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Monitoring of tiger and associated species in Nihal-Bhakra corridor of Terai Arc Landscape, India

Anwar M.* **and Chowdhury D.M.R.**
World Wide Fund for nature-India, 172-B, Lodi Estate, New Delhi-110003, India
anwar.meraj@gmail.com

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Abstract

Wildlife corridors are the key to long term conservation of territorial big cats such as tiger. These corridors are known to provide access to the new forest patches to the dispersing tigers where they can establish their territories. Linear development in the absence of any smart green infrastructure increases fragmentation of the wildlife habitat and poses threat to the wild animals including tigers. Present study aimed to monitor tiger and its associated species in a corridor by using 30 pairs of camera traps in a period of 30 days. In total, fifteen mammalian species were recorded in addition to tiger. World's smallest wild cat i.e. rusty spotted cat was also recorded from the study area which is first capture of the species from this corridor. However, largest terrestrial mammal photo-captured during the study was elephant.

Keywords: Wildlife corridor, Tiger, Terai Arc Landscape, Camera trap, Bottleneck.

Introduction

It is now well known fact and recognized that for survival of tigers *Panthera tigris* and other large carnivores, loss and degradation of habitat is the primary long term threat[1-3]. Fragmentation is another major threat to biological diversity as people transform the landscape to accommodate their needs[4,5]. Many of Asia's protected areas are relatively small and isolated[6]. The chances for long term survival of mega fauna in many of these protected areas are slim[7,8] unless they are linked by natural habitat corridors to permit dispersal of tigers and their prey and are buffered to minimize impacts from other land uses. Therefore, a landscape level approach accommodating corridors and buffer zones is essential to a long term tiger conservation strategy[9,10].

In 1930's tiger habitat in the foothills of the Himalayas was continuous for over 1800 km from west of Corbett National Park, India, through the lowlands of Nepal, Sikkim and Bhutan to eastern India[11]. This tract of forests is known as Terai Arc Landscape (TAL) which is highly fragmented now. Johnsingh et al identified 12 corridors connecting isolated patches of the forests in TAL[12]. Nihal-Bhakra is one of the priority corridors which provide connectivity to the Terai Central forest division with Ramnagar forest division which is next to the Corbett tiger reserve (CTR). Signs of leopard and tigers were recorded from this corridor in the earlier studies carried out by Wildlife Institute of India, Dehradun[12,13].

However, functional status of this corridor with reference to tiger is lacking and obviously, this knowledge is vital for the conservation of tiger at landscape level. Functionality of this corridor might provide refuge to the spill over population of the tigers from CTR and Ramnagar division in the forests of Terai Central division and surrounding divisions which act as buffers of CTR. Therefore, present study was designed to monitor this corridor using automatic camera traps by recording tiger and other mammalian species.

This study intended to reveal the functionality of the corridor with the help of movement patterns of the individual tigers passing through this corridor in a month time of the study. Monitoring of the Nihal-Bhakra corridor aimed to identify individual tigers using the corridor, assess functional status of the corridor with reference to tiger and generate baseline of mammalian fauna in the corridor.

Study area: Nihal-Bhakra corridor is an important corridor of Terai Arc Landscape and administratively comes under Nainital district of Uttarakhand state of India. The contiguous forests of Fatehpur range of Ramnagar and Gadgadia range of Terai Central division known as Nihal-Bhakra corridor, forms a 4 km wide bottleneck ($29^0 14' 04''$ N-$79^0 22' 13''$E and $29^0 13' 45''$ N-$79^0 24' 32''$E) at a place where Kaladhungi-Haldwani road bisects the forest (Figure-1).

Johnsingh et al described about corridors that enable tiger movement between Ramnagar FD and Terai Central FD, which otherwise would be an isolated forest block[12]. One of these corridors is Nihal-Bhakra. Forest patches of Bhakra and Pipalpadav range of Terai Central division also borders the southern portion of this corridor. Corridor area of Ramnagar Forest Division annually gets boulder and dirt deposition from the watershed situated in the north[13]. Nihal River enters the Fatehpur range from the north as single stream and disappears into a number of tributaries on the floor of the forest.

