2	$\chi^2 = 1.10, P = 0.29$	3	8
Coyote			
Phase 1	$\chi^2 = 0.03, P = 0.85$	18	16
Phase 2	$\chi^2 = 0.06, P = 0.80$	25	28
Opossum			
Phase 1	$\chi^2 = 2.96, P = 0.09$	14	29
Phase 2	$\chi^2 = 0.46, P = 0.50$	45	38
Raccoon			
Phase 1	$\chi^2 = 3.78, P = 0.05$	14	31
Phase 2	$\chi^2 = 1.53, P = 0.22$	23	35
Bobcat			
Phase 1	$\chi^2 = 0.04, P = 0.85$	16	18
Phase 2	$\chi^2 = 3.21, P = 0.07$	35	18

differ between blocks with cameras not masked of human scent and blocks with cameras that masked human scent. In both phases, fox and coyote detections by camera traps were unaffected by masking (or not) human scent. Opossums were potentially detected more at cameras that did not mask human scent in Phase 1, but a larger sample size would be necessary to verify this result, especially because opossum detections were unaffected by camera traps that were deployed with no restrictions on masking human scent in Phase 2. In Phase 1, more cameras that did not mask human scent successfully photographed raccoons than cameras that masked human scent, but there was no effect of masking human scent on raccoon detection in Phase 2. Bobcats detections by camera traps were unaffected by masking (or not) of human scent in Phase 1, but potentially more bobcats were detected in blocks that masked human scent in Phase 2. Similar to opossums, a larger sample size would be necessary to verify this result.

Attractants

A positive effect of sardines as an attractant was observed, compared with the control, in Phase 2 but this attractant had no effect in Phase 1 when all mesocarnivores combined were analysed (Table 2). Cameras baited with sardines increased the proportion of successful trap nights compared with control cameras, and increased the number of blocks mesocarnivores were detected at in Phase 2. A potential increase in repeated detections was also observed in Phase 1, but the result was not significant. We had limited success detecting foxes in this study, and the results reflect the low sample size. Sardines had no effect on foxes in Phase 1 and no foxes were detected at control cameras in Phase 2. Two blocks that were baited with sardines photographed foxes in Phase 2, and these successful blocks recorded foxes on six trap nights. More cameras detected coyotes in Phase 2, and we observed more repeat detections of coyotes in both phases when cameras were baited with sardines compared with control cameras. Potentially cameras in Phase 1

Table 2. Percentage of cameras, successful trap nights and blocks that detected mesocarnivore species at camera traps baited with sardines compared with control sites, Holly Shelter Game Land, Pender County (NC, USA), 2018

For all Chi-squared statistics, d.f. = 1. ↑, increased detections due to the attractant; –, no effect of the attractant

Species	Statistics	Control	Sardines	Effect
All mesocarnivores				
Cameras				
Phase 1	$\chi^2 = 0.50, P = 0.48$	61	72	–
Phase 2	$\chi^2 = 6.61, P = 0.01$	44	75	↑
Trap Nights				
Phase 1	$\chi^2 = 2.38, P = 0.12$	13	20	–
Phase 2	$\chi^2 = 6.77, P < 0.01$	31	48	↑
Blocks	$\chi^2 = 4.97, P = 0.03$	63	94	↑
Fox				
Cameras				
Phase 1	$\chi^2 = 0.00, P = 1.00$	6	6	–
Phase 2	$\chi^2 = 3.15, P = 0.08$	0	9	–
Trap nights				
Phase 1	$\chi^2 = 1.89, P = 0.17$	<1	3	–
Phase 2	$\chi^2 = 6.17, P = 0.01$	0	5	↑
Blocks	$\chi^2 = 2.13, P = 0.14$	0	13	–
Coyotes				
Cameras				
Phase 1	$\chi^2 = 3.44, P = 0.06$	6	17	–
Phase 2	$\chi^2 = 4.40, P = 0.04$	13	34	↑
Trap nights				
Phase 1	$\chi^2 = 3.87, P < 0.05$	<1	5	↑
Phase 2	$\chi^2 = 6.37, P = 0.01$	4	13	↑
Blocks	$\chi^2 = 2.38, P = 0.12$	19	44	–
Opossum				
Cameras				
Phase 1	$\chi^2 = 0.00, P = 1.00$	22	22	–
Phase 2	$\chi^2 = 4.75, P = 0.03$	19	44	↑
Trap nights				
Phase 1	$\chi^2 = 0.00, P = 1.00$	5	5	–
Phase 2	$\chi^2 = 1.59, P = 0.21$	13	20	–
Blocks	$\chi^2 = 2.02, P = 0.16$	38	63	–
Raccoon				
Cameras				
Phase 1	$\chi^2 = 0.81, P = 0.37$	11	22	–
Phase 2	$\chi^2 = 1.18, P = 0.28$	19	9	–
Trap nights				
Phase 1	$\chi^2 = 0.42, P = 0.52$	3	5	–
Phase 2	$\chi^2 = 0.88, P = 0.35$	11	7	–
Blocks	$\chi^2 = 1.41, P = 0.23$	38	19	–
Bobcat				
Cameras				
Phase 1	$\chi^2 = 0.81, P = 0.37$	22	11	–
Phase 2	$\chi^2 = 0.11, P = 0.74$	16	19	–
Trap nights				
Phase 1	$\chi^2 = 0.12, P = 0.73$	4	3	–
Phase 2	$\chi^2 = 0.00, P = 1.00$	6	6	–
Blocks	$\chi^2 = 1.41, P = 0.23$	19	38	–

