Yellow-throated Martens *Martes flavigula* in the Kanchenjunga Conservation Area, Nepal

Angelika APPEL[1] and Ambika Prasad KHATIWADA[2]

Abstract

The Yellow-throated Marten *Martes flavigula* occurs in a broad variety of habitats including temperate and alpine bioclimatic zones in the Himalayas. In the Kanchenjunga Conservation Area in Nepal's Eastern Himalayas, it was among the most frequently camera-trapped carnivores, with photographs from an elevation range of 3,252–4,510 m. This latter constitutes the globally highest altitudinal record of the species.

Keywords: altitudinal range, anthropogenic pressure, camera-trapping, Eastern Himalayas, habitat use, highest elevation record

Introduction

The Kanchenjunga trans-boundary landscape encompasses 14 protected areas and six conservation corridors covering 7,754 km^2 of the Eastern Himalayas in eastern Nepal, Sikkim and Darjeeling (India) and western Bhutan (Shakya & Joshi 2008). The Eastern Himalayas are amongst the 'Global 200' ecoregions harbouring a highly distinctive and irreplaceable biodiversity (Olson & Dinerstein 1998). They are recognised as a global biodiversity hotspot (Myers *et al*. 2000). Centuries-old pilgrim and trade routes pass through the Nepali part of the Kanchenjunga landscape in the country's north-east, connecting markets for agricultural produce between the Himalayan foothills and the Tibetan plateau (Das 1902, Müller-Böker & Kollmair 2000). Agriculture, the traditional occupation and main livelihood of local people, includes shifting cultivation for food grains and potatoes (Aryal *et al*. 2010) and livestock husbandry for milk production and transport of goods (Müller-Böker & Kollmair 2000). The area surrounding the Kanchenjunga massif was included into Nepal's protected area system in 1997. An amendment to the National Parks and Wildlife Conservation Act of 1973 allowed for the designation of 'conservation areas' as a distinct protected area category (Heinen & Shrestha 2006). The Kanchenjunga Conservation Area (Kanchenjunga CA) is conceptualised as people-oriented, reconciling rural development and conservation of cultural traditions and wildlife (Gurung 2006). It encompasses four administrative areas, so-called Village Development Committees (VDCs), consisting of 79 widely scattered settlements; 4,931 people living in 977 households were estimated to reside permanently inside the Kanchenjunga CA as of 2001 (Mountain Spirit 2007).

In the 1990s, wildlife research in the Kanchenjunga CA focused on its flora and vegetation (Carpenter *et al*. 1994, Yonzon 1996). During the past decade, activities shifted to conservation projects related to Snow Leopard *Panthera uncia* (Ikeda 2004), Red Panda *Ailurus fulgens* (Mahato & Karki 2005) and, more recently, Dhole *Cuon alpinus* (Khatiwada 2011).

In the Himalayas, the Yellow-throated Marten *Martes flavigula* inhabits tropical rainforests, subtropical foothills and temperate to alpine habitats (Sathyakumar 1999, Datta *et al*. 2008, Sathyakumar *et al*. 2011, Appel *et al*. 2013). In and around the Indian part of the Kanchenjunga landscape, the Marten has been camera-trapped in several protected areas of Arunachal Pradesh, Sikkim and Darjeeling recently (Datta *et al*. 2008, Sathyakumar *et al*. 2011, Mallick 2013). Carpenter *et al.* (1994), Yonzon (1996) and Katuwal *et al*. (2013) reported sightings in the Kanchenjunga CA, but information about its ecology in this rugged landscape is sketchy.

This article reports Yellow-throated Marten camera-trap records in the south-eastern part of the Kanchenjunga CA, and speculates on its habitat use, activity pattern, avoidance behaviour and tolerance for human-induced disturbance.

