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Short communication

Camera traps at northern river otter latrines enhance carnivore detectability along riparian areas in eastern North America

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ABSTRACT

We evaluated the efficacy of placing camera traps at river otter (*Lontra canadensis*) latrines (discrete sites in riparian areas where otters regularly deposit scats, urine, and anal secretions) to detect other carnivores occupying Great Swamp National Wildlife Refuge, New Jersey, USA. We postulated that scents at latrines may serve as an attractant to other carnivores and evaluated this premise by using camera traps to compare carnivore detection rates (overall and by species) and richness (overall and for each survey month) between latrine ($n = 5$) and non-latrine riparian areas ($n = 5$). On average carnivore richness was about 1.7 times higher than that of a non-latrine, and mean richness was higher at latrines for all survey months. Likewise, the overall carnivore detection frequency was 3.5 times greater at latrines, and the detection frequencies for red foxes (*Vulpes vulpes*), northern raccoons (*Procyon lotor*), river otters, mink (*Neovison vison*), long-tailed weasels (*Mustela frenata*), and Virginia opossums (*Didelphis virginiana*) were greater at latrines. American black bears (*Ursus americanus*) and eastern coyotes (*Canis latrans*) where detected more frequently at non-latrines. Our study provides evidence that placement of camera traps at otter latrines may serve as a new and novel approach for monitoring carnivore populations in riparian areas.

1. Introduction

Use of camera-trap surveys is particularly effective when collecting information on rare and elusive mammals, such as many species in the Order Carnivora (Kays and Slauson, 2008). For instance, based on a review of 266 camera-trap studies conducted from 2008–2013, Burton et al. (2015) point out that carnivores were the focus of 64.7% of those studies. Although camera trapping continues to expand in carnivore investigations, applications for use of camera-trap surveys to detect carnivores are still developing and can benefit from further refinement and innovation (Harmsen et al., 2010; Meek and Pittet, 2012). In North America, northern river otter (*Lontra canadensis*; hereafter otter[s]) latrines may serve as an attractant for sympatric carnivores and be ideal locations to place camera traps to detect carnivores.

Otters establish latrines by consistently depositing scat, urine, and anal secretions (hereafter collectively referred to as excrement) at discrete sites along riparian areas and other aquatic environments (Ben-David et al., 1998; Swimley et al., 1998). The accumulation of excrement at latrines causes them to have a distinct strong and persistent odor. Latrines often exhibit prominent visual characteristics caused by otters scraping vegetation and soil litter into piles (Stevens and Serfass,

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2005). Camera traps positioned at latrines have been used to study otter visitation patterns, group composition, seasonality in marking, and detectability (Olson et al., 2005, 2008; Stevens and Serfass, 2008; Green et al., 2015; Day et al., 2016). Interestingly, camera traps at latrines in Pennsylvania and Maryland, USA, documented several carnivore species (S. Stevens, pers. comm.) at rates speculated to be higher than at non-latrine riparian areas (hereafter non-latrines).

Olfactory and visual cues (i.e., excrement and scrapings) contributed by otters at latrines may serve as attractants for other carnivores, accounting for frequent detections. For example, the excrement deposited by otters at latrines may function in the same capacity as a lure (e.g., skunk tincture or catnip; Long et al., 2008). Further, in many carnivore species a behavior known as overmarking is common, in which an animal deposits its own scent atop scent marks of conspecifics (Brown and MacDonald, 1985; Rodgers et al., 2015). This overmarking behavior may likewise apply to heterospecifics. However, carnivores have been suggested to frequent riparian areas as travel corridors and for foraging (Serfass and Brooks, 1998; Hilty and Merenlender, 2004). Hence, frequent detections of carnivores at latrines may be primarily attributable to frequent use of riparian areas. If so, camera traps positioned at non-latrines may be equally or more effective in detecting carnivores than those at latrines.

As part of a larger project that used camera-trap surveys to monitor carnivores (Wagnon, 2015), we evaluated and compared carnivore detections between latrines and non-latrines. Our specific objectives were to use camera traps to: (1) evaluate if carnivores are regularly detected at otter latrines; and (2) determine if detections and richness are similar or vary between latrines and non-latrines. To the best of our understanding, this study represents the first of its kind evaluating latrines as potential sites to detect carnivores with camera traps.

