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Summary and highlights of small carnivore photo-captures during a field season in the central Western Ghats, India

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Abstract

Camera-traps are very efficient at detecting certain types of cryptic species such as small carnivores and, because many small carnivore species remain poorly understood, such records can substantially advance our understanding of these species's conservation status, distribution, habitat relationships, diel activity patterns and other aspects of their biology and ecology. However, camera-trap surveys are expensive (in terms of equipment, effort, human power and cost) to conduct at large spatial scales. It is often possible to collate such records from large-scale surveys targeted at other taxa that are more likely to receive funding for conservation monitoring. This paper presents a summary and some notable records from camera-trap surveys, primarily targeted at monitoring of Tiger *Panthera tigris* and Leopard *P. pardus* populations, in the Malenad landscape of Karnataka and adjacent areas of Goa and Kerala, part of the Western Ghats biodiversity hotspot in India. Investing a total trap effort of 20,245 trap-days across 566 camera trap locations during the 2013-14 field season, we obtained 4452 images of small carnivores from 3204 distinct detection events of 11 species. Significant photo-captures include Brown Palm Civet *Paradoxurus jerdoni* in Nagarahole, Bandipur and Biligiri Rangaswamy Temple Tiger Reserves, Leopard Cat *Prionailurus bengalensis* in Bandipur, and Brown Mongoose *Herpestes fuscus* and Nilgiri Marten *Martes gwatkinsii* in Talakaveri Wildlife Sanctuary.

Keywords: By-catch records, data processing, endemics, landscape-scale surveys, species occurrence

Introduction

Over the last few decades, camera-trap surveys have revolutionised field studies in wildlife biology, from generating species inventories and occurrence records to long-term studies investigating population dynamics (Karanth et al. 2006, O'Connell et al. 2011). Particularly for some cryptic and poorly understood taxa such as small carnivores, camera-trap surveys are extensively used to generate reliable and verifiable records of species occurrence, as is evident from even a cursory look at recent issues of *Small Carnivore Conservation*. These records may be used to simply update the known distributional limits of species, to assess species–habitat relationships (in which case the modelling framework used must reasonably reflect the underlying processes that generated the data), to investigate species's diel activity patterns and other aspects of their behaviour, and to examine phenotypic variation in populations. Camera-traps are typically much more efficient at detecting

cryptic/nocturnal species than are direct observations (Mathai et al. 2013), and are also more reliable (and independently verifiable) than detections based on indirect signs such as scats and tracks. Camera-trap surveys, however, tend to be expensive (in terms of equipment, effort, human power and cost) to conduct at spatial scales sufficiently large to assess species's distributions reliably. There exists vast potential to mine data sets from surveys targeted at charismatic species (such as large cats [Felidae], which receive much greater conservation and research funding) for 'by-catch' data on other taxa, including small carnivores. This paper presents a summary and some notable records from camera-trap surveys conducted in the Malenad landscape of Karnataka, India, from November 2013 to June 2014.

Methods

The camera-trap surveys were conducted by the Centre for Wildlife Studies, under a long-term Tiger population monitoring programme across eight protected areas (PAs) within the circa 38,000 km^2 Malenad landscape (Karanth et al. 2011) forming the bulk of the central Western Ghats: Mhadei Wildlife Sanctuary (WLS; Goa), Kali (previously known as Dandeli–Anshi) Tiger Reserve (TR), Bhadra TR, Talakaveri WLS, Nagarahole TR, Bandipur TR, Biligiri Rangaswamy Temple (BRT) TR (all in Karnataka) and Wayanad WLS-North (Kerala). Table 1 contains details of the dominant vegetation types in each PA. Data from Nagarahole and Wayanad-North (Tholpetty Range) were processed together as these are contiguous. While surveys in Nagarahole, Bandipur, BRT and Bhadra covered the entire reserves and areas outside (Nagarahole, Bhadra), only small parts of Mhadei, Kali and Talakaveri were covered.

Table 1. Details of dominant vegetation types, number of camera-trap locations, durations of sampling and trap effort, by protected area.

