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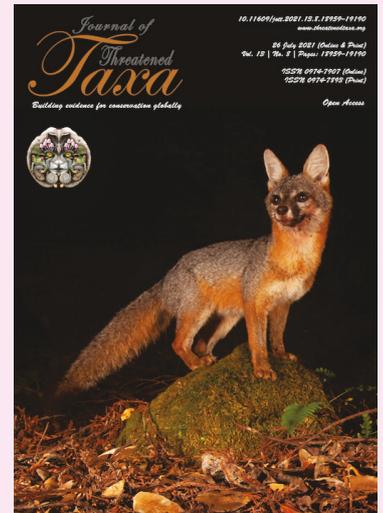
### COMMUNICATION

#### ON THE OCCURRENCE OF THE HIMALAYAN WOLF *CANIS LUPUS*, L. 1758 (MAMMALIA: CARNIVORA: CANIDAE) IN THE GAURISHANKAR CONSERVATION AREA, NEPAL; ITS EXISTENCE CONFIRMED THROUGH SIGN AND VISUAL EVIDENCE IN ROLWALING VALLEY

Bishnu Prasad Pandey, Shankar Man Thami, Rabin Shrestha & Mukesh Kumar Chalise

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## On the occurrence of the Himalayan Wolf *Canis lupus*, L. 1758 (Mammalia: Carnivora: Canidae) in the Gaurishankar Conservation Area, Nepal; its existence confirmed through sign and visual evidence in Rolwaling Valley

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**Abstract:** The Himalayan Wolf *Canis lupus* L., a top predator of the Third Pole, is proposed to be of a distinct wolf lineage (*C. himalayensis*) relative to the Holarctic Grey Wolf as described by mtDNA analyses. A biodiversity survey organized by the Gaurishankar Conservation Area Project (GCAP) has captured images of wolves in three different regions, and the study team has observed wolf scats in five additional regions above the tree line in Rolwaling Valley. Further, interviews with local herders provided evidence of wolf depredation of livestock in the area. The Rolwaling Valley in the Gaurishankar Conservation Area was the study area which was divided into 12, 4 x 4 km (16 km<sup>2</sup>) grid cells, each supplied with one camera trap operated continuously from June to November 2019 (only 6 out of 12 cameras functioned for the duration of our study). Wolf detections were recorded by camera traps from Yalung Pass (4,956 m), Tsho-Rolpa glacial Lake (4,536 m) and the Dudhkunda ridgeline (5,091 m). The photo capture rate index (PCRI) for wolves was 0.71. Our study reports the first photographic evidence of the Himalayan Wolf in the Rolwaling Valley.

**Keywords:** Camera trap, PCRI, Scat.

**Nepali:** चिनको तिब्बती पठार लगायत नेपाल, भारत समेतका उच्च हिमाली क्षेत्रमा पाइने हिमाली व्वाँसो यस क्षेत्रको खाद्य शृंखलाको उच्चस्थानमा रहि पर्यावरणलाई जीवन्त राख्ने प्राणी हो । बंसाण विक्षेपणबाट यस क्षेत्रमा पाइने व्वाँसो युरोप, एसिया लगायतमा पाइने प्रजाति भन्दा फरक रहेको भनि प्रमाणित गरिसकेको छ, यद्यपि बाहिरी आवरणबाटमात्र छुट्टयाउन मुस्किल छ । राष्ट्रिय प्रकृति संरक्षण कोष, गौरीसंकर संरक्षण क्षेत्र आयोजनाले त्रिभुवन विश्वविद्यालय तथा जैविक विविधता अध्ययन समाज, ललितपुर समेतको सहकार्यमा संरक्षण क्षेत्रको रोल्वालिङ उपत्यकामा गरेको जैविक विविधता अध्ययनको क्रममा यस उपत्यकाका तीन स्थान (दुधकुण्डको डाँडा ५०९१ मी., च्छोरोल्पा हिमताल ४५३६ मी. र येल्जुड भञ्ज्याङ ४९५६ मी.) मा व्वाँसोको तस्वीर खिच्न सफल भएवाट यस क्षेत्रमा बिगत लामो अवधीदेखि व्वाँसोको अवस्थितीबारेको रहेको सूचना अभावको अवस्था चिर्दै नेपालमा संरक्षित प्रजातिमा सूचीकृत यो प्रजातिको विचरण गौरीसंकर संरक्षण क्षेत्रमा रहेको प्रमाणित भएको छ । यसको अतिरिक्त स्थानीय बासिन्दाहरूसँगको छलफल तथा अनुसन्धानका क्रममा गरिएको स्थलगत निरीक्षणको क्रममा अन्य ५ स्थानमा समेत व्वाँसोको उपस्थिति रहेको देखिएको छ । यस उपत्यकाको अलावा नुम्बुर हिमाल क्षेत्रको नुम्बुर उपत्यकामा समेत व्वाँसोको चिन्हहरू भेटिएको छ । यसअनुसन्धानका क्रममा व्वाँसोको उपस्थिति सूक्ष्मेका भन्दा माथिका सबै मोहोडाहरू, खोलाकिनार, तथा चुचुराहरू, मानववस्ती नजिक तथा पदमार्गमा समेत पाइएको छ । सुनपाती, डालेचुक तथा पुपीका पोथा एवं बगर, हिमपहिरो र हिमनदी रहेको क्षेत्रमा समेत व्वाँसो पाइएको छ । अनुसन्धानका लागि उपत्यकाको क्षेत्रलाई १६ वर्ग किलोमिटरका वर्गाकार क्षेत्र निर्धारण गरि सबैक्षेत्रहरूमा एउटाको दरले 'तालो रगतको उपस्थिति पत्तालग्नु स्वचालित रूपमा संचालन हुने' क्यामेरा जडान गरिएको थियो । अनुसन्धान कार्य २०७६ जेठ देखि पुससम्म ६ महिना संचालन गरिएकोथियो । त्यस उपत्यकामा व्वाँसोको संख्या यकिन गर्न नसकिएपनि त्यहाँ प्रति १०० रातमा ०.७१ पटक तस्वीर खिच्न सकिने देखिएको छ ।