and blocks in Phase 2 had more detections of coyotes if they were baited with sardines, but the results were not significant. In Phase 1, sardines had no effect on the capture success or successful number of trap nights for opossums. More cameras baited with sardines, and potentially more blocks with sardines, detected opossums in Phase 2. The number of successful trap nights for opossums did not differ between treatments. Detection of both bobcats and raccoons was unaffected by sardines in both phases of the study.

Castor oil did not improve the capture success or the number of successful trap nights of all mesocarnivores combined in either phase (Table 3). Similarly, there was no difference in capture success or the number of successful trap nights between castor oil and control treatments when bobcats, opossums and raccoons were analysed specifically in either phase. Further, no foxes were photographed on any camera baited with castor oil in either phase. Coyotes were the only species that may have been attracted to cameras with castor oil. The evidence for this attractant was limited to more repeated detections at cameras baited with castor oil compared with controls in Phase 1 and possibly more detections at cameras baited with castor oil in the same phase.

Similar to castor oil, FAS tablets did not improve detection of all mesocarnivores combined compared with the control in either phase (Table 4). For species-specific analyses, the detection of coyotes and raccoons was unaffected by FAS tablets in either phase. Opossums were detected less frequently at cameras baited with FAS tablets in Phase 2 because we observed fewer successful trap nights in blocks that had cameras baited with FAS tablets compared with control blocks. However, none of the other analyses for opossums in either phase indicated an effect of FAS tablets on opossum detection. Although we observed no significant differences between this attractant and the control in either phase for fox, these species could possibly be attracted to FAS tablets as indicated by the Phase 1 trap night, Phase 2 camera and block Chi-squared results. Bobcats appeared unaffected by FAS tablets as an attractant, except for the possibility of repeat trap detections at cameras baited with FAS tablets in Phase 2.

SFE also did not improve the capture success or the number of successful trap nights of all mesocarnivores combined in Phase 1 or 2 (Table 5). Detection of opossums and fox was unaffected by SFE in either phase. Overall, coyotes appeared to be attracted to cameras and blocks baited with SFE compared with the controls, with stronger support in the Phase 2 analyses compared with Phase 1. In contrast, SFE appeared to potentially deter bobcats and raccoons. Raccoons appeared unaffected by SFE in Phase 1, but there were potentially more detections at control blocks and repeat detections compared with blocks baited with SFE in Phase 2. Similarly, we observed a potential increase in detection at control cameras and repeat detections in Phase 1 for bobcats, but bobcats were unaffected by SFE in Phase 2.