Study area

The Kanchenjunga CA extends over 2,035 km^2 and encompasses an impressive mountain landscape ranging in elevation from 1,200 to 8,586 m. The protected area adjoins the Qomolongma National Nature Reserve in Tibet to the north and is contiguous with the Khangchendzonga Biosphere Reserve (Khangchendzonga BR) in Sikkim, India, to the east (Bhuju *et al*. 2007). The Kanchenjunga CA comprises temperate, alpine and nival climatic zones with more than 60% consisting of rocks, glaciers and rivers (Bhuju *et al*. 2007). The seasonal climate is dominated by the June–September monsoon. Annual rainfall was 2,055 mm in 2007, with a maximum monthly precipitation of about 500 mm in July decreasing to about 340 mm in September (Devkota *et al*. 2012).

The study area was located in the southern part of the Kanchenjunga CA, south-west of Mount Kanchenjunga, the main peak of the Kanchenjunga massif that rises within an aerial distance of about 30 km. In the northern and north-western periphery of the study area flows the Simbuwa Khola, a glacial outflow of Mount Kanchenjunga. The core area encompassed by camera-traps comprised about 45 km^2 stretching from 27°28′22″N, 87°51′22″E to 27°29′09″N, 87°57′53″E in the south, and from 27°32′33″N, 87°55′20″E to 27°34′25″N, 87°58′49″E in the north. This area is about 10 hours' walk from the nearest settlements, Hellok of Tapethok VDC in the west and Sherpagaon of Yamphudin VDC in the south-east (Fig. 1). Walking uphill and down dale from Sherpagaon covers an elevation range of 1,800–4,600 m.

Dobremez (1972) combined climatic and phytogeographic regions to describe bioclimatic zones in the Nepal Himalayas. Relevant to our survey, the elevation range of 2,501–3,000 m constitutes the upper temperate; 3,001–3,500 m the lower subalpine; 3,501–4,000 m the upper subalpine; 4,001–4,500

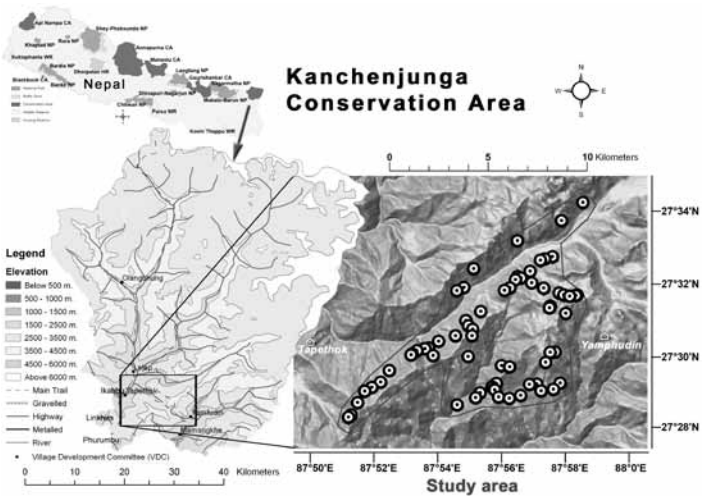

Fig. 1. The Kanchenjunga Conservation Area, Nepal, showing the study area and locations of camera-trap stations (black and white dots).

m the lower alpine; and 4,501–5,000 m the upper alpine bioclimatic zone. Yonzon (1996) described the intermittently occurring forests in the upper temperate bioclimatic zone of the Kanchenjunga CA as comprising stands of fir *Abies spectabilis*, birch *Betula utilis*, hemlock *Tsuga dumosa*, juniper *Juniperus wallichiana*, maple *Acer* and larch *Larix griffithii;* conifer stands prevail in the subalpine zone and are interspersed with shrublands dominated by rhododendron *Rhododendron* and *Juniperus*; *Calamagrostis*, *Carex*, *Festuca* and *Trisetum* are predominant species growing in the subalpine and alpine grazing areas. Shrubs and meadows are found up to 5,000 m elevation.