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For **Author details, Author contributions & Acknowledgements** see end of this article.



## INTRODUCTION

The Himalayan Wolf *Canis lupus* is a top predator of the Third Pole (Prater 1971; Menon 2003; Chetri et al. 2017; Boitani et al. 2018; Werhahn et al. 2020). It was proposed to be a distinct wolf lineage (*C. himalayensis*; Aggarwal et al. 2007) relative to the Holarctic Grey Wolf as described by mtDNA analyses (Sharma et al. 2004; Chetri et al. 2016; Chetri et al. 2017; Werhahn et al. 2017; Boitani et al. 2018). Categorized as 'Least Concern' by the IUCN (Boitani et al. 2018), it is considered 'Critically Endangered' by the National Red List in Nepal (Jnawali et al. 2011). International trade is generally prohibited by CITES (The Convention on International Trade in Endangered Species of Wild Fauna and Flora) with the Himalayan Wolves in Nepal listed under Annex 1 (listed species are the most endangered species and are threatened with extinction; CITES 2019). Furthermore, capture, killing, and trade are strictly prohibited as well by declaring this species under Schedule-I in Nepal by The National Parks and Wildlife Protection Act, 1973 (NLC 1973).

In and around the lap of the Himalaya, wolves were recorded by researchers at the Indo-Pakistan Himalaya and also from the Himachal Pradesh and Uttarakhand states of India near the western border of Nepal above 3,500m (Sharma et al. 2004; Bhattacharya & Sathyakumar 2010; Chetri et al. 2016; Werhahn et al. 2017). In Nepal, the wolf is reported from all the Himalayan protected area systems and adjoining wilderness areas above 4,000 m (Subba et al. 2017). The areas that are considered main wolf habitat in Nepal include Manasalu and Annapurna Conservation Area (Chetri et al. 2016, 2017, Subba et al. 2017), Shey Phoksundo National Park and Humla district of western Nepal (Werhahn et al. 2017; Subba et al. 2017), Dhorpatan Hunting Reserve (Jnawali et al. 2011), and Kanchenjunga Conservation Area (Jnawali et al. 2011; Subba et al. 2017); and now its existence has also been confirmed in the Gaurishankar Conservation Area (this study).

## RESEARCH METHODS

### Study area

The Gaurishankar Conservation Area (GCA) is one of the newest protected areas of Nepal, covering 2,179 km<sup>2</sup> in the northern part of the Ramechhap, Dolakha, and Sindhupalchok districts of the Bagmati Province of Federal Democratic Republic of Nepal (Bajracharya et al. 2011, NLC 2074 VS). It extends between 85°46.8'-

86°34.8' East & 27°34.2'-28°10' North, and ranges in elevation 980–7,134 m (Bajracharya et al. 2011; GCAP 2013). The GCA was established in 2010 (GoN 2010) connecting two national parks in the high mountains (i.e., Sagarmatha National Park in the east and Langtang National Park in the west) with the northern boundary extending to the Nepal-China border (Bajracharya et al. 2011). The valley is situated in the northeastern corner of the GCA, approximately 50 km west of Mt. Everest (Sacherer 2011).

Our study area included 16 major vegetation types, river valleys of Koshi River basin, snow-capped mountains, and temperate-alpine grasslands supporting 565 species of vascular plants, 76 (71 species described in GCAP, 2013 and five added from this study) species of mammals, 252 species of birds, 12 species of amphibians, 27 reptiles, and 27 species of fishes (Bajracharya et al. 2011; GCAP 2013). The Rolwaling valley (hereafter, "the valley" unless otherwise indicated) is home to elusive mountain species including Snow Leopard *Panthera uncia*, Red Panda *Ailurus fulgens*, Musk Deer *Moschus leucogaster*, Red Fox *Vulpes vulpes*, Himalayan Monal Lophophorus *impejanus*, Satyr Tragopan *Tragopan satyra*, and many more species. The valley elevation ranges 2,000–7,134 m.

