Effectiveness of non-invasive techniques for surveying activity and habitat use of the Indian fox Vulpes bengalensis in southern India

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Source: Wildlife Biology, 13(2) : 219-224

Published By: Nordic Board for Wildlife Research

URL: https://doi.org/10.2981/0909-6396(2007)13[219:EONTFS]2.0.CO;2

SHORT COMMUNICATION

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Effectiveness of non-invasive techniques for surveying activity and habitat use of the Indian fox *Vulpes bengalensis* in southern India

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Vanak, A.T. & Gompper M.E. 2007: Effectiveness of non-invasive techniques for surveying activity and habitat use of the Indian fox *Vulpes bengalensis* in southern India. - Wildl. Biol. 13: 219-224.

Non-invasive techniques for monitoring wildlife are increasingly used by researchers to identify the presence of carnivores in particular habitat types. For mid-sized carnivores the two primary methods used are camera trapping and track plates, both of which function by attracting an animal to a census apparatus which then records the visit by photograph or by track imprint. These techniques have rarely, however, been used to survey Asian mid-sized carnivores, and thus the value of the techniques in this region remains hypothetical. We used cameras and track plates to survey Indian foxes *Vulpes bengalensis* in and around Rollapadu Wildlife Sanctuary in the arid grasslands of central Andhra Pradesh and in Ranebennur Wildlife Sanctuary in western Karnataka. By surveying, we also address issues relating to fox activity and habitat use patterns. Cameras rapidly and efficiently detected the presence of foxes, and allowed us to show that foxes at both sites were strictly nocturnal during the periods of data collection. There was a significant relationship between grassland height and the latency to detection of foxes at Rollapadu. At both sites, foxes rarely visited the track plate stations that were run concurrently with cameras. We recommend that researchers attempting to survey foxes use cameras rather than enclosed track plates, and that efforts to survey other species non-invasively include an experimental design that allows for validation of the survey technique.

Key words: activity, habitat, Indian fox, non-invasive techniques, Vulpes bengalensis

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Received 22 August 2005, accepted 18 January 2006

Associate Editor: Asir J.T. Johnsingh

Identifying the presence of a carnivore species is usually the first step towards understanding its distribution, habitat needs and demography. However, most carnivore species are notoriously difficult to survey because of their relatively low population densities and elusive nature. Fortunately, non-invasive methodologies for furthering our knowledge of carnivores are increasingly available. For instance, a suite of non-invasive techniques, including camera-trap photography, track plate techniques and scent station survey techniques, have been used and found to be effective in assessing the presence/absence, and in some cases the relative abundance, of mesocarnivores in North America, Australia and Europe (Zielinski & Kucera 1995, Zielinkski & Stauffer 1996, Gese 2001, Wilson & Delahay 2001, Richardson 2002, Campbell 2004). In more biodiverse regions of the world, however, these techniques have not been widely applied. While camera-trapping is a technique of choice for surveying species with coat patterns that are individually recognizable, such as large felids (Karanth & Nichols 1998, Maffei et al. 2004), the Indian subcontinent also contains a broad array of small and mid-sized carnivores, most of which have never been robustly studied. Because invasive (i.e. live-capture) techniques are difficult to use in India due to local norms and regulations, a non-invasive approach seems particularly appealing. Such an approach, however, requires evidence that the technique of choice is appropriate for the species of interest.

The Indian fox *Vulpes bengalensis* has a broad geographic range, which includes much of India and Pakistan (Gompper & Vanak 2006), but the distribution of the species within this range is patchy, and even where present the species typically occurs at low densities (Johnsingh & Jhala 2004, A.T. Vanak, unpubl. data, Vanak 2005). This low density, like with many carnivores, increases the difficulty of surveying the species using traditional methods of capture or direct observation. Camera and track plate based approaches are therefore appealing, but because the species has never previously been surveyed using such an approach, it is unclear if these techniques are sufficiently powerful to detect the species where present. For fox species inhabiting other regions of the globe, there is apparent disparity in the relative value of cameras and track plates for detecting presence (Gompper et al. 2006). In particular, for some fox species track plates are often avoided by foxes when the plate is partially enclosed by boxes that are used to protect the detection apparatus from the weather. If, however, track plates are not avoided, such a detection apparatus may be particularly powerful relative to cameras because of the low expense of the apparatus, and because recent innovations may allow for the separation of individuals based on microscopic analyses of footprints (Herzog et al. 2007). In contrast, identification of individuals from species with relatively invariable coat patterns such as foxes is rarely possible when camera trapping is used.