Protected area	Dominant vegetation types[a]	No. camera-trap locations	Duration of sampling (days)	Trap effort (trap-days)
Bhadra	DDF, MDF, SEG, *shola*, teak	122	59	6928
Bandipur	DDF, SAV, teak	134	31	4154
BRT	SCR, DDF, MDF, *shola*	103	34	3493
Kali	DDF, MDF, SEG, EVG	17	10	151
Mhadei	MDF, SEG	12	14	122
Nagarahole	DDF, MDF, teak	141	31	4361
Talakaveri	EVG, SEG, *shola*	11	54	269
Wayanad	DDF, MDF, SEG, teak	26	31	767
Totals		566		20,245

[a]DDF: tropical dry deciduous forest; MDF: tropical moist deciduous forest; SEG: tropical semi-evergreen; EVG: tropical wet evergreen; *shola*: mosaic of montane grasslands on slopes and stunted evergreen *shola* forests in mountain folds; teak: teak *Tectona grandis* plantation; SCR: thorn scrub and dry evergreen; SAV: savanna woodland.

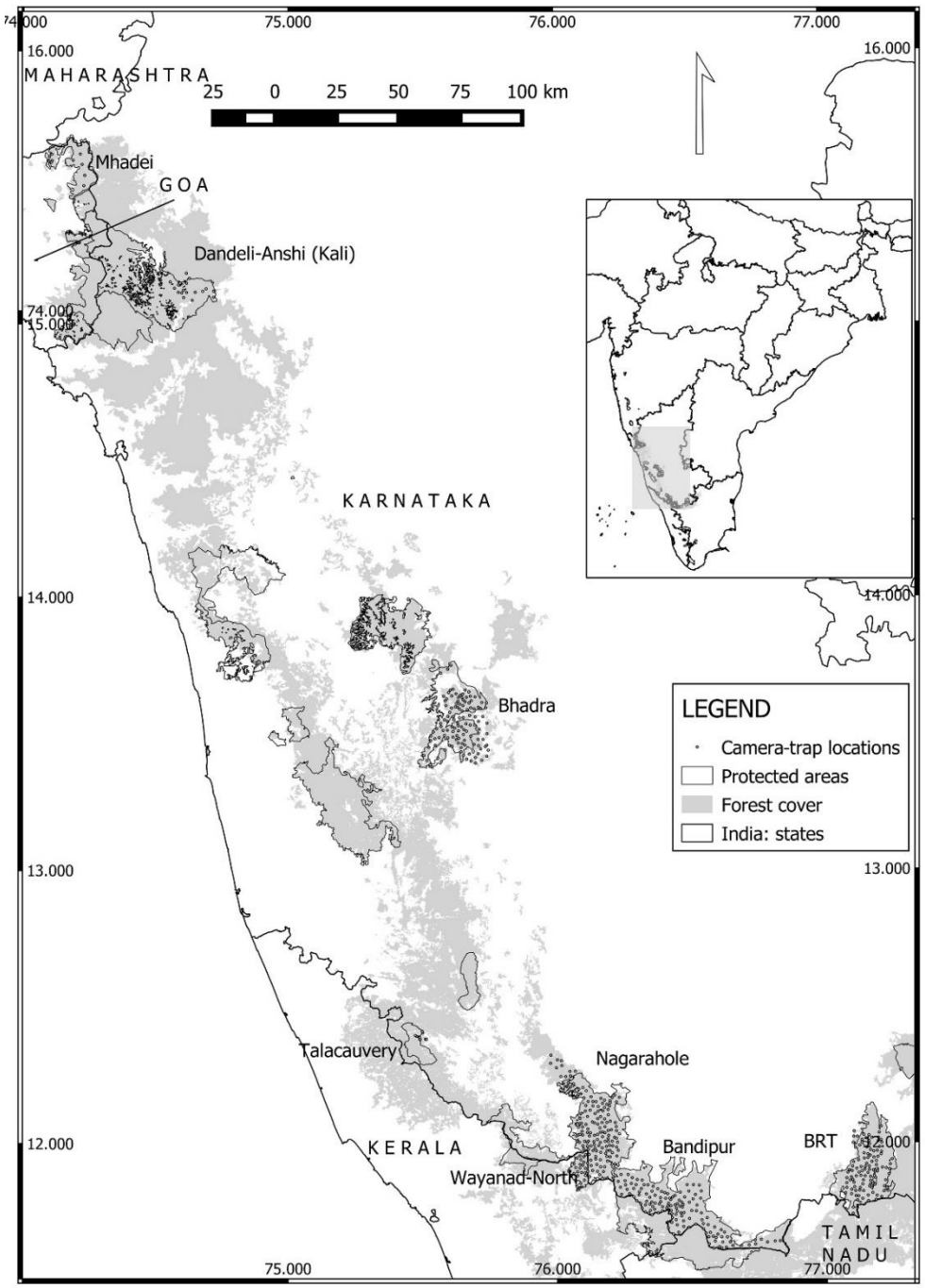

Fig. 1. Map of the study landscape, showing camera-trap locations, protected areas surveyed and forest cover. The inset map shows the location of the study landscape on the Indian peninsula.

Figure 1 shows camera-trap locations across these eight PAs. The surveys were carried out between the first weeks of November 2013 and June 2014 across all sites, with a maximum duration of 59 days at any given site. Details of the number of locations, duration of sampling and total camera-trap survey effort in each site are presented in Table 1. The locations of camera-traps in these PAs optimised capture probabilities of large cats, and

were spaced 2-3 km apart to ensure at least two to three camera-trap locations within individual Tiger home ranges, while also exposing the entire local population (or the entire protected area) to the sampling to the extent possible (Karanth et al. 2002, 2017). Camera-trap locations were mainly along forest roads and trails and were selected based on preliminary reconnaissance surveys to identify areas frequently used by Tigers. At each location, a pair of camera traps (mainly Panthercams; Olliff et al. 2014) was set up on either side of the road/trail (to obtain images of both flanks simultaneously, for the purpose of identifying individual Tigers), approximately 3.5 m from the centre of the road/trail (Karanth et al. 2002, 2017). In Talakaveri WLS, camera-trap surveys were carried out along with pre-baiting prior to live capture and radio-collaring of small carnivores (Jathanna 2016, Jathanna et al. in prep.). Here, traps were located away from roads and trails (to minimise the risk of theft), and a single camera-trap was placed facing a box-trap baited with chicken entrails (without a trap door during pre-baiting) at each location.