Table 3. Percentage of cameras, successful trap nights and blocks that detected mesocarnivore species at camera traps baited with castor oil compared with control sites, Holly Shelter Game Land, Pender County (NC, USA), 2018

For all Chi-squared statistics, d.f. = 1. ↑, increased detections due to the attractant; –, no effect of the attractant; n.a., not applicable

Species	Statistics	Control	Castor oil	Effect
All mesocarnivores				
Cameras				
Phase 1	$\chi^2 = 0.05$, $P = 0.83$	61	65	–
Phase 2	$\chi^2 = 0.06$, $P = 0.80$	44	41	–
Trap nights				
Phase 1	$\chi^2 = 0.82$, $P = 0.36$	13	17	–
Phase 2	$\chi^2 = 1.43$, $P = 0.23$	31	24	–
Blocks	$\chi^2 = 0.00$, $P = 1.00$	63	63	–
Fox				
Cameras				
Phase 1	$\chi^2 = 0.97$, $P = 0.32$	6	0	–
Phase 2	n.a.	0	0	n.a.
Trap nights				
Phase 1	$\chi^2 = 0.94$, $P = 0.33$	<1	0	–
Phase 2	n.a.	0	0	n.a.
Blocks	n.a.	0	0	n.a.
Coyotes				
Cameras				
Phase 1	$\chi^2 = 2.43$, $P = 0.12$	6	24	–
Phase 2	$\chi^2 = 2.08$, $P = 0.15$	13	3	–
Trap nights				
Phase 1	$\chi^2 = 4.15$, $P = 0.04$	<1	5	↑
Phase 2	$\chi^2 = 0.70$, $P = 0.40$	4	2	–
Blocks	$\chi^2 = 1.19$, $P = 0.28$	19	6	–
Opossum				
Cameras				
Phase 1	$\chi^2 = 0.11$, $P = 0.73$	22	18	–
Phase 2	$\chi^2 = 0.10$, $P = 0.76$	19	22	–
Trap nights				
Phase 1	$\chi^2 = 0.01$, $P = 0.92$	5	5	–
Phase 2	$\chi^2 = 1.70$, $P = 0.19$	13	8	–
Blocks	$\chi^2 = 0.00$, $P = 1.00$	38	38	–
Raccoon				
Cameras				
Phase 1	$\chi^2 = 0.96$, $P = 0.33$	11	24	–
Phase 2	$\chi^2 = 0.11$, $P = 0.74$	19	16	–
Trap nights				
Phase 1	$\chi^2 = 0.18$, $P = 0.67$	3	4	–
Phase 2	$\chi^2 = 1.45$, $P = 0.23$	11	6	–
Blocks	$\chi^2 = 0.14$, $P = 0.71$	38	31	–
Bobcat				
Cameras				
Phase 1	$\chi^2 = 0.15$, $P = 0.70$	22	28	–
Phase 2	$\chi^2 = 0.00$, $P = 1.00$	16	16	–
Trap nights				
Phase 1	$\chi^2 = 0.02$, $P = 0.88$	4	7	–
Phase 2	$\chi^2 = 0.58$, $P = 0.45$	6	9	–
Blocks	$\chi^2 = 0.18$, $P = 0.67$	19	25	–

Species behaviour

Species interacted with attractants differently, as observed by the different approaches (i.e. distance, speed) taken towards the attractant ($F_{15,386} = 2.79$, $P < 0.01$). Bobcats came closest to control film canisters and remained furthest away from the sardines and SFE (Fig. 3). Opossums, raccoons and fox came closest to sardines, whereas coyotes came closest to SFE. Opossums and raccoons came closer to all the attractants ($F_{4,386} = 3.32$, $P = 0.01$) than bobcats (Fig. 4). Overall, all mesocarnivores appeared to have come closer to canisters baited with sardines than the control and FAS tablet canisters

Table 4. Percentage of cameras, successful trap nights and blocks that detected mesocarnivore species at camera traps baited with fatty acid scent (FAS) tablets compared with control sites, Holly Shelter Game Land, Pender County (NC, USA), 2018

For all Chi-squared statistics, d.f. = 1. ↓, decreased detections due to the attractant; –, no effect of the attractant