Few streams of the Nihal lead into Bhakra River flowing on the eastern part of Fatehpur and Gadgadia ranges. These two rivers may not provide water to the wildlife round the year because at places water disappears beneath the rocks in dry season-characteristic of bhabar area. Haripura and Baur reservoirs are situated in the extreme south-west of this corridor which provides water to the wildlife in drier season.

Important tree species recorded in this corridor were *Shorea robusta, Ehretia laevis, Mallotus phillipensis, Acacia catechu, Aegle marmelos*, and *Lagerstroemia parviflora* while under plantation *Tectona grandis, Dalbergia sissoo* and *Trewia nudiflora* were found. Important fauna of this corridor includes tiger, leopard, elephant, sambar, chital and nilgai.

This corridor provides connectivity to a larger forest patch of Tanda, Gadgadia, bhakra, Pipalpadav and Haldwani ranges of Terai Central and Brahni, Bannakheda ranges and south Gabua block of Terai West forest division. This area serves as supporting buffer for spill over population of tigers and other wildlife of nearby forest of CTR and Ramnagar division. Contiguity of the forests of Terai East division in the south east breaks near Lalkuan town due to blockage of Gola river corridor.

There are four villages/hamlets (Fatehpur. Ratanpurisai, Puranpurharaksingh, and Nawarmulaharaksingh) on the eastern and 12 villages/hamlets (Chandnichaur, Chorajali, Gulzarpurbanki, Gulzarpurramsingh, Puranpur, Devipur, Rampur, Bedrampur, Lachampur, Pratappur, Khadakpur, and Surpur) on the western side and two villages (Chausila and Mithaaonla) on the northern side of the Nihal-Bhakra corridor (Figure-2). Anthropogenic pressure from these hamlets on the corridor are tremendous. Illicit felling, illegal boulder and sand mining, extraction of fuel wood and other NTFPs, farming on lease plot, cattle grazing and occasional prey base poaching are major threat to this corridor.

