Half-yearly update

Project: Ecology and conservation of small carnivores in the Western Ghats,

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INTRODUCTION

The Western Ghats biodiversity hotspot supports a diversity of small carnivore species: four species of mongooses (gray mongoose *Herpestes edwardsii*, ruddy mongoose *H. smithii*, stripe-necked mongoose *H. vitticollis* and brown mongoose *H. fuscus*), two civet species (small Indian civet *Viverricula indica* and Malabar civet *Viverra civettina*), two palm civets (common palm civet *Hermaphroditus paradoxurus* and brown palm civet *H. jerdoni*), up to three otters (smooth-coated otter *Lutrogale perspicillata*, small-clawed *Aonyx cinereus* and possibly Eurasian otter *Lutra lutra*), one marten (Nilgiri marten *Martes gwatkinsii*) and up to four small cats (Leopard cat *Prionailurus bengalensis*, rusty-spotted cat *Prionailurus rubiginosus*, Jungle cat *Felis chaus* and, possibly, fishing cat *Prionaiurus viverrinus*). Of these, the stripe-necked and brown mongooses, Malabar civet, brown palm civet and Nilgiri marten are endemic to the Western Ghats-Sri Lanka hotspot, while the ruddy mongoose and rusty-spotted cat are endemic to the Indian sub-continent.

Small carnivores are known to play important functional roles in forest systems across the world through predation (Fryxell et al. 1999, Bowman et al. 2006) and competition (thereby influencing numbers and biomass of prey species, competitors as well as through indirect effects on different trophic levels; Terborgh 1988). As seed dispersers, they affect the distribution of forest trees and thus help maintain tree diversity in tropical forests (Terborgh 1988, Rabinowitz 1991, Pigozzi 1992, Willson 1993, Pendje 1994, Clevenger 1996, Hickey et al. 1999, Otani 2002, Schaumann & Heinken 2002, Alves-Costa & Eterovick 2007, Zhou, Slade, Newman, Wang & Zhang 2008). However, the group has received little conservation or research attention in south Asia, and remains poorly understood in terms of biology, ecology, conservation status and responses to human impacts. Not only do we know virtually nothing about these species' social and spacing systems, habitat use, demographics, and other aspects that have direct consequences to how the species respond to human pressures, for most (especially the rarer and disturbancesensitive such as the brown mongoose and Nilgiri marten) species, there is a serious lack of information on distribution, occurrences and current conservation status. This study addresses this knowledge gap by generating information and understanding of small carnivores relevant to their conservation.

The broad goal of my research is to investigate the biology and ecology of small carnivores, focussing especially on species endemic to the Western Ghats and Sri Lanka biodiversity hotspot (the Nilgiri marten *Martes gwatkinsii*, brown mongoose *Herpestes fuscus* and stripe-necked mongoose *H. vitticollis)*, to generate understanding relevant to their conservation. The specific research objectives are:

1. To characterise ranging, habitat use, activity patterns, social organisation, breeding biology, diet of the study species, and identify factors that influence these attributes;
2. To understand the interaction of key human impacts (hunting, prey depletion, habitat loss or habitat fragmentation) with the above aspects of the species' ecology, and examine the consequences for species' persistence;
3. To construct and validate predictive models of species occupancy at the scale of the distributional range. The model will help both predict and understand current patterns of persistence, and identify areas for species-based conservation.

These objectives are being met using a wide variety of approaches, including secondary information and key informant surveys, direct encounter surveys, camera trap surveys, scat surveys and scat collection, live capture, radio-collaring and radio-tracking, and occupancy modelling using camera trap data.

PROGRESS PRIOR TO GRANT PERIOD

Starting in early 2010, I first carried out large-scale surveys across the Western Ghats in Karnataka, Kerala and Tamil Nadu, covering a variety of landuse types from protected areas (low-medium and high elevation evergreen forests, shola grasslands, moist deciduous forest), cardamom, coffee, tea, rubber, areca and cashew plantations, open agriculture, and settlements. The surveys relied mainly on secondary information from local communities, hunters, forest department staff, plantation managers and workers, among others. The unstructured interviews covered species' occurrence in specific localities and habitats, perceptions of status, natural history and behavioural observations, and current pressures, especially from hunting or retaliatory killing, and generated critical information on the occurrence and current status of these small carnivores, as well as of other wildlife across large parts of the Western Ghats (Jathanna 2010).