Materials and methods

Ours was the second camera-trapping survey in this area. It was designed to find Dhole, using 19 Moultrie units equipped with GS D40 cameras. We deployed all units between 24 June and 14 July 2012 and moved them to a second adjacent survey block between 25 July and 16 August 2012. From 15 August onwards we shifted camera-traps to a third adjacent block, where 17 units were active until 5 September 2012. Between 7 and 27 September 2012, 15 units were active in a fourth block. Camera-traps were deployed singly, positioned up to 60 cm above ground, set to 24-hour operation, and used no baits. The terrain is too rugged and steep for a homogeneous distribution of camera-traps, so we placed them foremost along narrow trails that connect settlements with higher-elevation subalpine and alpine pastures used during the monsoon season. AK interviewed herders in August 2010 and concluded that Dholes also use these trails (Khatiwada 2011).

We used a Garmin GPS eTrex 10 unit to determine coordinates (datum WGS84) and elevation of each camera-trap station, and noted habitat characteristics and crown coverage. All elevations are given as delivered by the GPS unit; the level of accuracy is not known. Camera-trap images recorded the time of photograph. Sunset and sunrise times were obtained using the database of the Astronomical Applications Department of the United States Naval Observatory (2012).

'Camera-trap-days' comprise the number of 24-hour periods from deployment of a camera-trap until it was retrieved or stopped working through technical reasons or weather conditions. Photographs showing either single individuals or social units of several individuals each comprise one detection for the species. Based on O'Brien *et al*. (2003), notionally independent photographs were 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. The average 'photo-capture interval' (PCI) is the number of camera-trap-days per notionally independent photograph (IP) of the species.

Results

Camera-traps in 70 stations gave a total sampling effort of 1,114 camera-trap-days. In 59 stations, trapping sessions lasted an average of 15.6 days ranging from 12 to 20 days. In 11 stations, camera-traps operated for only 1–10 days each. In total 6,513 photographs of vertebrate species comprised 1,015 IPs, out of which 111 IPs (9.95% of all) were of wild mammals: ungulates (27 IPs, 2.66%), canids (25 IPs, 2.46%), unidentifiable mammals (15 IPs, 1.48%), cats (14 IPs, 1.38%), Yellow-throated Marten (11 IPs, 1.08%), rodents (11 IPs, 1.08%), bears (5 IPs, 0.49%), Red Panda (2 IPs, 0.2%) and a bat (1 IP, 0.1%). The remaining IPs were triggered by birds (101 IPs, 9.95%), local people (376 IPs, 37.04%) and domestic animals (427 IPs, 42.07%) including livestock and Domestic Dogs *Canis familiaris*. Table 1 details the sampling effort in each bioclimatic zone, and the IPs and PCIs of Yellow-throated Marten photographed therein; Table 2 details the records individually.

All photographs of Yellow-throated Martens were taken during the day. The earliest was two hours 14 minutes after sunrise, the latest one hour before sunset. Seven IPs show single individuals, four show duos. Martens were camera-trapped at eight stations between the southernmost at 27°28′22″N, 87°51′22″E and the northernmost at 27°32′53″N, 87°57′50″E (Fig. 2), ranging in recorded elevation from 3,252 to 4,510 m. The latter elevation provided three IPs: on 28 July, 6 and 10 August 2012.

Of 33 camera-trap stations in forested habitat, two recorded Martens in the lower subalpine (3 IPs, PCI 68), as did one in the lower alpine bioclimatic zone (1 IP, PCI 18). Of 17 stations in shrubland, one recorded Martens in the lower subalpine (1 IP, PCI 88), as did one in the lower alpine bioclimatic zone (1 IP, PCI 32). Both shrubland sites are about 600 m aerial distance from the nearest forest patch, in both cases located downhill. Of 20 stations in meadows, two recorded Martens in the lower alpine (2 IPs, PCI 14), as did one (3 IPs, PCI 16) in the upper alpine bioclimatic zone (Fig. 3). These stations were about 1,400–1,700 m from the nearest forest patch, in all cases downhill.