2. Materials and methods

2.1. Study area

Our study was conducted in the 3144 ha wildlife preserve of Great Swamp National Wildlife Refuge (hereafter referred to as Refuge), New Jersey, USA (Fig. 1). The Refuge is located about 50 km west of downtown New York City, New York, USA, and is located entirely within the Piedmont physiographic province (US Fish and Wildlife Service, 2014). Five streams flow through the Refuge, all comprising part of the headwater system within the Passaic River drainage. Our study was focused on the western portion of the Refuge, which also contains 5 wetland impoundments (Fig. 1). Nine carnivores were known to occur at our study site: red fox (*Vulpes vulpes*), coyote (*Canis latrans*), northern raccoon (*Procyon lotor*), American mink (*Neovison vison*), otter, gray fox (*Urocyon cinereoargentueus*), striped skunk (*Mephitis mephitis*), long-tailed weasel (*Mustela frenata*), and American black bear (*Ursus americanus*) (US Fish and Wildlife Service, 2014). The Virginia opossum (*Didelphis virginiana*) was also known to occur at the Refuge, and was included as a target species because this predator may fill a similar ecological role as other mid-sized carnivores (Gompper et al., 2006; for convenience we hereafter include the Virginia opossum in collective references to carnivore detections).

2.2. Data collection

From May to August in 2013 and 2014, we conducted otter latrine searches along all streams and wetland impoundments. For a latrine to be selected for a camera-trap site we established two criteria: (1) latrines were separated by a straight-line distance >1 km; and (2) the riparian areas associated with latrines did not impede access to other carnivores (e.g., areas with dense vegetation patterns were excluded). Five latrines met these conditions and were included in the analysis.

For our comparison camera traps were placed at the 5 latrines, each paired with a corresponding non-latrine camera trap. Each latrine and non-latrine was considered a sampling pair, and pairs were labeled 1–5 (Fig. 1). The intended distance between camera traps comprising a sampling pair was to be 100 m, but actual distances between paired camera traps ranged from 70 to 127 m ($\bar{x} = 102.8$ m). This variation in distance was attributable to our second criterion used for our latrine selection, which required that conditions at a site would not impede target species from moving through the detection zone of the camera trap (e.g., areas with dense vegetation or other characteristics interpreted as likely to impede animal's movements along the riparian area were excluded). Otters typically mark 1–2 m from the water's edge (Swimley et al., 1998), which was the case in our study. Hence, camera traps at both latrines and non-latrines were installed about 3–4 m from the water's periphery. All camera traps were attached to a tree using a mounting strap, and positioned to face perpendicular to the shoreline about 0.5–1 m off the ground.

Camera-trap surveys were conducted from 1 August 2014–27 February 2015. Camera traps were checked at the beginning of each survey month to replace SD cards and batteries if necessary. Additionally, we recorded the presence/absence of otter excrement during each camera check by noting if excrement was deposited at a latrine since the last check. Two Reconyx® digital cameras (Reconyx Inc., Holmen, Wisconsin, USA) and 8 Cuddeback® digital cameras (Nontypical Inc., Green Bay, Wisconsin, USA) were used in the study. The same make of camera traps were used at each sampling pair. Camera traps were programmed to take 1 image with a 15-s delay between images.

2.3. Data analysis

We summarized all images from camera traps by species and location. Images of the same species at a site were identified as temporally independent if separated by >60 min (i.e., a detection). Also, we used the maximum number of individuals

