Ecology & conservation of small carnivores in the Western Ghats

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SUMMARY

Despite the important roles small carnivores play in forests, little research or conservation attention has been directed at these species in the Western Ghats, which harbours a rich assemblage. Consequently, little is known about their conservation status, biology, ecological requirements and responses to human activities. This project attempted to address this critical knowledge gap by examining the conservation status, occurrence patterns, threats, space use and other aspects of basic biology of three small carnivore species endemic to the Western Ghats: Nilgiri marten, brown mongoose and stripe-necked mongoose. These aspects were studied using a variety of approaches and techniques including unstructured interview and key informant surveys, encounter rate surveys, scat collection and camera trapping. During the project I also carried out some preliminary work towards later, in-depth field research such as collecting DNA samples from museum specimens, learning laboratory genetic techniques, and designing hair snare surveys in the field towards estimating population-level parameters. Despite long unanticipated delays in obtaining research permits and severe restrictions placed initially on the fieldwork, the project has managed to generate substantial amounts of information on the occurrence, status, natural history, biology and ecology of the study species, other carnivores as well as other wildlife, in different areas of the Western Ghats, and especially in and around the intensive study area.

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INTRODUCTION

Small carnivores (civets, palm civets, mongooses, martens and otters, belonging to the families Viverridae, Herpestidae and Mustelidae), play key roles in forest systems, such as regulation of prey populations (Fryxell *et al.* 1999; Bowman *et al.* 2006) and seed dispersal (Rabinowitz 1991; Schaumann & Heinken 2002; Alves-Costa & Eterovick 2007; Zhou, Slade, Newman, Wang & Zhang 2008), with effects on all levels of the ecosystem (Terborgh 1988). Because many of them require primary and unfragmented forests with healthy prey assemblages, they also serve as indicators of healthy forests (Zielinski & Kucera 1995). Because of these specific ecological requirements, small distributional ranges, dependence on intact prey assemblages and sensitivity to the combined effects of habitat loss and fragmentation, small carnivores (with some exceptions) are generally susceptible to human impacts (Eisenberg 1989), and many species have suffered drastic population declines and range contractions (Schipper *et al.* 2008).

While the conservation status and biology of small carnivores in Europe, North America and Africa are well understood, little is known about the small carnivore assemblage in the Western Ghats of southern India. The Western Ghats support a rich array of small carnivores, with two species of civets, two palm civets, four mongooses, three otters and one marten, of which the Malabar civet *Viverra civettina*, Nilgiri marten *Martes gwatkinsii* and the brown palm civet *Paradoxurus jerdoni* are endemic to the Western Ghats, while the brown mongoose *Herpestes fuscus* and stripe-necked mongoose *H. vitticollis* are endemic to the Western Ghats and Sri Lanka (all endemics occur in the wet evergreen forests or adjoining habitats). While there have been a few studies and surveys specifically directed at these species (Rai & Kumar 1993; Yoganand & Kumar 1995; Mudappa 2001, 2006; Mudappa *et al.* 2007), most of the available information on the natural history, distribution and conservation status of small carnivores in the Western Ghats comes from opportunistic sightings by field researchers. Small carnivore biologists have emphasised the urgent need to generate information on the conservation status of small carnivores in the Western Ghats, as well as the responses of these species to various human activities (Wirth & Van Rompaey 1991).

This project aimed to address this lacuna by studying the biology of endemic small carnivores in the Western Ghats. Focussing on the endemic Nilgiri marten, stripe-necked mongoose and brown mongoose, the project addressed knowledge gaps hindering science-

based conservation of small carnivores. Towards this goal, the project examined their natural history, biology and ecology to allow assessment of conservation status, identification of key threats and understanding the mechanisms by which those threats operate, towards the development of conservation strategies informed by science.

I. PRELIMINARY SURVEYS

The initial surveys, carried out in 2010, attempted to address the critical knowledge gap on small carnivores by generating preliminary data on the current status and occurrence of these species, and also served as a pilot study for the longer-term ecological study to follow immediately. The main focus of the surveys was the endemic Nilgiri marten, along with the brown mongoose, stripe-necked mongoose and other small carnivore species.

Objectives of the survey

1. A preliminary assessment of the occurrence and status of small carnivores in the Western Ghats.
2. A pilot study to identify potential field sites for a longer-term ecological study of small carnivores, as well as to identify key issues facing small carnivore conservation that can be addressed in the subsequent applied study.

Surveyed sites

Fieldwork commenced in January 2010, with visits to plantation areas adjoining Protected Areas (PAs). Following the issue of the Karnataka Forest Department permit in mid-March 2010, sites within PAs were visited. Surveyed locations are shown in Fig 1. and listed in Table 1. The surveys covered protected areas, as well as intervening and adjoining reserved forest, revenue land forests and plantations in Karnataka and Kerala (Fig. 2 a-d).

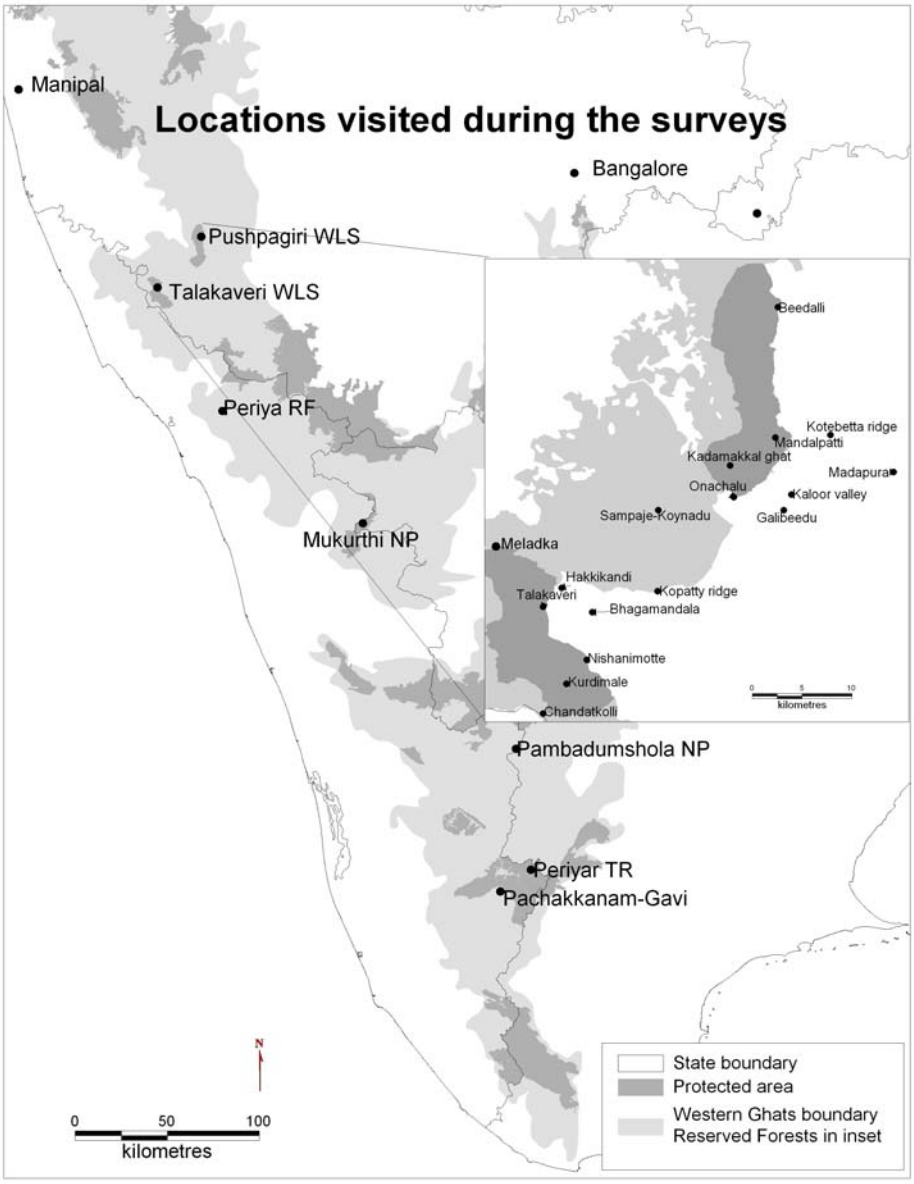

Figure 1: Map of locations visited during the initial survey. Inset shows locations within, around and between Talacauvery WLS and Pushpagiri WLS. GIS data sources: ATREE, CEPF and CWS.