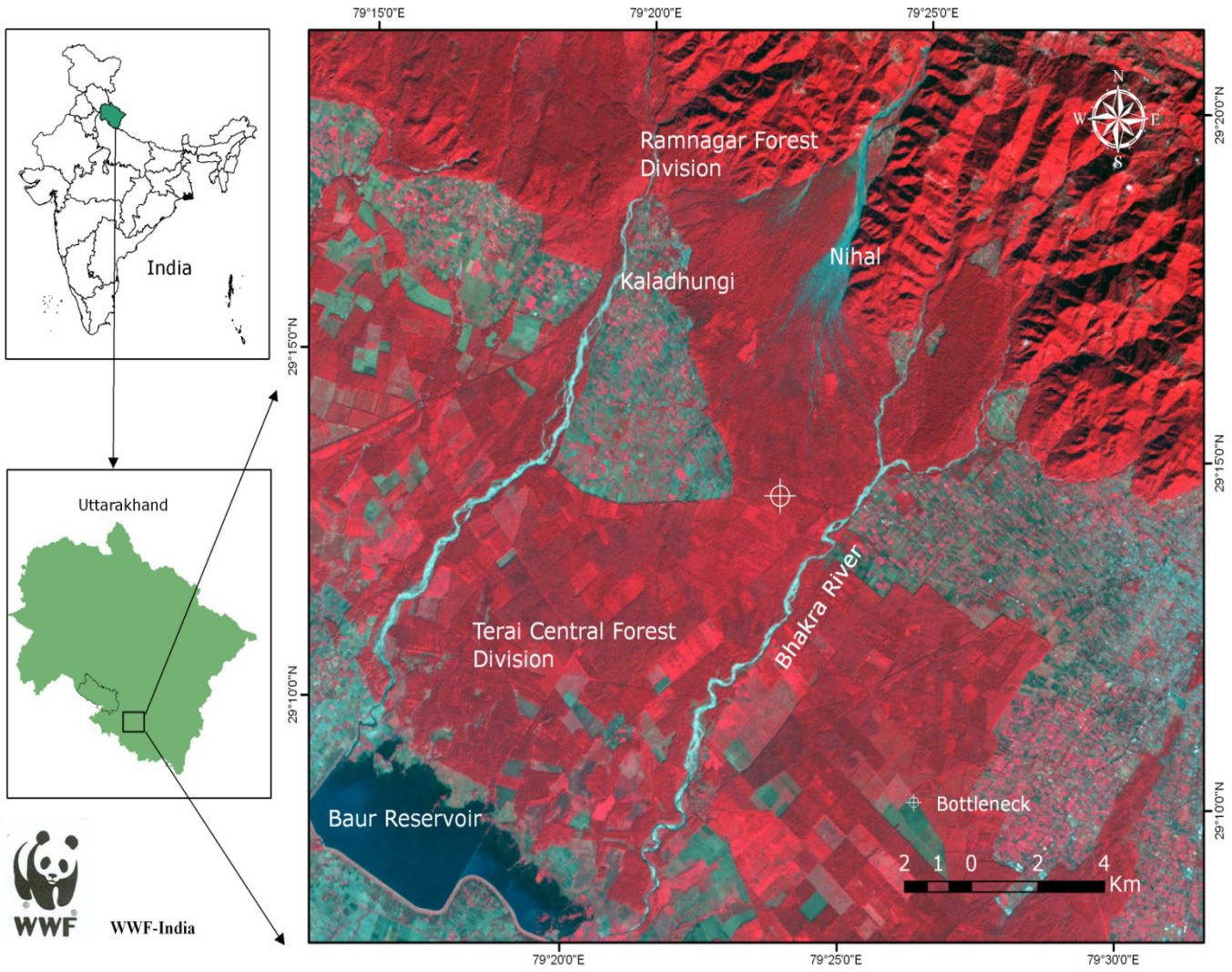

Figure-1: Location of Nihal-Bhakra corridor in the state of Uttarakhand of India (Red shades depict forest cover).

