VERTEBRATE ZOOLOGY

63 (1): 111 – 121
30.4.2013

SENCKENBERG

Small carnivores in the Annapurna Conservation Area, Nepal

Angelika Appel[1*], Geraldine Werhahn[2], Raju Acharya[3], Yadav Ghimirey[3] & Bidhan Adhikary[3]

[1] Independent conservationist, Bad Marienberg, Germany; * Corresponding author: angie(at)wild-cat.org — [2] Wildlife biologist and conservationist, Salenstein, Switzerland — [3] Friends of Nature, P.O. Box 23491, Kathmandu, Nepal

Accepted 07.ii.2013.
Published online at www.senckenberg.de/vertebrate-zoology on 19.iv.2013.

Abstract

The leopard cat *Prionailurus bengalensis*, large Indian civet *Viverra zibetha* and yellow-throated marten *Martes flavigula* are widely distributed through much of South and Southeast Asia, but their ecology remains poorly understood. We recorded these small carnivores during a camera trapping survey in the eastern mid-hills of the Annapurna Conservation Area, Nepal. This protected area is the largest in the country and represents Himalayan mountain ecosystems. Our study area comprised an elevation range of 1550 – 2950 m in upper subtropical to upper temperate bioclimatic zones. During a sample effort of 370 trap days, leopard cat was the most commonly recorded carnivore, followed by large Indian civet and yellow-throated marten. We obtained the highest altitudinal record of a large Indian civet in Nepal at an altitude of 2420 m. Capture rates for small carnivores were broadly similar across bioclimatic zones. The level of human activity was low in the temperate bioclimatic zone during the late winter season when the study was conducted.

Key words

Leopard cat, large Indian civet, yellow-throated marten, camera trapping, capture rate, central Himalaya.

Introduction

Published information about the distribution and ecology of small carnivores in the Himalayas is sparse. In Nepal, wildlife scientists and conservationists focused on charismatic and flagship species during the past 40 years. Tiger *Panthera tigris*, Great Indian rhinoceros *Rhinoceros unicornis*, and gharial *Gavialis gangeticus* in the subtropical jungles of the Himalayan foothills attracted the attention of foreign (McDougal 1977) and Nepali researchers (Adhikari 2002, Maskey 2008). Since the mid-1980s, snow leopard *Panthera uncia* in the high-altitude mountains became a second focus (Jackson 1996, Ale and Karky 2002). The late Pralad Yonzon was the first conservation biologist who also ventured into the country's mid-hills to study red panda *Ailurus fulgens* (Yonzon 1989). But still, there is clearly a substantial deficiency in baseline ecological data about carnivores in Nepal's mid-hill belt, in spite of them playing an important role in the forest ecosystems regulating mammal and bird populations.

In this article, we report capture rates for leopard cat *Prionailurus bengalensis*, large Indian civet *Viverra zibetha* and yellow-throated marten *Martes flavigula* obtained during a camera trapping survey in the eastern mid-hills of the Annapurna Conservation Area. We analyse activity pattern and habitat use of these species, discuss threats they face in the study area, and compare capture rates with reports from protected areas of South and Southeast Asia.

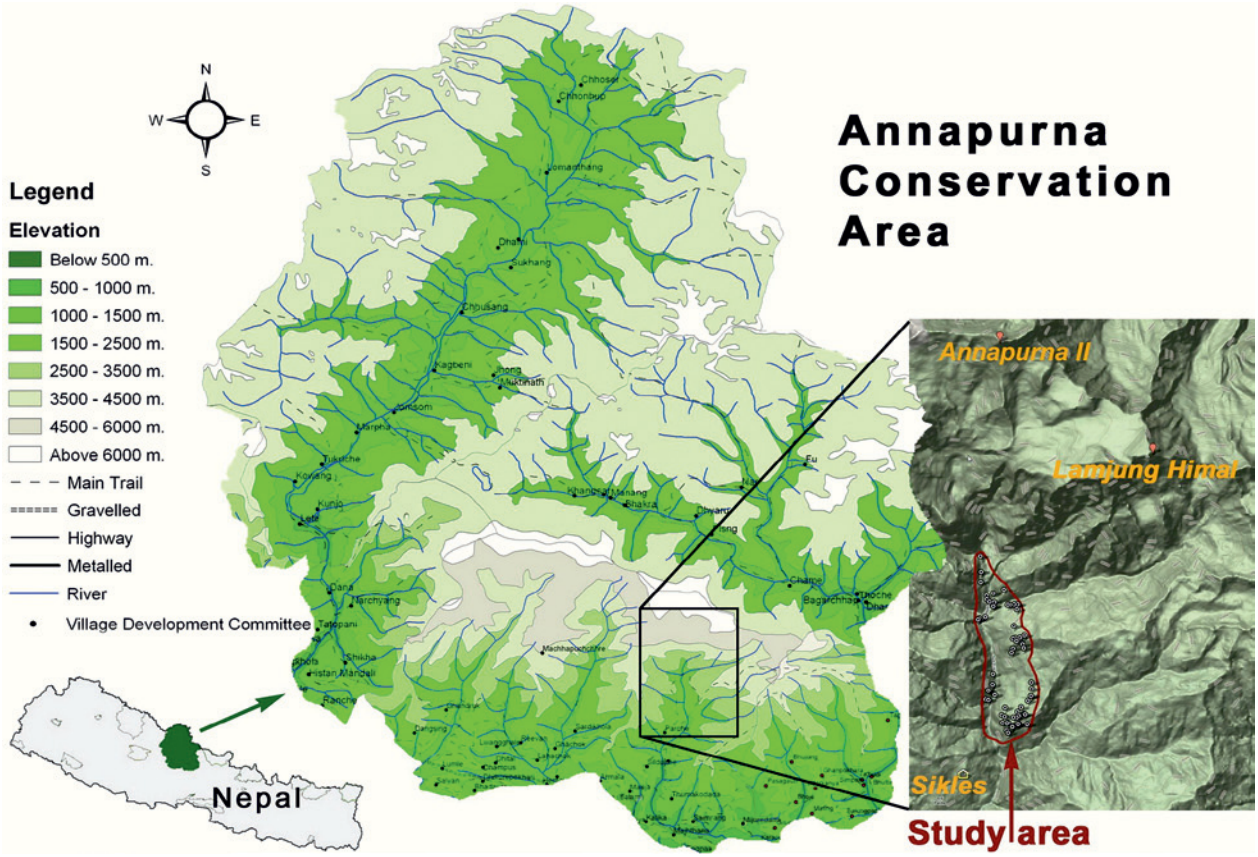

Fig. 1. Map of the ACA with study area marked in red.

Study area

The Annapurna Conservation Area (ACA) is located in the central Himalayas and is the largest protected area in Nepal extending over 7,629 sq km. It was established in 1985, and since 1992 is managed by the National Trust for Nature Conservation, a national NGO. The ACA represents mountain ecosystems to the north and south of the Himalayas and covers tropical, temperate, alpine and nival climatic regions, harbours 22 different forest types and 97 mammal species (BHUJU *et al*. 2007). The entire area is recognized as a global biodiversity hotspot (MYERS *et al*. 2000), and is one among the important Global 200 ecoregions (OLSON & DINERSTEIN 1998). The seasonal climate is dominated by the monsoon occurring between June and September. Annual rainfall in the southern Annapurna region is 3000 mm. Mid-hills in the ACA range from 1001–3000 m altitude and comprise the greatest ecosystem and species diversities in Nepal (BHUJU *et al*. 2007). These mid-hills are steep and canyoned by myriads of precipitous gorges and ravines, burbling creeks and spectacular waterfalls coercing travellers to wander up hill and down dale on narrow trails.