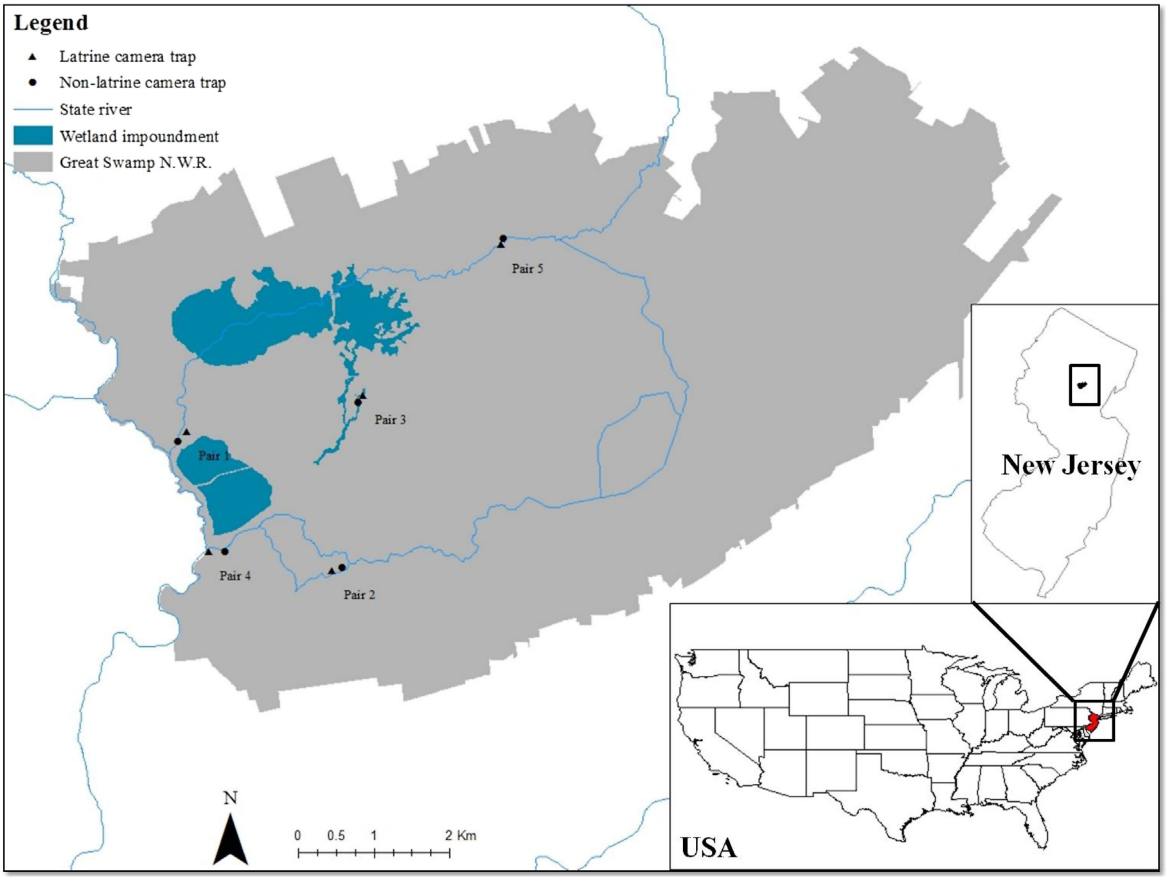

Fig. 1. Distribution of paired latrine ($n = 5$) and non-latrine ($n = 5$) camera-trap sites (labeled pair 1–5) sampled from 1 August 2014 -27 February 2015 at Great Swamp National Wildlife Refuge, New Jersey, USA. Straight line distances and distances following water courses from any latrine to the next nearest latrine ranged from about 1.2 to 2.7 km and about 1.5 to 3.2 km, respectively.

in an image for the analysis (i.e. an image with 2 individuals was recorded as 2 detections). We calculated carnivore species richness (overall and monthly), detectability (i.e., detections and detection frequencies; overall and by species), and naive occupancy (i.e., the proportion of camera traps where a species was detected; MacKenzie et al., 2006) between latrines and non-latrines. Detection frequencies were defined as the number of detections per 100/camera-trap days (e.g., Sollmann et al., 2013). A camera-trap day (TD) was defined as a 24 h period a camera trap was functional. We used descriptive statistics (i.e., sums, means [$\bar{x}$] and Standard Deviations [SD]) as a basis for comparison of species richness and detectability.

Our project is based on the underlying postulate that olfactory and/or visual cues contributed by otters at latrines serve as attractants to other carnivores. Fundamental to assessing this postulate is the presumption that otters have been visiting latrines and contributing to these cues during the survey. Hence, the monthly occurrences of otter visitations to the 5 latrines were documented by images and by noting excrement at latrines during camera checks. We used images of otter to calculate the overall and mean number of days latrines were visited (hereafter referred to as detection days) for each month of the study.

