Ecological Indicators 66 (2016) 230–234

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Comparing direct and indirect methods to estimate detection rates and site use of a cryptic semi-aquatic carnivore

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ARTICLE INFO

Article history:
Received 4 March 2015
Received in revised form 8 January 2016
Accepted 21 January 2016
Available online 11 February 2016

Keywords:
Camera trap
Detection
Habitat use
Lontra canadensis
Methodology
River otter
Scat

ABSTRACT

Monitoring animal populations can be challenging, particularly when working with species that are cryptic, rare, or occur at low densities. The northern river otter (*Lontra canadensis*) is a cryptic, semi-aquatic carnivore that has been intensively studied in recent decades, yet much of what is known about its ecology is a result of studies that have employed indirect methods of detection and monitoring. These indirect methods, such as latrine or other sign surveys, have been the primary approach used for studying distribution, abundance, and habitat use of otters, with minimal representation of direct methods. In this study, we compared direct (camera traps) and indirect (scat count surveys) methods of evaluating detection probabilities and site use patterns of otters at latrines. We found that the direct method produced a significantly greater monthly detection probability than the indirect method and that camera surveys resulted in fewer occurrences of false negatives than scat surveys. However, the number of scats deposited at a site was positively correlated with number of visits by otters at a site (Tau-b = 0.675). Thus, while cameras outperformed scat counts in terms of detection, the two methods were comparable in determining intensity of site use. We conclude that, depending on the parameter of interest, scat counts may be an acceptable surrogate for more direct methods of monitoring otters and other cryptic species. We caution, however, that in the absence of comparative methodological data, direct methods such as camera trapping should be preferred when making inferences about animal distribution, abundance, or habitat use.

1. Introduction

Monitoring animal populations is a critical, yet challenging component of conservation and management programs. Some species are relatively easy to detect and monitor, however, detecting and monitoring species that are cryptic (e.g., many carnivores) can be challenging. In addition, many species of carnivores occur at relatively low densities/abundance, creating even more difficult circumstances for monitoring activity and demographics (Kelly et al., 2008; Linkie and Ridout, 2011; Vine et al., 2009). In spite of these obstacles, biologists and managers are often tasked with developing reliable techniques that provide meaningful estimates of ecological metrics such as presence/absence, abundance, and habitat use (O'Connell et al., 2006).

Carnivore monitoring has traditionally relied on indirect indices to measure or evaluate presence or activity, with limited use of direct approaches (Conner et al., 1983; Palomares et al., 1998; Travaini et al., 1996). Such is the case for the northern river otter (*Lontra canadensis*, hereafter "otter"), a cryptic, semi-aquatic carnivore found throughout North America. The most common indirect approach used to study otter ecology is to survey for otter sign such as latrine sites or tracks (Crowley et al., 2012; Jeffress et al., 2011; Melquist and Hornocker, 1983). More recently, remote cameras have become a feasible, direct alternative for monitoring river otter activity at dens or latrine sites (Lerone et al., 2015; Leuchtenberger et al., 2014; Olson et al., 2008). However, few studies have used remote cameras and even fewer have conducted both scat and camera surveys (Guter et al., 2008; Lerone et al., 2015; Olson et al., 2008; Stevens and Serfass, 2008). Given the historic prevalence of

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http://dx.doi.org/10.1016/j.ecolind.2016.01.039
1470-160X/

indirect methods used to estimate population metrics and habitat use of otters, there is a lack of comparative information between indirect and direct methods, particularly for the northern river otter.