Our study area was located in the Hugu-Kori forest in the eastern mid-hills of the ACA, south of the peaks of *Annapurna II* and *Lamjung Himal* (Fig. 1). Our survey area lies in the upper reaches of the *Madi River* that cuts a deep gorge between the hills. The core area encompassed by camera traps comprised 10.55 sq km stretching between 28° 22.2′ N / 84° 7.4′ E in the south to 28° 26.9′ N / 84° 6.8′ E in the north, and from 28° 23.5′ N / 84° 8.2′ E in the east to 28°25.2'N / 84°6.7'E in the west. We covered an elevation ranging from 1550 m to 2950 m in upper subtropical to upper temperate bioclimatic zones, where the vegetation is dominated by *Quercus glauca* and accompanied by *Rhododendron*, *Ficus*, *Himalayacalamus asper* and *Daphne papyracea*. Various fern species form dense undergrowth. This mixed broadleaf forest is interspersed with shrubland, patches of grassland and barren land along riparian corridors. The area is off the main trekking route, and was fairly undisturbed during the late winter season when the present study was conducted. The nearest village *Sikles* is located a one- to two-day's walk to the south at 1920–2050 m altitude, and has about 4,000 inhabitants; their main source of subsistence is agriculture (GURUNG *et al.* 2011).

DOBREMEZ (1972) combined climatic and phytogeographic regions for describing vegetation in the Himalayas of Nepal. In the subsequent sections, we will follow his classification of bioclimatic zones and refer to the elevation range of 1501–2000 m as upper subtropical bioclimatic zone (USB zone), to the elevation range of 2001–2500 m as lower temperate bioclimatic zone (LTB zone), and to the elevation range of 2501–3000 m as upper temperate bioclimatic zone (UTB zone).

Table 1. Sampling effort.

Elevation range	West of Madi River		East of Madi River	
	Sites	Trap days	Sites	Trap days
1577 – 1999 m	5	29	3	7
2003 – 2494 m	6	27	35	258
2510 – 2928 m	1	6	9	43
Total	12	62	47	308

Table 2. Small carnivores recorded in our study area. * Capture rate (CR) = number of trap days per IC of a species (Carbone *et al*. 2001)

Species	ICs obtained	Elevations (in m)	Capture rate*
Leopard cat	32	one IC each at 1577, 1665, 2064, 2154, 2161, 2235, 2250, 2269, 2315, 2409, 2510, 2575, 2607, 2928 two ICs each at 1956, 2031, 2052, 2449 three ICs each at 2403, 2420 four ICs at 2174	11.56
Large Indian civet	11	one IC each at 1577, 2049, 2250, 2420 two ICs each at 2126, 2174 three ICs at 2128	33.64
Yellow-throated marten	10, including one video clip	one IC each at 2061, 2067, 2162, 2174, 2235, 2364, 2434, 2575, 2703 video at 2420	37. 0

Materials and Methods

Our survey was the first camera trapping survey conducted in this area, designed to identify the presence of wild cats, in particular clouded leopard *Neofelis nebulosa* and Asian golden cat *Pardofelis temminckii*. Camera trapping was carried out from 18 January to 20 February 2012, using 12 YetiCam units equipped with Sony DSC-P32 cameras and three Reconyx RM45 Rapidfire trail cameras. We mounted them at a height of 30 – 60 cm above ground, and kept the aerial distance between two consecutive camera traps at 100 – 1600 m depending on the accessibility of suitable trees bordering on wildlife trails. We used a Garmin GPS 60CSX unit to record coordinates, elevation and slope of each camera trap location, and noted habitat characteristics and crown coverage.

Captures taken during a total of 370 trap days comprised both still photographs and video clips. During 364 trap days, camera traps were set to photographic mode for 24 hours. During the remaining six trap days, one camera was set to video mode and operated only during day light hours (approx. 72 hours in total) as it is not equipped with automatic video back light.

We count captures showing single individuals and social units of several individuals as one detection for the species. Based on O'Brien *et al.* (2003), we define the independence of capture as (1) non-consecutive images of the same species, (2) consecutive images of the same species taken at an interval of more than 30 minutes, and (3) successive images of different individuals or, for social species, social units. We used time data on the camera trap images to analyse activity pattern of recorded small carnivores, and obtained sunset and sunrise times using the database of the Astronomical Applications Department of the United States Naval Observatory (2012).

Results

We deployed camera traps in 59 sites with a total sampling effort of 370 trap days. In 46 sites trapping sessions lasted an average of 7.3 days ranging from five to 13 days, and 13 sites were chosen opportunistically for one to four days. Our sample effort was concentrated in the LTB zone in the hills east of the *Madi River*. Details are presented in table 1.

Our sampling effort yielded 1060 captures of vertebrate species, resulting in a total of 215 independent captures (ICs), out of which 149 ICs (68.66 % of all) account for wild mammals: ungulates (55 ICs, 25.35%), cats (53 ICs, 24.42%), rodents (16 ICs, 7.37%), civets (11 ICs, 5.07%), mustelids (10 ICs, 4.61%), bears (3 ICs, 1.38%), and primates (1 IC, 0.46%). Details about ICs of small carnivores photographed in our study area are presented in table 2.

The remaining ICs comprised birds (49 ICs, 22.58% of all) and unidentifiable furry wildlife (5 ICs, 2.3%), livestock (10 ICs, 4.61%), dogs (3 ICs, 1.38%) and a single local person (1 IC, 0.46%). Human and livestock activity in the elevations differed significantly. All ten ICs of livestock and two ICs of dogs were recorded in two trap sites in riverine area below 2090 m. Five of the livestock ICs (50%) show a large herd of goats accompanied by a herder that travel from their camp site to pasture land and back, crossing the small bridge shown in Fig. 6. One dog and a single local man were photographed in shrubland at an elevation of 2162 m on 18 and 19 February.

Potential prey species of small carnivores recorded during our survey include mice and birds. Of 16 ICs de-

picting rodents, 12 ICs (75%) were taken of mice *Apodemus*, three ICs of Himalayan crestless porcupine *Hystrix brachyura,* and one capture of an orange-bellied Himalayan squirrel *Dremomys lokriah.* The birds photographed include kalij pheasant *Lophura leucomelanos* and laughingthrushes *Garrulax.* We frequently noted calls and droppings of hill partridge *Arborophila torqueola* and satyr tragopan *Tragopan satyra*.

Leopard cat

Leopard cat was the most commonly recorded carnivore in our study area, with the northernmost IC taken at 28°25.819'N / 84°7.137'E. In the USB zone, we obtained four ICs in 36 trap days (CR 9) from three sites located in forest and shrubland. In the LTB zone, we obtained 24 ICs in 285 trap days (CR 11.88) from 14 sites, of which one was in riverine habitat and 13 in forest. Four ICs were taken in 49 trap days (CR 12.25) from four forested sites in the UTB zone.