Following the large-scale surveys, I carried out site-based field research in Talacauvery Wildlife Sanctuary using camera traps and direct encounter surveys which shed light on fine-scale habitat use, diel activity patterns, and also helped assess the efficacy of different baits in attracting small carnivore species. During this time, I also designed and tested hair snare surveys of Nilgiri martens within the study area for subsequent DNA-based species and individual identification, towards estimation of population parameters such as abundance and density through spatially explicit capture recapture modelling (Gardner et al. 2009, 2010, Royle et al. 2009). I collected tissue samples from museum specimens of small carnivores and learnt laboratory DNA techniques such as extraction, PCR amplification, agarose gel electrophoresis and sequencing.

In late 2013 and early 2014, I carried out pre-baiting for my study species, which entailed placing a box trap in carefully selected locations in forest and plantation areas and placing some bait (typically, chicken entrails) to entice small carnivores to enter the trap. This is done along with a camera trap facing the box trap door, to enable me to assess whether the study species are entering the trap and to observe their behaviour at these times (using video camera traps). The box trap is placed without a door, so that the animals are free to enter and exit. The purpose of pre-baiting is a) to make the animals comfortable in entering the trap and b) to be able to predict within a small window of time when the animal is likely to enter the trap during the actual live capture, so that the project veterinarian and I can stand by to sedate the animal and radio-collar it in a very short period of time following its capture. Live-trapping was then conducted for brown mongoose at locations regularly visited by the species during the pre-baiting. The traps were continuously monitored from a few hundred meters away using a telemetry antenna and receiver to check if an animal had entered the trap (the trap was rigged with a radio-collar to start transmitting as soon as an animal was captured). A young male brown mongoose was captured in March 2014. It was successfully and safely immobilised using a mixture of Ketamine HCl-Xylazine HCl, and fitted with a radio-collar. The individual was radio-tracked following its release and provided the first-ever radio-location data on ranging and habitat use patterns for the endemic brown mongoose.

PROGRESS DURING GRANT PERIOD

Pre-baiting and camera trapping

Following a break in fieldwork due to delays in renewal of the research permit by the Forest Department, I resumed pre-baiting in December 2014, both within Talacauvery WLS as well as in plantation areas adjacent to the sanctuary. As before, pre-baiting was carried out along with camera traps, to provide photo-capture data to help assess diel activity patterns, patterns of occupancy and fine-scale habitat use, as well as to a) to make the animals comfortable in entering the trap and b) to be able to predict within a small window of time when the animal is likely to enter the trap during the actual live capture, so that the project veterinarian and I can stand by to sedate the animal and radio-collar it in a very short period of time following its capture, thus reducing stress for the captured individual.

Pre-baiting during the current reporting period resulted in the captures of several small carnivore species, including brown mongoose, gray mongoose, brown palm civet, small Indian civet and leopard cat (Figs. 1-4).

Fig. 1: Photo-captures of the endemic brown mongoose *Herpestes fuscus*

Fig. 2: Photo-captures of gray mongoose *H. edwardsii*

Fig. 3: Photo-captures of the endemic brown palm civet *Paradoxurus jerdoni*

Fig. 4: Photo-captures of leopard cat *Prionailurus bengalensis* and small Indian civet *Viverricula indica*

In addition to helping prepare for live-trapping, the photo-capture data are being used to examine patterns and determinants of habitat occupancy, diel activity patterns, and fine-scale spatio-temporal segregation among sympatric small carnivore species (see section on *Multi-site camera trap data* below).