The photo-captures of small carnivores and small felids were separated from the larger camera-trap image data (more than 700,000 images; K. U. Karanth, unpublished data) and collated into a spreadsheet using MS-DOS commands; where required, the time and date recorded on the EXIF metadata on each image were corrected based on slate shots (i.e. exposures of a slate with GPS-derived time, date and the location written on it) taken by field teams when the camera was set up and when it was checked to retrieve images. Based on the corrected dates and times, simultaneous photo-captures taken by the two camera-traps deployed at each location were matched to define distinct photo-capture events, defined based on a time difference of at least 60 seconds between successive captures of the same species at a camera-trap location. We carefully identified species photo-captured; photographs which were in any way unclear or contained only a part of the animal's body sufficiently incomplete to lead to any degree of ambiguity in species identity were discarded to ensure no false-positive detections. In a few cases, species identity was confirmed with the help of a small carnivore expert familiar with the set of species we photo-captured.

Results and discussion

The camera-trap surveys yielded 4452 images of small carnivores across the eight PAs. After matching images from the same capture event and discarding photo-captures that could not be unambiguously assigned to species, we had 3204 distinct capture events of 11 small carnivore species. Table 2 provides a summary of the photo-captures of small carnivores, by PA and by species. The Small Indian Civet *Viverricula indica* appeared to be both ubiquitous (photo-captured in 298 locations across all eight PAs) and common (1036 detections), followed by the Common Palm Civet *Paradoxurus hermaphroditus*, of which we obtained 650 detections at 180 locations in all PAs other than Talakaveri.

Table 2. Number of distinct photo-capture events (no. of locations), by species and protected area (PA); values in boldface are discussed further in the main text.