Species	Statistics	Control	FAS	Effect
All mesocarnivores				
Cameras				
Phase 1	$\chi^2 = 0.24, P = 0.63$	61	53	–
Phase 2	$\chi^2 = 0.06, P = 0.80$	44	47	–
Trap nights				
Phase 1	$\chi^2 = 0.82, P = 0.36$	13	17	–
Phase 2	$\chi^2 = 0.34, P = 0.56$	31	28	–
Blocks	$\chi^2 = 0.14, P = 0.71$	63	69	–
Fox				
Cameras				
Phase 1	$\chi^2 = 0.37, P = 0.54$	6	18	–
Phase 2	$\chi^2 = 2.06, P = 0.15$	0	6	–
Trap nights				
Phase 1	$\chi^2 = 3.08, P = 0.08$	<1	5	–
Phase 2	$\chi^2 = 1.06, P = 0.30$	0	3	–
Blocks	$\chi^2 = 2.13, P = 0.14$	0	13	–
Coyotes				
Cameras				
Phase 1	$\chi^2 = 0.44, P = 0.51$	6	12	–
Phase 2	$\chi^2 = 0.16, P = 0.69$	13	9	–
Trap nights				
Phase 1	$\chi^2 = 1.15, P = 0.28$	<1	2	–
Phase 2	$\chi^2 = 0.15, P = 0.70$	4	3	–
Blocks	$\chi^2 = 0.24, P = 0.63$	19	13	–
Opossum				
Cameras				
Phase 1	$\chi^2 = 0.69, P = 0.41$	22	12	–
Phase 2	$\chi^2 = 0.48, P = 0.49$	19	13	–
Trap Nights				
Phase 1	$\chi^2 = 0.89, P = 0.35$	5	3	–
Phase 2	$\chi^2 = 7.37, P < 0.01$	13	4	↓
Blocks	$\chi^2 = 0.58, P = 0.44$	38	33	–
Raccoon				
Cameras				
Phase 1	$\chi^2 = 0.31, P = 0.58$	11	18	–
Phase 2	$\chi^2 = 0.37, P = 0.54$	19	25	–
Trap nights				
Phase 1	$\chi^2 = 0.01, P = 0.93$	3	3	–
Phase 2	$\chi^2 = 0.17, P = 0.68$	11	13	–
Blocks	$\chi^2 = 0.13, P = 0.72$	38	44	–
Bobcat				
Cameras				
Phase 1	$\chi^2 = 0.11, P = 0.73$	22	18	–
Phase 2	$\chi^2 = 0.41, P = 0.52$	16	22	–
Trap nights				
Phase 1	$\chi^2 = 0.01, P = 0.93$	4	4	–
Phase 2	$\chi^2 = 2.00, P = 0.16$	6	12	–
Blocks	$\chi^2 = 0.67, P = 0.41$	19	31	–

Table 5. Percentage of cameras, successful trap nights and blocks that detected mesocarnivore species at camera traps baited with synthetic fermented egg (SFE) compared with control sites, Holly Shelter Game Land, Pender County (NC, USA), 2018

For all Chi-squared statistics, d.f. = 1. ↑, increased detections due to the attractant; –, no effect of the attractant; n.a., not applicable