Live trapping, capture, radio-collaring and radio-tracking

We resumed live trapping for brown mongoose in April 2015, once the species was seen to be regularly visiting pre-baiting sites. A second young male brown mongoose was captured on 15th April 2015, safely immobilised using a combination of Ketamine HCl and Xylazine HCl (Kreeger & Arnemo 2007, Ostrowski 2007), radio-collared and released following full recovery (Figs 5, 6). Because the species is listed as Vulnerable by the IUCN RedList (but the current assessment, to which I contributed, will revise that status) and under Schedule II of the Indian Wildlife Protection Act (1972), a number of precautions were followed during live-trapping, chemical immobilisation, radio-collaring and the subsequent release (Table 1). Throughout the induction, the animal's vital signs were monitored, and the individual was tested for Rabies using a field testing kit (the test was negative). Prior to its recovery, hair samples and a small amount of blood (<0.1 ml) were collected and stored in Queen's lysis buffer for subsequent genetic work. The safe and successful immobilisation has helped standardise protocols for future handling of live individuals of this and related species.

Following the individual's release, it was radio-tracked (Fig. 7), using standard triangulation methods (Mech 1983; Kenward 2001). Homing-in was not used as the individual tended to move through cane (*Calamus spp.*) and reed (*Ochlandra spp.*) thickets, and would move away before being sighted if approached, thus defeating the purpose of radio-tracking. This work represents the second time a brown mongoose has been radio-collared and tracked in the field; the first time was under the same project but prior to the grant period.

Fig. 5: Radio-collar attachment on a brown mongoose

Fig. 6: Monitoring vitals of the brown mongoose

Fig. 7: Radio-tracking in the field following recovery and release. Right to left: Project PI, project veterinarian, field assistant

Trapping locations chosen so that there is no chance of the trap being discovered by humans/domestic dogs, etc.
Extensive pre-baiting carried out to determine the location and approximate time the species is likely to enter the trap, so that live-trapping can be carried out in a small window of time when the PI can stand by to call the project veterinarian and sedate the animal at the earliest, thus minimising stress to the animal.
Live trapping carried out only during the time the approved project veterinarian is available (between 0900 and 1630 hrs) and able to arrive at short notice. At other times, the door is removed and the trap is not set, but pre-baiting is continued.
Animal sedation only carried out by the approved project veterinarian, handling and radio-collaring only carried out in his presence.
Field assistants and PI present within approx. 150 m from one trap and approx. 250 m from the other trap as long as the trap is set to capture animals.
Radio-collar attached to the box trap and a magnet to the trap door, so that the magnet gets pulled off the radio-collar if the door closes, thus activating the radio-collar and transmitting a signal. I monitor whether the collars are transmitting signals every 5 minutes from the Talacauvery APC using radio-telemetry antennae and receivers.
All care taken to ensure no or minimal stress to the animal. This includes staying at a distance and remaining silent till the animal is sedated, covering the trap with a cloth once the animal is inside, and minimising the amount the trap is handled/moved.
The dosage of the sedation drugs (Ketamine HCl + Xylazine HCl) and reversal drug (Yohimbine HCl) accurately calculated based on the animal's weight using a preformatted MS-Excel spreadsheet. This is calculated as the difference between a) the weight of the box trap + animal and b) that of the box trap alone (obtained in advance). This ensures that the animal is not over- or under-dosed, which may happen if weight is assessed visually. Dosage per kg body weight is based on available literature on sedation of closely related species and has been vetted by experienced wildlife veterinarians.
Animal removed from the trap only after it is fully sedated, which also ensures no stress.
Corneal lubricant (i.e. LacriGel) applied to the eyes before the face is lightly covered with a cloth.
From the time the animal is removed from the trap to the time the reversal agent (Yohimbine HCl) is administered, vital parameters continuously monitored. These include temperature (using a thermometer), respiration (using a stethoscope) and heart rate.
Once the radio-collar has been fitted and samples collected, the animal is injected with the correct amount of Yohimbine HCl as well as dexamethasone to ensure smooth revival.
Animal placed back in the box trap after this, and released only after it is fully revived.
Printed Anaesthetic Record used to monitor and record vitals.