Location	Land use and vegetation type
Talacauvery (Talacauvery Wildlife Sanctuary; WLS)	*Shola*-grasslands, *Acacia* plantations, cattle grazing grounds, medium elevation evergreen forests, cardamom-coffee plantations.
Hakkikandi (Talacauvery WLS)	Medium elevation evergreen forests, cardamom-coffee plantations, paddy fields, settlements
Nishanimotte (Talacauvery WLS)	*Shola*-grasslands, medium elevation evergreen forests, adjoining settlements and paddy fields.
Kurdimale (Talacauvery WLS)	Low elevation evergreen forests, abandoned cardamom plantations.
Chandatkolli	Low elevation evergreen forests, mixed plantations, settlements.

(Talacauvery WLS)	
Bhagamandala	Coffee-cardamom plantations, paddy fields, settlements
Meladka camp-Karike (Talacauvery WLS)	Semi-evergreen forests, mixed plantations
Kopatty ridge (Pattighat Reserved Forest; RF)	Coffee-cardamom plantations, settlements, medium elevation evergreen forests, *shola*-grasslands.
Sampaje-Koynadu (Sampaje RF)	Low elevation semi-evergreen forests, coffee, areca, rubber, cashew and mixed plantations
Galibeedu (south of Pushpagiri WLS)	Cardamom-coffee plantations, settlements, degraded and patchy evergreen forests (revenue lands), grasslands.
Kaloor (south of Pushpagiri WLS)	Cardamom-coffee plantations, settlements, paddy fields, adjoining medium elevation evergreen forests.
Onachalu (southwest of Pushpagiri WLS)	Cardamom-coffee plantations, tea plantations, settlements, paddy fields, adjoining medium elevation evergreen forests and grasslands
Kadamakkal ghat (Pushpagiri WLS)	Medium to low elevation evergreen forests, abandoned cardamom-coffee plantations, rubber plantations.
Mandalpatti (Pushpagiri WLS)	*Shola*-grasslands, medium elevation evergreen forests, cattle grazing grounds.
Kotebetta ridge	*Shola*-grasslands, degraded scrub jungle (revenue), coffee-cardamom plantations.
Mukkodlu valley (west of Kotebetta)	Coffee-cardamom plantations, abandoned coffee plantations, paddy fields, patches of medium elevation evergreen forests (revenue lands).
Madapura (southwest of Kotebetta)	Settlements, coffee-cardamom plantations, paddy fields.
Beedalli-Pushpagiri (Pushpagiri WLS)	Medium to low elevation evergreen forests, *shola*-grasslands, adjoining coffee plantations and cattle grazing grounds.
Pachakkanam-Gavi (south of Periyar TR):	Cardamom plantations, surrounded by medium elevation evergreen forests.
Karadikaval (Periyar TR)	Semi-evergreen and moist deciduous forests.
Around Thekkady (Periyar TR)	Moist deciduous, semi-evergreen and wet evergreen forests
Mukurthi National Park	*Shola*-grasslands, wattle and pine plantations.
Pampadumshola National Park (NP)	Medium elevation evergreen forest, wattle and pine plantations.
Periya RF and Gurukula Botanical Sanctuary	Medium elevation evergreen forest, mixed plantations, restored lands.

Table 1. List of locations in the Western Ghats visited during the preliminary surveys

Survey methods

The surveys employed unstructured interviews with local forest communities, hunters, forest department staff, coffee, cardamom and tea planters, among others. A large number of local persons were approached while in the field, an initial assessment was made of each person's familiarity with local wildlife using general questions about wildlife and natural history, and if found to be knowledgeable, they were questioned in detail. These interviews covered species'

occurrence in specific localities and habitats, perceptions of status, natural history and behavioural observations, and current pressures, especially hunting.

Because the surveys relied mainly on secondary reports from local communities, great care was taken to filter out unreliable information, in several ways. First, as described above, a general assessment was made of each person's familiarity with wildlife and natural history, and persons not knowledgeable were not questioned further. Next, each respondent was asked a few specific questions about species' identification and natural history, the answers to which were already known based on information available in the literature and personal observations. Finally, species identification was tested by asking them to identify photographs of small carnivores; a few pictures of non-native species were included in the set of pictures, and if the respondent claimed familiarity with these, the interview was disregarded. Species identification by the interviewees was taken as confirmed only if they volunteered some specific and unmistakable diagnostic characteristic (e.g. yellow/ orange throat patch in martens, or their odd mustelid gait when on the ground) of each species before being shown the pictures, since considerable confusion exists regarding local names for species in different languages, and since several similar species are often lumped together. Care was taken during the interview not to ask any leading questions or questions likely to prompt specific responses. Occurrence reports were narrowed down geographically as far as possible by asking the respondents to describe the location relative to prominent landmarks. Although the focus of the interviews was endemic small carnivores, knowledgeable respondents were also asked about large carnivores, ungulates, primates and other wildlife, as well as current pressures such as biomass extraction and hunting.

Apart from assessing species occurrence and status, the surveys also assessed each site for its potential as a study site for the longer-term study in terms of extent of suitable habitat, connectivity to other sites, current disturbances, habitat status, access, road network, availability of knowledgeable local guides and other logistics (e.g. availability of potential base camp).

Fig 2a. *Shola*-grasslands in Talakaveri WLS

Fig 2b. *Shola*-grasslands and medium elevation evergreen forests in Talakaveri WLS

Fig 2c. A view of Kaloor valley, showing patchy revenue land forests (foreground, on the slopes), paddy fields and plantations (middle) and medium elevation evergreen forests of Pushpagiri WLS in the distance

Fig2. *Shola*-grasslands around Mandalpatti, with the Pushpagiri peak in the distance.

Survey results and discussion

Based on the results of the surveys, the occurrence, status and aspects of the natural history of the study species and other wildlife are described below, by species. For the three study species, information from published literature and other sources is summarised first, followed by findings of the present surveys. Transliteration of local names broadly follows Kittel (1894). Except for the common langur, scientific names follow Wilson & Reeder (2005).

Study species

Nilgiri marten: The species (Fig.3) is endemic to the Western Ghats (excluding Sri Lanka). Wirth & Van Rompaey (1991) note that it is "the rarest and least known species of the true martens of the genus *Martes*". Schreiber *et al.* (1989) and Wirth & Van Rompaey (1991) called for urgent field surveys and research into the species' occurrence, status and ecology. It is currently listed as Vulnerable by the IUCN RedList (Choudhury *et al.* 2008) and under Schedule II of the Indian Wildlife (Protection) Act (1972).

Fig. 3: Nilgiri martens *Martes gwatkinsii*. Photo: © R. Prakash

Prior information on the species comes from a handful of sighting reports (both published as well as personal communications) by biologists and naturalists working in different parts of the Western Ghats. The species is distributed patchily, starting at the southernmost tip of the Western Ghats in Kalakkad-Mundanthurai TR (KMTR) (Mudappa 2001, 2002; Mudappa *et al.* 2007). The northern limit of its distribution appears to be in the forests of Charmadi-Kanapadi, which borders Kudremukh National Park to the south; N. Jain (*pers.*

comm.) reports that local communities in Charmadi describe the species accurately while those in Kudremukh are not familiar with the species. Balakrishnan (2005) also failed to detect it in Kudremukh despite extensive surveys. Karanth (1985) reports the occurrence of Nilgiri martens in the Shiradi-Sampaje stretch immediately to the south of Charmadi as well as in forests farther south. Areas known to harbour the species include KMTR, Peppara WLS, Neyyar WLS, Gavi range of Ranni Forest Division (FD), Periyar TR, Srivilliputtur WLS, High Wavies, Pambadumshola National Park (NP), Palni hills, Eravikulam NP, Anamalai TR-Grass Hills NP, Valparai Plateau, Chinnar WLS, Nelliampathy RF, Attapadi RF, Muthikkulam RF, Nilambur South RF, Silent Valley NP, Mukurthi NP-Upper Bhavani, Naduvattam RF-Nilgiris, Brahmagiri WLS, Kerti RF, Padinalknad RF, Talacauvery WLS, Pattighat RF, Pushpagiri WLS, Bisle RF, Charmadi-Kanapadi RF (Hutton 1949a,b; Karanth 1985; Schreiber *et al.* 1989; Madhusudan 1995; Yoganand & Kumar 1995; Christopher & Jayson 1996; Gokula & Ramachandran 1996; Kurup & Joseph 2001; Mudappa 2001, 2002; Balakrishnan 2005; Kumara & Singh 2007; Mudappa *et al.* 2007; Krishna & Karnad *in press.*; D. Jathanna *unpublished data*; H. N. Kumara *pers. comm.*; N. Jain *pers. comm.*, M. Balasubramaniam *pers. comm.*; R. Vijayan *pers. comm.*; K. J. Varkey *pers. comm.*; V. Ramachandran *pers. comm.*; R. Nayak. *pers. comm.*; S. Chirukandoth *pers. comm.*; G. Mehra *pers. comm.*; N. A. Naseer *pers. comm.*).