Where scat surveys and remote cameras have been simultaneously used to monitor northern river and Eurasian otters there are mixed results regarding the accuracy and reliability between these two methods (Guter et al., 2008; Lerone et al., 2015; Olson et al., 2008; Stevens and Serfass, 2008). In three out of four of these studies, investigators reported either poor performance by cameras or frequent malfunctions rendering cameras unreliable; thus, scat surveys provided a more accurate representation of otter site use (Lerone et al., 2015; Olson et al., 2008; Stevens and Serfass, 2008). However, studies that reported deficiencies of remote cameras either used early model cameras, "low-end" cameras (e.g., Cuddeback Attack, Bushnell Trophy Cam HD, Bolymedia Scoutguard SG560D, as defined by Rovero et al., 2013), and/or only a few cameras (Lerone et al., 2015; Olson et al., 2008; Stevens and Serfass, 2008). Recent advances in camera technology have minimized failures that plagued earlier models and improved overall reliability (O'Connell et al., 2011). Furthermore, there is evidence that high-end cameras outperform low-end cameras by capturing more species more often (Hughson et al., 2010; Kelly and Holub, 2008). Because of low sample size, use of low-end cameras, and recent technological advances, past investigations may not be representative of the current reliability of remote cameras. In the absence of comparative studies between scat surveys and modern, high-end cameras, it is difficult to conclude that one method is more or less accurate or reliable than the other.

Our objective was to compare the relative performance of direct (remote cameras) and indirect (scat surveys) methods for monitoring otters at latrines. Specifically, we determined how well these methods performed in terms of estimating detection rates and measuring otter site use. We hypothesized that modern, high-end cameras would provide a more reliable estimate of both detection and site use of otters than scat surveys. We therefore predicted that the direct method would result in fewer false negatives than the indirect method, and that correlation between methods would be weak. If, however, detection rates and measures of site use were highly correlated between the two methods, then scat surveys should be considered an equally reliable method for the estimation of otter detection and site use.

2. Methods

Our study area comprised 64 km of the Provo River and its tributaries along the Wasatch Range of the Rocky Mountains in north-central Utah. This area, known as Heber Valley (40°30′26″ N, 111°26′59″ W), has an annual average temperature of 8.1 °C with a summer average of 19.2 °C and a winter average of −3.3 °C. Annual precipitation averages 41.2 cm and consists mostly of snowfall from late fall through early spring (National Oceanic and Atmospheric Administration, 2000). The study area contained 2 large reservoirs and the river itself winds through multiple towns and agricultural areas (for more details on the study area see Day et al., 2015) near Heber City, Utah.

2.1. Latrine surveys

We initially surveyed for river otter latrines by walking the length of riverbanks in our study area on two separate occasions. Once located, we identified otter scat from that of other species by its size, shape, odor, contents, and the presence of mucous (Greer, 1955). When we discovered a latrine site, we counted the number of fresh (i.e., wet, soft, pungent) otter scats. After counting scats, we recorded a GPS location and removed all scat from the site, so as not to recount old scats during future visits.

After the initial riverbank surveys, we continued to search for latrine sites from February 2010 through February 2012 by radiotelemetry of 23 translocated otters (Day et al., 2013). After we found a latrine, we removed all scat and monitored the site on a monthly basis for the next three months. If we did not find scat during subsequent visits within this three-month period, we discontinued monitoring the site. If we did find scat during the initial three months we continued to monitor the latrine site monthly for the duration of the study, regardless of how much time passed between uses.

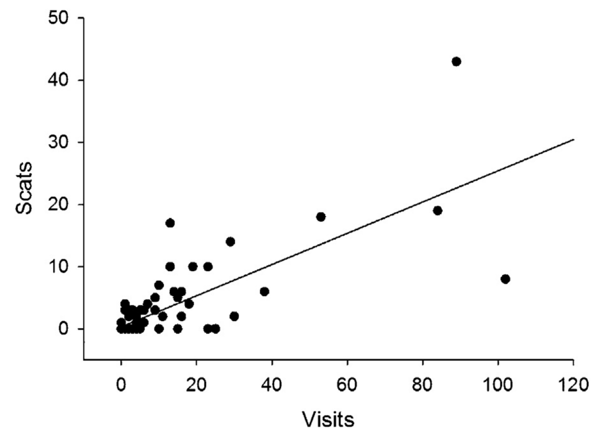

Fig. 1. Number of scats collected and visits recorded by remote cameras (Tau-*b* correlation = 0.675, $p < 0.001$) of northern river otters (*Lontra canadensis*) monthly at Provo River, Utah, 2011–12.

