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Detection Bias in Noninvasive Track Surveys of Mammalian Predators in Illinois

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ABSTRACT

We compared the species of mammalian predators detected by track surveys using sooted track plates, natural soil, and fine sand as track-collecting substrates. Some species, such as coyotes, foxes, and bobcats, were detected less frequently by track plates than by more natural substrates. In contrast, raccoons and opossums did not show substrate avoidance. Additional data from camera traps and snow tracking in one study did not reveal any species of mammalian predators not detected by sand stations. Potential sampling bias due to responses of different species to tracking substrate or baits and lures used as attractants should be kept in mind when designing predator surveys.

INTRODUCTION

Knowledge of presence-absence and relative abundance of mammalian predators is important to biologists and managers because these species often play a key role in ecosystem processes (Gittleman and Gompper 2005, Roemer et al. 2009). Because mammalian predators can be elusive and occur at low population densities, direct survey methods are challenging. Capture methods also are time consuming and invasive (Barea-Azcon et al. 2007). Thus, various methods have been developed to detect mammalian predators noninvasively. Of these, the most simple and economical are those using baited track stations to lure animals and capture their tracks for identification (Linhart and Knowlton 1975, Connor et al. 1983, Taylor and Raphael 1988). Here, we compare 3 such methods using data from 2 studies in central and southern Illinois, and discuss potential benefits and biases of each.

Mammalian predators vary considerably in body size, diet, and behavior. As a consequence, survey techniques may be biased in their ability to detect different species (Gompper et al. 2006). For example, in 1 study in Illinois, coyotes (*Canis latrans*) and foxes (red foxes, *Vulpes vulpes* and gray foxes, *Urocyon cinereoargenteus*) were rarely detected, and bobcats (*Felis rufus*) were not detected by sooted track plates although they were commonly seen (e.g., coyotes) or known to occur (e.g., bobcats) in the study area (Heske 1995). Some animals may be wary of and avoid stepping on foreign tracking surfaces (Gompper et al. 2006). Additionally, track stations often use bait as an attractant, and different species may react differently to different bait types.

We conducted track surveys of mammalian predators during 2 studies designed to compare species detected by different methods: sooted aluminum track plates (Taylor and Raphael 1988), track stations using a substrate of imported sand (Connor et al. 1983), and track stations using a substrate of naturally occurring soil cleared of debris. We also used remote camera traps and snow-track surveys at one site to determine if these methods detected any species not detected by our track stations. By conducting multiple noninvasive survey techniques simultaneously at each site, we sought to determine which methods were most effective at detecting a range of mammalian predators, and which methods contained biases leading to the detection of some species but not others. Although tracks of additional species such as squirrels (*Sciurus niger* and *S. carolinensis*), chipmunks (*Tamias striatus*), mice (mostly *Peromyscus* sp.), deer (*Odocoileus virginianus*), various birds, frogs, toads, and turtles were observed, we focused our analysis on mammalian predators.

METHODS

Cache River, 1994

We conducted surveys along 14 transects in the Cache River area of southern Illinois during May-July 1994. Five 1-km transects were set in upland or bottomland forest interior (>300 m from forest edge) and three 1-km transects were set under forest canopy but <10 m from forest edge in and around the Cache River Natural Area in Johnson County, IL. Additionally, six 500-m transects were set in riparian forest along the Cache River in Johnson and Pulaski counties. Each transect consisted of 5 track stations (1-km transects) or 3 track stations (500-m transects) spaced 250 m apart. At stations 1, 3, and 5 on 1-km transects, and stations 1 and 3 on 500-m transects, we placed sooted track plates consisting of two 1 m x 0.5 m sheets of 0.32-gauge aluminum coated with soot from a kerosene torch. The two plates were set side-by-side on a cleared, level, 1-m^2 area with an open tin of sardines in soybean oil in the center as bait. At stations 2 and 4 (1-km transects), and at station 2 (500-m transects), we made track stations using the natural soil as substrate by clearing a 1-m diameter circle of debris and softening and smoothing the soil with an iron rake. We then excavated a 10-cm deep by 6-cm wide hole in the center of the circle with a garden bulb planter, and placed approximately 15 cc of predator lure (Power River Paste, O'Gorman Enterprises, Inc., Broadus, MT) into the hole, which was then loosely stuffed with vegetation. Finally, we misted the hole and surrounding ground with red fox urine. While setting all stations, we wore rubber boots and gloves to reduce human scent. Each transect was set and checked for 5 consecutive days in May, June, and July, for a total of 15 survey nights per transect. Soil was raked and smoothed, and bait and track plates were replaced as needed during each check. Data were recorded as each carnivore species that left tracks at a station between successive checks.