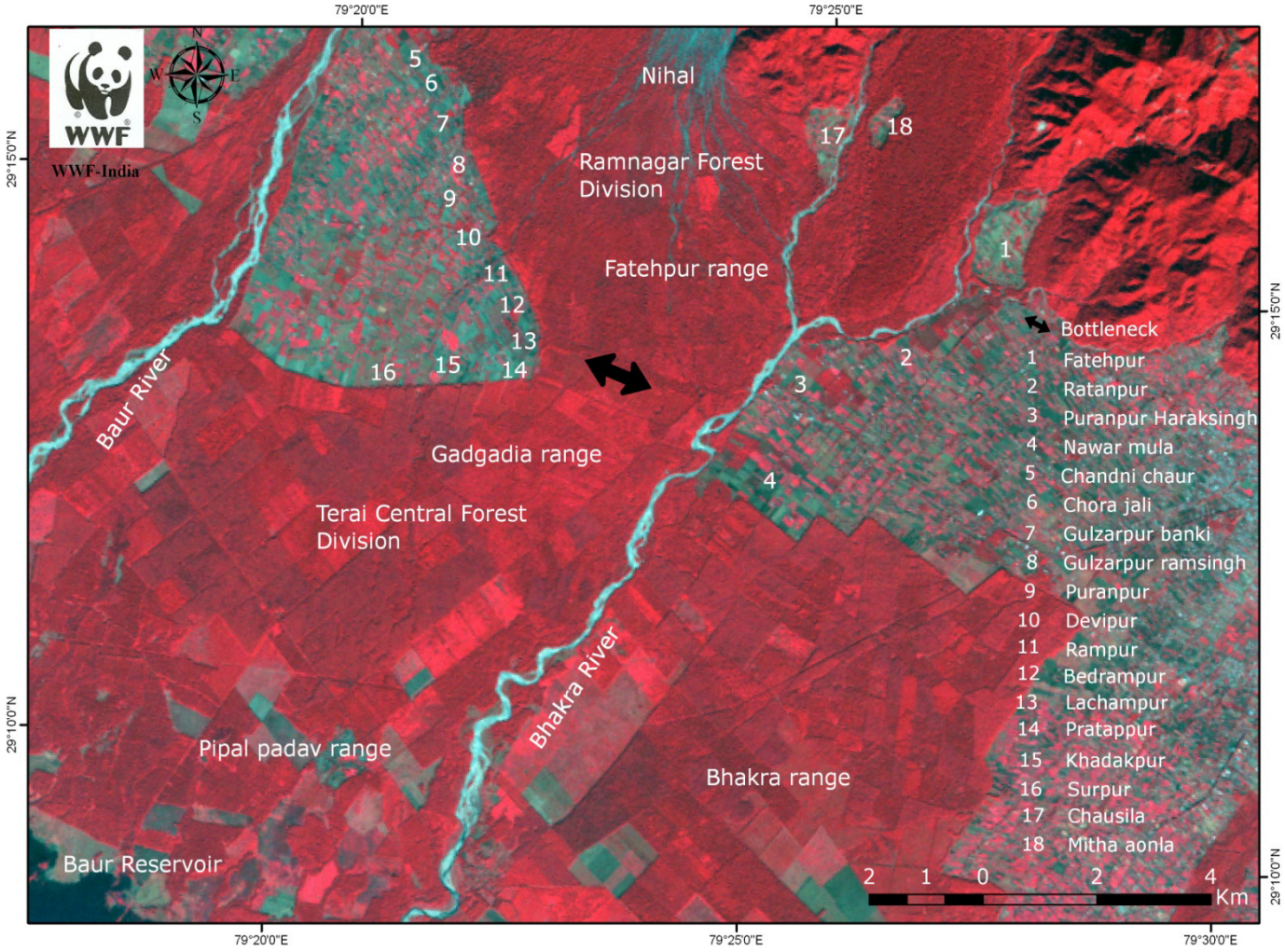

Figure-2: Location of villages around Nihal-bhakra corridor.

Methodology

Monitoring exercise of the Nihal-Bhakra corridor was carried out between 1 June and 30 July 2012. Collected data was segregated to species level besides blank and over exposed photographs for further analysis.

Preliminary survey: Carnivore sign survey was carried out between 1 June and 25 June 2012 by teams comprising a field biologist and trained field assistants. Site selection for deploying the camera trap was based on systematic surveys carried out in the Nihal-Bhakra corridor. During the survey, information regarding signs of big cats which were seen in the form of scats, scrapes, rake marks and pugmarks filled in a data sheet. Herbivore usage of areas was also noted based on occurrence of evidences like track sets, pellets or dung and also based on direct sightings. Animal trails or paths likely to have maximum possibility of capture of tiger based on above mentioned assessment were identified. Over these identified path/trail, a suitable site for putting the camera traps was selected and location was marked using Garmin eTrex GPS receiver.

Data collection: Geo-coordinates of the sites were overlaid in a grid size of 2x2 km² over an image (ETM$^+$ of 2009) of the corridor area. Corridor area was covered completely by 30 grids meant to be sampled for the present study (Figure-3). Camera trapping was carried out between 1July and 30 July 2012 by deploying 30 pairs of Cuddeback 'Attack' camera traps. In each grid, traps were placed three to six m away from the centre of the trail to photograph the animal clearly, when the camera would trigger.

The time interval was kept 15 seconds between successive captures to maximize the chance of taking photographs of cubs following the mother or pair of animals moving close together. Cameras were set to operate 24 hours /day. In case of wider paths and stream, movement of the target animal was channelled towards deployed camera traps by using fallen tree branches. Camera traps were checked frequently and any mal-functioning camera trap was replaced immediately to avoid any loss of data. Alkaline batteries were used in the camera traps and discharged batteries were timely replaced with a set of new one.