All 32 ICs show single individuals on the ground. One IC (3.13%) was taken 57 min before sunset, 25 ICs (78.13%) were taken after dark between 19:54 h and 5:51 h, three ICs (9.38%) 25–52 minutes before sunrise, and three ICs (9.38%) 31–92 minutes after sunset. We did not obtain any capture during day-light hours, indicating a chiefly nocturnal activity during the study period.

Photographs were clustered around four locations (Fig. 3). In the hills west of the *Madi River*, two ICs were taken in 62 trap days (CR 31), both below 1670 m. This south-western part of the study area is a day's walk from *Sikles*. East of the river, we obtained 30 ICs in 308 trap days (CR 10.27) clustered around three locations above 2019 m altitude. The northern cluster comprises five ICs taken in the forest and two ICs in riverine habitat. This cluster is traversed by a tributary of the *Madi River*, but a small bridge built for livestock crossing (seen in Fig. 6) connects trails between the south-eastern and north-western hills. The eastern cluster includes all ICs taken above 2500 m altitude. ICs in the southern cluster were all taken in forested habitat in the LTB zone.

Large Indian civet

Large Indian civet was recorded only in the southern part of the surveyed area (see Fig. 5), with the northernmost IC taken at 28°23.327'N / 84°8.157'E. In the USB zone, we obtained one IC in 36 trap days (CR 36) in a forested habitat (Fig. 4). In the LTB zone, we obtained 10 ICs in 285 trap days (CR 28.5) from six sites, one of which was located in shrubland and the remaining in forested areas. In the UTB zone, we did not obtain any image in 49 trap days. The photograph taken on 7 February at 3:14 h at the elevation of 2420 m at 28°23.327'N / 84°8.157'E constitutes the highest altitudinal record of a large Indian civet in Nepal.

Fig. 2. Leopard cat at an altitude of 2449 m (Photo: Friends of Nature).

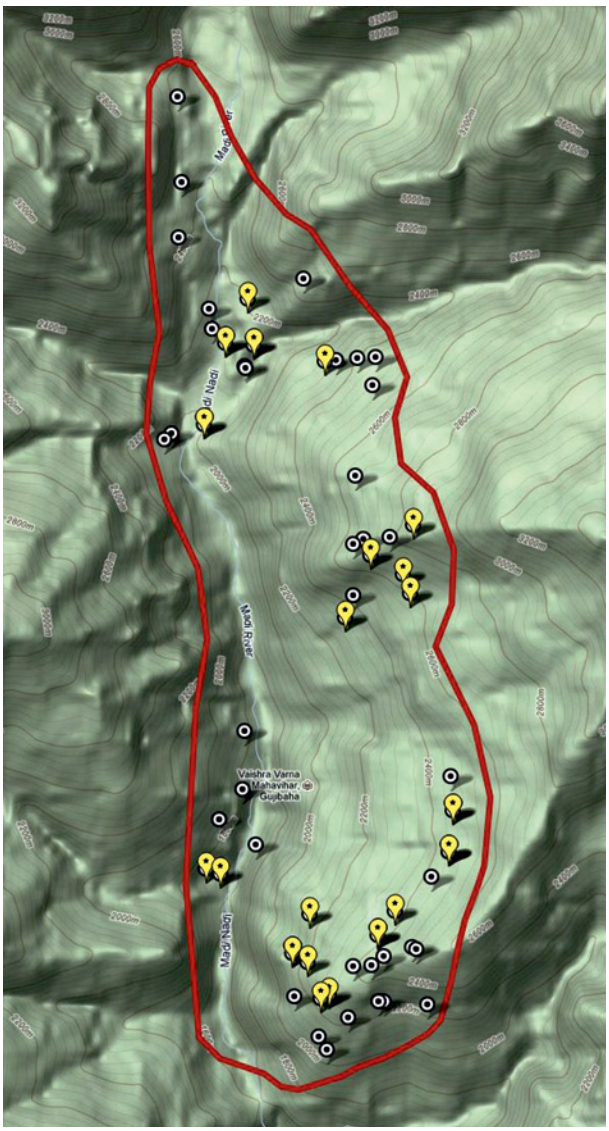

Fig. 3. Leopard cat records marked in yellow.

Fig. 4. Large Indian civet at an altitude of 1577 m in the Hugu-Kori forest. Photo: Friends of Nature.

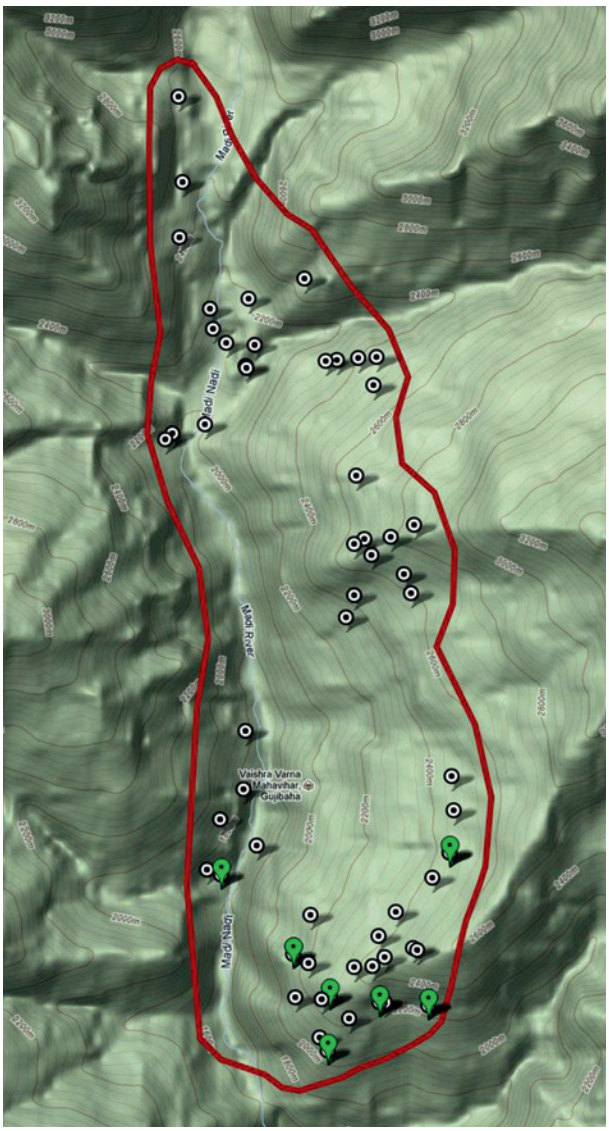

Fig. 5. Large Indian civet records marked in green.

All ICs show single individuals on the ground. They were photographed after dark between 89 minutes after sunset (2 ICs) and 88 minutes before sunrise (1 IC). Eight ICs (72.73%) were taken at night between 20:30 h and 4:52 h, indicating a chiefly nocturnal activity at this time of year.