2.2. Remote camera sampling

After one year of monitoring latrines, we randomly selected 10 sites for sampling with remote cameras in addition to continued monitoring of scat deposition (Fig. 1). We monitored these 10 latrines for one year, from March 2011 through February 2012, for a total of 3310 trap nights. For a latrine to be eligible for camera placement, the only requirement was that we collected scat in more than one month. Monitored latrines were an average of 3379 m (±SD 3875 m) apart, and total distance between the furthest two latrine sites was 34.01 km. Following the categorization of cameras as proposed by Rovero et al. (2013), we used "high-end" infrared (no-flash) cameras (Reconyx PC900, Reconyx Inc., Holmen, WI). We placed cameras approximately 3 m from the edge of latrine sites at 0.5–1 m above the ground. We programmed cameras to the 'high' sensitivity level, and to record two images per capture event (spaced 1 s apart) with a quiet period of 15 s between events. We visited cameras once per month to count scats and to perform camera maintenance.

We examined each image and recorded all identifiable species present, but did not attempt to distinguish between individuals of any given species. We separated images of otters from images of all other species and extracted date and time stamps associated with each image. Using the date and time stamps, we then sorted otter images into visits. We defined two separate "visits" as two consecutive images of otters separated by at least 30 min of otter inactivity. We used 30 min to make our results comparable to other studies that used the same time interval to separate visits (e.g., Hall et al., 2013; Michalski and Peres, 2007; Stevens and Serfass, 2008). Because 30 min was an arbitrary choice, however, we also analyzed our data using 1 h intervals to define visits to see if this choice affected results. With visits delineated, we recorded the maximum number of otters observed in a single picture during a given visit to produce a total count of otter visits. Accounting for multiple otters during a visit in this fashion would likely correlate with scat counts better than viewing all visits as equal and regardless of the number of individuals present.

2.3. Data analysis

To compare detection rates between the two methods, we created monthly encounter histories for scat counts and camera images. Each encounter occasion encompassed roughly one month, resulting in 12 monthly encounters for each of the 10 sites ($n = 120$). Photo sampling periods for each month corresponded with the dates of scat collection, so that effort was constant across the two methods (with effort here defined as the number of days between collections of both scat and images). We defined an otter detection as encountering ≥1 scat or ≥1 image within the encounter period. Assuming all sites to be occupied during the study (as confirmed via radio-telemetry), we then calculated detection rates by dividing the number of detections by the number of monthly encounter occasions (120). We used the z-test for proportions to compare detection rates between camera images and scat counts. We also totaled the number of detection discrepancies, i.e., false negatives, where we detected an otter visit with one method and not the other. We then used a chi-square analysis to determine if these discrepancies occurred more often using one method than the other.

To evaluate how indirect and direct measures of otter site use (i.e., visitation) at latrines relate to each other we used correlation analyses. Since our data were not normally distributed and contained many zero ties, we used Kendall's Tau-b correlation; a non-parametric statistical approach that accounts for ties occurring due to zero-visit data among both methods (Kendall, 1962). We correlated otter visits and scat counts to determine the strength of the relationship of the two measures. We used Program R to conduct statistical analyses (R Development Core Team, 2011) and set $\alpha = 0.05$ for all comparisons.

3. Results

We recorded a total of 3956 images of otters from remote cameras during March 2011 through February 2012. From these images, we recorded 758 visits of otters (mean = 6.32 visits/site/month, SE ±1.51, range = 0–102). Our remote cameras operated throughout the sampling period without any apparent malfunctions. During the same sampling period, we collected 228 scats from the 10 monitored latrine sites (mean = 1.86 scats/site/month, SE ±0.49, range = 0–43).