Gaurishankar Conservation Area includes two 'beyul' (a Tibetan word meaning sacred) valleys named Lapchi and Rolwaling where the majority of human inhabitants (i.e., the Sherpa community) follow Buddhism where as in other valleys, there is a mosaic of Hindu-Buddhist religion occurring (Bajracharya et al. 2011; Sacherer 2011; GCAP 2013). The Rolwaling valley is sacred landscape guided by Tibetan Buddhism and inhabited by the Sherpa community. Followers of the 'Padmasambhava' sects of Buddhism (Sacherer 2011) strictly obey and maintain a ban on animal sacrifice and consumption of animal meat, and people in this region believe that consuming meat products and burning of garlic brings misfortune (Lama 2019). Thus, wild animals are not harvested for their meat, providing some measure of wildlife protection. Traditionally, the valley dwellers rely on the agro-pastoral economy with transhumance animal herding, the primary cause of human-wolf negative interaction in this valley. Although, the killing of animals is prohibited, the last known wolf pack in this area was poisoned by Yak herders ~50 years ago (Sherpa 2019).

The Rolwaling Valley (215 km<sup>2</sup>) covers the landscapes of lower temperate forests up to the alpine zone. Major vegetation types of the study area were *Quercus* forests, lower-temperate mixed broadleaved forests, upper

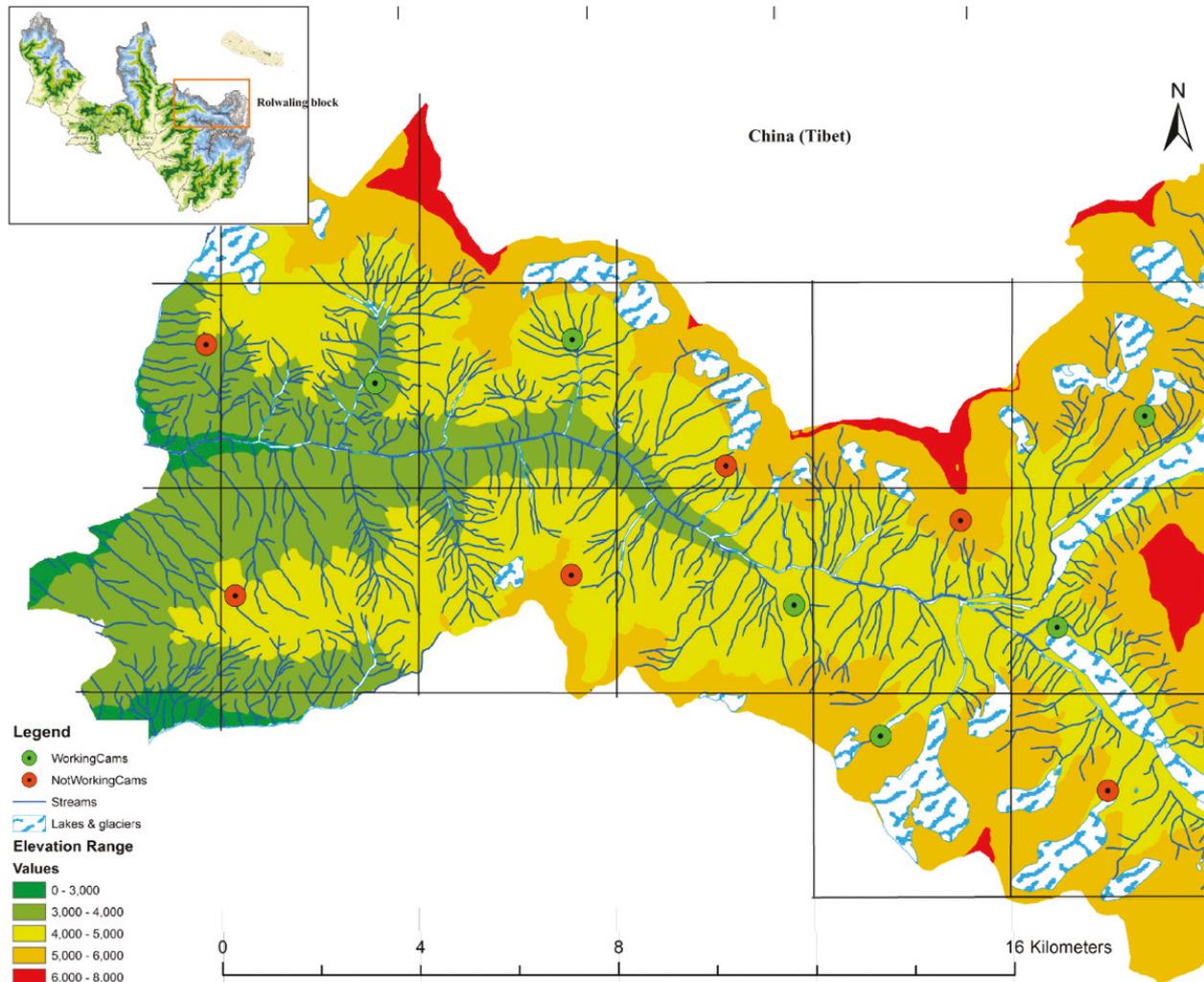


Figure 1. Research blocks in Gaurishankar Conservation Area.