PA	Species[a] HEED	HESM	HEVI	HEFU	PAHE	PAJE	VIIN	FECH	PRBE	PRRU	MAGW	Totals by PA
Bhadra	26 (13)	26 (17)	365 (70)	0 (0)	35 (14)	60 (28)	504 (96)	17 (5)	95 (36)	23 (6)	0 (0)	1151
Bandipur	21 (11)	205 (66)	65 (24)	0 (0)	192 (61)	1 (1)	138 (53)	54 (31)	2 (1)	59 (31)	0 (0)	737
BRT	14 (10)	46 (27)	46 (21)	0 (0)	331 (60)	35 (6)	224 (61)	77 (22)	22 (11)	20 (12)	0 (0)	815
Kali	0 (0)	1 (1)	6 (3)	0 (0)	1 (1)	0 (0)	10 (6)	2 (1)	3 (2)	1 (1)	0 (0)	24
Mhadei	3 (3)	0 (0)	1 (1)	0 (0)	4 (2)	0 (0)	2 (1)	0 (0)	0 (0)	0 (0)	0 (0)	10
Nagarahole	13 (9)	31 (21)	32 (19)	0 (0)	60 (31)	2 (2)	131 (63)	10 (6)	8 (8)	36 (14)	0 (0)	323
Talakaveri	0 (0[b])	0 (0)	0 (0)	58 (4)	0 (0)	6 (2)	8 (6)	0 (0)	2 (2)	0 (0)	1 (1)	75
Wayanad	6 (1)	6 (5)	6 (3)	0 (0)	27 (11)	0 (0)	19 (12)	0 (0)	5 (4)	0 (0)	0 (0)	69
Total events by species (no. of locations across all PAs)	83 (47)	315 (137)	521 (141)	58 (4)	650 (180)	104 (39)	1036 (298)	160 (65)	137 (64)	139 (64)	1 (1)	3204

[a] HEED: Grey Mongoose *Herpestes edwardsii*; HESM: Ruddy Mongoose *H. smithi*; HEVI: Stripe-necked Mongoose *H. vitticollis*; HEFU: Brown Mongoose *H. fuscus*; PAHE: Common Palm Civet *Paradoxurus hermaphroditus*; PAJE: Brown Palm Civet *P. jerdoni*; VIIN: Small Indian Civet *Viverricula indica*; FECH: Jungle Cat *Felis chaus*; PRBE: Leopard Cat *Prionailurus bengalensis*; PRRU: Rusty-spotted Cat *P. rubiginosus;* MAGW: Nilgiri Marten *Martes gwatkinsii*. [b] Grey Mongoose was photo-captured at one location near Talakaveri outside the survey period reported here.

We did not obtain any photo-captures of otters during the 2013-14 field surveys, although at least two species are known to occur in different parts of the study landscape and have also been photo-captured during other field seasons by the Centre for Wildlife Studies (K. U. Karanth, unpublished data). The Small-clawed Otter *Aonyx cinereus* occurs in hill streams along the main Western Ghats ridge (where its presence was easily confirmed during our camera-trap surveys based on its distinctive spraints) and the Bababudans range, and the Smooth-coated Otter *Lutrogale perspicillata* occurs in larger

rivers (such as the Cauvery, Kabini and Bhadra) and in reservoirs formed by damming these rivers. We also did not obtain any records of species whose presence in the region is uncertain (Malabar Civet *Viverra civettina*, Fishing Cat *Prionailurus viverrinus*) or only recently confirmed (Eurasian Otter *Lutra lutra*; Mudappa et al. 2018).

The large number of small carnivore images obtained during surveys primarily designed for large cats indicates that small carnivores (even species of the predominantly arboreal palm civets) do extensively use forest roads and trails. Below, we discuss some notable photo-captures in our data set.

Brown Palm Civet Paradoxurus jerdoni

The photo-captures obtained in Nagarahole (2), and Bandipur (1; Fig. 2a, b) are the first occurrence records for these PAs and are particularly significant since these areas support mainly deciduous forests with a few small patches of evergreen forest along Nagarahole's western edge, where the two photo-captures occurred. Kumara & Singh (2007) state that they were unable to sight the species in Nagarahole, despite much effort to locate it. Rajamani et al. (2002) also did not obtain sightings of the species in any deciduous forest areas during their surveys (which included Nagarahole, BRT and Bhadra), though they do mention a few sightings in coffee estates and moist deciduous forests outside the survey period. The single photo-capture in Bandipur was obtained along the reserve's south-western border with Wayanad WLS-South, close to the transition from dry to moist deciduous forest. The photo-captures in Talakaveri were unsurprising, as the sanctuary is well within the species's known habitat and range. In Bhadra, we obtained 60 photo-captures of the species (Table 2) including in moist and dry deciduous forests over 8 km from the nearest evergreen patch, which is considerable given that Mudappa (2001) estimated 95% minimum convex polygon home ranges from radio-telemetry of seven individual Brown Palm Civets to range from 3.6 ha to 50.9 ha.