We identified both differences and similarities between remote cameras and scat counts in terms of monitoring otters at latrine sites. The number of monthly otter visits (measure of site use) recorded by remote cameras was correlated with monthly counts of otter scat (Tau-$b = 0.675$, $p < 0.001$; Fig. 1). When we used 1 h intervals between photos to define visits (as opposed to 30 min), the correlation was reduced but still positive and significant (Tau-$b = 0.555$, $p < 0.001$). However, the overall monthly detection rate for remote cameras (0.43) was 1.50 times greater than that of scat counts (0.28; $z = -2.43$, $p = 0.015$; Fig. 2). Of 120 site-months sampled, we recorded 20 site-months where we detected otters with cameras, but not scat (range: 1–149 images of otters). However, we only recorded two site-months where we collected scat (only 1 scat in each instance) but no images of otters. There was a significant difference between the number of discrepancies (false negatives) for each method ($\chi^2 = 14.727$, $p < 0.001$).

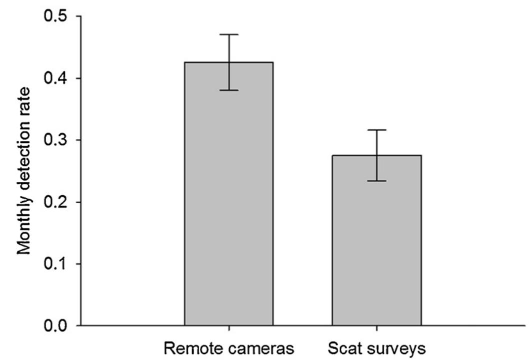

Fig. 2. Monthly detection rates of northern river otters (*Lontra canadensis*) by remote cameras and scat surveys at Provo River, Utah, 2011–12.

4. Discussion

The indirect approach to monitor monthly site use (scat surveys) was correlated (Tau-$b = 0.675$) with monthly number of direct observations of visits of otters recorded by cameras. While not an overwhelming correlation, this result does show that an increase in scat deposition (and the subsequent counting of scat) indicates an increase in otter visitation as recorded by remote cameras. Our results therefore support the idea that scat counts may, in certain instances, be used in place of direct methods to obtain metrics of animal activity (e.g., visitation rates or habitat selection). In most instances during our study where false absences occurred, the number of otter visits captured by cameras was low (≤5 for 17 out of 20). This means that rare or elusive species may be more susceptible to false negatives from scat counts than the northern river otter, a social species (Gorman et al., 2006) that commonly produces large and conspicuous latrines. Likewise, scat counts are more likely to provide accurate data for populations at high densities. For the two largest discrepancies between photos and scat counts, a heavy snowfall was likely responsible for burying any scats that were deposited that month. Thus, while inclement weather was a rare problem in our relatively dry climate, it does have the ability to reduce the effective sampling period and thus the reliability of scat counts as a method for monitoring or detecting otters. When designing similar studies, the interval between collections should be chosen carefully with considerations for local climate.

While our study is the first to perform this analysis for the northern river otter, our results do agree with a similar study conducted on the Eurasian otter. Guter et al. (2008) examined daily (as opposed to monthly) visitation rates, and found a weaker but still positive relationship ($R^2 = 0.14$) between number of scats deposited and number of otters that visited during a given night. Our higher correlation value indicates that indirect methods may perform better with longer intervals between sampling periods.

Camera surveys performed better at detecting otters than scat surveys at latrines. Monthly detection rates were significantly greater using cameras as opposed to scat surveys, and cameras also resulted in significantly fewer false negatives (2 as opposed to 20 false negatives from scat surveys), where otters were detected by one method and not the other. These results confirm our initial hypothesis that, given properly functioning high-end cameras, the direct method of surveying would be more reliable than the indirect method. This result is again supported by Guter et al. (2008), in which the authors examined daily detection rates and found that otters were regularly recorded by cameras on nights when no scat was present.