These sighting reports indicate that the species is found mainly in evergreen forests and *shola*-grasslands (Hutton 1949a,b; Madhusudan 1995; Christopher & Jayson 1996 and citations therein; Gokula & Ramachandran 1996; Kurup & Joseph 2001; Mudappa 2001, 2002; Balakrishnan 2005; Mudappa *et al.* 2007; Krishna & Karnad *in press* and citations therein; H. N. Kumara *pers. comm.*; V. Ramachandran *pers. comm.*; R. Nayak. *pers. comm.*; S. Chirukandoth *pers. comm.*; G. Mehra *pers. comm.*; N. A. Naseer *pers. comm.*), with two records from moist deciduous forests adjoining wet evergreen forests (Christopher & Jayson 1996; *pers. comm.* by J. Joshua in Mudappa 2002). There are a few reports of the species' occurrence in plantations (described as occasional) adjoining evergreen forests, including tea, wattle *Acacia mearnsii*, *Eucalyptus spp.*, and coffee-cardamom (Schreiber *et al.* 1989; Madhusudan 1995; Gokula & Ramachandran 1996; V. Ramachandran *pers. comm.*). Although there are a few reports from low elevation forests (*pers. comm.* by J. Joshua, cited in Mudappa 2002; Christopher & Jayson 1996) most reports are from medium to high elevation evergreen forests and montane *shola*-grassland areas, as noted by Balakrishnan (2005).

These reports indicate that the species seems equally at ease on the ground and in trees (with approximately half the reported sightings in trees and the other half on the ground or on fallen logs). The species seems fairly carnivorous with several reports of it chasing or feeding on the Indian chevrotain *Moschiola meminna* (Christopher & Jayson 1996; Kurup & Joseph 2001; Mudappa 2002), Indian monitor *Varanus bengalensis* (Mudappa 2002) and Indian giant squirrel *Ratufa indica* (Hutton 1949a; V. Ramachandran, *pers. comm.*), in addition to feeding on wild honey (Christopher & Jayson 1996) and probing fallen logs (Kurup & Joseph 2001), probably for invertebrates or reptiles. The number of individuals seen at each sighting ranges from 1-4, with the maximum sightings of solitary individuals followed closely by several sightings of pairs. All sighting reports indicate that the species is clearly diurnal.

During the present surveys, several respondents were familiar with the Nilgiri marten. Throughout most of its range in Karnataka, the species is known as *maranâi (mara = tree, nâi* = dog), while in the northern parts of the surveyed area (within and around Pushpagiri WLS) the species is known as *jênubĕkku* or *thênubĕkku* (*jênu = thênu* = honey, *bĕkku* = cat). Because common and brown palm civets are known as *marapaṭṭi* in adjoining Kerala (*paṭṭi* = dog in Malayalam), several reported sightings of the '*maranâi*' turned out to be palm civets on further enquiry.

The survey revealed that the species is sighted regularly in contiguous evergreen forests and *shola*-grasslands as well as in plantations and around settlements immediately adjacent to reserved forests. The species' distribution within the surveyed area seems to be more or less continuous, with the only possible discontinuity being between Pattighat R.F. and Kadamakkal R.F., along the Madikeri-Sampaje-Sullia highway. Potential habitat in Kerala is broken up into at least the following forest complexes: 1) Neyyar WLS-Peppara WLS-Shendurney WLS (contiguous with KMTR); 2) Ranni FD-Periyar TR (contiguous with Srivilliputtur WLS and the High Wavies); 3) Pambadumshola NP-Eravikulam NP-the Nelliampathies (contiguous with the Palnis-Anamalai TR-Grass Hills NP-Valparai Plateau-Chinnar WLS); 4) Attapadi RF-Muthikkulam RF-Nilambur South RF-Silent Valley NP (contiguous with Mukurthi NP and the Nilgiris) and 5) Wyanad plateau-Periya RF-Aaralam

WLS (occurrence likely, given presence in adjoining Brahmagiri WLS). It is unclear whether these populations are fragmented further.

Most reported sightings were of pairs or solitary individuals during the day, either moving (both on the ground and on trees) or raiding bee boxes. Nearly all respondents familiar with the species commented on its penchant for raiding bee boxes. Beekeepers reported that bee boxes placed close to the forest boundary were very likely to be overturned and taken apart. Although most respondents attributed this to its liking for honey, a few who had observed the species carefully noted that the martens actually fed on the bee larvae. One respondent reported that if the boxes were secured to the ground using wires to prevent martens from toppling them, martens would even bite through the wood (another respondent claimed that the species gnawed dead wood and ate the powder; this may have been because he observed a marten gnawing through a bee box or disintegrating a fallen log while foraging for invertebrates or reptiles). Interestingly, the species was also reported from plantation areas where apiculture is not practised. While some respondents reported that the species is seen more often in large evergreen forest patches, many felt that sightings are more common in plantation areas. However, because time spent by the interviewees in plantations is much greater than that spent in the forests, these observations by themselves are uninformative on fine-scale habitat use by the species. Most respondents reported that sightings within plantation areas peaked between late November and February, though a few claimed that the peak was in April-May, and even June-October. The survey indicated that the species' occurrence extends into plantations adjoining forests but declines rapidly with distance from the forest boundary; in plantation areas 3 km to 5 km away from the nearest contiguous forest, locals reported that the species did not occur locally (many of them had heard of but never seen Nilgiri martens), while in plantation areas 1 km to 3 km away from the nearest forest, a few respondents reported occasional sightings. Thus although the species is an obligate of evergreen forests, parts of the annual or seasonal home ranges likely encompass human-dominated landscapes, at least for individuals close to the plantation-forest interface. It would be of great ecological and conservation significance to characterise seasonal patterns in and determinants of fine-scale habitat use and ranging, as well as to understand how exactly the probabilities of habitat use and occurrence decline with increasing distance from the forest.

The surveys covered an altitudinal range of approximately 160 m to 1500 m above mean sea level (a.s.l.). While Nilgiri marten occurrence was reported from all surveyed forest areas higher than approximately 700 m a.s.l., lower elevation forest areas had few sightings, with no reports during these surveys from forests that were below approximately 400 m a.s.l. Reports exist of the species at elevations even lower elsewhere in the Western Ghats (Christopher & Jayson 1996; *pers. comm.* by J. Joshua, cited in Mudappa 2002) but most published records are from much higher elevations (including the highest areas in south India: the Eravikulam plateau, Mukurthi N.P. and the Palni Hills). Balakrishnan (2005) also notes that all seven sightings reported in his paper were above 600 m a.s.l., although he declines to comment on altitudinal preferences of the species, since both forest occurrence and survey effort were concentrated in higher elevations during his study. However, the fact that during the present survey, local communities at lower elevations did not report the species clearly indicates that the species prefers (but may not be restricted to) higher elevations.

Respondents reported that Nilgiri martens are not especially cautious while moving, either through forests or plantations, but usually run away on seeing humans or domestic dogs. A few reported that the animals were quite inquisitive if at a safe distance or that they growled before fleeing or on being treed by dogs. Most respondents commented on the speed with which martens moved, especially through the canopy, jumping from tree to tree. Most were not able to describe the species' tracks or scats, but one respondent reported that at certain times of the year marten scats can be identified through the presence of beeswax, which appears whitish in the scat. Nobody interviewed during these surveys had seen a marten den site, but many knew that the species rests in tree hollows.