To assess whether cameras and track plates are appropriate techniques for identifying the presence of Indian foxes, we surveyed for foxes at multiple sites within two wildlife sanctuaries in south-central India where foxes were known to be present based on prior surveys (Manakadan & Rahmani 2000, A.T. Vanak, unpubl. data, Vanak 2005). We also used the collected data to assess the activity patterns and habitat use of this relatively unstudied species. Up till now, no telemetry-based study of Indian foxes has been carried out. Several studies, however, have given baseline insights into Indian fox ecology. Johnsingh (1978), for instance, noted that foxes are primarily nocturnal or crepuscular, although little quantitative data are available to address Indian fox activity patterns in detail. We therefore used our data to further test this observation, specifically by assessing the hypothesis that Indian foxes will visit survey apparatus at night. We also examined the microhabitat of sites where Indian foxes were identified. Manakadan & Rahmani (2000) found that Indian foxes are more likely to be found in open grassland than in more shrubby areas. To extend this, we tested the hypothesis that Indian foxes will be more rapidly detected at sites that are more open (i.e. lacking shrubs, having shorter grass height and therefore greater visibility).

Material and methods

We surveyed the Rollapadu Wildlife Sanctuary (WLS), Andhra Pradesh, and Ranebennur WLS, Karnataka, over a period of 21 and 13 days, respectively, in June-July 2004. Rollapadu WLS is a semi-arid, short-grassland protected area covering 6.14 km^2 within a mosaic of crop lands and grazing lands. The communal and private grazing lands also sometimes maintain fox populations that are contiguous with those in the wildlife sanctuary (Manakadan & Rahmani 2000, A.T. Vanak, unpubl. data). Ranebennur WLS is 119 km^2, consisting primarily of exotic eucalyptus hybrid plantations with patches of managed grassland and short, dense scrub forest (Karanth &

Singh 1981). The survey was carried out in an area of approximately 8 km^2 within the Hulatti range of the Ranebennur WLS. This is the most intensively patrolled area of the wildlife sanctuary and has a mix of mature eucalyptus plantation, open grassland and scrub forest (A.T. Vanak, unpubl. data).

Maps of study areas were overlaid with a 1-km^2 grid, and four grid cells were randomly selected at each site. An 800-m transect consisting of five track stations spaced 200 m apart along the transect line was located inside each grid cell. Each track station consisted of a black rectangular plastic box that enclosed an aluminium track plate (Fowler & Golightly 1994, Gompper et al. 2006). The distal half of the track plate was covered adhesive side up with a white CON-TACT™ sheet, and the proximal half was dusted with a fine coating of photocopier toner powder (Belant 2003). Bait and/or lure were placed at the distal end of the aluminium plate just beyond the contact paper. An animal attracted by the bait entered the box and transferred the toner powder adhering to its foot to the contact sheet, thereby providing a positive track impression. Ten dual-sensor passive infra-red camera traps (Camtrakker™ and Deercam™) were simultaneously deployed within each survey area to complement the track stations. The cameras were set so as to record the date and time when triggered.

Commercially available carnivore lure (Kishel's Canine Supreme) and boiled chicken eggs were used as bait to attract animals within range of the cameras and track stations. Track stations and camera traps were checked daily and were rebaited and reset as necessary. Individual or multiple occurrences of a species in either the camera traps or the track stations per capture night were considered as a single capture event of that species. Based on this information, for each technique we calculated a daily capture rate and latency to detection (LTD) for initially discerning the presence of a species at the two sites and at specific survey localities within each site.

Based on the date and time imprint from the camera traps, we categorised each Indian fox photo capture in one-hour intervals to generate a daily activity pattern. We further examined how LTD for the first photo per site correlated with several habitat variables measured at the site. We used line intersect sampling, based on Ringvall & Stahl (1999), consisting of four 25-m transects to quantify vertical density, grass height, canopy cover, ground cover and tree and shrub density. The camera trap or track plate stations were used as the centre of the grid. We measured vegetation at nine plots at a distance of 12.5 m along each line transect. At each plot, vertical density was quantified using a Robel pole (Robel et al. 1970) by taking visual obstruction readings at 1 m in each cardinal direction. Other measures included canopy cover using a spherical densiometer (Daubenmire 1959) and maximum vegetation height. Ground cover was estimated by eye and included predominant types such as bare soil, rocks, grass, herbs and leaf litter (Best et al. 1997). Human-use indices included 1) distance to nearest road, 2) frequency of road use (i.e. hourly, daily, weekly) and 3) whether signs of grazing and woodcutting were present at the site. We ran a Spearman's rank correlation of LTD vs habitat variables to detect patterns of microhabitat use.