In 56 of 70 stations (80% of all stations), photographs were triggered by local people and/or domestic animals. These stations are termed 'disturbed sites' henceforward, whereas the term 'undisturbed sites' refers to the remaining 14 stations where only wildlife was photographed. Human-induced disturbance apparently varied between the bioclimatic zones (Fig. 4). Domestic Dogs were part of social units comprising livestock and people that triggered photographs. Additionally, they triggered 91 IPs (8.97% of all IPs) in altogether 25 stations (35.71% of all stations). In 17 of these stations

Table 1. Survey effort and records of Yellow-throated Marten *Martes flavigula* in the southern part of the Kanchenjunga Conservation Area, Nepal, June–September 2012.

Elevation range of camera-trap stations	Bioclimatic zone and habitat type	Number of camera-trap stations	Number of camera-trap-days	Martens recorded		
				n° stations	IPs	PCI
2,535–2,991 m	Upper temperate forest and shrub	7	114	0	0	0
3,015–3,494 m	Lower subalpine forest, shrub and meadow	21	345	3	4	86
3,514–3,948 m	Upper subalpine forest, shrub and meadow	28	446	0	0	0
4,173–4,446 m	Lower alpine forest, shrub and meadow	11	162	4	4	41
4,510–4,540 m	Upper alpine meadow	3	47	1	3	16
	Total	70	1,114		11	101

IPs: the number of notionally independent photographs; PCI: photo-capture interval, the number of camera-trap-days per notionally independent photograph (see text for definitions).

Table 2. Records of Yellow-throated Marten *Martes flavigula* in the southern part of the Kanchenjunga Conservation Area, Nepal, with dates, time, elevation, habitat and coordinates from north to south.

Date in 2012	Time	Elevation	Habitat	Coordinates
11 August	07h42	4,173 m	forest	27°32′53″N, 87°57′50″E
28 July	07h31	4,206 m	shrubland	27°32′48″N, 87°57′28″E
28 July	07h28	4,280 m	rocky grassland	27°32′00″N, 87°57′34″E
28 July	11h32	4,510 m	rocky grassland	27°31′49″N, 87°58′12″E
6 August	15h24	4,510 m	rocky grassland	27°31′49″N, 87°58′12″E
10 August	17h34	4,510 m	rocky grassland	27°31′49″N, 87°58′12″E
2 August	10h27	4,340 m	rocky grassland	27°31′30″N, 87°57′46″E
28 June	10h03	3,252 m	forest	27°29′49″N, 87°56′14″E
28 June	10h28	3,266 m	forest	27°29′19″N, 87°56′04″E
3 July	12h40	3,266 m	forest	27°29′19″N, 87°56′04″E
14 September	11h35	3,459 m	shrubland	27°28′22″N, 87°51′22″E

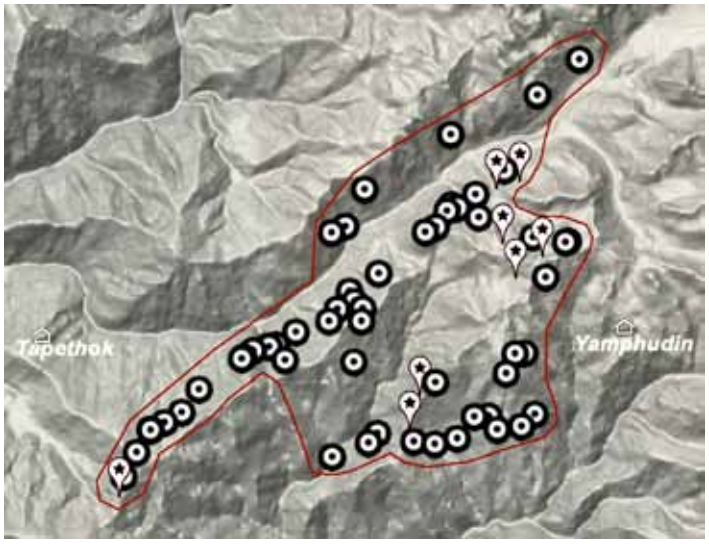

Fig. 2. Location of camera-traps in the southern part of the Kanchenjunga Conservation Area, Nepal; white stars indicate those with records of Yellow-throated Marten *Martes flavigula*.