Species	Statistics	Control	SFE	Effect
All mesocarnivores				
Cameras				
Phase 1	$\chi^2 = 0.02, P = 0.89$	61	56	–
Phase 2	$\chi^2 = 1.00, P = 0.3.2$	44	56	–
Trap nights				
Phase 1	$\chi^2 = 0.30, P = 0.58$	13	15	–
Phase 2	$\chi^2 = 0.50, P = 0.48$	31	36	–
Blocks	$\chi^2 = 0.58, P = 0.44$	63	75	–
Fox				
Cameras				
Phase 1	$\chi^2 = 0.37, P = 0.54$	6	11	–
Phase 2	n.a.	0	0	n.a.
Trap nights				
Phase 1	$\chi^2 = 1.04, P = 0.31$	<1	2	–
Phase 2	n.a.	0	0	n.a.
Blocks	n.a.	0	0	n.a.
Coyotes				
Cameras				
Phase 1	$\chi^2 = 1.17, P = 0.28$	6	17	–
Phase 2	$\chi^2 = 3.38, P = 0.07$	13	31	–
Trap nights				
Phase 1	$\chi^2 = 2.85, P = 0.09$	<1	4	–
Phase 2	$\chi^2 = 6.37, P = 0.01$	4	13	↑
Blocks	$\chi^2 = 3.56, P = 0.06$	19	50	–
Opossum				
Cameras				
Phase 1	$\chi^2 = 0.56, P = 0.46$	22	33	–
Phase 2	$\chi^2 = 1.34, P = 0.25$	19	32	–
Trap Nights				
Phase 1	$\chi^2 = 0.30, P = 0.58$	5	6	–
Phase 2	$\chi^2 = 0.04, P = 0.84$	13	13	–
Blocks	$\chi^2 = 0.13, P = 0.72$	38	44	–
Raccoon				
Cameras				
Phase 1	$\chi^2 = 0.00, P = 1.00$	11	11	–
Phase 2	$\chi^2 = 1.18, P = 0.28$	19	9	–
Trap nights				
Phase 1	$\chi^2 = 0.15, P = 0.70$	3	2	–
Phase 2	$\chi^2 = 2.21, P = 0.14$	11	5	–
Blocks	$\chi^2 = 2.76, P = 0.10$	38	13	–
Bobcat				
Cameras				
Phase 1	$\chi^2 = 2.22, P = 0.14$	22	6	–
Phase 2	$\chi^2 = 0.13, P = 0.72$	16	13	–
Trap nights				
Phase 1	$\chi^2 = 2.98, P = 0.08$	4	<1	–
Phase 2	$\chi^2 = 0.07, P = 0.79$	6	7	–
Blocks	$\chi^2 = 1.00, P = 0.00$	19	19	–

($F_{4,386} = 1.95$, $P = 0.10$; Fig. 5). All species approached the attractants at similar speeds ($F_{4,137} = 1.99$, $P = 0.10$). Cameras baited with SFE appeared to result in a faster approach by all mesocarnivores ($F_{4,137} = 3.46$, $P = 0.01$), whereas cameras baited with sardines resulted in the slowest approach (Fig. 6).

Discussion

Masked versus non-masked human scent

Researchers may not need to mask their scent when deploying camera traps while targeting several common mesocarnivores in study sites similar to Holly Shelter Game Land. Areas with

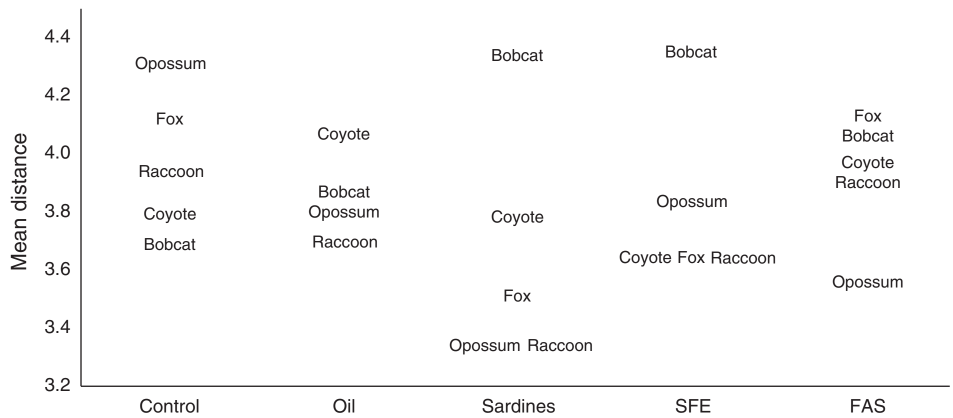

Fig. 3. Mean distance of each species from attractant based on interactions between each species and attractant type in an assessment of the effectiveness of different attractants and human scent on mesocarnivores, Holly Shelter Game Land, Pender County (NC, USA), 2018. Labels are located at each mean for comparison among species within each attractant to show the interaction between species and attractant ($F_{15,386} = 2.79, P < 0.01$). No foxes approached traps baited with castor oil. FAS, fatty acid scent; SFE, synthetic fermented egg.