temperate broadleaved forests, rhododendron forests, and upper temperate conifer forests (Bajracharya, et al. 2011). The higher areas are covered by *Abies-Juniper* forests and birch-rhododendron forests, whereas the alpine zone comprises alpine shrub land, scrubland, open grassland, glaciers, and rocky outcrops (Bajracharya et al. 2011; GCAP 2013). Himalayan Tahr *Hemitragus jemlahicus*, Hanuman Langur *Semnopithecus schistaceus*, Common Goral *Naemorhedus goral*, Assamese Monkey *Macaca assamensis*, Himalayan Monal, Blood Pheasant, Royal's Pika *Ochotona roylei* are frequently observed along the trails while pellets of Red Panda *Ailurus fulgens*, Musk Deer *Moschus leucogaster* and Himalayan Serow *Capricornis thar* are visible in off trails. Scats and fresh tracks of Snow Leopard *Panthera uncia*, common Leopard *Panthera pardus*, Wolf, Red Fox, and Weasels *Mustella* sp. are common along the forest trails used by local herders, livestock, and

wildlife. Important prey species for top predators of high mountain; the Blue Sheep has neither been reported by researchers (Ale et al. 2010) nor by the local herders in this valley (Lama 2019; Sherpa 2019) though historical collection of Blue Sheep horn is reported in Ale et al. (2010).

#### Blocks and grids

We divided the GCA into five blocks as defined by geographical barriers and ease of research management and we selected the Rolwaling Valley block for this study. A recent research objective in this valley was to assess mammalian diversity, with grids created to target Snow Leopard detection (Jackson et al. 2005). The valley covers 215 km<sup>2</sup> with accessible areas divided into 16 km<sup>2</sup> square grids (Figure 1) following Jackson et al. (2005). We focused our monitoring efforts on those grids above 3,000 m targeting large mammals

of the upper temperate-alpine region with low human habitation (Bajimaya 2000). Altogether, we placed one camera in each of the 12 grids that were 3,000–5,500 m in elevation.

### Camera trapping

In the current study, the target species were the elusive species of the highlands including the Snow Leopard, Wolf, Lynx and their prey species. Camera trapping was selected as the primary method given feasibility and logistical challenges. (i.e., limited resources precluded transect and genetic surveys).

The study team tried to minimize disturbance to wildlife throughout the survey, although livestock herders traveled periodically to the survey area. Cameras were placed far from major trekking routes and the primary trails used by herders were omitted for camera security reasons. This also minimized the chance of capturing images of non-target animals (livestock) and humans. Cameras were left unattended for an extended period (around six months), during which the possibility of wildlife occurrence was estimated to be the highest based on various signs and marks of animals.

Bushnell Trophy Camera Brown (Model 119436) and Bushnell Trophy Camera w/viewscreen (Model 119455) were used for monitoring animals. Cameras operated continuously for six months between 09 June and 09 November 2019. Cameras were set to image capture mode with one minute lag between triggers with three images captured per trigger. No fixed camera height was applied as per the objective of the study but cameras were set to focus around 30 cm height over the trail i.e. some cameras were tilted to achieve the specified focal height.

We identified sites of likely animal movement within each grid by visually examining the site characteristics. The sites with high frequency of signs of animal like tracks, scat deposits, pellets, rubbing on trees, scent marks, and trail junctions were selected for camera installment, following the Snow Leopard monitoring manual for Nepal (Bajimaya 2000). Moreover, valley bottoms and ridgelines, where the likelihood of megafauna movement is high (Jackson et al. 2005), were also selected for camera deployment. No baits or trail modifications were used.

### Data analysis

Photocapture rate index (PCRI) is used as an index of animal abundance because of its general relationship with the density of target species (Rovero & Marshall 2009; Lahkar et al. 2018). Although, its application is

better suited to the prey species (Rovero & Marshall 2009; Lahkar et al. 2018), we applied it to predators as well because of limited data available for capture recapture analysis and because individual identification of wolves was not reliable.

We calculated total operation time summing up data from all cameras that were functional (6 out of 12) (i.e., six cameras were not functional: four cameras triggered continuously resulting in filled SD cards within a couple of days, rain water leakage damaged the storage device in one camera, and one camera was lost during this study). Every photo event was recorded by a photo analysis using a digital projector. To define a photographic event, 30 minutes between events of same species was used to assure independent data points.

### Additional lines of evidence

Wolf scats were opportunistically observed and recorded during other field work. Also, interviews were conducted with local herders to obtain information on wolf depredation of livestock in the area.

## RESULTS AND DISCUSSION

The PCRI for mammals and birds were calculated separately (Table 1). Among mammals, Pika was the most frequently photographed, followed by cattle (Yak), Red Fox, Yellow-bellied Weasel, and Wolf (0.71 animals per 100 nights, i.e., 0.71 PCRI values) (Table 1). Ungulate prey species that are frequently observed along mountain slopes, such as the Himalayan Tahr, Common Goral, and the Himalayan Serow, had lower PCRI values. However, game birds such as Blood Pheasant, Himalayan Snow Cock, and Himalayan Monal, were frequently photographed (Table 1).