Fig. 3. Two Yellow-throated Martens *Martes flavigula* in the southern part of the Kanchenjunga Conservation Area, Nepal, on rocks at an elevation of 4,510 m, 28 July 2012 (Photo: Ambika Khatiwada).

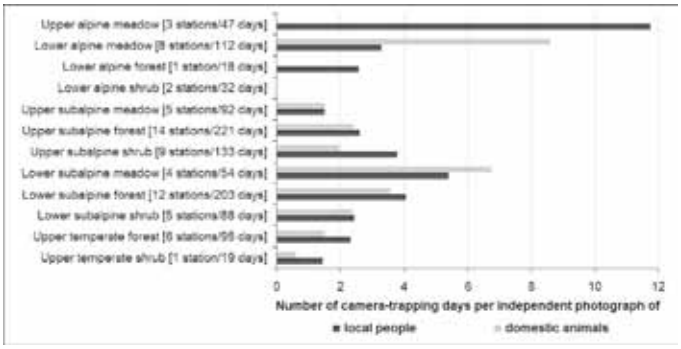

Fig. 4. Photo-capture interval (PCI) of local people and domestic animals in the various bioclimatic zones and habitats surveyed in the southern part of the Kanchenjunga CA, Nepal.

(24.29% of all stations), they preceded or followed groups of livestock and people within one hour in 37 IPs (40.66% of all Domestic Dog IPs). Solitary Dogs triggered the remaining 54 IPs (59.34% of all Domestic Dogs IPs) in 22 stations (31.43% of all stations). Whether the latter were feral or herding Dogs is unclear.

In undisturbed sites, Martens were recorded at a PCI of 46, at one station each in lower subalpine forest and in lower alpine shrubland. In disturbed sites, they were recorded at a PCI of 122, at six stations in the lower subalpine and both alpine bioclimatic zones. In these six disturbed sites, local people triggered 21 IPs (5.58% of all local people IPs at all stations). In only one instance, people were accompanied by a Domestic Dog. Martens were recorded 17 hours to five days later than the most recent preceding people, and one hour to 12 days earlier than the next group of people, including the one with the Dog. Livestock triggered 10 IPs (2.97% of all domestic animal IPs at all stations) in two of these six disturbed sites. They were photographed at least four days later than the Martens, but not preceding them.

Discussion

Four IPs at elevations of 4,340–4,510 m indicate that Yellow-throated Martens use higher elevations during the monsoon season than previously known in the Kanchenjunga landscape. Martens have been recorded in hill forests of Darjeeling up to 3,323 m (Mallick 2013) and in alpine habitat of the Khangchendzonga BR up to 4,010 m (Sathyakumar *et al*. 2011). The Marten duo at 4,510 m constitutes the globally highest-elevation record of the species to date. Above this elevation, survey effort was low (31 camera-trap-days in two stations) and Martens might occur but have been overlooked. Although effort below the lowest record (3,252 m) was more (257 camera-trapping days at 16 stations), it is still plausible that Martens occurred there, but went unrecorded.

The highly agile Marten was observed in groups of up to four in the Himalayas (Carpenter *et al*. 1994, Sathyakumar 1999, Appel *et al*. 2013) and in Southeast Asia (Duckworth 1997, Grassman *et al*. 2005, Parr & Duckworth 2007, Than Zaw *et al*. 2008). Its diurnal activity in the Kanchenjunga CA is consistent with activity patterns reported elsewhere (Grassman *et al*. 2005, Parr & Duckworth 2007, Than Zaw *et al*. 2008, Appel *et al*. 2013). Nandini & Karthik (2007) and Parr & Duckworth (2007) accounted of groups of Martens that tolerated close human proximity while foraging. The Martens in our study area perhaps have a low tolerance for human-induced disturbance: they were not photographed in bioclimatic zones with a high human and livestock frequency.