Although illegal hunting for local consumption is both widespread and intense throughout the surveyed area (using guns, dogs and snares), martens are usually not eaten, since the animals are reported to have an unpleasant odour (several respondents claimed that the odour emanated from the orange/ yellow throat patch). Despite this, martens are killed whenever possible (usually with guns), mainly because they raid bee boxes, as noted by Kumara & Singh (2007). Several respondents reported having killed Nilgiri martens, some quite recently at the time of the survey. This sustained and regular removal of individuals is

likely to severely depress population densities, for a species that occurs at low densities even in the best and least disturbed habitats.

Brown mongoose: Little is known about this species, although it appears to be more common within its range than the Nilgiri marten. The species is endemic to the Western Ghats and Sri Lanka (Pocock 1939, Phillips 1984), where it has been reported from wet evergreen forests and plantations. Camera trap surveys in these areas usually yield photographs of the species (Mudappa 2002; D. Jathanna *unpublished data*, Fig. 4; N. Prakash *pers. comm.*). These camera trap surveys indicate that the brown mongoose appears to be less diurnal than other congeneric species (possibly crepuscular), with most photo-captures occurring around dawn or dusk, occasionally later in the night (Mudappa 2002; D. Jathanna *unpublished data*; N. Prakash *pers. comm.*), although direct sightings occasionally occur during the day. Mudappa (2002) found that the species would frequent garbage dumps, and seemed to prefer groundnut bait, while fresh fish has also been used successfully (N. Prakash *pers. comm.*). Locations within south India where the species has been recorded from previously include KMTR, Peermedu, the High Wavies, the Palnis, the Nilgiris, Virajpet (south Coorg), Talacauvery WLS and Brahmagiri WLS (Pocock 1939, Prater 1971, Corbet & Hill 1992, Mudappa 1998, D. Jathanna *unpublished data*), ranging from 900-1850 m a.s.l (Prater 1971).

Fig 4. The brown mongoose *Herpestes fuscus*. Photo: D. Jathanna

During the present surveys only a few respondents were familiar with the species, partly because different species of mongoose are not always distinguished, and possibly because it is more nocturnal and restricted to rainforests compared to other species. Locally, it is known as *malĕ kîri* or *malaṇgîri* (*malĕ* = hill/ hill forest, *kîri* = mongoose), some respondents described it as *haṇdi kîri* (*haṇdi* = pig), while respondents in the northern parts of the surveyed area (in and around Pushpagiri WLS) described the species as *haṇdi čhĕdarikĕ*. Reported occurrences

included the southern part of Talacauvery WLS (around Nishanimotte), Sampaje RF (needs verification) and the Beedalli area of Pushpagiri WLS. All sightings reported during the survey were in evergreen forests, semi-evergreen forests or *sholas*, both during the day and night.

Stripe-necked mongoose: The most widely distributed of the study species, this species is also the most common within its range. It is also endemic to the Western Ghats and Sri Lanka, and is found in a variety of habitats including *shola*-grasslands, wet evergreen forests, moist and dry deciduous forests, and in tea, coffee and cardamom plantations (Karanth et al. 2001; Mudappa 2002; Van Rompaey & Jayakumar 2003 and citations therein). It is often found along streams and swampy fallows, especially in drier forests (Van Rompaey & Jayakumar 2003; D. Jathanna *pers. obs.*). Van Rompaey & Jayakumar (2003) state that the species is more common between 400 and 1400 m a.s.l. However, this may not be true given that the species is extremely common in areas at much higher altitudes, such as the Thai Shola-Upper Bhavani area in the Nilgiris and Pambadumshola N.P. bordering the Palnis (A. Das *pers. comm.*, D. Jathanna *pers. obs.*). Reported occurrences of the species include KMTR, Periyar TR, the High Wavies, Pambadumshola N..P., Eravikulam NP, Anamalais TR, the Nelliampathis, the Nilgiris, Mudumalai WLS, Bandipur TR, Nagarahole NP, Bhadra TR, Kudremukh NP, Uttara Kannada district, and the western border of Kodagu (Coorg) (Pocock 1937, 1941; Mudappa 1998; Karanth et al. 2001; Van Rompaey & Jayakumar 2003 and citations therein; D. Jathanna *unpublished data* and *pers. obs.*; N. Prakash *pers. comm.*, Fig. 5). Some of the local names listed in the literature include *sewapu kîri*, *sare kîri* (Tamil), *chĕn kîri* (Malayalam) and *kĕmpu kîri* (Kannada) (Hutton 1949b; Prater 1971). In Sri Lanka the stripe-necked mongoose has been recorded feeding on chevrotain, black-naped hare *Lepus nigricollis*, bandicoot, field rats, birds and reptiles (Prater 1971).

Fig 5. The stripe-necked mongoose *Herpestes vitticollis.* Photo: © N. Prakash

The species' occurrence was recorded at most places covered during the present surveys. Most respondents in Kodagu positively identified it as *kokkĕ kêṇi* (*kokkĕ* = hook, possibly because the tip of the tail is usually held up), while those in and around Pushpagiri WLS identified it as *kĕmpu čhĕdarikĕ* or *kĕmpu kĕdarikĕ* (*kempu* = red, *kĕdarikĕ* = dishevelled); none of the respondents used the previously listed local name *kĕmpu kîri* (Prater 1971). Respondents in Kerala knew the species as *sĕn kîri*. Interestingly, while respondents in Karnataka usually reported the presence of one or two species of mongoose in a locality, the stripe-necked mongoose was usually not included among these, as it is (for unknown reasons) considered somewhat distinct from other mongoose species. These respondents described the species' affinity to streams and swampy areas (including paddy fields) where it was said to forage for crabs. While the species was reported as well as sighted in medium and high elevation forests (both during these surveys and previously), its occurrence in low elevation evergreen forests is still unclear.

In addition to the brown and stripe-necked mongooses, respondents reported the occurrence of *maddu kîri* (gray mongoose *H. edwardsi*) and *hâvu kîri* (*hâvu* = snake, unclear which species was referred to). A fourth mongoose species in south India, restricted mostly to deciduous forests and possibly disturbed evergreen forests is the ruddy mongoose (*H. smithi*) (Prater 1971, Mudappa 2002).

Other carnivores

Otters: Several respondents reported the presence of otters along streams, although they were not able to identify the species from pictures. However, given their description of the size (very small) as well as the terrain and habitat (small to medium-sized hill streams) these otters were found in, it is likely that the species found in the study area is the small-clawed otter *Aonyx cinereus,* rather than the smooth-coated otter *Lutrogale perspicillata* (which is a large species found in rivers and reservoirs in the plains) or the Eurasian otter *Lutra lutra* (a large species, whose presence in the Western Ghats needs confirmation). Throughout the study area, otters are known by the generic name *nîrnai* (*nîru* = water). Otters were reported to be common in streams within forest areas as well as in coffee and cardamom plantation areas even at considerable distances from the nearest forest, and occasionally near waterlogged paddy fields. Respondents reported that otter presence can usually be established using their spraints containing crab shells, often found on rocks along streams as reported by

Perinchery et al. (2011) and from tracks along banks. One respondent reported a sighting of 4-5 individuals, including young.

Brown palm civet: While not all respondents distinguished between brown and common palm civets, those who did identified brown palm civets as *pûbâla bĕkku*, *hûbâla bekku* (*pû* = *hû* = flower, *bâla* = *tail,* referring to the white tail-tip sometimes found in the species) or, confusingly, simply as *bekku*. Animals were most often seen at night while feeding on fruiting trees such as *Ficus spp.* or *Caryota urens*. Although the species certainly occurs in plantations and around homesteads that are adjacent to or surrounded by forests, it was not possible to determine how far from the forest boundary the species occurs, since respondents (especially those away from forests) often did not distinguish the species from the common palm civet. Previous camera trap surveys have yielded multiple photo-captures from *shola*-grasslands and medium elevation evergreen forests (D. Jathanna *unpublished data*) as well as in plantation areas ~3 km away from the forest edge (A. Goel, *pers. comm.*). Both palm civet species are heavily hunted (as also noted by Kumara & Singh 2007), usually with guns and spot-lights. However, based on the reported occurrences as well as the number of fresh scats encountered, palm civets appear to be fairly common in forests and plantations.

Common palm civet *Paradoxurus hermaphroditus*: The species is distributed widely in forest areas (where it overlaps with the endemic brown palm civet), plantations and even around small settlements. Almost all respondents were familiar with the species, and most referred to it as *kabĕkku*, while a few called it *kâdubĕkku* (*kâdu* = forest) or *kaḷambĕkku*. The species' distribution extends over most of south and southeast Asia.