Middle Fork Fish and Wildlife Area, 1995

We conducted surveys along 15 transects at the Middle Fork Fish and Wildlife Area (MFFWA) in Vermilion County, IL in August and September 1995. Transects were set under forest canopy <5 m from forest edge. Each transect was 500 m long and contained 3 stations spaced 250 m apart. At one station, we placed sooted aluminum track plates as previously described. At a second station, we cleared a 1 m x 2 m area of vegetation and

raked it smooth, and then covered it with fine sand to a depth of 1-2 cm. At a third station, we placed a Trailmaster automatic infrared camera trap (Model TM 1500, Goodson and Associates, Lenexa, KS). The infrared emitter and receiver were set 3 m apart, with the beam located 18 cm above ground level. All stations were baited with a piece of raw chicken (neck, back, gizzard). Order of station type (track plates, sand, camera) along each transect was randomly stratified such that each station type was in the middle on 5 transects. Transects were checked on 3 consecutive days during 1 period in August and 1 period in September, for a total of 6 survey nights per station. Track plates were replaced, sand was raked smooth, and bait was replaced as necessary. Data from cameras were recorded as number of nights that photos were taken of each species, regardless of number of photos or individuals in each photo, to be comparable to track data and because individuals of the species detected could not be distinguished in photos. In addition, we walked each transect on a single day in December following a snowfall and recorded each species for which we found snow tracks along each transect.

We evaluated substrate bias by comparing detections on track plates and either natural soil (Cache River) or fine sand (MFFWA) to the number expected if detection was random in each study using chi-square tests. We evaluated each study separately because of their different substrates and baits, and pooled data for coyotes, foxes, bobcats, domestic cats (*Felis catus*), and long-tailed weasels (*Mustela frenata*) into a single category (Other carnivorans) because of small sample sizes for each species.

RESULTS

In our combined surveys using sooted track plates (n = 630 survey nights), natural soil track stations (n = 330 survey nights), sand track stations (n = 90 survey nights), camera trap stations (n = 90 survey nights), and snow tracking (7.5 km of transect walked), we detected 7 species of mammalian predator: Virginia opossums (*Didelphis virginiana*), raccoons (*Procyon lotor*), foxes, coyotes, bobcats, domestic cats, and long-tailed weasels. We could not distinguish tracks of red foxes from those of gray foxes in most cases, so we pooled these as “fox.” Bobcat tracks were only detected in southern Illinois, but bobcats were likely not present in MFFWA at the time of our study. In contrast, domestic cats were detected only at MFFWA, where they were regularly observed. In previous live-trapping at MFFWA, domestic cats that were captured appeared scruffy and aggressive (E. J. Heske, pers. obs.). We therefore consider domestic cats at MFFWA to be either feral or free-roaming farm cats.