The Yellow-throated Marten inhabits a broad variety of bioclimatic zones and habitats ranging from mixed evergreen (Duckworth 1997, Grassman *et al.* 2005), deciduous and degraded forest (Datta *et al.* 2008) to upper temperate (Appel *et al*. 2013) and subalpine forest (Mallick 2013). It is often recorded along rivers (Duckworth 1997, Datta *et al.* 2008, Than Zaw *et al*. 2008, Sathyakumar *et al*. 2011, Appel *et al*. 2013, Mallick 2013). But none of these authors refer to Martens in grassland landscapes. In our study area, Martens were recorded foraging in rocky alpine meadows whereas stations in subalpine meadows yielded no such photographs, although each was surveyed to similar intensity. The frequency of people and domestic animals along trails through subalpine meadows was higher than in alpine meadows. The habitat surrounding these trails does not offer quick escape routes or hiding places for Martens when people and livestock approach. Therefore, variation in Marten photo-capture frequency between meadow types could reflect the effects of human and livestock activity. However, it might simply result from differing intrinsic suitability of these habitats, or perhaps a spurious pattern from the low numbers of records.

Previous Marten records in shrubland may be limited to one sighting by Duckworth (1997) in a lowland semi-evergreen habitat in Lao PDR; this was in scrub over recently abandoned cultivation, within 150 m of a forest patch and 500 m of extensive forest (J. W. Duckworth *in litt*. 2014). In the Kanchenjunga CA, Martens use very different forms of shrubland. Some of these shrublands may be on land deforested several decades to centuries ago, whereas others may not be significantly anthropogenic at all. Their origin has not yet been studied in the Kanchenjunga CA. Shrublands in the Sagarmatha National Park farther north-west in the Himalayas have been estimated at 30 to more than 5,000 years of age (Byers 2005).

Camera-traps along trails in upper temperate forests showed a high frequency of people and domestic animals. The lack of Marten records at these forest stations (with a total survey effort of 95 camera-trapping days) coincides with a 46.8% lower sampling effort than at subalpine forest stations. In contrast, Appel *et al*. (2013) recorded Martens in undisturbed upper temperate forest in Nepal's Annapurna CA at a PCI of 24.5 days, despite a much lower sampling effort. Camera-trapping in the temperate zone of our study area might have been too limited to record Martens in disturbed sites.

The lack of photographs in upper temperate and upper subalpine forests does not necessarily indicate the Marten's absence there. It might reflect a low probability of photographing it on the forest floor in disturbed sites. Martens preceded livestock by an average of four days at the few stations recording both, but were not recorded subsequently. Nor were they photographed at stations previously frequented by Dogs. The latter were recorded in more than a third of all stations. Although perhaps just a coincidence, given the few records of Martens, this may indicate that Martens avoid the ground level in sites used by Dogs.

Herding Dogs sniff out and cause the death of ground-dwelling mammals that might otherwise not be found by

people (Young *et al*. 2011, Appel *et al*. 2013). Hence, their presence in the Kanchenjunga CA may also affect space use of other small carnivores. In the adjacent Khangchendzonga BR, Sathyakumar *et al*. (2011) recorded Masked Palm Civet *Paguma larvata*, Large Indian Civet *Viverra zibetha* and Binturong *Arctictis binturong* in temperate bioclimatic zones; and Stone Marten *Martes foina*, Yellow-bellied Weasel *Mustela kathiah*, Siberian Weasel *Mustela sibirica* and Mountain Weasel *Mustela altaica* in subalpine bioclimatic zones. Therefore, these species might be present in the Kanchenjunga CA of Nepal as well.

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[1]Auf dem Dörnchen 14, 56470 Bad Marienberg, Germany. Email: angie@wild-cat.org
[2]c/o National Trust for Nature Conservation, Post Box 3712, Lalitpur, Nepal.