3. Results

Camera traps at latrines recorded 1018 TD ($\bar{x} = 203.6 \pm 8.2$ TD). A single latrine (pair 3) was not monitored for 19 TD in October because of battery failure. Camera traps at non-latrines recorded 983 TD ($\bar{x} = 196.6 \pm 8.4$ TD). Camera traps at 3 non-latrines were non-functional for 54 TD either because batteries failed or the camera trap malfunctioned: 16 TD were lost at pair 1 in November, 16 TD at pair 2 in December, and 22 TD at pair 3 in February. Eight carnivore species were recorded during our study, totaling 1060 detections with 3.7 times more detections at latrines than at non-latrines ($n = 835$, $\bar{x} = 167.0 \pm 94.2$ SD and $n = 225$, $\bar{x} = 45.0$, ± 31.5 SD, respectively). Species detected, were raccoon ($n = 641$), red fox ($n = 185$), otter ($n = 158$), mink ($n = 44$), opossum ($n = 25$), long-tailed weasel ($n = 3$), coyote ($n = 3$), and black bear ($n = 1$). Otters were only detected at latrines, and the single detection of a black bear was at a non-latrine.

Mean richness at a latrine was about 1.7 times higher than that of a non-latrine ($\bar{x} = 5.4 \pm 0.5$ SD, range = 5–6 species versus $\bar{x} = 3.2$, ± 1.1 SD, range = 2–5 species, respectively). Similarly, mean richness was higher at latrines for all survey

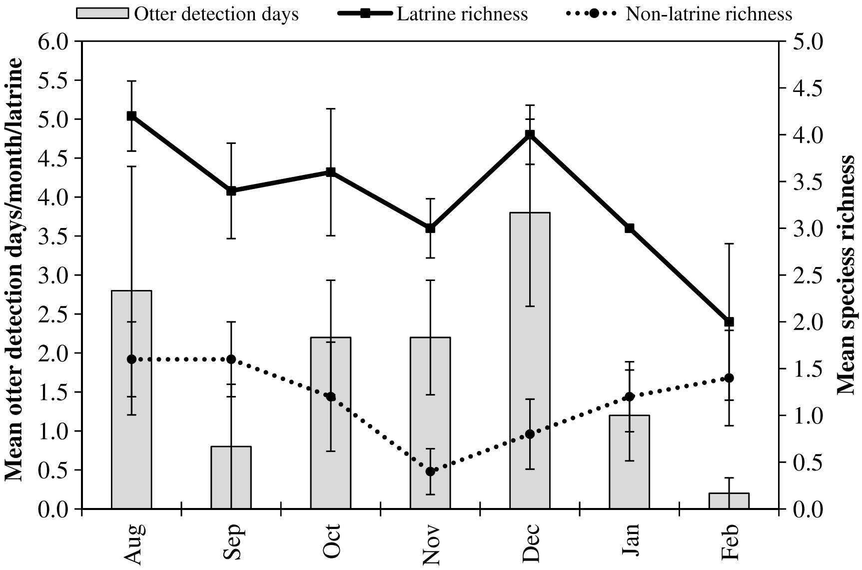

Fig. 2. Mean monthly carnivore richness at latrines ($n = 5$) and non-latrines ($n = 5$), and the mean number of otter detection days/month/latrine at Great Swamp National Wildlife Refuge, New Jersey, USA, from 1 August 2014 to 27 February 2015.

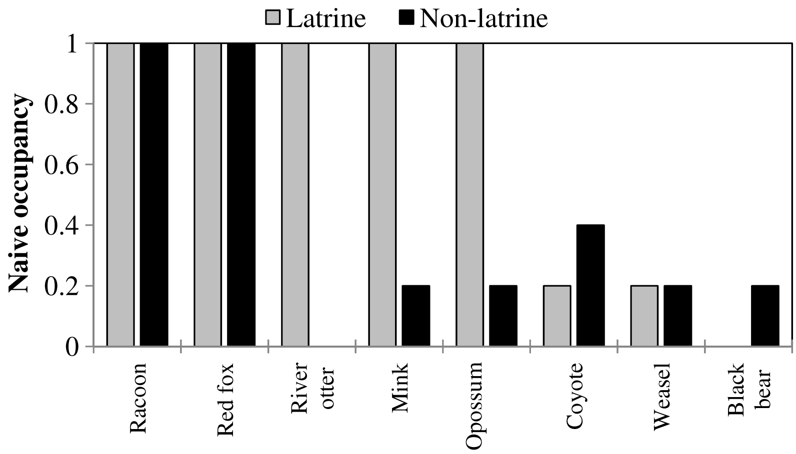

Fig. 3. Naive occupancy (i.e., proportion of camera traps to detect species) for carnivores at latrines ($n = 5$) and non-latrines ($n = 5$) at Great Swamp National Wildlife Refuge, New Jersey, USA, from 1 August 2014 to 27 February 2015.