Direct approaches to monitoring species have often provided more accurate sampling information across taxa than indirect approaches (e.g., Cromsigt et al., 2009; Dufrene and Breda, 1995). For otters, direct and indirect methods of monitoring activity have resulted in different conclusions about otter activity patterns (Martin et al., 2010). Other studies have demonstrated that camera trapping (direct method) can be useful for obtaining data for metrics such as presence and richness of otters and other carnivore species (Wilting et al., 2010), or for obtaining information on sex, age, and individual identification (Pickles et al., 2011). Others, however, have not experienced similar success in using camera traps to reliably detect otters. For example, camera traps alone have essentially failed to record the presence of Eurasian otters entirely, possibly due to the decreased temperature of the body surface of otters that have recently emerged from the water (Lerone et al., 2015). It also may be difficult to achieve high-quality results in tropical areas, where humidity and flooding can interfere with camera functionality. Others problems have included a lack of reliability in camera surveys due to equipment malfunction (Olson et al., 2008; Stevens and Serfass, 2008). We did not experience any equipment malfunctions during our monitoring period, and suggest that advances in remote camera technology and the use of high-end cameras have made these surveys extremely reliable in detecting semi-aquatic mammals, regardless of their physical state.

Despite a lack of empirical evidence that latrine and scat surveys may be indicative of habitat use for the northern river otter (for *Lutra lutra* see Kruuk et al., 1986; Mason and Macdonald, 1987; Kruuk and Conroy, 1987), these methods have been used widely to determine and make predictions about otter latrine/habitat use. For example, some studies have identified habitat features associated with latrine occurrence, independent of intensity of use (Dubuc et al., 1990; Shardlow, 2005). Others have used scat counts or revisitation rates to determine habitat selection (Anderson and Woolf, 1984; Crowley et al., 2012; LeBlanc et al., 2007; Newman and Griffin, 1994; Trusso, 1997), or developed models to predict latrine locations based on associated habitat features (Depue and Ben-David, 2010; Swimley et al., 1998; Trusso, 1997). While latrine site selection is an important component of otter ecology, the habitat features selected by otters for latrines do not necessarily translate to habitat features essential for otter fitness (Van Horne, 1983). Therefore, questions about the use of scat surveys to indicate habitat use remain. Our results contribute to addressing such questions and clarifying previous results by demonstrating that scat counts are indicative of use, though not reliable for detection at latrine sites.

In studies where an indirect method and remote camera have been used simultaneously, there have been a variety of outcomes, largely dependent upon the target species, quality of camera, and the indirect method employed. Studies involving remote cameras have historically disagreed about the reliability of using this method to study wildlife ecology relative to alternative methods (e.g., Barea-Azcon et al., 2007; Gompper et al., 2006; Monterroso et al., 2014). This discrepancy may reflect the technological improvement of cameras over time and the differential use of low- versus high-end models. Earlier studies employing cameras commonly faced challenges ranging from latent responses of cameras to malfunctions resulting in the inability to record data (Cutler and Swann, 1999; Gompper et al., 2006; Hackett et al., 2007; Hernandez et al., 1997). Recent studies have found cameras to be better than indirect approaches in detecting target species as well as other species in general, resulting in greater measures of richness and diversity (Li et al., 2012; Monterroso et al., 2014; Paull et al., 2012; Vine et al., 2009). The results from our study corroborate other recent camera studies and indicate that modern, high-end cameras (direct method) may provide more accurate and reliable indices of animal presence and site use than do indirect methods.

Acknowledgments

We thank the Utah Division of Wildlife Resources, Utah Wildlife in Need, and Idaho Fish and Game for providing funding and support for this project. We thank three anonymous reviewers whose contributions greatly improved the quality of the manuscript. We also thank many technicians and volunteers who analyzed camera pictures and counted and collected otter scat.

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