Sooted track plates detected primarily raccoons and opossums, and also detected weasels on 3 occasions in MFFWA; they did not detect foxes, coyotes, or bobcats (Tables 1 and 2). Soil track stations detected all species except weasels (which also were not detected by track plates in the Cache area in 1994), and sand track stations detected all species but bobcats (which likely were not present at MFFWA in 1995). Camera traps at MFFWA in 1995 detected raccoons and opossums, but no other wild mammalian predators. Snow tracking detected all species at MFFWA detected by the other methods, with the exception of opossums. It is likely that activity by opossums was curtailed during the cold spell associated with the snow event; opossum tracks have been observed in snow at MFFWA on other occasions (E.J. Heske, pers. obs.).

Raccoons were detected more often by track plates than by soil track stations in the Cache area ($\chi^2_1 = 21.66$, $p < 0.001$), as were opossums ($\chi^2_1 = 48.16$, $p < 0.001$; Fig. 1A, Table 1). In contrast, foxes, coyotes, and bobcats were only detected by soil track stations in 1994 ($\chi^2_1 = 15.0$, $p < 0.001$; Table 1), although the number of detections per survey night was low (Fig. 1A). At the MFFWA in 1995, raccoons were more readily detected by cameras than either type of track station (Fig. 1B), but detections of raccoons by track plates and sand stations did not differ ($\chi^2_1 = 1.0$, $p = 0.317$, Table 2). In contrast, opossums were more readily detected by track plates and sand stations than by cameras (Fig. 1B), but like raccoons, detections of opossums by track plates and sand stations did not differ ($\chi^2_1 = 0.62$, $p = 0.431$; Table 2). Foxes and coyotes were only detected by sand stations, domestic cats were detected by both sand stations and cameras, and long-tailed weasels by both types of track stations (Table 2), but all at low frequency (Fig. 1B). Detections of our pooled category, Other carnivorans, did not differ between track plates and sand stations ($\chi^2_1 = 2.28$, $p = 0.131$), however, sample size was small and weasels appeared to respond differently to substrate than the canids and felids. Detections of foxes, coyotes, and domestic cats at MFFWA were similar to detections of foxes, coyotes, and bobcats in the Cache area, and detections by track plates and sand stations differed ($\chi^2_1 = 7.0$, $p = 0.008$) when only these canids and felids were considered.

DISCUSSION

The type of substrate used to collect tracks of mammalian predators can bias detection, as suggested by others (e.g., Heske 1995, Gompper et al. 2006). In our comparisons, sooted aluminum track plates did not detect canid species such as coyotes or foxes, nor did they detect bobcats or domestic cats. These species may be wary of foreign substrates, and thus avoid stepping on the aluminum surface. Sooted track plates readily detected raccoons and opossums, and to a lesser extent, weasels, however. Sooted track tubes were used to survey for weasels in southern Illinois by Richter (2005), for example. Raccoons and opossums often exploit anthropogenic food resources and acclimate to human disturbance (e.g., Prange et al. 2004); unfamiliar substrates may not deter these species. It would be interesting to determine if coyotes and foxes acclimated to urban settings lose their wariness of such substrates as well. Advantages of sooted track plates are that they yield very clear tracks, which can be “lifted” with tape for future identification by more experienced observers, and they can be moved and reused in multiple locations (Taylor and Raphael 1988). Several pre-sooted track plates can be carried into remote areas in specialized backpacks, whereas bags of sand for sand stations (10 – 20 kg/station) are difficult to transport away from roads.

The natural soil track stations used in our 1994 surveys mimicked food caches of foxes (Schwartz and Schwartz 1981), and were similar to bait stations used by fur-trappers. Thus, substrate and bait type were confounded in this comparison. Sardines are an attractive bait for raccoons and opossums, which may have been less attracted to the commercial carnivore lure used at the natural soil stations. It is clear, however, that potential biases in responses of predators to both substrate and bait should be considered when interpreting results of track station surveys. Natural soil track stations have the advantage of using a substrate familiar to the species being surveyed and do not require the import of outside material other than bait. Tracks at natural soil stations can be difficult to read and identify, however, and are easily affected by adverse weather conditions.