months (Fig. 2). The biggest differences between monthly richness occurred during November and December when mean richness at a latrine was 3.0 and 4.0, respectively, in comparison to 0.4 and 0.8, respectively, at a non-latrine (Fig. 2). The mean overall carnivore detection frequency was 3.5 times greater at latrines (82.0 detections/100 TD ± 41.1 SD) than non-latrines (23.3 detections/100 TD ± 15.0 SD), and detections and detection frequencies for all species (except for black bears and coyotes) were higher at latrines (Tables 1 and 2). The raccoon was the most commonly detected carnivore at latrines and non-latrines with detectability at latrines about twice that at non-latrines (43.6 detections/100 TD ± 25.9 SD and 20.7 detections/100 TD ± 18.3 SD, respectively). Likewise, respective detectability for red foxes (16.1 detections/100 TD ± 15.8 SD), opossums (2.4 detections/100 TD ± 1.6 SD), and mink (4.2 detections/100 TD ± 7.5 SD) at latrines was 8-fold, 24-fold, and 42-fold to detectability at non-latrines (Table 2). At non-latrine sites, red foxes (2.0 detections/100 TD ± 1.1 SD) were the only carnivore other than raccoons with a detection frequency > 1.0 detections/100 TD (Table 2). Naive occupancy was higher for otters, mink, and opossums at latrines; equal for raccoons, red foxes, and long-tailed weasels at latrines and non-latrines; and higher for coyotes and black bears at non-latrines (Fig. 3). The biggest difference in naive occupancy occurred for otters, opossums, and mink (1.0, 1.0, and 1.0, respectively at latrines versus, 0.0, 0.2, 0.2, respectively at non-latrines) (Fig. 3).

We recorded 66 detection days ($\bar{x} = 13.2$ detection days/latrine ± 6.5 SD, range = 9–24) of otters at latrines. On average, otters were documented at latrines 2.0 detection days/month/latrine ± 1.2 SD (range of monthly means = 0.2–3.8). The mean number of detection days for otters was highest in December and lowest in February (Fig. 2). For August and September

Table 1
Total number of carnivore detections overall, by sampling pair, and by species from camera traps placed at latrines (L) and non-latrines (NL) at Great Swamp National Wildlife Refuge, New Jersey, USA, from 1 August 2014 to 27 February 2015.

Species	Pair 1		Pair 2		Pair 3		Pair 4		Pair 5		Overall	
	L	NL[a]	L	NL[a]	L[a]	NL[a]	L	NL	L	NL	L	NL
Raccoon	61	9	171	23	107	81	62	13	41	73	442	199
Red fox	15	5	87	3	13	1	40	7	10	4	165	20
River otter	62	0	28	0	30	0	19	0	19	0	158	0
Mink	1	0	36	1	1	0	4	0	1	0	43	1
Opossum	5	1	3	0	6	0	1	0	9	0	24	1
Coyote	0	0	0	1	1	0	0	1	0	0	1	2
Weasel	0	0	2	1	0	0	0	0	0	0	2	1
Black bear	0	0	0	0	0	1	0	0	0	0	0	1
Total	**144**	**15**	**327**	**29**	**158**	**83**	**126**	**21**	**80**	**77**	**835**	**225**

[a] Camera trap that lost TD either form battery failure or camera trap malfunction. The non-latrine camera trap at pair 1 lost 16 TD in November; the non-latrine camera trap at pair 2 lost 16 TD in December; and the non-latrine and latrine camera traps at pair 3 lost 22 and 19 TD in February and October, respectively.

Table 2
Mean species-specific detection frequencies at latrines and non-latrines at Great Swamp National Wildlife Refuge, New Jersey, USA, from 1 August 2014 to 27 February 2015.