Small Indian civet *Viverricula indica*: The species is known locally as *kathri bĕkku,* and occasionally as *punugu bĕkku*. It is common in forest areas as well as around settlements and paddy fields (where it was reported to hunt rats) close to forests. This species is also found across much of south and southeast Asia.

Leopard cat *Prionailurus bengalensis*: Only a few respondents knew this species. Local names reported for the species include *čhiriku bĕkku* (*čhiriku* = leopard) and *huli bĕkku* (*huli* = tiger). One respondent reported a species known locally as *kâdu kotti*, with a description that

matched either the leopard cat or the small Indian civet. All leopard cat sightings reported were from forests.

Jungle cat *Felis chaus*: Several respondents were familiar with the species, and described its penchant for raiding chicken coops in homesteads close to forests. Locally known as *kâdu bĕkku*.

Leopard *Panthera pardus*: Surprisingly few respondents reported having actually seen leopards. Most reports were of livestock killed by leopards. Several reported instances of striped hyenas *Hyaena hyaena* lifting domestic dogs are likely to also be leopards, given that these reports were from *shola*-grassland areas and wet evergreen forests along the main Western Ghats ridge; there appears to be considerable confusion between leopards and hyenas throughout the surveyed area. Local names for the leopard included *čhirathĕ*, *daragu* (= leaf litter) *huli* (Kannada) and *kirku nari* (Kodava).

Tiger *Panthera tigris*: Tigers were reported to be seen very occasionally, most often when they lifted cattle either grazing in forests or in fields adjacent to forests. The Mukkodlu valley (Mukkodlu, Mutlu, Hamiyala villages) between Pushpagiri WLS and the Kotebetta ridge appears to have a fairly regular problem of cattle depredation by tigers and leopards. However, given that confirmation of cattle depredation by tigers and leopards is carried out by forest watchers and guards not always familiar with wildlife, when the animal is not actually sighted it is possible that leopard kills may sometimes be attributed to tigers, and vice versa. Very few respondents had actually sighted tigers within the forest areas surveyed. Local names include *huli*, *pattĕ huli* (*pattĕ* = stripe) (Kannada), *pili* (Tulu) and *nari* (Kodava).

Dhole *Cuon alpinus*: A few respondents reported dhole, locally known as *kĕnnâi* (= red dog), from *shola*-grassland and evergreen forest areas in Talacauvery WLS, Pushpagiri WLS and the Kotebetta ridge.

Jackal *Canis aureus*: Jackals (*guḷḷĕ nari*) were often reported from villages, plantations and paddy fields even at large distances from the nearest forest, but only occasionally from within forests. In some forest areas, respondents reported having neither seen nor heard jackals over several years.

Sloth bear *Melursus ursinus*: The sloth bear appears to be conspicuously absent throughout the surveyed area. No respondent reported ever having seen the species or its signs (such as digging of termite mounds, or its easily identifiable scats) anywhere along the Western Ghats ridge between Talacauvery WLS and the northern parts of Pushpagiri WLS. This apparent absence was also noted in an earlier survey covering the main ridge and lower elevation areas between (and including) Brahmagiri WLS, Talacauvery WLS and the intervening reserved forests (D. Jathanna *unpublished data*). The species is known to occur in evergreen forest areas elsewhere in the Western Ghats, but these areas are contiguous with deciduous forests, whereas the Western Ghats forests in Kodagu are separated from deciduous forests by a wide belt of plantations. A few respondents reported that the species is said to be present in the low elevation semi-evergreen forests around Subrahmanya (west of Pushpagiri WLS).

Other large mammals

Sambar *Rusa unicolor*: Sambar appeared to occur at low densities in Talacauvery WLS and Pattighat RF, but seemed to be completely absent along the eastern border of Pushpagiri WLS, along the Kotebetta ridge and in the intervening Mukkodlu valley; respondents reported never having seen the species in these areas and no signs (e.g. pellets, tracks) were detected during the surveys. Given that *shola*-grassland areas elsewhere provide excellent habitat to sambar both at low (e.g. Kudremukh N.P.) and high (e.g. Nilgiris) elevations (D. Jathanna *pers. obs.*), this absence from a large area is surprising and probably indicates extremely high hunting pressures. Sambar were reported to occur along the low elevation forests along the western border of Pushpagiri WLS, west of Girigadde, in Kujimalai, Kothanadaka and near Kadamakkal.

Muntjac *Muntiacus muntjac*: The species occurs throughout the surveyed area, and is known by the local names *kĕmpa*, *kĕmma* or *kyâma*, occasionally as *kâdu kuri* (*kuri* = sheep). Occurrences recorded during the survey were in evergreen forests, *shola*-grasslands, as well as plantation areas even far away from reserved forests or PAs (but with small patches of degraded forest interspersed within plantations). Despite the fact that it is hunted fairly heavily in the area, the species appears to be widely distributed at moderate densities, unlike sambar.

Indian chevrotain: The chevrotain (also known as mouse deer), is known locally as *barikha* or *kûra haṇdi*. It is widespread in the surveyed area, and was reported from large forests at all

elevations, as well as from small patches of forests in predominantly plantation areas, although there were no reports from areas that only had plantations. It is one of the most heavily hunted species, but seems to persist despite this heavy pressure.

Gaur *Bos frontalis*: Gaur appear to be distributed patchily throughout the surveyed area. They were reported (and detected from signs) along the eastern border of Pushpagiri WLS and in Talacauvery WLS. They were also reported to occasionally visit the Mukkodlu valley. However, in most places gaur densities appear to be very low relative to similar habitats elsewhere.

Asian elephant *Elephas maximus*: Elephant signs were recorded throughout the surveyed areas. Respondents reported that elephants typically visit a locality and stay for a few days before moving on, returning after weeks or months. Many respondents' reported that elephants regularly raided crop fields. The problem appeared to be most severe around Kaloor (south of Pushpagiri WLS), villages along the eastern boundary of Pushpagiri, in the Mukkodlu valley and around Kotebetta.

Common langur *Semnopithecus entellus*: Common langur were reported by several respondents, but appear to be patchily distributed at low densities across the surveyed area. Respondents in Mandalpatti, Mukkodlu and Kotebetta reported that they had not seen langur locally.

Bonnet macaque *Macaca radiata*: Barring a few habituated troops close to forest department camps, bonnet macaques also seem to be patchily distributed and uncommon. Forest troops were reported to be extremely shy.

Lion-tailed macaque *Macaca silenus*: Because these surveys focussed more on higher altitude areas, only a few respondents reported having actually sighted lion-tailed macaques. Reported locations where the macaques were definitely sighted were Subrahmanya RF (west of Girigadde), Marigundi (Pushpagiri WLS) and Paisarimale (Pattighat RF). In addition to these, several respondents reported sightings of a *karimuccha* (*kari* = black, *muccha* = langur), which Karanth (1985) lists as a local name for the Nilgiri langur *Trachypithecus johnii*. However, given that the northernmost known distribution of the Nilgiri langur is the Brahmagiri WLS well to the south of the surveyed area, it is unlikely that the reports were of

this species. One possibility is that the name *karimuccha* refers to the common langur (descriptions of the species tended to be vague), with the *kari* being a reference to the langur's black face. None of the respondents were familiar with the names *Karingada* or *Moṇṇamuccha* listed by Karanth (1985) as local names for lion-tailed macaques in Kodagu, but used the more general Kannada name *siṇgaḷika* instead.

Slender loris *Loris tardigradus*: The species was reported from several locations within the surveyed area, from contiguous evergreen forests, *sholas*, degraded forests as well as plantation areas. While it is known as *kâdu papa* (= forest infant) in Kannada, in Kodava it is known as *čhingĕkûḷi*, and as *kâdu bale* or *uṛiyoḷu* in Tulu.

Indian pangolin *Manis crassicaudata*: Pangolins were reported from throughout the surveyed area, where they are known as *čhippandi*. Although opportunistic sightings were reportedly infrequent, the species is hunted very regularly, typically by digging them out of burrows.

Indian porcupine *Hystrix indica*: Widely distributed across the surveyed area, the species is also hunted heavily, using guns, by digging them out of burrows, and even using trained dogs.

Indian giant squirrel *Ratufa indica*: Locally known as *kĕnjari* or *kĕndaḷilu*, Indian giant squirrels seem to be distributed throughout the study area, but at low densities. They were sighted and heard in Talacauvery WLS and Pushpagiri WLS during the surveys, but appeared to be extremely wary of humans. Respondents reported that the species is hunted, but is usually extremely hard to approach.