Sand track stations detected more species of mammalian mesopredators than either track plates or cameras in our 1995 study, and detected all the species confirmed as present at MFFWA in our snow-tracking survey. Adding a small amount of mineral oil to fine sand before spreading it as a substrate also improves clarity of tracks (Hoffman and Heske 2003). We also recommend using a commercial attractant such as fatty acid scent rather than food baits at sand stations, as food baits degrade quickly in hot, humid weather, attract insects, and tracks at stations can be obliterated when species such as raccoons or opossums consume the bait on the station and forage through the sand for more (E. J. Heske, pers. obs.; Cottam et al. 2009). Sand stations cannot be moved like sooted track plates, however, they can be reused by smoothing the sand and re-baiting, and can be left in place for longer periods of time to habituate animals. Sand stations have been used in a variety of studies (e.g., Connor et al. 1983, Heske et al. 1999, Cottam et al. 2009), and our comparison shows that they introduce less bias in species detection than sooted track plates. The widespread use of similar track stations for detection and monitoring of carnivorans by wildlife or natural resource agencies is supported by our data.

Trailmaster camera traps used in our 1995 study detected raccoons and opossums, but failed to detect foxes, coyotes, or weasels. More extensive use of camera traps at MFFWA in 1996 (Heske et al. 1999) also added fox squirrels, white-tailed deer, domestic cats, domestic dogs, striped skunks (*Mephitis mephitis*), and humans to the list of mammals photographed, but recorded only a single photograph of a coyote in contrast to 11 records of coyote tracks at sand stations on the same transects (E. J. Heske, unpublished data). Coyotes and foxes may be wary of approaching cameras (Hernandez et al. 1997, Gompper et al. 2006), and smaller species such as weasels may be missed by cameras due to their size (Gompper et al. 2006, Tobler et al. 2008). Camera traps have many advantages; for example, they can be left in place for long periods of time, are less susceptible to inclement weather, and can provide information on individual identities of some detected species. The cameras we used in our surveys were early-generation technology, and left in place for only a short period of time. Significant advancements in camera-trap technology have been made since our study, and numerous studies have since reevaluated their effectiveness (Silveira et al. 2003, Gompper et al. 2006; Tobler et al. 2008). Neilsen et al. (2009) effectively used camera surveys to detect coyotes, red and gray foxes, and bobcats throughout southern Illinois. We include our camera data here primarily to show, along with the snow-tracking data, that the species detected in our track surveys were representative of the species present at MFFWA at the time of our study (i.e., cameras did not detect additional species missed by track surveys).

Our study confirmed the suspicion that sooted track stations can underestimate detection of some mammalian predators, particularly canids and felids (Heske 1995, Gompper et al. 2006). Natural soil track stations detected these predators much better than track plates, however, sand stations yielded tracks that were often clearer and easier to identify. The relationship between counts from track stations and population density has been questioned by some (e.g., Smith et al. 1994), and relationships are likely non-linear (MacFarland 2009). Our comparisons underscore an additional source of uncertainty. Track stations may be most useful in presence-absence surveys or as an index for comparisons within a species when the functional relationship between track counts and population density can be assumed constant across sampling sites. As with any such endeavor, sur-

vey methods, including choice of tracking substrate and bait, should be chosen based on the goals and target species of the particular study.

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Figure 1: Detection per station night of mammalian predators by 4 noninvasive survey techniques in A) Cache River State Natural Area and vicinity, Johnson and Pulaski counties, IL (1994), and B) Middle Fork Fish and Wildlife Area, Vermilion County, IL (1995). In 1994, track plates were baited with sardines and soil track stations were baited with a commercial predator lure. In 1995, all stations were baited with pieces of raw chicken.