Results

We operated camera traps at 12 localities in Rollapadu WLS for a total of 102 camera trap nights (mean number of trap nights/camera = 8.5 ± 1.8 SE) and at 13 localities in Ranebennur WLS for a total of 104 camera trap nights (8 ± 0.99 SE). The cameras recorded presence of Indian fox, golden jackal *Canis aureus*, jungle cat *Felis chaus* and domestic dog *Canis familiaris* at both sites as well as grey wolf *Canis lupus* and monitor lizard *Varanus bengalensis* at Rollapadu (Table 1). In Rollapadu, we obtained 51 capture

Table 1. Photographic and track plate detection rates quantified as records per survey night for species in Rollapadu and Ranebennur Wildlife Sanctuaries. Total number of capture events per species is given in parentheses and ND indicates that the species was present but not detected.

	Rollapadu WLS		Ranebennur WLS	
Species	Camera traps	Track plates	Camera traps	Track plates
Indian fox	0.5 (51)	0.0	0.11 (11)	0.009 (1)
Grey wolf	0.02 (2)	0.0	ND	ND
Golden jackal	0.04 (4)	0.0	0.02 (2)	0.0
Jungle cat	0.04 (4)	0.008 (2)	0.01 (1)	0.0
Domestic dog	0.03 (3)	0.016 (4)	0.04 (4)	0.009 (1)
Grey mongoose	ND	ND	0.0	0.017 (2)
Monitor lizard	0.02 (2)	0.025 (6)	ND	ND

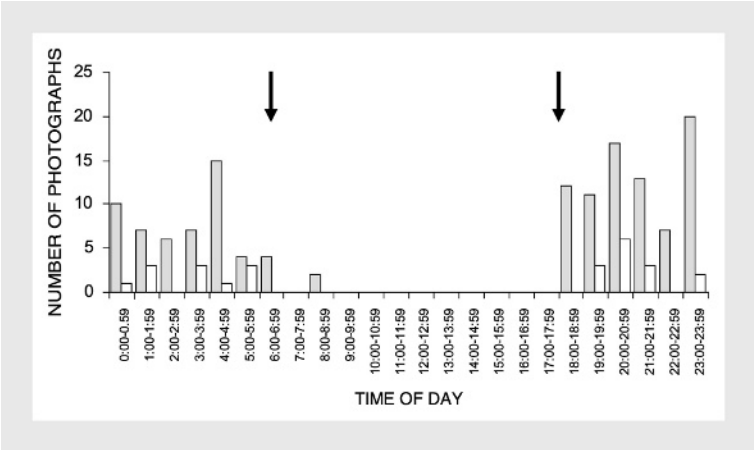

Figure 1. Activity patterns of Indian foxes at Rollapadu Wildlife Sanctuary (■) and Ranebennur Wildlife Sanctuary (□) during June-July 2004, as identified by visitations at camera stations. The arrows indicate sunrise (06:45-06:55) and sunset (18:20-18:23) during the data collection period.

events of the Indian fox at 83% (N = 10 of 12) of the camera trap sites, while in Ranebennur we obtained 11 capture events at 38% (N = 5 of 13) of camera trap sites. Latency to detection for the Indian fox in Rollapadu was 2.7 days ± 0.83 SE (N = 10), while in Ranebennur it was 4.2 days ± 2.03 SE (N = 5).

Track stations were run for 245 track station nights at Rollapadu WLS and 115 nights at Ranebennur WLS. The number of track station nights at Ranebennur was lower due to theft of track stations at this site. Despite the relatively short latency to detection of foxes based on camera trapping, track plates were inefficient at detecting the presence of foxes at both sites. We recorded the presence of domestic dog, monitor lizard and a small felid (probably jungle cat) in Rollapadu, but did not detect foxes using track stations (see Table 1). At Ranebennur, we detected Indian fox on one occasion (LTD = 7 days) as well as grey mongoose *Herpestes edwardsii* and domestic dog (see Table 1).