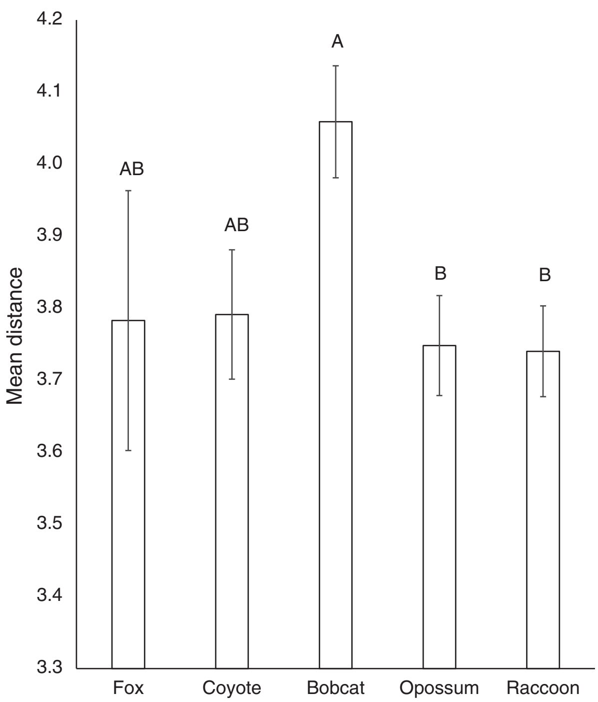

Fig. 4. Mean distance of each species from attractant per species in an assessment of the effectiveness of different attractants and human scent on mesocarnivores, Holly Shelter Game Land, Pender County (NC, USA), 2018. Data are given as the mean ± s.e.m. Different letters above columns indicate significant differences ($P = 0.01$).

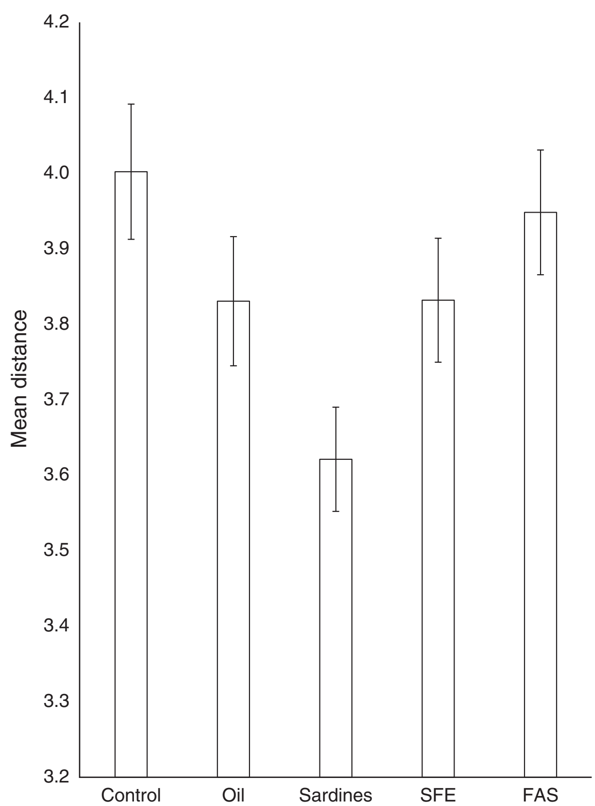

Fig. 5. Mean distance species approached attractant per attractant type in an assessment of the effectiveness of different attractants and human scent on mesocarnivores, Holly Shelter Game Land, Pender County (NC, USA), 2018. Data are given as the mean ± s.e.m. Type III sums of squares indicates a potential difference between attractants ($P = 0.10$). FAS, fatty acid scent; SFE, synthetic fermented egg.

frequent human traffic, such as near roads or trails, could mask the human scent on camera traps or result in mesocarnivores becoming acclimated to human scent in the area (Larrucea *et al.* 2007). Given the well travelled nature of Holly Shelter Game Land, it is probable that the prevalent human scent in the area reduced our attempts of completely masking human scent at the camera traps.