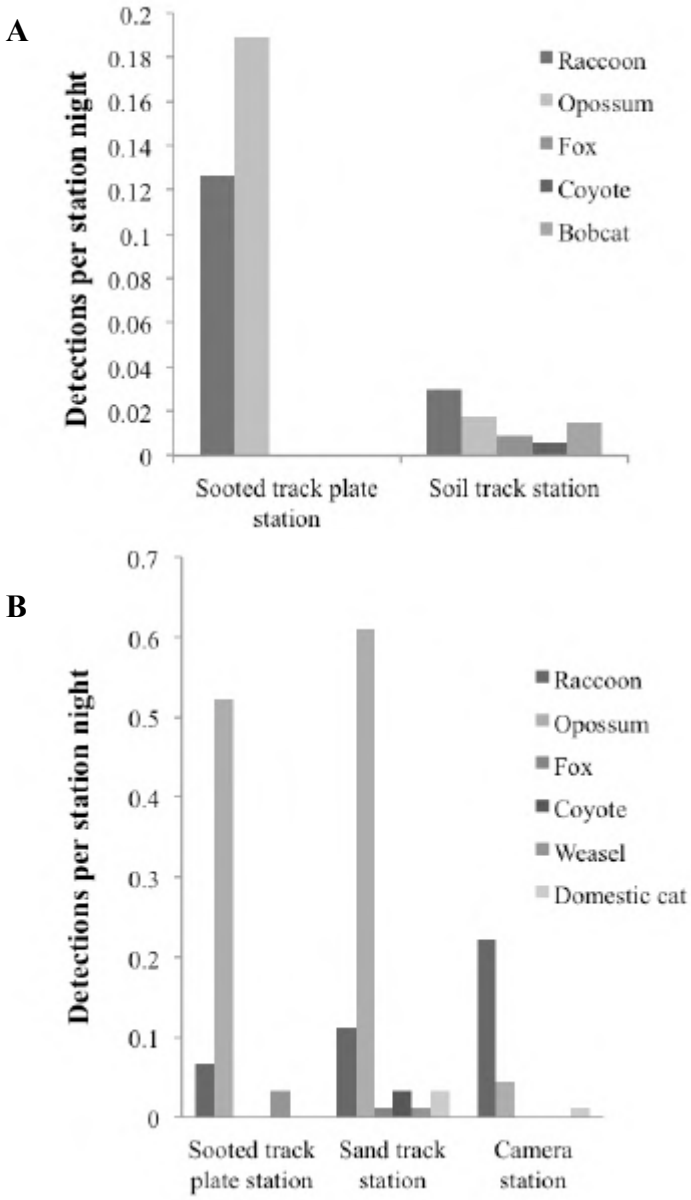

Table 1: Number and species of mammalian predators detected by noninvasive survey techniques in Cache River Natural Area and vicinity, Johnson and Pulaski counties, IL in 1994 (n=870 total station nights).

Species	Sooted track plate station	Soil track station	χ^2_1	p
Raccoon	68	10	21.66	<0.001
Opossum	102	6	38.16	<0.001
Fox	0	3	15.0*	<0.001
Coyote	0	2		
Bobcat	0	5		
Station-nights	540	330		

*Data pooled for fox, coyote, and bobcat to allow statistical analysis.

Table 2: Number and species of mammalian predators detected by noninvasive survey techniques in Middle Fork Fish and Wildlife Area, Vermilion County, IL in 1995 (n=270 total station nights). Chi-square test compares detections on sooted track stations to sand track stations only.

Species	Sooted track station	Sand track station	Camera station	Snow track survey	χ^2_1	p
Raccoon	6	10	20	3	1.0	0.317
Opossum	47	55	4	0	0.62	0.431
Fox	0	1	0	4	2.28*	0.131
Coyote	0	3	0	7		
Domestic Cat	0	3	1	1		
Weasel	3	1	0	0		
Station-nights	90	90	90	na		

*Data pooled for fox, coyote, long-tailed weasel, and domestic cat for statistical analysis. If data are only pooled for fox, coyote, and domestic cat (i.e., exclude weasel), $\chi^2_1 = 7.0$, $p = 0.008$.