Printed Protocol Sheet with one field assistant at all times, this also serves as a checklist for procedures. All protocols vetted by experienced wildlife veterinarians.
Printed Key Information Sheet on hand at all times for quick reference.
Animal weight and drug dosage to be administered calculated using a pre-formatted excel spreadsheet on my laptop to avoid calculation mistakes while in the field.
All required sedatives and reversal agents obtained from reputed veterinary chemists and checked to ensure that they are not past expiry date.
Drugs for any medical emergency, however unlikely, on hand in the sedation kit. These include dexamethasone (ensures smooth recovery), diazepam (in case of seizures), taxim (a broad spectrum antibiotic), prednisolone (similar to dexamethasone), atropine (in case of bradycardia) and adrenaline (in case of anaphylaxis), ambu bags with intubation tubes (in case of respiratory depression), water (in case of hyperthermia) and a blanket (in case of hypothermia). However, these are very unlikely to be required as drug dosage is based on accurately measured body weight.
Table 1: Safety protocols followed during live capture, sedation and release.

Multi-site camera trap data

For my third research objective, I will use my own camera trap capture data, supplemented by camera trap-based photographic captures of small carnivores in surveys conducted by CWS in protected areas across the Western Ghats: Dandeli-Anshi, Bhadra, Nagarahole, Bandipur and Biligiri Rangaswamy Temple (BRT) Tiger Reserves (TR), in addition to contiguous areas in the states of Goa to the north and Kerala to the south. These sites cover extremely wide ranges of climatic, latitudinal, ecological and floristic gradients, as well as a wide range of anthropogenic disturbance . This work commenced in December 2014, and has been carried out concurrently with the live capture and radio-telemetry. Once the photographs have been collated (a non-trivial task, given that well over 700,000 photographs need to be carefully searched for small carnivore captures, captures of opposite flanks matched for each capture, and date/time corrected if and when the camera trap's internal clock has lost time between checks!), and unambiguously identified to species (ambiguous and unclear photographs will be discarded), the geo-referenced photo-capture data (along with information on camera-trap deployment periods and locations) will be used to examine:

1) Species-habitat relationships across several species (covering a range of body sizes and diets) and habitats (from thorn scrub through dry and moist deciduous to wet evergreen and montane shola forests) . This analysis will use occupancy models (MacKenzie et al. 2002, 2006) that account for imperfect and variable detection, thus removing the confounding effect of spatially variable detectability on inferred species-habitat relationships. The analysis will also examine the consequences (for inferred species-habitat relationships) of applying commonly used analytical frameworks (e.g. presence only-based spacies distributon models, presence-absence approaches such as logistic refression) that do not fully account for sampling realities such as spatially

uneven sampling and imperfect, variable detection (Yackulic et al. 2013) that are ubiquitous in field data. This will be the first time that habitat occupancy patterns are carefully examined for the full suite of small carnivore species in the Western Ghats, using reliable camera trap data (which eliminates the problem of false positives) and in a statistical framework that closely describes how the data could have been generated from the underlying ecological process (i.e.habitat relationships for each species) overlaid with the observation process (consisiting of where camera traps were located, and how species were photo-captured or not over multiple temporal replicates conditional on true occupancy state remaining constant over the duration of sampling).

2) Patterns of co-occurrence and segregation of small carnivore species in space and time. This analysis will use multi-state occupancy modelling (Mackenzie et al. 2009) reframed in a multi-species context (Mackenzie et al. 2004) to assess spatial co-occurrence. As in the analysis of species-habitat relationships, the framework accounts for imperfect detection that can vary across space and also in response to the presence of other species, whether or not these are detected. Circular statistical distribution (such as the von Mises distribution) and generalised linear modelling will be used to examine temporal activity patterns within species and temporal overlap/partitioning between species. For those species that do not show clear temporal or spatial segregation, randomisation procedures such as the Multiple Response Permutation Procedure (MRPP) will be used to test if observed segregation or co-occurrence along *both* spatial and temporal axes is clearly different from what would be expected by chance alone.

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