Based on visitation times recorded at camera stations at both sites, Indian foxes were entirely nocturnal (Fig. 1). With one exception, all visitations (N = 160) to camera stations occurred after sunset. The distributions of activity at the two sites differed subtly, but significantly (paired t = 4.18, df = 23, P = 0.0004); foxes in Rollapadu were more active early in the evening (during 18:30-24:00 hours) than later in the evening, a pattern not apparent from the Ranebennur data. However, given that identification of activity patterns was a secondary focus of the study, and that samples sizes from Ranebennur were small, this observation should be considered preliminary.

Because of the low number of sites where foxes were detected in Ranebennur, we used only the Rollapadu data to assess microhabitat preferences. We found a significant relationship between grass height and LTD (Spearman's Correlation coefficient = 0.66, P = 0.037), indicating that foxes were detected at sites with lower grass height sooner than in taller grass areas. There was no significant relationship (P > 0.05) detected between LTD and canopy cover, tree density, vertical cover, ground cover or any of the human-use indices.

Discussion

Camera traps performed better than track plate stations in recording presence of Indian fox as well as several other carnivores in the surveyed areas. At survey units where foxes were detected by use of cameras, the lag to detection was relatively short at both sites (2.7-4.2 days). In contrast, track stations performed poorly in detecting the presence of Indian foxes (see Table 1). While track plates have been widely used as a low-cost yet effective means of surveying large areas for a variety of small and mid-sized carnivores in forested regions of North America (Zielenski & Kucera 1995, Zielenski & Stauffer 1996, Richardson 2002, Campbell 2004, Gompper et al. 2006), the technique is apparently of limited value in detecting Indian foxes. It is possible that track stations did not detect the target species because of wariness of entering an anthropogenically modified enclosed space (the box surrounding the track plate). Indeed, we find it likely that track plates may have had increased detection success were it not enclosed in a box. Such a design, however, would require a far larger track plate to avoid removal of bait without leaving a print and would be of limited value in the monsoon season.

In our survey, camera traps detected more species than track stations (e.g. wolves and jackals), although the size of the track stations limited larger carnivores from being detected. The Indian fox was by far the most commonly captured carnivore in the camera traps at both sites (N = 62 events). Excluding the larger canids, only one mammalian species was detected by track stations and not by camera traps (grey mongoose). Monitor lizards (N = 6) were most commonly recorded at track stations, but on a per survey-night basis, detection rates of cameras and track plates were similar for this species (see Table 1). This contrast between the apparent value of track plates for monitor lizard detection and the value of cameras for mammals may be due in part to heterothermic body temperature of these large reptiles; at decreased body temperatures the lizards may not trigger the camera sensor.

The ecology of the Indian fox remains poorly understood, but the data collected at two sites for this study support the observations made by Johnsingh (1978) in southern Tamil Nadu, i.e. that the Indian fox is largely nocturnal. Our data also further support the hypothesis that Indian foxes occur at higher densities in more open areas. Manakadan & Rahmani (2000) examined Indian fox habitat use in Rollapadu WLS and observed that dens were more likely to be dug in open habitats rather than in dense vegetation, which could potentially provide cover for predators (Manakadan & Rahmani 2000). If LTD correlates coarsely with population density of foxes (i.e. a higher population density of foxes should result in a shorter LTD), then the initial observations made here of shorter LTD with lower grass height suggest greater fox numbers in areas with short grassland, which may also relate to reducing susceptibility to potential predators.

The use of track plate stations is considered a powerful survey technique for studies of carnivores given the low cost of equipment, ease of use and portability. However, the logistical demands in terms of manpower and time are usually similar to that required for camera traps, and as seen in this study and others (Van Schaik & Griffiths 1996, Bridges et al. 2004), the latter can potentially collect more detailed capture information such as that required to assess activity patterns, and either technique can be incorporated into a study of habitat use or landscape ecology (e.g. Van Schaik & Griffiths 1996, Dijak & Thompson 2000, Richardson 2002, Campbell 2004). Therefore, even though camera traps require a greater initial investment and also have higher running costs (film and processing), they seem to be a more reliable means of detecting carnivore species in the Indian grasslands.

Acknowledgements - we acknowledge the Andhra Pradesh and Karnataka State forest departments for permits and logistical help at the field sites. We thank Dr. K. Ullas Karanth, WCS-India Program and Samba Kumar of the Centre for Wildlife Studies, Bangalore, for technical and logistic support, and Mr. Aditya Bhaskaran for field assistance.

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