Photographs were clustered around two locations in forested habitat (Fig. 5). Only one was taken in the hills west of the *Madi River* in 62 trap days (CR 62) at 1577 m altitude in the south-western part of our study area. East of the river, we obtained 10 ICs in 308 trap days (CR 30.8) that were concentrated in forested habitat on the southerly exposed slope of the hill. The area encompassed by the outermost coordinates of this cluster is 114.16 ha computed using the Gauss' area formula. ICs in this cluster were taken within 10 days.

We obtained four photographs of large Indian civet at the same location as leopard cat within one day of each other. In one occasion large Indian civet visited a location 2.5 days later than leopard cat.

Yellow-throated marten

Yellow-throated marten was recorded as far north as 28°25.541'N / 84°7.586'E. We did not obtain any capture in the USB zone. In the LTB zone, we obtained eight ICs in 285 trap days (CR 35.63), of which one IC was taken in riverine habitat (Fig. 6). Nine ICs were taken along wildlife trails in forested areas (Fig. 7) including two ICs in 49 trap days (CR 24.5) in the UTB zone.

All ICs show martens on the ground. Six ICs of all (60%) depict single individuals, including one captured at the foot of a tree climbing upwards. Two individuals were captured in three ICs (Fig. 7), and one IC depicts three martens (Fig. 6). They were photographed from 23 minutes after sunrise (1 IC) during day-light hours (8 ICs) to 21 minutes before sunset (1 IC), indicating a chiefly diurnal activity.

Photographs were clustered around three locations in the east of the river (Fig. 8). The northern and southern clusters are situated in the LTB zone, and the small one in the centre above 2570 m altitude. In each cluster, single individuals as well as groups were photographed.

We obtained six ICs at locations where none of the other small carnivores were captured. Three ICs were taken at the same location as leopard cat within one to two days of each other. One was captured about 14.5 hours later than large Indian civet at the same location.

Discussion

Our camera trapping effort revealed the presence of a small carnivore community comprising at least leopard cat, large Indian civet, and yellow-throated marten. Cap-

Fig. 6. Three yellow-throated martens chasing each other near a tributary of the Madi River at an altitude of 2023 m. Photo: Friends of Nature.

Fig. 7. Yellow-throated marten in the Hugu-Kori forest waiting for his mate that is rummaging about in the background. Photo: Friends of Nature.

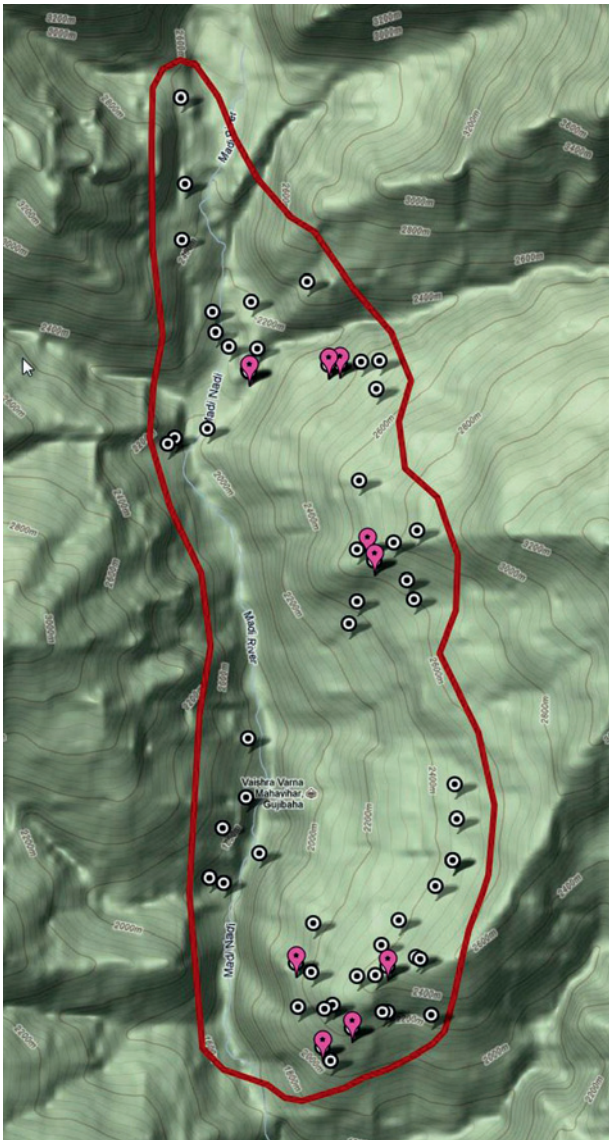

Fig. 8. Yellow-throated marten records marked in pink.

ture rates suggest that they constitute the major small predators of the surveyed area. They were camera-trapped at broadly similar rates in the LTB zone (CR 6.79), below 2000 m (CR 7.2) and above 2500 m (CR 8.17). All ICs show adult, or at most subadult, individuals without the company of offspring.

In the end of January it was snowing for a few days at elevations above 2000 m, with temperatures around freezing point in the early morning. All ICs of small carnivores obtained above 2500 m were taken during the first five days of February, when snow had melted but temperatures in the night were still below 5ºC (41ºF). Therefore, we consider it likely that our slightly lower capture rates in this elevation range reflects the sparse food resources at this time of year.

We recorded the highest level of human disturbance (CR 26.43) in elevations below 2060 m, where 12 of 14 ICs depicting local people and livestock were captured between 29 and 30 January. They do not use higher elevated pastures during winter and spring, but four temporary campsites at altitudes of 2200–2550 m indicate that these are in use during the summer and monsoon months. Therefore, it will be thrilling to survey this area at a later time of year and to document, how the increasing presence of humans and livestock affects the carnivore community in the Hugu-Kori forest.

The limited duration of our survey does not allow inferences about the general or seasonal absence of small carnivores and their detectability in forested habitats and steep terrain. We will now list all the other small carnivores of the subtropical and temperate zones of Nepal that we did not record, and discuss possible reasons.

Masked palm civet *Paguma larvata* is one of the major predators inhabiting the temperate zone of the eastern Himalayas, and was frequently recorded by camera traps at elevations of 1750–2700 m in Sikkim (Sathyakumar *et al*. 2011). In February 2008, one individual was sighted at an altitude of about 2200 m in a forest patch

at Phulchoki Hill located about 27°37'N / 85°16'E in the southeast of the Kathmandu Valley (Hem Baral pers. comm.). Our lack of records suggests it may avoid wildlife trails. Small Indian civet *Viverricula indica* is considered rare in the western Himalayas (Sathyakumar 1999), but common in the north-eastern part of its Indian range (Choudhury 1999). It is mostly camera-trapped in grasslands and in riverine habitat (Mudappa 2002), and prefers dense shrubbery for resting and foraging (Su Su & Sale 2007). Common palm civet *Paradoxurus hermaphroditus* is common in Himalayan forests (Choudhury 1999), but finds most of its year-round needs of shelter and food in dense canopy where it feeds on up to 21 species of fruit; ground-dwelling animal prey forms only a minor part of its diet (Su Su & Sale 2007). Due to their semi-arboreal life style (Su Su & Sale 2007), both civets are not detected by ground-level camera traps as frequently as terrestrial small carnivores. The semi-arboreal spotted linsang *Prionodon pardicolor* is uncommon all over its range and rarely observed (Van Rompaey 1995, Choudhury 1999) as it is probably an ambush hunter in the understorey (Will Duckworth pers. comm.). Ghose *et al*. (2012) accounted of only the second photographic record in India where two individuals were captured at altitudes of 2569 m and 3014 m in forested habitats in Sikkim in early spring 2012.