Large brown *Petaurista philippensi* and Travancore flying squirrel *Petinomys fuscocapillus*: Most respondents only reported presence of the large brown flying squirrel, known locally as *pânja, hârabekku* or *pârabekku* (= flying cat), which is widespread. A few respondents were familiar with the Travancore flying squirrel, which is known as *ili* (= rat/ mouse) *pânja* or *daragu pânja*. The Travancore flying squirrel was reported from Pattighat RF and Sampaje RF.

Species	Known occurrences	Remarks
Nilgiri marten	KMTR, Peppara, Neyyar, Gavi, Periyar, Srivilliputtur, High Wavies, Pambadumshola, Palnis, Eravikulam, Anamalais, Valparai, Chinnar, Nelliampathy, Attapadi, Muthikkulam, Nilambur, Silent Valley, Mukurthi -Upper Bhavani, Naduvattam, Brahmagiri, Kerti, *Padinalknad*, *Talacauvery*, *Pattighat*, *Pushpagiri*, Bisle, Charmadi-Kanapadi. Not sighted / camera-trapped during surveys despite targeted effort.	Occurs at very low densities; seems to prefer (but not restricted to) higher elevations; occurs < 3-5 km from contiguous forest; persecuted by bee-keepers but apparently not usually eaten.
Brown mongoose	KMTR, Peermedu, High Wavies, Palnis, Nilgiris, Virajpet, Brahmagiris, Talacauvery, *Pushpagiri*	Not generally known even by local communities; distribution very poorly known; seems fairly common where it does occur.
Stripe-necked mongoose	KMTR, Periyar, High Wavies, Pambadumshola, Eravikulam, Anamalais, Nelliampathis, Nilgiris, Mudumalai, Bandipur, Nagarahole, Bhadra, Kudremukh, Uttara Kannada district, Padinalknad,Talacauvery, *Pushpagiri*	Broad range of habitats; fairly common but less so in evergreen forests; often along streams;
Gray mongoose	Very widely distributed and common, but less so in evergreen forests; sighted frequently in Talacauvery	More common in agricultural and semi-urban areas.
Ruddy mongoose	A dry forest species; not detected during surveys.	Reported occurrences in evergreen forests need confirmation, likely to be sightings of stripe-necked mongoose (which is actually more reddish in appearance).
Small-clawed otter	Eravikulam, Anamalais, *Padinalknad*, Talacauvery, *Pattighat*, *Pushpagiri*	Appears fairly common; easily detected from spraints; not detected in Mukurthi despite searches along streams
Eurasian otter	--	Report of occurrence in the Western Ghats needs confirmation
Smooth-coated otter	Known to occur in large rivers, reservoirs in the plains; not detected/reported during the project.	Known to be subject to hunting pressure for pelts.
Brown palm civet	Widely distributed along evergreen forest areas and adjoining plantation areas in the Western Ghats. Detected in Mukurthi, Talacauvery, Pattighat and Pushpagiri during the project.	Heavily hunted for consumption, but appears to withstand this pressure; found in plantation areas much farther from forest than known home range dimensions, likely resident in such areas. Not always distinguished from common palm civet by local communities.
Common palm civet	Wide distribution, generally in drier forests, some overlap with brown palm civets in evergreen areas. Not directly detected during the project.	Also heavily hunted but seems to persist at high densities.
Small Indian civet	Very wide distribution, common in diverse habitats. Camera trapped frequently in and around Talacauvery.	Used to be captured for production of perfume, current pressures unclear.
Malabar civet	Not detected / reported during the project.	Current status and even species status uncertain.

Table 2. Summary of occurrences of small carnivores in the southern and central Western Ghats. Underlined sites indicate direct sightings / camera trap captures / unambiguous sign detection, *italicised* sites indicate occurrences based only on secondary information from local communities during the project. All other occurrences based on published information or personal communications by biologists.

Utility and limitations of interview surveys to assess occurrence and status

Interview surveys proved to be an effective and efficient method of assessing the occurrence, status and pressures faced by small carnivores and other wildlife, but with some important caveats. First, it is imperative to filter respondents, since familiarity and knowledge about wildlife varies greatly even within forest and forest-edge communities. Having chosen knowledgeable respondents, it may be necessary to apply a second filter on the information

provided by these respondents; even extremely knowledgeable respondents often mixed natural history with local lore and myths. Simply relying on indigenous knowledge will introduce unreliable information which would be hard to separate when the information is summarised. However, while applying these filters, there may be a tendency to reject reliable information that is not consistent with previous understanding of a species' natural history or even with the interviewer's own biases, a form of confirmation bias. Thus the information generated will tend to be conservative, and may exclude reliable but unexpected results. This is a necessary limitation of relying on secondary information. However, small carnivore species cannot be surveyed using direct sightings (since they are usually elusive, rare and often nocturnal) or signs such as tracks and scats (since signs of several similar-sized species cannot be unambiguously identified to species). Camera trap surveys often work well (e.g. Mudappa 1998), but cannot be applied at large spatial scales over a short period of time. Detectability is an issue that has not been addressed in these surveys, so it cannot be assumed that species are truly absent in the areas where they were not recorded.

Conservation issues in the surveyed areas

Hunting: Local hunting is by far the most critical problem faced by many species in the surveyed area. Practised by most communities, economic and occupational groups, it is both widespread and intense. Respondents often spoke freely about hunting, even in the presence of forest department staff. Most hunting is carried out with guns (including licensed and unlicensed shotguns, or locally made muzzle-loaders, often borrowed), dogs (or a combination of guns and dogs) and snares. Respondents reported that during festivals large groups go out with dogs flushing animals that are then either shot or caught by the dogs. At other times, hunters go out alone or in small groups, and locate prey by eye-shine using improvised spotlights. Hunting at night seemed to be more common than during the day. Depending on the species, both sit-and-wait as well as walk-and-seek techniques (Madhusudan & Karanth 2002) are employed. Species such as pangolin and porcupine are dug out of burrows or trained dogs are sent into the burrows. Snares are used mainly for wild pig and black-naped hare. Mammal species reported to be hunted the most were brown and common palm civets, Indian chevrotain, wild pig, black-naped hare, porcupine, Indian giant squirrel, pangolin and muntjac. Other commonly hunted species include grey junglefowl *Gallus sonneratii* (shotguns, snares) and Indian monitor (dogs).

Given the intensity of hunting throughout the surveyed area, it is unsurprising that these species occur at extremely low densities, and are perhaps absent from large areas. During the surveys, sightings of large mammals or their signs in the area were extremely scarce compared to evergreen forests and *shola*-grasslands in other areas, almost certainly an effect of the heavy and sustained removal. Madhusudan & Karanth (2002) demonstrated that hunting intensity was significantly related to the perceived rarity of species in Kudremukh NP (north of the surveyed area) and to actual densities in Nagarahole NP. Kumara & Singh (2004) showed that differing hunting practices in Brahmagiri WLS-Kerti RF (south of the surveyed area) and Sirsi-Honnavara (far to the north) had marked effects on the relative abundances of various mammals, as measured by encounter rates. Thus, the 'empty forests' (Redford 1992) along the western border of Kodagu are a result of intensive hunting, which needs to be urgently addressed.

Cattle grazing: Heavy grazing of cattle is mainly localised to grassland areas around Talacauvery and Mandalpatti. Respondents reported that up to a few hundred cattle graze in small areas within the sanctuary boundaries at certain times of the year. Apart from leading to intense competition with wild herbivores for forage, heavily grazed areas are also subject to changes in grass, herb and shrub composition, reduced regeneration of trees, soil compaction, nutrient depletion, fires (set by graziers) and increased conflict due to depredation by large carnivores (Karanth 1985; Madhusudan 2000, 2004). During the survey, cattle and their signs (tracks and dung) were frequently encountered in these areas, unlike wild herbivores. However, given that these areas have traditionally been used as grazing grounds (*gô mâḷas*) even before notification of the sanctuaries, immediate and complete exclusion of cattle may not be feasible or desirable.