In BRT, we obtained 35 photo-capture events of Brown Palm Civet (Table 2; Fig. 2c), all of them in the evergreen, *shola*-grassland and coffee plantation areas along the main ridge in the east-central part of the reserve. Our photo-captures of the species here are significant as they are the first verified records of its presence in BRT since Morris's museum collections in the 1940s (Rajamani et al. 2002). Despite investing targeted search effort, Rajamani et al. (2002), Kumara & Singh (2007) and Kumara et al. (2012) were unable to confirm the presence of Brown Palm Civet in BRT using direct observation-based surveys, underscoring the efficacy of camera-trap surveys in confirming the occurrence of cryptic, nocturnal and even arboreal species such as the palm civets. Rajamani et al. (2002) were also unsure of the veracity of the location records of museum specimens reportedly collected in BRT (by R. C. Morris, as listed in their table 1), though they list presence of the species in BRT as likely, based on its proximity to the Nilgiris massif (straight line distance circa 50 km). The pelage of individuals photo-captured in BRT was unusually

dark, in fact nearly black; see Fig. 2c), and unlike that of individuals photo-captured anywhere else, certainly in our surveys and to our knowledge in any other photographic record. It would be of great interest to investigate demographic and genetic connectivity/divergence among populations of Brown Palm Civet in remnant evergreen forests separated by large swathes of deciduous forests, commercial plantations, open agriculture and settlements, and to assess the effects of historical and recent anthropogenic land-use changes on the species's population genetics, possibly based on non-invasive faecal DNA.

Stripe-necked Mongoose Herpestes vitticollis

The species was never photo-captured in the wettest camera-trap locations (in Talakaveri), although D.J. (pers. obs.) made several sightings of the species both within the forest and in commercial cardamom–coffee plantations areas 2-5 km from evergreen forests, while we obtained a large number of photo-captures in Bhadra, BRT, Nagarahole and Bandipur. A possible reason for this could be that camera-trapping in Talakaveri was conducted exclusively away from forest roads and trails unlike in the other sites. This might indicate that photo-capture rates of the species (and perhaps movements) are much higher along roads than away from them.

Brown Mongoose Herpestes fuscus

The species, known to be an obligate of wet evergreen forests, was photo-captured only in Talakaveri WLS (Fig. 2d) and adjoining plantation areas during pre-baiting prior to live capture and radio-collaring. Our surveys did cover evergreen forest areas to the north (in Bhadra, Kali and Mhadei), but we did not obtain photo-captures of the species in these areas, nor are there any sighting records of the species north of Kodagu District, Karnataka. A recent record of the species in the dry deciduous forests of Tadoba-Andhari TR in central India (Chaoji 2020) is clearly misidentification of the Grey Mongoose *Herpestes edwardsii*. Although the species is known to be largely nocturnal with limited activity during the day (Mudappa 1998, 2002, Sreehari & Nameer 2013, Sreehari et al. 2013, 2016, Mudappa & Jathanna 2015, Kamath & Seshadri 2019), individuals quickly showed cathemeral activity once they learned that the box-traps were baited, visiting the traps through the day and night (leading to the large number of photo-captures relative to the low trap effort at this site; Table 2), and also spending time within or on top of the box-trap to groom themselves after consuming the bait (unlike Brown Palm Civets, Small Indian Civets and Leopard Cats, which remained wary and avoided entering the box-traps). In one location, two individuals regularly visited the trap. Based on the size difference between the two individuals, it was likely that this was a female with her pup (Fig. 2d). Although both individuals were photo-captured, only the larger individual usually entered the trap to

consume the bait. In the following season (2014-15), we obtained a photo-capture of the species in a coffee plantation about 3 km from the nearest large forest patch (Talakaveri) but within 1 km of steep, uncultivated (forested) slopes.