Crab-eating mongoose *Herpestes urva* has historically been reported from the ACA along the banks of streams (Baral & Shah 2008), but has not been recorded above 1200 m in the Prek chu watershed of the Khangchendzonga Biosphere Reserve, Sikkim, despite intensive camera trapping effort (Sathyakumar *et al*. 2011). Small Asian mongoose *Herpestes javanicus* inhabits a wide variety of habitats ranging from the vicinity of human habitations, scrublands and grassland (Choudhury 1999) to open lowland degraded deciduous forest (Duckworth 1997) with records up to 5000 feet (1524 m) in the Kathmandu Valley (Hinton & Fry 1923). It has rarely been sighted in evergreen and semi-evergreen forest (Duckworth et al. 2010). Yellow-bellied weasel *Mustela kathiah* is considered common across the Himalayas at the elevation range of 1800–4000 m (Sathyakumar 1999), and has been sighted in a degraded montane forest patch and a scrubby coombe in Laos (Duckworth and Robichaud 2005). It was recorded by a camera trap at an altitude of 2457 m in the Makalu-Barun National Park in eastern Nepal but at a quite low CR of 1184 (Ghimirey & Acharya 2012). Small Asian mongoose and yellow-bellied weasel successfully evaded camera traps employed during several months in protected areas in Arunachal Pradesh of north-eastern India (Datta *et al*. 2008), in the eastern Himalayas (Sathyakumar *et al*. 2011), and in Myanmar (Than Zaw *et al*. 2008). One of the least-known mustelids in the world, the stripe-backed weasel *Mustela strigidorsa* (Abramov et al. 2008) is listed as occurring in the ACA (Baral & Shah 2008), though Abramov *et al*. (2008) traced no solid records from Nepal; it has lastly been recorded from Sikkim in the 19th century, and is suspected to be an inconspicuous denizen of under-surveyed regions (Grassman et al. 2002). Both Siberian weasel *Mustela sibirica* and mountain weasel *Mustela altaica* are reported from the ACA and adjacent national parks (Jnawali *et al*. 2012), but have been recorded by Sathyakumar *et al*. (2011) only above 3000 m and 4000 m, respectively.

Jungle cat *Felis chaus* is the most common wild cat in Nepal (Jnawali *et al*. 2012) and in India (Mukherjee 2004) where it was photographed at elevations of 1750–4010 m in Sikkim at a CR of 744.7 (Sathyakumar *et al*. 2011). Its preference for open and scrubland habitats (Mukherjee 2004) and the hunting pressure therein may explain the paucity of records in closed forests in the cat's Indochinese range (Duckworth *et al*. 2005) and the lack of records in mixed evergreen and deciduous forests of protected areas in Thailand (Grassman 2003, Jenks *et al*. 2011). Golden jackal *Canis aureus* is fairly common in much of its range, and inhabits forested, mangrove, agricultural and semi-urban habitats in India (Jhala & Moehlman 2004). In the Himalayas, jackal ascend occasionally into alpine habitats (Baral & Shah 2008), but has been recorded only below 2500 m in Sikkim at a low CR of 1407 (Sathyakumar et al. 2011). Bengal fox *Vulpes bengalensis* allegedly occurs up to temperate zones in protected areas adjacent to the ACA (Baral & Shah 2008), but avoids dense forest, and prefers flat and undulating terrain in grassland habitat (Johnsingh & Jhala 2004). The siting of our camera traps along trails was equally inappropriate to find Eurasian otter *Lutra lutra* and smooth-coated otter *Lutrogale perspicillata* as both are closely associated with streams and lakes with bank side vegetation, and migrate to lower altitudes during winter; rising temperatures and increasing availability of spawning fish entice otters to use higher elevations during spring, summer and monsoon seasons (Kafle 2009). Hog badger *Arctonyx collaris*, large-toothed ferret badger *Melogale personata* and honey badger *Mellivora capensis* are reported to occur in subtropical and temperate forests of Nepal, but have not been sighted in the ACA (Baral & Shah 2008, Jnawali *et al*. 2012). Latter was photographed by a camera trap deployed for tiger monitoring in the Chitwan National Park located in the country's subtropical Terai lowlands (Gurung 1983).

Hunting, firewood collection and seasonal livestock herding in high elevation pastures cause the main disturbances in the forests of this area. It is common practice for the human inhabitants of the ACA to use trees for timber and firewood, and to collect non-timber forest products (NTNC 2009). According to local people, hunting of birds and deer (Cervidae) is prevalent in the area. During excursions in our study area, we found only one stone trap set up for catching large carnivores, and one smaller wooden trap for catching birds. The main potential threat to small carnivores in the Hugu-Kori forest of the ACA is livestock grazing, since herders are accompanied by dogs that may sniff out and cause the death of many ground-sleeping nocturnal mammals that would otherwise not be found by people.

Leopard cat

Our camera trapping results indicate that the leopard cat is the most commonly recorded carnivore in the Hugu-Kori forest of the ACA. The clustering of ICs suggests that there are at least four individuals resident in our study area:

- three in the hills east of the river; and
- one in the hills west of the swiftly flowing *Madi River* that can be crossed by people using a suspension bridge south of the study area.

Results of the most comprehensive study of leopard cats to date showed a similar spatial pattern: in a tropical forest habitat radio-collared males moved 1.0 – 1.6 km daily in home ranges of up to 5.8 sq km, while the female used home ranges of about half this size (Grassman 2000).

The globally highest altitudinal record of a leopard cat was obtained in September 2012 at 4500 m in the Kangchenjunga Conservation Area (WCN 2012), located farther east in the Himalayas. Since in 25 of 32 cases, leopard cats passed our camera traps well after dark, we corroborate their mainly nocturnal activity pattern recorded during a survey in the Makalu-Barun National Park (Ghimirey *et al.* 2012). Also Grassman (2000) reported a crepuscular activity with nocturnal peaks between the onset of the rainy season in June and end of February during the dry season.

Prionailurus bengalensis has globally been assessed on the IUCN Red List of Threatened Species as *Least Concern.* In Nepal, the felid has been assessed as *Vulnerable* under criterion C2a in view of a small population size estimated from observations and field records to number about 2,500 or fewer mature individuals across subpopulations (Jnawali *et al*. 2012).

Large Indian civet

Our capture rate of large Indian civet indicates that this viverrid shows less activity on wildlife trails than leopard cat. Whether it is less common, or simply spends more of its foraging time off wildlife trails, remains uncertain. At least two individuals are resident in the surveyed area, one each in the west and in the east of the *Madi River.* The cluster, in which ICs were taken, is significantly smaller than the home range reported in a tropical forest, and may represent just a part of the area used over a longer period of time. Rabinowitz (1991) accounted of a radio-collared adult male individual that moved within a 12 sq km large area, and had a mean monthly home range of 5.4 sq km, which increased to 7.7 sq km at the onset of the cold season. Since all ICs were taken after dark, we corroborate the nocturnal activity pattern reported by Rabinowitz (1991), Duckworth (1997) and Bista *et al*. (2012).