Not masking human scent on equipment affected the success of capturing raccoons, opossums and bobcats, indicating that some species may be more sensitive to the presence of human

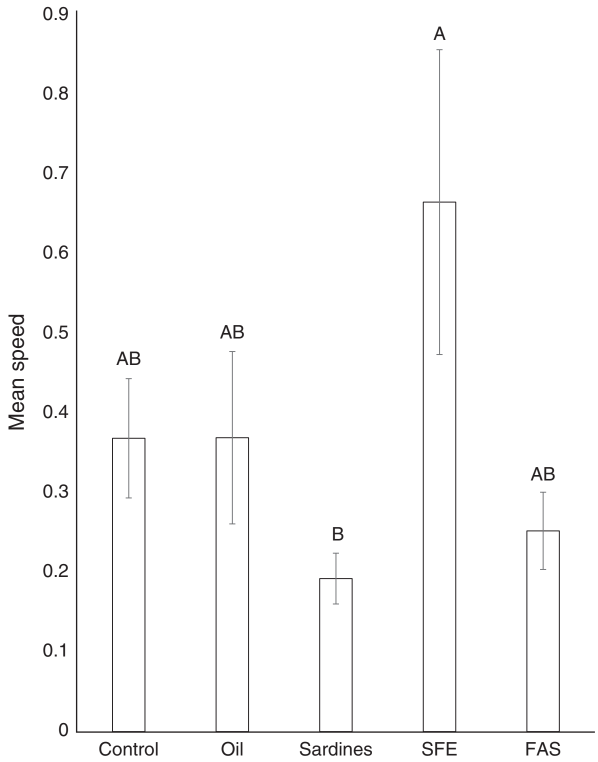

Fig. 6. Mean speed (distance per second) of animals toward bait per attractant type in an assessment of the effectiveness of different attractants and human scent on mesocarnivores, Holly Shelter Game Land, Pender County (NC, USA), 2018. Data are given as the mean ± s.e.m. Different letters above columns indicate significant differences ($P = 0.01$).

scent than others. As observed in Phase 1, opossums and raccoons may have been attracted to camera traps that were not masked, potentially because these species often associate humans with food (DeVault *et al.* 2004; Link 2004). However, evidence of raccoon and opossum attraction to human scent was not found in Phase 2, where there was more human scent per block. Muñoz *et al.* (2014) found that the detection of scent-motivated species, such as raccoons, did not differ between areas where human scent was masked and areas where it was not. These authors placed cameras 75–150 m away from each other, a much closer distance than the cameras in the present study, even within blocks during Phase 2. Thus, both studies suggest human scent may have no effect on opossum and raccoon detection. In contrast with opossums and raccoons, we found evidence that bobcats may avoid human scent, particularly when the number of cameras, and therefore human scent, in an area increased. Similarly, George and Crooks (2006) found bobcats exhibited shifts in their spatial and daily activity patterns to avoid humans in areas with greater human presence. The 'landscape of fear' concept, where animals identify human activity as a perceived threat (Muñoz *et al.* 2014), could explain the aversion of bobcats to human scent because Holly Shelter Game Land is largely used for regulated hunting and trapping. The other mesocarnivores in this study can be hunted and trapped as well, but they did not exhibit this aversion to cameras that did not mask human scent. That being said, a larger sample size of bobcats is necessary to confirm these findings.

Attractants

When broadly targeting all mesocarnivores, sardines were the only attractant to outperform the control treatment in species detection. During camera studies using meat baits, peak activity of camera traps was estimated within the first 4 days after deployment (Vine *et al.* 2009). Presumably, the decreased activity after 4 days was attributed to the meat baits being removed by early animal visitors to the sites. Removal of sardines occurred infrequently in the present study and was often caught on camera, with opossums observed as the primary culprit. Individually, sardines were the most effective attractant at luring coyotes to camera traps compared with the controls in both phases. We also observed repeated detections of coyotes in both phases at cameras that had been baited with sardines, indicating that residual scent may still attract coyotes at locations where sardines were removed.

The results also suggest increasing the presence of sardines within a block may increase the attraction of all mesocarnivores broadly, and specifically opossums, to the area. By increasing the number of camera traps in a block, thereby increasing the presence of the attractant, there is a greater chance of more than one of the camera traps within the block remaining relatively undisturbed and continuing to lure mesocarnivores to the area. More cameras in a survey area also equates to a greater probability of capturing the target species (Lesmeister and Nielsen 2011; Rovero *et al.* 2013; Lesmeister *et al.* 2015). However, funding is often limited in research studies, and increasing the number of cameras, especially over a large study area, may not be feasible.