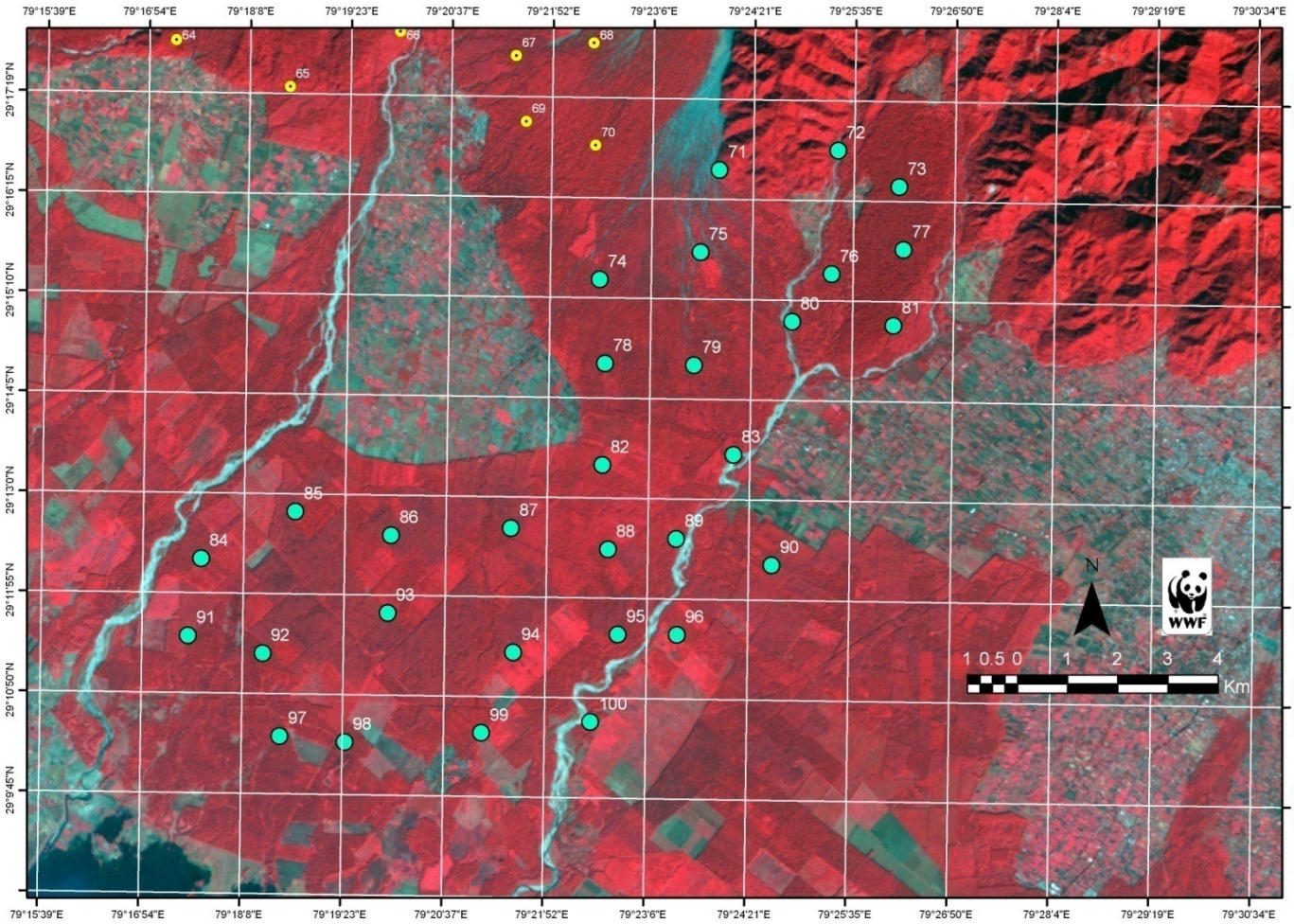

Figure-3: Grid map of Nihal-Bhakra corridor with the camera sites numbered from 71 to 100. Grid size was of 2x2 km².