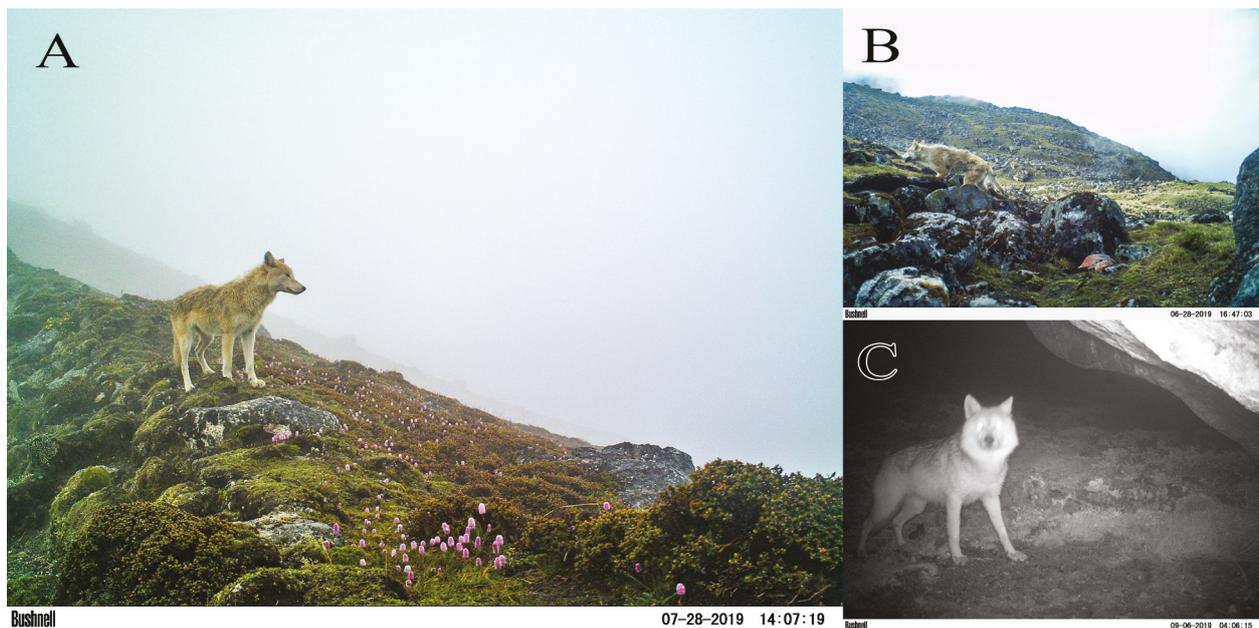
Based on the photographic evidence, all wolf detections consisted of single wolves, no packs or pairs were detected in the six captures of wolf (Figure 2). Sniffing on scent sprays and travel were common behaviors observed. The movements of wolf were recorded by three cameras located at 5,091 m, 4,536 m, and 4,956 m in the Rolwaling Valley. This is the first ever photographic record of wolf presence, not only in Rolwaling Valley, but also in the GCA.

Wolves were captured during early morning (07:12:14), mid-day (14:07:19 & 16:47:03), and night (01:22:02, 04:05:35, 20:57:31). All the capture sites were in open grass land and moraines above tree line. No preference over the geographical aspects was observed as animals were caught on southern, valley bottom,



**Table 1. Photo capture rate index (PCRI) values for captured animals.**

Mammals			Birds		
Species	Events	PCRI	Species	Events	PCRI
Pika	75	8.85	Blood Pheasant	28	3.30
Cattle	66	7.78	Himalayan Snow Cock	25	2.95
Red Fox	23	2.71	Red-billed Chough	20	2.36
Yellow-bellied Weasel	8	0.94	Himalayan Monal	14	1.65
<b>Wolf</b>	<b>6</b>	<b>0.71</b>	Blue Whistling Thrush	6	0.71
Common Goral	4	0.47	Alpine Accentor	2	0.24
Himalayan Serow	3	0.35	Hoopoe	2	0.24
Stone Marten	3	0.35	Snow Partridge	2	0.24
Snow Leopard	3	0.35	Laughing Thrush	1	0.12
Human	2	0.24	Raptor	1	0.12
Yellow-throated Marten	2	0.24	Tibetan Snow Cock	1	0.12
Himalayan Tahr	1	0.12	Yellow-billed Chough	1	0.12
Musk Deer	1	0.12			
Red Panda	1	0.12			
Small cat	1	0.12			
Total mammal events	198		Total bird events	103	



**Image 1. Photographs from all sites of Wolf captures: A—from Dudhkunda ridgeline | B—from Yalung pass | C—from Tsho-Rolpa glacial lake. © NTNC/GCAP.**

and northern aspects. Interestingly, the Wolf and Snow Leopards were using the same trails and deposited their signs in front of the camera. The other predators captured were Red Fox, Yellow-bellied Weasel were captured on the sites where Wolves were captured; so were the Pika, Yak, and Snow Cocks. The cameras in the

periphery recorded Musk Deer, Red Panda, Himalayan Monal, Blood Pheasant *Ithaginis cruentus*, Goral, Himalayan Tahr, Himalayan Serow, and some small birds. Despite evidence of frequent human disturbances (such as tourist's visits, animal herding, pilgrimage), just a single event was recorded by a camera during our study.



Image 2. Scat observed in: a—Dudhkunda moraine at 4,735 m | b—Ramding up at 4,072 m | c—Gumdel at 4,017m. © Authors.

Table 2. Other signs of wolf presence in the Rolwaling valley.