Our sample effort includes the highest altitudinal record of a large Indian civet in Nepal, and four ICs taken at elevations above 2170 m, where the species has previously not been reported in other parts of the world. Pocock (1939) knew of records from the Indian foothills of the eastern Himalayas up to 7,000 feet (2133 m), with a higher abundance at elevations around 3,000 feet (915 m). Two individuals were radio-collared in the Chitwan National Park (Joshi *et al*. 1995), but a publication did not result from this research. Farther west in the Terai, the viverrid was observed in the Bardia National Park (Per Wegge, pers. comm.) and photographed by camera traps in the Indian Dudhwa National Park and the adjacent Katerniaghat Wildlife Sanctuary (Bista *et al.* 2012). The latter protected area is connected to the Bardia National Park by two corridors (Sinha 1999). Farther west, the civet was also recorded in Nepal's Suklaphanta Wildlife Reserve (Hem Baral, pers. comm.) and in the Indian Nandhour Forest Division (Bista *et al.* 2012).

Local people in the ACA perceive large Indian civets as a species that potentially preys upon their poultry, and kill them in precaution or retaliation. One of the authors, RA, was informed in February 2012 by a villager that in the previous evening a dog had bitten a large Indian civet to death near *Sikles*.

Viverra zibetha has globally and nationally been assessed as *Near Threatened.* The population in Nepal is guessed as not being abundant (Jnawali *et al*. 2012). The species is widespread in Myanmar, where it is among the most commonly camera-trapped small carnivores (Than Zaw *et al.* 2008). In southern China, the population is likely to be extremely low due to intense trapping pressure and the viverrid's requirement for large vegetated habitats (Lau *et al*. 2010).

Yellow-throated marten

Our results suggest that the yellow-throated martens in our study area use wildlife trails to a far lesser extent than leopard cat. The lower capture rate obtained is however not an indicator for the mustelid being less common than other small carnivores as it is known to use a dimension that was not part of our survey, namely trees 60 cm above ground as high up as 15 m into the canopy (Nandini & Karthik 2007). The mustelid uses habitat and available resources therein in a profoundly different manner, both in space and time, from leopard cat and large Indian civet. Our results corroborate the primarily diurnal activity pattern reported by Grassman *et al.* (2005) who tracked five radio-collared adult individuals during both rainy and dry seasons.

The yellow-throated marten has been recorded in the Himalayas in a diverse altitudinal range up to 4010 m in alpine habitat (Sathyakumar *et al.* 2011). It inhabits a broad variety of bioclimatic zones and habitats ranging from mixed evergreen (Grassman *et al.* 2005) and deciduous forest (Kawanishi & Sunquist 2004, Datta *et al*. 2008) to grasslands and rocky montane scrub (Than Zaw *et al*. 2008). It is described as the most adaptable and versatile mustelid of Southeast Asia, both in feeding

Table 3. Capture rates in protected areas of South and Southeast Asia for *Prionailurus bengalensis* (PB), *Viverra zibetha* (VZ) and *Martes flavigula* (MF). Sources: 1) Ghimirey et al. 2012; 2) Sathyakumar et al. 2011; 3) Datta et al. 2008; 4) Than Zaw et al. 2008; 5) Grassman 2003; 6) Jenks et al. 2011; 7) Kawanishi and Sunquist 2004

Protected area	Habitat and elevation	Season; duration (in weeks)	CR values for		
			PB	VZ	MF
Hugu-Kori forest	mixed broadleaf forest, 1553 – 2928 m	late winter; 5	11.56	33.64	37.0
Makalu-Barun National Park and Buffer Zone, Nepal [1]	temperate broadleaf to subalpine conifer forest, 1980 – 3254 m	spring, winter, summer; 11	74	not specified (ns)	ns
Khangchendzonga Biosphere Reserve, Sikkim, India [2]	mixed temperate to alpine watershed, 1750 – 4200 m	all seasons continuously; ca. 110	37.02	67	30.7
Namdapha National Park, India [3]	dipterocarp forest, 150 – 1300 m	twice from autumn to winter; ca. 32	ns	140	384
Pakke Wildlife Sanctuary and Tiger Reserve, India [3]	moist evergreen forest, 150 – 300 m	late winter to summer, autumn; ca. 39	ns	58	0
Hukaung Valley, Myanmar [4]	grasslands and wetlands, 220 – 300 m	all seasons; ca. 48	ns	441.8	490.9
Alaungdaw Kathapa National Park, Myanmar [4]	deciduous forest, 300 – 380 m	monsoon; 7	ns	73.7	1621
Phu Khieo Wildlife Sanctuary, Thailand [5]	mixed evergreen forest, 700 – 1100 m	all seasons intermittently	306	68	1224
Khao Yai National Park, Thailand [6]	mixed deciduous forest, 100 – 1350 m	autumn to spring; ca. 20	1565	169.2	0
Taman Negara National Park, Malaysia [7]	dipterocarp forest, 70 – 898 m	all seasons; 42 – 57	226.67	2007.7	2007.7

habits and social structure (Grassman *et al*. 2005, Parr & Duckworth 2007). We found scats forming single and up to three strands measuring around 1.2 cm in diameter that are likely of yellow-throated marten (see Tsai 2007). These scats included residues of rodents such as hairs and tiny pieces of bone as well as grainy remains of berries or figs. This finding is hardly surprising as this inquisitive gourmand is not exclusively carnivorous but forages on a very wide range of food (Parr & Duckworth 2007), and apparently prefers a mixed and balanced diet except aquatic wildlife. The highly agile marten does not seem particularly solitary, but has also been sighted as pairs and in groups of three in the western Himalayas (Sathyakumar 1999), in protected areas in Myanmar (Than Zaw *et al*. 2008), Thailand (Grassman *et al*. 2005, Parr & Duckworth 2007) and Laos (Duckworth 1997).

Martes flavigula has globally and nationally been assessed as *Least Concern.* The mustelid is widely distributed across Nepal, with a population assumed to be abundant and lack of any major threats (Jnawali *et al.* 2012).

Comparing capture rates

As shown in table 3, we obtained significantly higher capture rates for leopard cat (PB) and large Indian civet (VZ) than documented in other protected areas of South and Southeast Asia. In only one protected area yellow-throated marten was captured at a higher rate, namely in the eastern Himalayas.