Data analysis: Data was collected systematically by giving specific code to each camera traps in the field. Stored photographs in the memory cards of the camera traps were transferred into coded folders for each camera, date and location information. Photographs were segregated at the level of different species for further analysis. Clear photographs of the tiger were manually identified and individual tigers were given a unique identification code (T1, T2, and T3) following the unique stripe pattern on the forequarters, limbs, flanks, and sometimes even tail[14-16]. Sex of the individual tiger was ascertained based on the visible genital organ. Corridor usage by Minimum number of tigers (M_{t+1}) was assessed with the help of collected data.Whereas functionality of the corridor was described by generating minimum convex polygon (MCP) using ArcGIS and Hawth's analysis tool[17]. MCPs were generated based on the spatial recaptures of individual tigers.

Unique captures of the wild fauna of the corridor were used in the calculation of relative abundance index[18] (RAI) for each mammalian species. Animal individual captures more than once in an hour were excluded from the calculations[19] to minimise scoring of same individual multiple times and as a compromise for missing individuals[20]. Total number of trap days was divided by total number of photographs of a species to calculate number of days required to capture a photograph of the species (RAI_1). It (RAI_1) is expected to decrease with an increase in density of the animal. RAI_2 is expressed in terms of number of captures per 100 trap days for which unique captures of a species from all of the trap locations were summed up and divided by total number of trap days and it is expected to increase with an increase in density of the animal[18].

Results and discussion

The monitoring of Nihal-Bhakra corridor with reference to tiger, involved an effort of 900 trap days using 30 pairs of camera traps. This study documented presence of tiger and 15 other wild mammalian species in the sampled area of the corridor.

Tigers of Nihal-Bhakra corridor: A road between Kaladhungi and Haldwani towns bisects Nihal-Bhakra corridor at a point where width of the forest is just 4 km, clearly dividing it into northern and southern portions. Tigers were recorded in both the portions of the corridor. In the entire study duration, Altogether

three tigers were recorded in the sampled corridor. Unique IDs were allocated to these tigers as per the database of the tigers. Sexes of all of the three tigers were determined owing to availability of their clear photographs. Out of the three tigers, two were male and one was female (Figure-4). Female tiger (T3) was captured once in the entire study and a male (T1) was photo captured seven times while another male tiger (T2) was photo captured only four times. Cumulative new tiger capture curve was found stabilized during 10th occasion whereas total number of captures for tiger was steady throughout the session (Figure-5). No lactating tigress or one with cubs was photo captured during the study period. All of the tiger images were recorded during night time when anthropogenic disturbances decreases considerably. Tiger captures were concentrated into two lots, one in Fatehpur range touching Kaladhungi range of Ramnagar FD and second in PipalPadav range bordering with Bhakra and Gadgadia ranges of Terai West FD. The tiger of second lot might be extending its movement in Bhakra range as well, where camera traps were not deployed due to logistic constraints.

Functional status of the corridor with reference to tiger: The functionality of the corridor with reference to tiger could be work out with the help of spatial recaptures of an individual tiger across the corridor. Tigers are widely known to have natural markings (stripe pattern) which help in individual identification[14]. Camera traps revealed the movements of the individual tigers in the Nihal-Bhakra corridor. A male and a female tiger (T1 and T3) was found using the northern portion while another male tiger (T2) was recorded restricting its movement in the southern portion of the corridor (Figure-6). No female tiger was recorded from the southern portion of the corridor probably due to an increase in disturbance from adjoining human settlements. The male tiger T1, whose movements were concentrated to the northern portion of the corridor, once crossed this corridor and photo captured at the camera station number 96 situated in the southern portion (Figure-6). Very next day same individual was found back to the northern portion of the corridor (Camera station number 74). This up and down movement of the tiger demonstrate that the corridor is still functional and can serve as a conduit to access forested area of Terai Central forest division by the spill over population of the tigers of Ramnagar division. The estimated density of the tigers in Ramnagar division was quite high[21] (15 tigers/100 sq km) and through this connectivity, forest patches of Terai Central division would act as buffer of Ramnagar division, which might provide refuge to the spill over tigers. Adequate buffer around the source population of the tiger would help in its long term conservation in the landscape[9,22,10]. Vehicle movements on the Haldwani-Kaladhungi road pose threat to the movement of the wildlife including tigers through this corridor. Anthropogenic pressure from the villages of eastern and western side of the corridor might degrade the habitat of this corridor to the extent impeding the movement of wildlife including tiger.