Place	Altitude (in m)	Aspect (degrees)	Slope (degrees)	Sign type	Age	Habitat	Vegetation	Disturbance	Remarks
Ramding Up	4,072	110	22	Scat	Fresh	Scrubland	<i>Rhododendron anthopogon</i>	Mountaineering & Grazing	During site selection
Beding-Na	3,967	192	23	Livestock depredation	Old	Scrubland	<i>Juniperussp</i>	Trekking & Grazing	Inferred from interview
Na	4,413	262	40	Livestock depredation	Fresh/ old	Scrubland	<i>Rhododendron anthopogon</i>	Trekking & Grazing	Inferred from interview
TshoRolpa-Dudhkunda	4,735	312	5	Scat	Old	Moraine	<i>Rhododendron anthopogon</i>	Trekking & Grazing	During site selection
Dudhkunda lekh (near camera trap)	5,060	265	28	Scat	Old	Open grassland	Grasses	Grazing	During site selection
Dudhkunda	4,872	187	15	Scat	Old	Glacier	<i>Rhododendron anthopogon</i>	Trekking & Grazing	During site selection
Gumdel (outside this valley)	4,017	307	38	Scat	Fresh (collected in 2016)	Scrubland	<i>Abies spectabilis</i>	Grazing	During reconnaissance survey

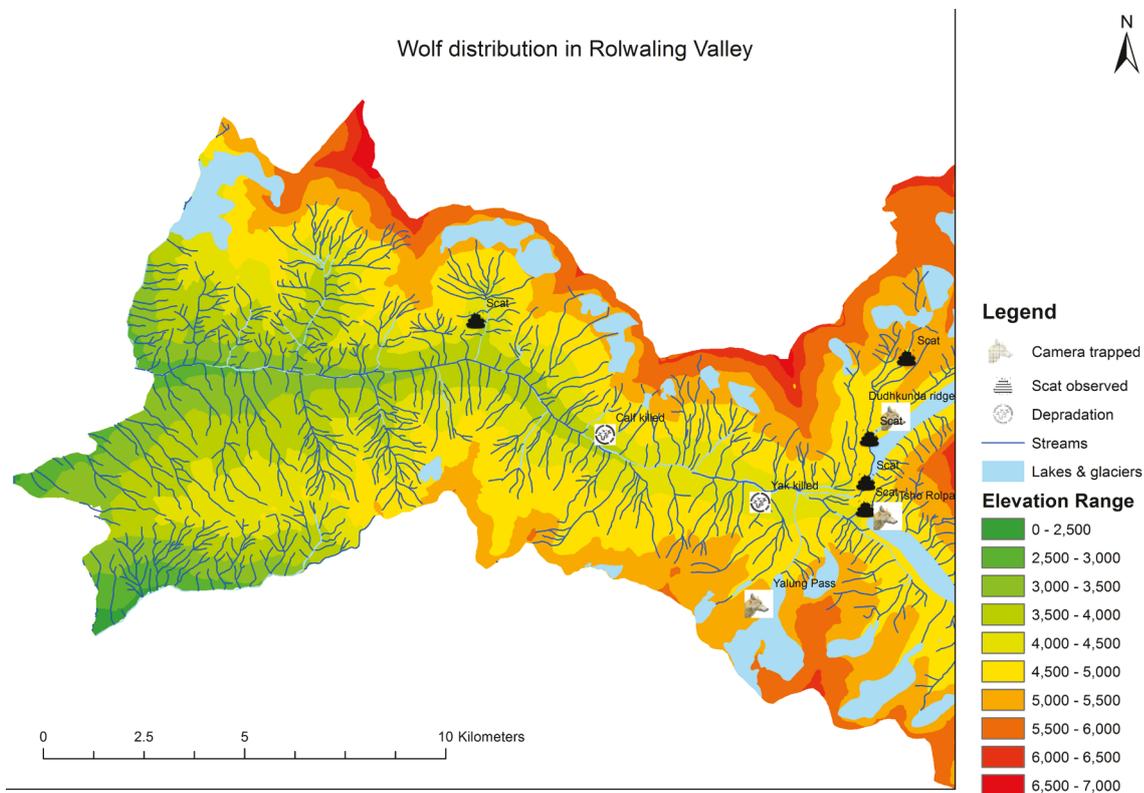


Figure 2. Wolf detections from camera traps, scat, and depredations recorded in the Rolwaling Valley, Nepal during 2019.



### Scat observation and depredation history

Scats of wolves were observed during transect walks for finding suitable camera sites (Figure 3). Identifiable scats were observed over 3,900 m on *Rhododendron anthopogon* dominated scrublands, on the human/domestic animal tracks. Also, tracks were observed in moraines. Recently, a couple of livestock depredation events near Naa village of the valley were recorded. In both occasions herders had managed to chase down small packs of Wolves (Lama 2019; Sherpa 2019). Table 2 and Figure 2 show the sites where signs of Wolf were found and general site characteristics. Earlier, a reconnaissance survey carried out by GCAP (2016) also observed Wolf scat in the Numbur Valley (behind Yalung Peak).

Although, the presence of the wolf in GCA was reported based on interviews and indirect signs (Bajracharya et al. 2011), our study confirms its presence through photographs, scat observations, and information from livestock depredations (Figure 4). This paper reports the first visual proof of the wolf in Rolwaling Valley. To our knowledge, this is probably the first ever photograph of the wolf in the Gaurishankar landscapes visually confirming its re-colonization in the valley.