Extraction of non-timber forest produce (NTFP): Communities living close to forests in the surveyed area extract a wide range of NTFP, including *Calamus spp.* (*betta,* cane), *Garcinia spp.* (*punarpuḷi*, fruit), *Myristica spp.*(*râmpatrĕ* or *râmanadikĕ* , fruit), *Canarium strictum* (*dhûpa*, resin), *Vateria indica* (*biḷi dhûpa*, resin), *Acacia sinuata* (*sîgĕ*, fruit), *Zyziphus spp.* (*goṭṭĕ haṇṇu*, fruit), *Cinnamomum spp.* (*dâlčhini*, bark), among others. Areas that are used heavily for extraction appear extremely degraded. Large areas of low elevation evergreen forests along the western edge of the surveyed area have been degraded to moist deciduous or semi-evergreen forests from wet evergreen. Many of the species extracted are also key resources for wildlife,

including small carnivores. Extraction of NTFP also serves as a cover for carrying out other illegal activities in forests, including hunting.

Assessment of potential sites for an intensive study of small carnivores

In addition to assessing occurrence and status of small carnivores and other wildlife in the surveyed area, a second objective was to assess different localities as potential field sites for a longer-term ecological study of small carnivores. This assessment was based on the occurrence and relative abundance of the study species, landscape context of the study area (large intact forests adjacent to human-dominated plantation areas), current disturbances, habitat status, availability of knowledgeable local assistants and other logistical considerations (e.g. base camp, access to supplies). Within Karnataka, the only location that satisfied all the above requirements was Talacauvery.

II. SITE-BASED WORK IN AND AROUND TALACAUVERY WLS

Based on the findings of the initial surveys, I established camp at Talacauvery Wildlife Sanctuary (WLS) in late January 2011, after signing an MOU with the DCF, Madikeri Wildlife Division. Talacauvery WLS is located along the western border of Kodagu district, Karnataka, and straddles the main Western Ghats ridge. Because the elevation ranges from approximately 100 m above mean sea level (a.s.l) to over 1500 m a.s.l., Talacauvery WLS supports diverse vegetation types, ranging from semi-evergreen and low elevation wet evergreen along the western border, through medium elevation wet evergreen forests, to montane *shola*-grasslands in the higher elevation areas. The sanctuary has several reports of the study species based on secondary information, direct sightings and/ or camera trap captures.

Camera trap surveys

Objectives & methods

I carried out camera trap surveys of small carnivore species in the study area. These surveys were meant to i) understand fine-scale patterns of occurrence, ii) examine diel activity patterns and iii) assess the efficacy of different baits in attracting small carnivore species. Camera traps were placed 30-50 cm above the ground along small animal trails and streams

(major trails and roads were avoided since these are heavily used by cattle and people) close to the Talacauvery Anti-poaching Camp. These were located in different habitats/ micro-habitats such as *shola* interior, *shola* edge, tree plantation, ridge top, slope, valley bottom, among others. Bait used included chicken entrails, fruit and honey, as well as no bait (to assess the effect bait has on photo-capture rates).

Results

Small carnivore species photo-captured to date in the camera trap surveys include brown mongoose and brown palm civet *Paradoxurus jerdoni* (Fig. 6), both captured multiple times in different locations. Other species photo-captured include Indian chevrotain *Moschiola meminna*, Muntjac *Muntiacus muntjak*, Indian porcupine *Hystrix indica* and white-bellied wood rat *Rattus satarae* (Fig. 7). Apart from the camera trap captures, other species sighted and/ or detected from signs during this period include stripe-necked mongoose *Herpestes vitticollis*, gray mongoose *Herpestes edwardsii*, muntjac, black-naped hare *Lepus nigricollis*, bonnet macaque *Macaca radiata*, jungle striped squirrel *Funambulus tristriatus*, dusky striped squirrel *F. sublineatus*, brown palm civet (scats only), small-clawed otter *Aonyx cinereus* (spraints only), Asian elephant *Elephas maximus* (dung only), sambar *Rusa unicolor* (pellets only) and Indian porcupine (quills only). The camera trap surveys revealed that endemic small carnivore species have high photo-capture rates in Talacauvery WLS (brown mongoose: 11.9 photographs/ 100 trap-days; brown palm civet: 7.14 photographs/ 100 trap-days) relative to studies conducted in other areas of the Western Ghats (e.g. Mudappa 1998), possibly indicating healthy densities, although photo-capture probabilities may vary widely between studies, precluding such comparisons (Anderson 2001; Williams et al. 2002). Reports from local communities around Talacauvery indicate that the area also supports a healthy population of the endemic Nilgiri marten, which, however, was not captured during these surveys. The camera trap surveys have also provided useful information on optimal placement of camera traps for small carnivores. In addition, bait, especially chicken entrails, has a marked effect on photo-capture rates, and also seems to lower the incidence of false tripping (possibly by delaying animals long enough that they are captured within the frame rather than tripping the sensor but moving beyond the frame by the time the camera fires). Further, the camera trap surveys, along with the direct sightings and local reports, have also provided information on activity patterns and microhabitat use of small carnivores in the study area. The brown palm civet appears to be primarily nocturnal, while most brown

mongoose photo-captures occur late at night or very early in the morning (pre-dawn). Stripe-necked mongoose, gray mongoose and Nilgiri marten appear to be primarily (but not strictly) diurnal.

(a) (b)

Fig. 6. Camera trap captures of small carnivore species. Brown mongoose (a) and brown palm civet (b).

(a) (b)

(b) (d)

Fig. 7. Camera trap captures of other wildlife. Indian chevrotain (a), Muntjac (b), Indian porcupine (c) and white-bellied wood rat (d).

GPS mapping surveys

In addition to the camera trap surveys, I carried out surveys to map available roads, tracks and cattle trails within the study area using a hand-held global positioning system (GPS) unit. These were then imported into a geographic information system (GIS) platform and overlaid on other layers (Fig 8).

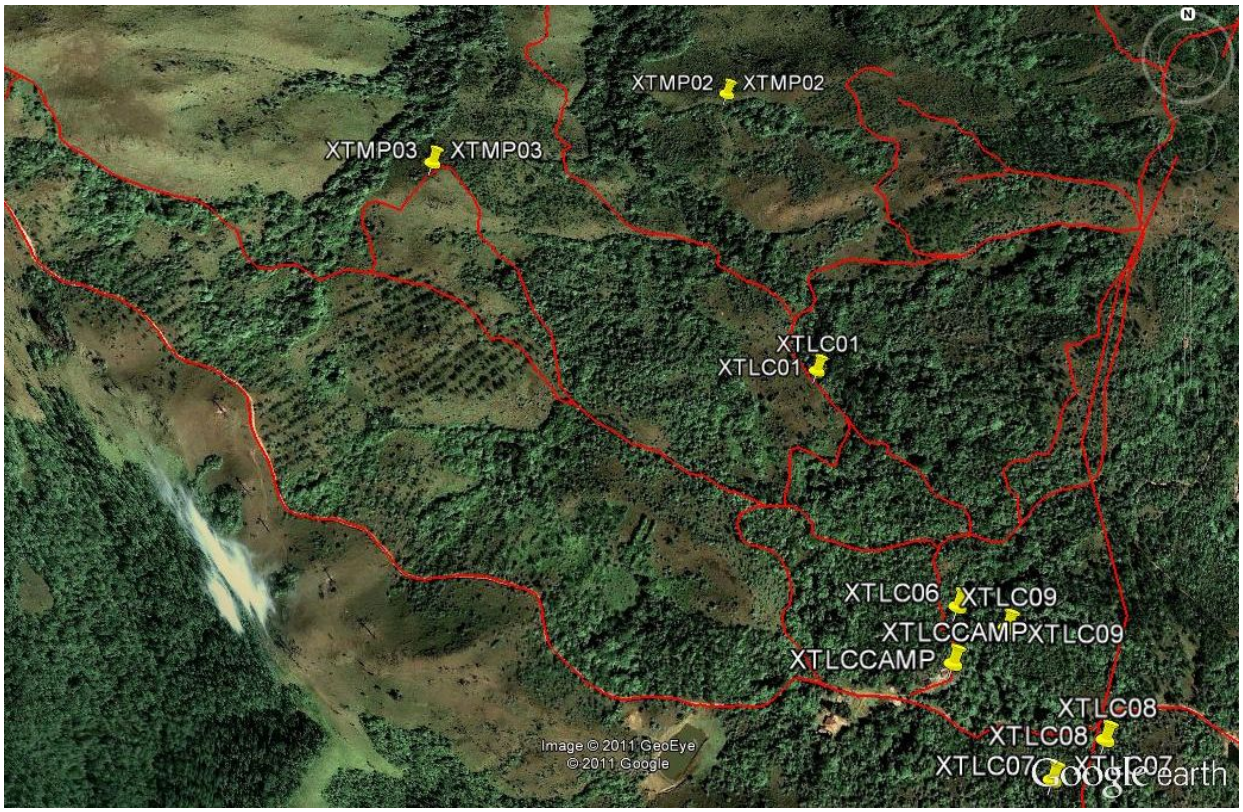

Fig. 8. Roads, cattle trails and human trails in a part of the study area, along with key waypoints, overlaid on a GoogleEarth image.