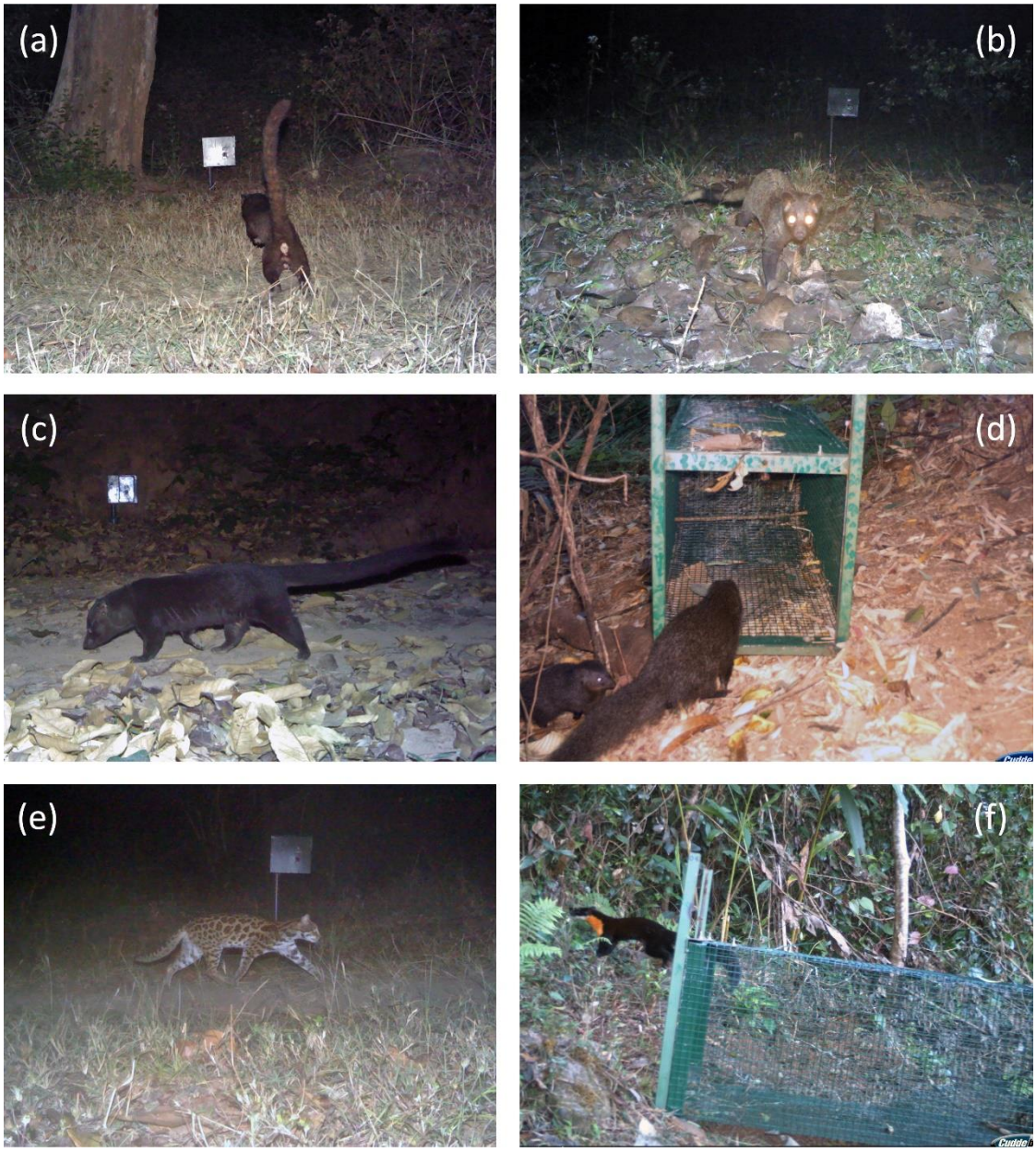

Fig. 2. Camera-trap images of small carnivores taken in the central Western Ghats, India, during 2013-14: (a) Brown Palm Civet *Paradoxurus jerdoni*, Bandipur, 9 January 2014; (b) Brown Palm Civet, Nagarahole, 7 December 2013; (c) Brown Palm Civet, BRT, 1 February 2014; (d) Brown Mongoose *Herpestes fuscus* (most likely female with young), Talakaveri, 27 December 2013; E: (e) Leopard Cat *Prionailurus bengalensis*, Bandipur; 6 January 2014; (f) Nilgiri Marten *Martes gwatkinsii*, near Talakaveri, 6 December 2013.