### CONCLUSION

This study provides the first ever photographic evidence confirming the presence of the Himalayan Wolf in the northern area (Rolwaling region) of GCA in Nepal. Six wolf-detection events were obtained by camera trapping, all consisting of single wolves. Also, the five wolf scats and tracks that were observed during camera sites selection and depredation information from local interviewees further confirmed the wolf's presence in this area. The sites, where the evidence of wolf were confirmed, also overlapped with areas used by snow leopard and red foxes. Although, this study was not intended to quantify human-carnivore conflict, interviews confirmed that Snow Leopards are not the only predators in Rolwaling region that accounts for human wildlife interactions, especially in relation to the depredation of domesticated animals such as mountain goat and sheep, as well as Yak and 'Djokpa' (cross breed between Yak and cow). Our study aimed to assess the mega faunal biodiversity in the Rolwaling area. Additional research is warranted, specifically a more in-depth assessment of the status, habitat range, behavior and ecological role of the Wolf. In part because

wolves may be contributing to human wildlife conflict in the high Himalayan regions, conservation interventions may be needed to prevent local extinction of this species as a result of human-retaliatory killings. Furthermore, because the taxonomy of this Wolf is being debated and may result in a unique species identified, we suggest a precautionary conservation strategy be developed and implemented.

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#### Communications

##### Distribution and habitat preferences of the Chinese Pangolin *Manis pentadactyla* (Mammalia: Manidae) in the mid-hills of Nepal

– Suman Acharya, Hari Prasad Sharma, Rajeev Bhattarai, Beeju Poudyal, Sonia Sharma & Suraj Upadhaya, Pp. 18959–18966

##### On the occurrence of the Himalayan Wolf *Canis lupus*, L. 1758 (Mammalia: Carnivora: Canidae) in the Gaurishankar Conservation Area, Nepal; its existence confirmed through sign and visual evidence in Rolwaling Valley

– Bishnu Prasad Pandey, Shankar Man Thami, Rabin Shrestha & Mukesh Kumar Chalise, Pp. 18967–18974

##### Group size, crowding, and age class composition of the threatened Sambar *Rusa unicolor* (Kerr, 1792) (Mammalia: Cetartiodactyla: Cervidae) in the semi-arid regions of northeastern Rajasthan, India

– Deepak Rai & Kalpana, Pp. 18975–18985

##### Study on the impacts of LULC change on the wildlife habitat and the livelihood of people in and around Dampa Tiger Reserve, Mizoram, India

– Sushanto Gouda, Janmejey Sethy, Netrapal Singh Chauhan & Harendra Singh Bargali, Pp. 18986–18992

##### Characterisation of breeding habitat of Grizzled Giant Squirrel *Ratufa macroura* (Mammalia: Sciuridae) in Chinnar Wildlife Sanctuary, Western Ghats, India

– Kiran Thomas & P.O. Nameer, Pp. 18993–19001

##### Seasonal prey availability and diet composition of Lesser Asiatic Yellow House Bat *Scotophilus kuhlii* Leach, 1821

– Shani Kumar Bharti & Vadmalai Elangovan, Pp. 19002–19010

##### Bird composition, diversity and foraging guilds in agricultural landscapes: a case study from eastern Uttar Pradesh, India

– Yashmita-Ulman & Manoj Singh, Pp. 19011–19028

##### Identification of a unique barb from the dorsal body contour feathers of the Indian Pitta *Pitta brachyura* (Aves: Passeriformes: Pittidae)

– Prateek Dey, Swapna Devi Ray, Sanjeev Kumar Sharma, Padmanabhan Pramod & Ram Pratap Singh, Pp. 19029–19039

##### Moths of the superfamily Gelechioidea (Microlepidoptera) from the Western Ghats of India

– Amit Katewa & Prakash Chand Pathania, Pp. 19040–19052

##### On the diversity and abundance of riparian odonate fauna (Insecta) of the midstream Chalakkudy River, Kerala, India

– C. Nitha Bose, C.F. Binoy & Franci K. Kakkassery, Pp. 19053–19059

##### Species diversity and abundance patterns of epiphytic orchids in Aralam Wildlife Sanctuary in Kerala, India

– Jis Sebastian, Durairaj Kathiresan & Giby Kuriakose, Pp. 19060–19069

##### Status and conservation needs of *Cycas pectinata* Buch.-Ham. in its natural habitat at Baroiyadhala National Park, Bangladesh

– M.K. Hossain, M.A. Hossain, S. Hossen, M.R. Rahman, M.I. Hossain, S.K. Nath & M.B.N. Siddiqui, Pp. 19070–19078

#### Review

##### Limitations of current knowledge about the ecology of Grey Foxes hamper conservation efforts

– Maximilian L. Allen, Alexandra C. Avrin, Morgan J. Farmer, Laura S. Whipple, Emmarie P. Alexander, Alyson M. Cervantes & Javan M. Bauder, Pp. 19079–19092

#### Short Communications

##### On the freshwater fish fauna of Krishna River, Sangli District, Maharashtra, India

– Suresh M. Kumbhar, Shrikant S. Jadhav, Swapnali B. Lad, Abhijit B. Ghadage, Satyawan S. Patil & C. Shiva Shankar, Pp. 19093–19101