There are potentially several causes for the large differences in CR values of these studies, most obviously idiosyncratic differences in the siting of camera-traps. The low CR values obtained for small carnivores presumably related to the much greater distance between camera traps as compared to our study design. We placed camera traps at a distance of 100 – 1600 m in order to identify the presence of medium-sized wild cats. Both surveys in Myanmar were primarily designed for assessing the conservation status of tigers and other large mammals with camera traps deployed 1 – 3 km apart (Than Zaw *et al*. 2008). In the Phu Khieo Wildlife Sanctuary Grassman (2003) kept the spacing at one to two units in one sq km. One unit was placed every 4 sq km in Malaysia's Taman Negara National Park – a study targeted at estimating tiger density (Kawanishi and Sunquist 2004). Low capture rates do not necessarily reflect low numbers of small carnivores, but rather a decreased probability to capture them along game trails used by large mammals. It is however possible that low capture rates elsewhere are indicative of low densities. In contrast to other surveys in the eastern Himalayas (Sathyakumar *et al*. 2011, Ghimirey *et al*. 2012), our study area was concentrated in the upper subtropical elevation zone, which harbours a larger spatio-temporal prey base than in higher altitudes. Additionally, the level of disturbance owing to human and livestock activity was higher in the Makalu-Barun National Park and Buffer Zone (Ghimirey *et al*. 2012) than in the Hugu-Kori forest. In both Pakke and Namdapha National Parks, poaching pressure is considered high; civets in particular are hunted for meat, medicine, and for decorative value; skins and skulls of both large Indian civet and yellow-throated marten were seen in village households (Datta *et al.* 2008). Increased human

traffic and domestic dogs in marginal areas near boundaries of Khao Yai National Park affected distribution patterns of wild mammals; capture rates were higher in central areas of this park where human impact was reduced (Jenks et al. 2011).

Acknowledgements

We are grateful to the Wuppertal Zoo Society, Germany, and the Point Defiance Zoo and Aquarium, USA, for providing the financial assistance to carry out the survey in the Hugu-Kori forest. Personnel of the Nepal Trust for Nature Conservation's Annapurna Conservation Area Project helped us obtain research permits and supported us logistically. We highly appreciated the excellent support of Pramod Gurung, Lal Gurung and Mohan Gurung provided in the field. We are much obliged to Igor Khorozyan and Marcus Cotton for reviewing earlier versions of the manuscript, and most sincerely thank Will Duckworth for his continuous encouraging and invaluable advice.

References

Abramov, A.V., Duckworth, J.W., Wang, Y.X. & Roberton, S.I. (2008): The stripe-backed weasel Mustela strigidorsa: taxonomy, ecology, distribution and status. – Mammal Review, **38**(4): 247–266.

Adhikari, T.R. (2002): The curse of success. – Habitat Himalaya, IX(3): 1–4.

Ale, S.B. & Karky, B.S. (2002): Observations on conservation of snow leopards in Nepal. – Proceedings of the Snow Leopard Survival Summit, Seattle, USA.

Baral, H.S. & Shah, K.B. (2008): Wild Mammals of Nepal. Himalayan Nature, Kathmandu.

Bista, A., Chanchani, P., Warrier, R., Mann, R., Gupta, M. & Vattakavan, J. (2012): Detection of Large Indian Civet *Viverra zibetha* in camera-trap surveys in and around Dudhwa National Park in the Terai Region of North India. – Small Carnivore Conservation, **47**: 54–57.

Bhuju, U.R., Shakya, P.R., Basnet, T.B. & Shrestha, S. (2007): Nepal Biodiversity Resource Book. Protected Areas, Ramsar Sites, and World Heritage Sites. – International Centre for Integrated Mountain Development, Ministry of Environment, Science and Technology, in cooperation with United Nations Environment Programme, Regional Office for Asia and the Pacific, Kathmandu.

Carbone, C., Christie, S., Conforti, K., Coulson, T., Franklin, N., Ginsberg, J. R., Griffiths, M., Holden, J., Kawanishi, K., Kinnaird, M.F., Laidlaw, R., Lynam, A., Macdonald, D., Martyr, D., McDougal, C., Nath, L., O'Brien, T.G., Seidensticker, J., Smith, J.D.L., Sunquist, M.E., Tilson, R. & Shahruddin, W.N.W. (2001): The use of photographic rates to estimate densities of tigers and other cryptic mammals. – Animal Conservation, **4**: 75–79.

Choudhury, A.U. (1999): Conservation of small carnivores (mustelids, viverrids, herpestids and one ailurid) in north Bengal, India. – Small Carnivore Conservation, **20**: 15–17.

Datta, A., Naniwadekar, R. & Anand, M.O. (2008): Occurrence and conservation status of small carnivores in two protected areas in Arunachal Pradesh, north-east India. – Small Carnivore Conservation, **39**: 1–10.

Dobremez, J.F. (1972): Les grandes divisions phytogeographiques du Nepal et de l'Himalaya. – Bulletin de la Société botanique de France, **119**: 111–120.

Duckworth, J.W. (1997): Small carnivores in Laos: a status review with notes on ecology, behaviour and conservation. – Small Carnivore Conservation, **16**: 1–21.

Duckworth, J.W., Poole, C.M., Tizard, R.J., Walston, J.L. & Timmins, R.J. (2005): The Jungle Cat *Felis chaus* in Indochina: A threatened population of a widespread and adaptable species. – Biodiversity and Conservation, **14**: 1263–1280.

Duckworth, J.W. & Robichaud, W.G. (2005): Yellow-bellied Weasel *Mustela kathiah* sightings in Phongsaly province, Laos, with notes on the species' range in South-East Asia, and recent records of other small carnivores in the province. – Small Carnivore Conservation, **33**: 17–20.

Duckworth, J.W., Timmins, R.J., Tizard, T. (2010): Conservation Status of Small Asian Mongoose *Herpestes javanicus* (É. Geoffroy Saint-Hilaire, 1818) (Mammalia: Carnivora: Herpestidae) in Lao PDR. – The Raffles Bulletin of Zoology, **58**(2): 403–410.

Ghimirey, Y. & Acharya, R. (2012): Records of Siberian Weasel Mustela sibirica and Yellow-bellied Weasel M. kathiah from Makalu–Barun National Park, Nepal. – Small Carnivore Conservation, **47**: 65–66.

Ghimirey, Y., Ghimire, B., Pal, P., Koirala, V., Acharya, R., Dahal, B.V. & Appel, A. (2012): Status of Felids in Makalu-Barun National Park, Nepal. – Cat News, **56**: 23–27.

Ghose, P.S., Sharma, B.K., Theengh, L.T., Shrestha, P. & Pintso, R. (2012): Records of Spotted Linsang *Prionodon pardicolor* from Barsey Rhododendron Sanctuary, Sikkim, India. – Small Carnivore Conservation, **47**: 67–68.

Grassman, L.I. Jr. (2000): Movement and diet of the leopard cat (*Prionailurus bengalensis*) in a seasonal evergreen forest in south-central Thailand. – Acta Theriologica, **45**(3): 421–426.

Grassman, L.I. Jr. (2003): Thailand cat project. – Final report to Cat Action Treasury.

Grassman, L.I., Kreetiyutanont, K. & Tewes, M.E. (2002): The back-striped weasel *Mustela strigidorsa* Gray, 1853 in northeastern Thailand. – Small Carnivore Conservation, **26**: 2.

Grassman, L.I. Jr., Tewes, M.E., Sily, N.J. (2005): Ranging, habitat use and activity patterns of binturong *Arctitis binturong* and yellow-throated marten *Martes flavigula* in north-central Thailand. – Wildlife Biology, **11**(1): 49–57.