Leopard Cat Prionailurus bengalensis

Given that in peninsular India the species is known to occur in relatively wet, cool, close-canopied forested areas such as moist deciduous and evergreen forests, and adjoining commercial tree plantations (Yoganand & Kumar 1995, Mudappa 2002, Kumara & Singh 2004, 2007, Kumara 2007, Nag 2008, Sridhar et al. 2008, Kumara et al. 2012, Kalle et al. 2013, Srivathsa et al. 2015), the two photo-captures in the dry deciduous forests of Bandipur (Fig. 2e) are noteworthy, particularly as they were obtained at a location in a fairly dry part of the reserve near the Kekkanhalla checkpost. Kumara & Singh (2007) report two direct sightings of the species in the reserve. Previous studies (Kalle et al. 2013, Srivathsa et al. 2015) mention the species's use of plantation areas and forests adjoining human settlements, and we obtained one photo-capture of the species in a cardamom–coffee plantation adjoining a small patch of unprotected forest between Bhagamandala and Talakaveri and also found a road-killed female next to a small uncultivated wooded patch in an intensively cultivated coffee plantation area near Ayyangeri village, some 4 km from the nearest forest, in November 2013 (D. Jathanna pers. obs.).

Nilgiri Marten Martes gwatkinsii

During pre-baiting prior to live trapping and radio-tracking of small carnivores (Jathanna et al. in prep), we obtained a single photo-capture of a Nilgiri Marten, which moved past the box-trap without entering it (Table 2; Fig 2f) at 08h06, 6 December 2013. The traps were located at the edge of a mixed coffee–cardamom plantation, along a path bordered on one side by dense *Strobilanthes* understory at the edge of a patch of unprotected forest about 2.2 km from the nearest large forest.

For poorly understood taxa such as small carnivores, reliable occurrence records (such as carefully validated photo-captures) can still add substantially to our understanding these species's conservation status, distribution, habitat relationships, diel activity patterns and other aspects of their biology and ecology. Given the large costs associated with conducting camera-trap surveys across landscape scales, we recommend the 'mining' of by-catch records from large-scale surveys targeted at species such as Tiger and Leopard, which are more likely to receive funding for conservation monitoring. In doing so, however, we note the following.

(i) It is relatively easy to obtain photo-captures of most small carnivores, but it is critical to reference photo-captures reliably in space and time and to ensure that false positive detections do not vitiate conclusions/inferences. To ensure this, it is important to invest very substantial time and effort to maintain meticulous records during fieldwork and to organise, process and validate camera-trap image and other associated data with care. This is particularly important when the number of camera-trap locations and the number of images obtained are large.

(ii) Use of information we have presented either in the summary (Table 2) or in the in the main text in any formal modelling framework to assess species–habitat relationships would be inappropriate and misleading. Such summary records lack associated information on where we sampled (including where we did not observe the species), how much we sampled the different locations and how each species was or was not detected across multiple sampling occasions even where present. Consequently, observation processes such as unequal sampling probability across space, unequal sampling effort over time across sites, and imperfect and spatially variable detectability (MacKenzie et al. 2002, 2018, Yackulic et al. 2013) can seriously mislead inferred species–habitat relationships, unless they are accounted for or it can be reasonably demonstrated that such observation processes are relatively invariant across space. To separate these potentially confounding observation effects ('noise') from 'signal' in the data that is actually informative on species–habitat relationships, it is necessary to use a modelling framework that explicitly accounts for these factors (fit to data that were generated from underlying processes that reasonably match the model). We are currently finalising analyses of habitat relationships for those species in our data set with adequate detections at a large number of locations (and therefore excluding Nilgiri Marten and Brown Mongoose), using such a modelling framework (Jathanna 2016). We do not suggest a blanket ban on any particular modelling approach nor do we prescribe one approach over another for all situations, but we do recommend that, when modelling species–habitat relationships, investigators carefully think about the key processes (ecological as well as observation) that likely generated the data and select a modelling framework that reasonably matches these processes.

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