##### Diversity and distribution of the large centipedes (Chilopoda: Scolopendromorpha) in the Phia Oac - Phia Den National Park, Vietnam

– Le Xuan Son, Nguyen Thi Tu Anh, Tran Thi Thanh Binh, Thu Anh T. Nguyen & Anh D. Nguyen, Pp. 19102–19107

##### Diversity of ants in Aarey Milk Colony, Mumbai, India

– Akshay Gawade & Amol P. Patwardhan, Pp. 19108–19117

##### First record of ghost shrimp *Corallianassa coutierei* (Nobili, 1904) (Decapoda: Axideidae: Callichiridae) from Indian waters

– Piyyush Vadher, Hitesh Kardani, Prakash Bambhaniya & Imtiaz Beleem, Pp. 19118–19124

##### A preliminary checklist of dragonflies and damselflies (Insecta: Odonata) of Vakkom Grama Panchayath, Thiruvananthapuram District, Kerala, India

– J. Arunima & P.O. Nameer, Pp. 19125–19136

##### Diversity pattern of butterfly communities (Lepidoptera) in different habitat types of Nahan, Himachal Pradesh, India

– Suveena Thakur, Suneet Bahrdwaj & Amar Paul Singh, Pp. 19137–19143

##### Descriptions of the early stages of *Vagrans egista sinha* (Lepidoptera: Nymphalidae) with notes on its host plant *Xylosma longifolia* Clos from the western Himalaya of India

– Pranav Gokhale & M.A. Yathumon, Pp. 19144–19148

#### Notes

##### First photographic record of Mishmi Takin *Budorcus taxicolor taxicolor* and Red Goral *Nemorhaedus baileyi* from Kamlang Tiger Reserve, Arunachal Pradesh, India

– Cheshta Singh & Deepti Gupta, Pp. 19149–19152

##### Utilisation of honey trap method to ensnare a dispersing sub-adult Bengal Tiger *Panthera tigris tigris* L. in a human dominated landscape

– Gobind Sagar Bhardwaj, Balaji Kari & Arvind Mathur, Pp. 19153–19155

##### First camera trap photographs of Indian Pangolin *Manis crassicaudata* (Mammalia: Pholidota: Manidae) from Pakistan

– Misbah Bint Riaz, Faraz Akrim, Siddiq Qasim, Syed Afaq Bukhari, Asad Aslam, Muhammad Waseem, Rizwana Imtiaz & Tariq Mahmood, Pp. 19156–19158

##### Photographic record of Lesser Flamingo *Phoeniconaias minor* (Aves: Phoenicopteridae) in Ramganga river, Bareilly, India

– Pichaimuthu Gangaikaran, Aftab A. Usmani, G.V. Gopi, S.A. Hussain & Khursid A. Khan, Pp. 19159–19161

##### Total length and head length relationship in Mugger Crocodiles *Crocodylus palustris* (Reptilia: Crocodylia: Crocodylidae) in Iran

– Asghar Mobaraki, Elham Abtin, Malihe Erfani & Colin Stevenson, Pp. 19162–19164

##### First record of the hoverfly genus *Spilomyia* Meigen (Diptera: Syrphidae) for Pakistan

– Muhammad Asghar Hassan, Imran Bodlah, Riaz Hussain, Azan Karam, Fazlullah & Azaz Ahmad, Pp. 19165–19167

##### Rediscovery of Watson's Demon *Stimula swinhoei swinhoei* (Elwes & Edwards, 1897) (Lepidoptera: Hesperidae: Hesperinae) in Meghalaya, India after 60 years

– Suman Bhowmik & Atanu Bora, Pp. 19168–19170

##### A record of *Ouraapteryx dierli* Inoue, 1994 (Lepidoptera: Geometridae: Ennominae) from the Garhwal Himalaya, India

– Arun P. Singh & Lekhendra, Pp. 19171–19172

##### Report of *Bradynopyga konkanensis* Joshi & Sawant, 2020 (Insecta: Odonata) from Kerala, India

– Muhammed Haneef, B. Raju Stiven Crasta & A. Vivek Chandran, Pp. 19173–19176

##### A new distribution record of *Bianor angulosus* (Karsch, 1879) (Araneae: Salticidae) from Kerala, India

– Nishi Babu, John T.D. Caleb & G. Prasad, Pp. 19177–19180

##### Notes on lectotypification of the Assam Ironwood *Mesua assamica* (King & Prain) Kosterm. (Calophyllaceae)

– Prantik Sharma Baruah, Sachin Kumar Borthakur & Bhaben Tanti, Pp. 19181–19184

##### On the rediscovery of a rare root parasite *Gleadovia ruborum* Gamble & Prain (Orobanchaceae) from Uttarakhand, western Himalaya, India

– Amit Kumar, Navendu V. Page, Bhupendra S. Adhikari, Manoj V. Nair & Gopal S. Rawat, Pp. 19185–19188

##### Occurrence of vivipary in *Ophiorrhiza rugosa* Wall. (Rubiaceae)

– Birina Bhuyan & Sanjib Baruah, Pp. 19189–19190

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