Gurung, A., Bryceson, I., Joo, J.H. & Oh, S.-E. (2011): Socio-economic impacts of a micro-hydropower plant on rural livelihoods. – Scientific Research and Essays, **6**(19): 3964–3972.

Gurung, K.K. (1983): Heart of the Jungle. – The Wildlife of Chitwan, Nepal. André Deutsch, London.

Hinton, M.A.C. & Fry, T.B. (1923): Bombay Natural History Society's Mammal Survey of India, Burma and Ceylon. Report no. 37: Nepal. – Journal of the Bombay Natural History Society, **29**: 299–428.

Jackson, R.M. (1996): Home range, movements and habitat use of snow leopard (*Uncia uncia*) in Nepal. – Ph.D. thesis, University of London.

Jenks, K.E., Chanteap, P., Damrongchainarong, K., Cutter, P., Cutter, P., Redford, T., Lynam, A.J., Howard, J., & Leimgruber, P. (2011): Using relative abundance indices from camera-trapping to test wildlife conservation hypotheses – an example from Khao Yai National Park, Thailand. – Tropical Conservation Science, **4**(2): 113–131.

Jhala, Y.V. & Moehlmann, P.D. (2004): Golden jackal *Canis aureus*. Pp. 156–161 In: Sillero-Zubiri, C., Hoffmann, M. and Macdonald, D. W. (eds.): Canids: Foxes, Wolves, Jackals and Dogs. Status Survey and Conservation Action Plan. – IUCN/SSC Canid Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

Jnawali, S.R., Baral, H.S., Lee, S., Acharya, K.P., Upadhyay, G.P., Pandey, M., Shrestha, R., Joshi, D., Lamichhane, B.R., Griffiths, J., Khatiwada, A., Subedi, N. & Amin, R. (compilers) (2012): The Status of Nepal's Mammals: The National Red List Series. – Department of National Parks and Wildlife Conservation Kathmandu, Nepal.

Johnsingh, A.J.T. & Jhala, Y.V. (2004): Bengal fox Vulpes bengalensis. Pp. 219–222 In: Sillero-Zubiri, C., Hoffmann, M. and Macdonald, D. W. (eds.): Canids: Foxes, Wolves, Jackals and Dogs. Status Survey and Conservation Action Plan. – IUCN/SSC Canid Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

Joshi, A.R., David, J.L. & Cuthbert, F.J. (1995): Influence of food distribution and predation pressure on spacing behavior in Palm Civets. – Journal of Mammalogy, **76**(4): 1205–1212.

Kafle, G. (2009): Review on Research and Conservation of Otters in Nepal. – IUCN Otter Specialist Group Bulletin, **26**(1): 32–43.

Kawanishi, K. & Sunquist, M.E. (2004): Conservation status of Tigers in a primary rainforest of peninsular Malaysia. – Biological Conservation, **120**: 329–344.

Lau, M.W., Fellowes, J.R. & Chan, B.P.L. (2010): Carnivores (Mammalia: Carnivora) in South China: a status review with notes on the commercial trade. – Mammal Review, (2010): 1–46.

Maskey, T.M. (2008): Gharial Conservation in Nepal. Wildlife Watch Group

McDougal, C. (1977): The Face of the Tiger. – Rivington Books and André Deutsch, London.

Mudappa, D. (2002): Observations of small carnivores in the Kalakad-Mundanthurai Tiger Reserve, Western Ghats, India. – Small Carnivore Conservation, **27**: 4–5.

Mukherjee, S. (2004): The importance of rodents in the diet of jungle cat (*Felis chaus*), caracal (*Caracal caracal*) and golden jackal (*Canis aureus*) in Sariska Tiger Reserve, Rajasthan, India. – Journal of the Zoological Society, **262**: 405–411.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B. & Kent, J. (2000): Biodiversity hotspots for conservation priorities. – Nature, **40**: 853–858.

Nandini, R. & Karthik, T. (2007): Field observations of Yellow-throated Martens *Martes flavigula* feeding on flowers in Meghalaya, North-east India. – Small Carnivore Conservation, **37**: 26–27.

NTNC (2009): Management Plan of Annapurna Conservation Area (2009–2012). – National Trust for Nature Conservation, Kathmandu, Nepal.

O'Brien, T.G., Kinnard, M.F. & Wibisono, H.T. (2003): Crouching tigers, hidden prey: Sumatran tiger and prey populations in a tropical forest landscape. – Animal Conservation, **6**: 131–139.

Olson, D. & Dinerstein, E. (1998): The Global 200. A representation approach to conserving the Earth's most biologically valuable ecoregions. – Conservation Biology, **12**: 502–515.

Parr, J.W.K. & Duckworth, J.W. (2007): Notes on diet, habituation and sociality of Yellow-throated Marten *Martes flavigula*. – Small Carnivore Conservation, **36**: 27–29.

Pocock, R.I. (1939): The fauna of British India, including Ceylon and Burma. Mammalia. – Volume 1. Taylor and Francis, London.

Rabinowitz, A.R. (1991): Behaviour and movements of sympatric civet species in Huai Kha Khaeng Wildlife Sanctuary, Thailand. – Journal of Zoology, **223**(2): 281–298.

Sathyakumar, S. (1999): Mustelids and Viverrids of the Northwestern and Western Himalayas. – Envis Bulletin Wildlife and Protected Areas, **2**(2): 39–42.

Sathyakumar, S., Bashir, T., Bhattacharya, T. & Poudyal, K. (2011): Assessing mammal distribution and abundance in intricate Eastern Himalayan habitats of Khangchendzonga, Sikkim, India. – Mammalia, **75**: 257–268.

Sinha, S.P. (1999): Current status and corridor survey between the Katerniaghat Wildlife Sanctuary, India and the Royal Bardia National Park, Nepal. WWF-India, New Delhi

Su Su & Sale, J. (2007): Niche differentiation between Common Palm Civet *Paradoxurus hermaphroditus* and Small Indian Civet *Viverricula indica* in regenerating degraded forest, Myanmar. – Small Carnivore Conservation, **36**: 30–34.

Than Zaw, Saw Htun, Saw Htoo Tha Po, Myint Maung, Lynam, A.J., Kyaw Thinn Latt & Duckworth, J.W. (2008): Status and distribution of small carnivores in Myanmar. – Small Carnivore Conservation, **38**: 2–28.

Tsai, C.-W. (2007): Food Resource Partitioning between Sympatric Yellow-throated Marten (*Martes flavigula chrysosphila*) and Siberian Weasel (*Mustela sibirica taivana*). – Master thesis, National Taiwan University.

United States Naval Observatory (2012): The Astronomical Almanac Online! Astronomical Applications Department, www.aa.usno.navy.mil/data/

Van Rampaey, H. (1995): The Spotted Linsang, *Prionodon pardicolor*. – Small Carnivore Conservation, **13**: 10–13.

WCN (2012): Leopard Cat found at 4500m. – Wildlife Conservation Nepal, downloaded from http://www.wcn.org.np/2012/09/17/News/Leopard-Cat-found-at-4500m-149.html

Yonzon, P. (1989): Ecology and conservation of the red panda in the Nepal-Himalayas. – Ph.D. thesis, University of Maine.