Scat collection surveys and genetic work

I also collected small carnivore scats in the study area and stored them in vials of absolute ethanol. These will be used to understand diets of the study species. Because identification of species based on morphology of the scat can be uncertain and ambiguous, I spent some time at the National Centre for Biological Sciences to learn laboratory genetic techniques such as extraction from scats/ tissue, polymerase chain reaction (PCR), agarose gel electrophoresis and sequencing, to eventually enable identification of small carnivore species from their scats. I also visited the Bombay Natural History Society (BNHS) museum in Mumbai in early October 2011 and collected samples from 3 Nilgiri martens, 2 brown mongooses, and 3

stripe-necked mongooses (see Fig. 9). These samples were initially obtained in Nilgiris, Coorg and Tranvancore (marten and stripe-necked mongoose) and Sri Lanka (brown mongoose) between 1913 and 1924. The genetic work has been postponed till I am able to obtain blood samples during live capture, in the current phase of my project, so that primers can be developed for both species identification (typically using mitochondrial DNA markers) and for individual identification (typically using microsatellite markers).

Figure 9. One of the specimens of Nilgiri marten from which samples were collected.

Design of hair snare surveys

During early-mid 2011, I designed hair snare surveys of Nilgiri martens within the study area. As indicated by the initial surveys, the species is known to raid bee boxes kept in plantations and apiaries adjacent to the sanctuary. I used bee boxes as bait to attract the species, and attempted to 'capture' hair by setting up a corral around each box covered with glue paper (originally meant to capture insect pests). These hair captures are known to yield DNA (Frantz et al. 2004, Zielinski et al. 2006, Kendall &McKelvey 2008, García-Alaníz et al. 2010), that can then be used for species and individual identification, permitting 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 carried out field trials of baited hair snares to assess efficacy of different approaches. A few bee boxes were purchased from nearby beekeepers, and I experimented with different options (snare placement, height of the corral, type of material, etc.). However, given the small number of hair snares that were deployed during this initial phase as well as forest department restrictions which prevented me from deploying more traps in a larger area, I was not successful in obtaining hair captures of Nilgiri martens. However, subsequent work using other bait provided very high captures of brown mongoose and carefully designed baited hair snare surveys for brown mongoose will be carried out in the current phase of my project.

Other activities during the project period

Courses and workshops conducted

During the tenure of this project I conducted courses on *Animal Population Ecology: i) Dynamics; ii) Sampling, Modelling & Estimation* and served as TA for the module on *Carnivores*, for the 2010-2012 & 2012-2014 batches of students, NCBS-CWS M.Sc. in Wildlife Biology & Conservation. In June 2010, I helped conduct (along with Dr. Ullas Karanth and Arjun Gopalaswamy) a data analysis concepts and applications workshop for the WCS-Panthera Foundation supported *Tigers Forever* initiative in Bangkok, for WCS country programs from Thailand, Cambodia, Myanmar, Laos, Malaysia, Indonesia and Russia. In August 2010, I conducted a class on *Population monitoring for wildlife conservation* for the Conservation Biology course organised by ATREE. In June 2011, I was invited to the Borneo Carnivore Symposium held in Kota Kinabalu, Sabah, Malaysia, as a resource person on methods to study carnivores. In late October-early November 2011, I was invited (along with Dr. Ullas Karanth and Arjun Gopalaswamy) to conduct an advanced course on *Animal Population Sampling and Analysis* at the Wildlife Institute of India, Dehradun for faculty and researchers of the institute. In January 2013, I was a resource person, along with Drs. D. R. Anderson, J. D. Nichols, K. U. Karanth, R. Sollmann and J. E. Hines, at an international workshop on *Analysis and Management of Animal Populations* at the Wildlife Institute of India, Dehradun. The workshop was jointly organised by Wildlife Conservation Society-India, Wildlife Institute of India and the Centre for Wildlife Studies. The invited participants included faculty, researchers and students from research institutions and organisations across India. I conducted a long workshop on *Occupancy sampling, modelling & estimation* at the Students' Conference on Conservation Science, Bangalore, September 2013. I also conducted a session

on *Population Estimation and occupancy modelling* at the IUCN SSC Otter Specialist Group's Asian Otter Conservation Meet, November 2013; sessions on distance sampling and capture recapture concepts and software sessions at the NTCA Phase IV Section 3 tiger-prey monitoring workshop organised by WCS-India, Bangalore, November 2013; and 2-3 day workshops for CWS/WCS-India research staff on concepts and applications of capture recapture (2011, 2012, 2013) and distance sampling (2013).

Visiting scholarship at Duke University

The project was temporarily suspended for 5 months during early 2012 as I was invited to visit Prof. Stuart Pimm's lab at the Nicholas School of the Environment (NSOE), Duke University, NC, USA as a visiting scholar for 4 months. While at Duke, I was able to attend three courses offered by NSOE faculty:

Models for environmental data, by Prof. James S. Clark focused on combining models and ecological data, and covered model building, computation and assessment, using both likelihood-based and Bayesian frameworks for inference.

Tropical ecology, taught by Prof. John Terborgh and Dr. Varun Swamy covered a range of topics relevant to ecologists conducting field studies in the tropics, from the causes of climate, through patterns in plant diversity at different spatial and temporal scales, succession, ecophysiology, mineral cycles, factors maintaining tropical diversity, functional interactions between plants, herbivores, frugivores and carnivores, role of predators in forest systems, trophic cascades, among many others.

Movement modeling was a seminar course led by Dr. James Clark. The focus was on hierarchical modeling of telemetry data where the observation and process parts of the model are clearly separated, and consisted of weekly group discussions of papers that used these approaches.

I was also able to interact with several students, researchers and faculty at Duke on various topics of mutual interest. I advised several students on designing surveys to estimate animal population parameters and analysing data from such surveys. I also gave a lecture at the *Big Cats Initiative* course led by Prof. Stuart Pimm on conceptual issues underlying abundance and density estimation for large felids, as well as field application of commonly used approaches.

Activities in late 2012 and early 2013

Following my return from Duke University, I resubmitted an application to the Karnataka Forest Department, for live capture and radio-telemetry work, continuation of the earlier camera trap and scat surveys and easing of the restrictions imposed in the original permit. Following numerous and protracted discussions, queries, clarifications and a presentation, the PCCF (Wildlife) issued a permit for live capture, radio-tagging and radio-tracking in March 2013; however finalising the MOU with the local DCF took several visits to Madikeri and was completed only in late-May 2013. As soon as the PCCF's permit was granted, I started the process of contacting manufacturers of radio-telemetry equipment, identifying equipment to be purchased (from Advanced Telemetry Systems and Communication Specialists, both in the US), placing orders and obtaining customs clearance for the import of the equipment. At the same time I discussed and started fabrication of mesh box traps (for safe live capture of small carnivores) with Mr. A. Javaji, Trogon Technologies, and the manufacture, testing and subsequent modification of the traps continued till mid-September 2013 (Fig 10), after which I returned to the field, set up camp and started pre-baiting prior to live capture (i.e. just after the tenure of the CEPF project).

Fig 10: A box trap placed in a plantation area near Talacauvery

Conclusion

Despite long and unanticipated delays in obtaining the requisite permits and the severe restrictions imposed initially, the project has managed to generate substantial amounts of information and understanding of the three study species, other carnivores as well as other wildlife in different areas of the Western Ghats, and particularly in and around the intensive study site (Talacauvery WLS). In addition, the initial work has allowed me to develop a strong rapport with local communities as well as forest department staff in and around

Talacauvery, and this on-going engagement will be critical during the current phase of my research. I am happy to report that the project has generated a lot of interest in the study species, especially the Nilgiri marten, among the forest department officers and staff. All this will hold me in good stead during the current phase of my research, when I am finally able to carry out radio telemetry-based research on these poorly understood species.

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