Species	Mean detection frequency (number of detections/100 trap days) (SD)	
	Latrine	Non-latrine
Raccoon	43.6 (25.9)	20.7 (18.3)
Red fox	16.1 (15.6)	2.0 (1.1)
River otter	14.8 (8.8)	0.0
Mink	4.2 (7.5)	0.1 (0.2)
Opossum	2.4 (1.6)	0.1 (0.2)
Coyote	0.1 (0.2)	0.2 (0.3)
Weasel	0.2 (0.4)	0.1 (0.2)
Black bear	0.0	0.1 (0.2)

a single latrine (pair 4) had no visitations by otters, and in February, a second latrine (pair 5) was not visited. All other latrines were visited by otters at least once during all survey months. We recorded fresh excrement, but no images of otters, at 3 latrines in September, 2 latrines in January, and 3 latrines in February.

4. Discussion

Carnivore detectability (overall and for most species) and richness was higher at latrines, adding support to the contention that otters may contribute cues that attract carnivores. Among the 8 species detected during our study, 5 (raccoon, red fox, otter, mink, and opossum) were detected much more frequently at latrines than non-latrines (Table 1). Further, at non-latrines detections were disproportionately representative of raccoons (i.e., 93.7% of total detections), and all other species were infrequently detected. Thus, carnivore detections at latrines may not be a reflection of frequent use of riparian areas, and rather, a reflection of carnivores investigating latrines. Infrequent detections and low naive occupancy of long-tailed weasels ($n = 3$), coyotes ($n = 3$), and black bears ($n = 1$) limited meaningful comparisons between latrines and non-latrines for these species. We suspect the low number of detections for these carnivores is a indication of their low densities at the Refuge, rather than false absences in riparian areas (note: These species were likewise seldom detected in uplands during Wagnon's (2015) extensive camera-trapping effort [$n = 51$] at the Refuge).

A variety of factors other than scent and visual disturbances could be plausible explanations for higher rates of carnivore detections at latrines in comparison to non-latrines. Indeed, the accumulation of otter detections would inflate carnivore detections and richness at latrines, however, when omitting otter detections from our comparison camera traps at latrines still outperformed non-latrines in detecting carnivores (e.g., total detections: 677 at latrines versus 225 at non-latrines; and richness: $\bar{x} = 4.4 \pm 0.5$ SD at latrines versus $\bar{x} = 3.2 \pm 1.1$ SD at non-latrines). Also, trails created by otters when entering and exiting the water could provide other carnivores easy access points into aquatic systems (e.g., for crossing, foraging, or drinking). Such trails are nonetheless an inherent characteristic of latrines and, thus, do not negate arguments for them serving as areas of enhanced detection rates for carnivores.

Our study area is a relatively small wildlife reserve in a single geographic area. The size of the Refuge created limitations in achieving site independence for individual carnivores and including a greater number of latrines for our comparison. Also, because camera-trap sites were checked only once per month we could not thoroughly compare carnivore visitations in relation to specific times otter excrement was deposited at latrines. Nonetheless, our study provides compelling evidence supporting the premise that carnivores may exhibit high detectability at latrines. Further validation of this premise can be best achieved by selection of latrines separated by greater distances, replication of the study across a variety of aquatic environments and geographic areas, and monitoring of latrines throughout all seasons. Such investigations would provide insight about latrines serving to attract not only the carnivores encountered in our study area, but as an attractant for carnivores in general. Annual monitoring would provide insight for determining if life history characteristics of some or all carnivores contribute to higher detection rates during certain months and would also better enable an assessment to determine if intensity of otter scent marking influences carnivore visitations to latrines (see Stevens and Serfass, 2008; Olson et al., 2008 as examples of monthly variation in frequency and intensity of otter visitation patterns at latrines). Furthermore, an evaluation of carnivore detectability at latrines used by other otter species may provide important insight into the effectiveness of this technique to study carnivores globally.

High carnivore visitation rates to latrines in riparian areas presents practical implications for monitoring this group of animals with camera traps. However, searching for latrines requires considerable initial-time investment, which could negate their value as sites for monitoring carnivores—especially if more traditional camera-trapping techniques involving attractants (i.e., food baits and/or lures) are equally or more effective in detecting carnivores in riparian areas. Such an assessment is needed before concluding that placement of camera traps at latrines as a practical way for studying and collecting data on carnivores. If latrines were proven to be particularly effective as sites for monitoring some or most carnivores in an area, the initial effort for detecting latrines could be offset for long-term monitoring projects because otters often maintain the same latrines over many years and multiple generations (Bowyer et al., 1995; Crait and Ben-David, 2007), which would negate the need for riparian surveys to locate latrines prior to initiating each new monitoring event.

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