Compared with sardines, castor oil was less effective in attracting coyotes but still outperformed the control cameras. However, increasing the scent of castor oil had no effect in improving the success of camera traps photographing coyotes, and this attractant did not improve detection rates of any other mesocarnivore in this study. These results were surprising given the common use of this attractant by fur trappers in the US (Noonan 2013).

Another popular attractant used in camera studies, FAS tablets, also produced surprising results in this study by not attracting opossums. Unlike sardine-baited canisters, opossums were not observed removing FAS tablet canisters from the area, possibly because there was no food reward. Alternatively, although FAS tablets had no effect on the capture success of bobcats in either phase, the increased presence of FAS tablets in Phase 2 could outweigh the possible aversion to human scent observed in Phase 1, but a larger sample size of replications would be necessary to observe a statistically significant difference. The use of SFE as an attractant also produced mixed results for individual species.

Increasing the number of camera traps in a survey area baited with SFE may improve coyote detection. However, raccoons were not as frequently detected at camera traps baited with SFE, particularly in Phase 2 when the scent was more prevalent. Bobcats were also detected less at cameras baited with SFE in Phase 1 than in Phase 2. One possible explanation is that the increased SFE in the block during Phase 2 resulted in dilution of a novel smell, reducing the bobcats' wariness and aversion to the camera traps.

The type of attractant may be of less importance than the fact that the camera traps are a novel stimulus in the environment, particularly for opossums, raccoons and fox. In a review of 226 camera trap studies, Burton *et al.* (2015) found only 22.9% of studies used baits and 9% used scented lures. The results of the present study support not using a scented lure or bait when targeting multiple mesocarnivores, thereby reducing potential biases in population estimates from their use (Oliveira-Santos *et al.* 2008; McCoy *et al.* 2011).

Species behaviour

In general, mesocarnivores approached sardines closer than any other attractant, further supporting the use of sardines in broadly targeted studies, if an attractant is deemed necessary. Of the five species, opossums and raccoons approached closest to camera traps baited with sardines. Opossums were primarily seen eating the bait, suggesting they came closer to consume the sardines, whereas raccoons may just be interested in the novel stimulus or presence of human scent in the area. Bobcats remained furthest from camera traps baited with sardines than the other species, and repeat detections of bobcats were less at sites baited with this attractant, suggesting that bobcats may have been less curious about the attractant than other species. In addition, although sardines appeared to have the strongest effect in luring coyotes to camera trap locations, coyotes came closest to canisters baited with SFE than any of the other attractants. This complements the evidence in our study that the presence of SFE increased the number of trap nights that photographed a coyote. Sardines followed closely behind SFE in how close coyotes came to the attractant, further providing evidence that coyotes are heavily attracted to sardines.

Mesocarnivores approached camera traps that were deployed using SFE at faster speeds compared with camera traps with sardines and generally faster than all other attractants. Fast movements through the detection zone of infrared cameras may result in ghost shots with no animals, which may explain the fewer detections of several of our target species to the SFE traps. Alternatively, because coyotes appeared attracted to traps with SFE, other species may be avoiding coyotes in the area. Mesocarnivores were slowest to approach the sardines, with more time passing, allowing a greater probability of detection and more pictures being taken. In these terms, the success of photographing mesocarnivores increases with sardines as a bait. The animal is not moving as fast, allowing for clearer images, easier species detection and a greater possibility of identifying individual markings.

Management implications

This study provided a comparative look at the interactive effects of both human scent and attractant variability on mesocarnivore detection within a single study area. Overall, species reacted differently to the various treatments, and managers should consider our results when designing future camera trap studies for mesocarnivores. Baiting camera traps with sardines, SFE or beaver castor oil would be beneficial when studying coyotes. Although foxes exhibited little response to most attractants, baiting cameras with FAS tablets could increase the number of repeat visits to a camera or block of cameras. Similarly, future bobcat studies should consider baiting cameras with FAS tablets while masking human scent. However, studies targeting coyote and fox may not need to mask human scent if the study area has a high human presence in general compared with an isolated study site. Baiting cameras with an attractant is not necessary for opossums or raccoons, but FAS tablets and SFE respectively should be avoided for each species. In addition, not masking human scent could improve capture success of both opossums and raccoons. An overall larger sample size would clarify these results in future studies.

Conflicts of interest

The authors declare no conflicts of interest.

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