Figure-4(a): Male tiger T1 photo-captured in Nihal-Bhakra corridor.

Figure-4(b): Male tiger T2 photo-captured in Nihal-Bhakra corridor.

Figure-4(c): Female tiger T3 photo-captured in Nihal-Bhakra corridor.

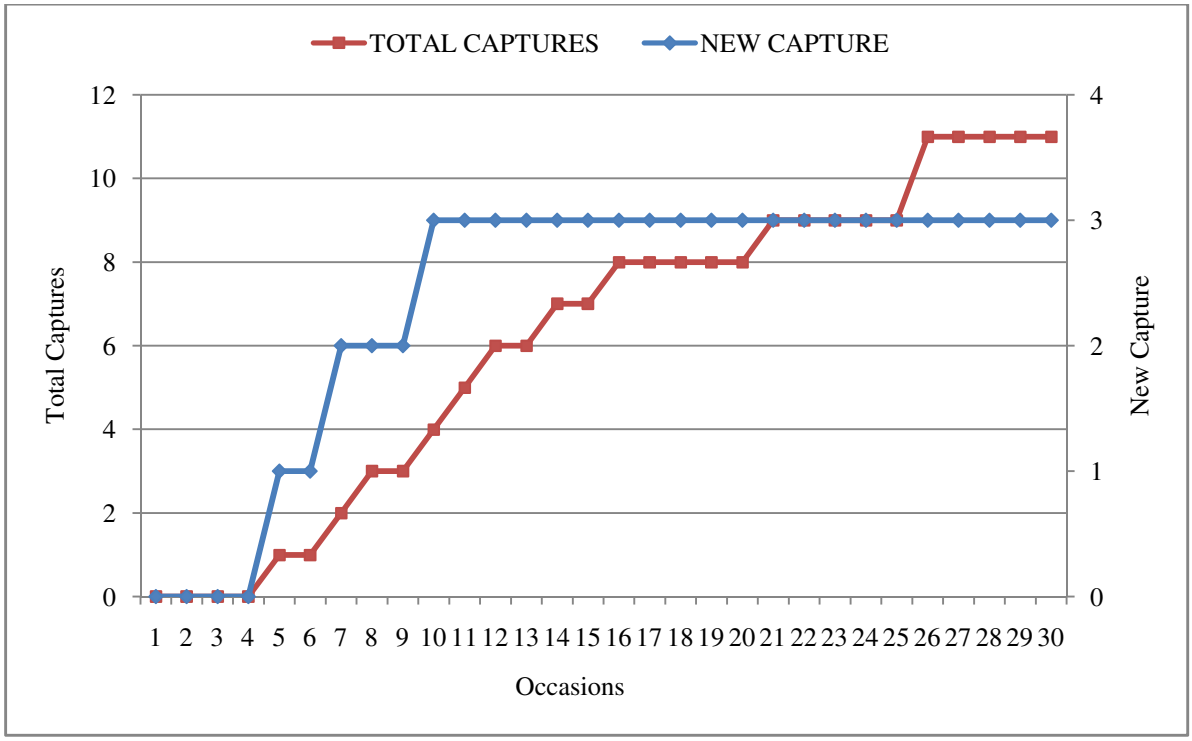

Figure 5: Cumulative rate of new captures of tiger in Nihal-Bhakra corridor.

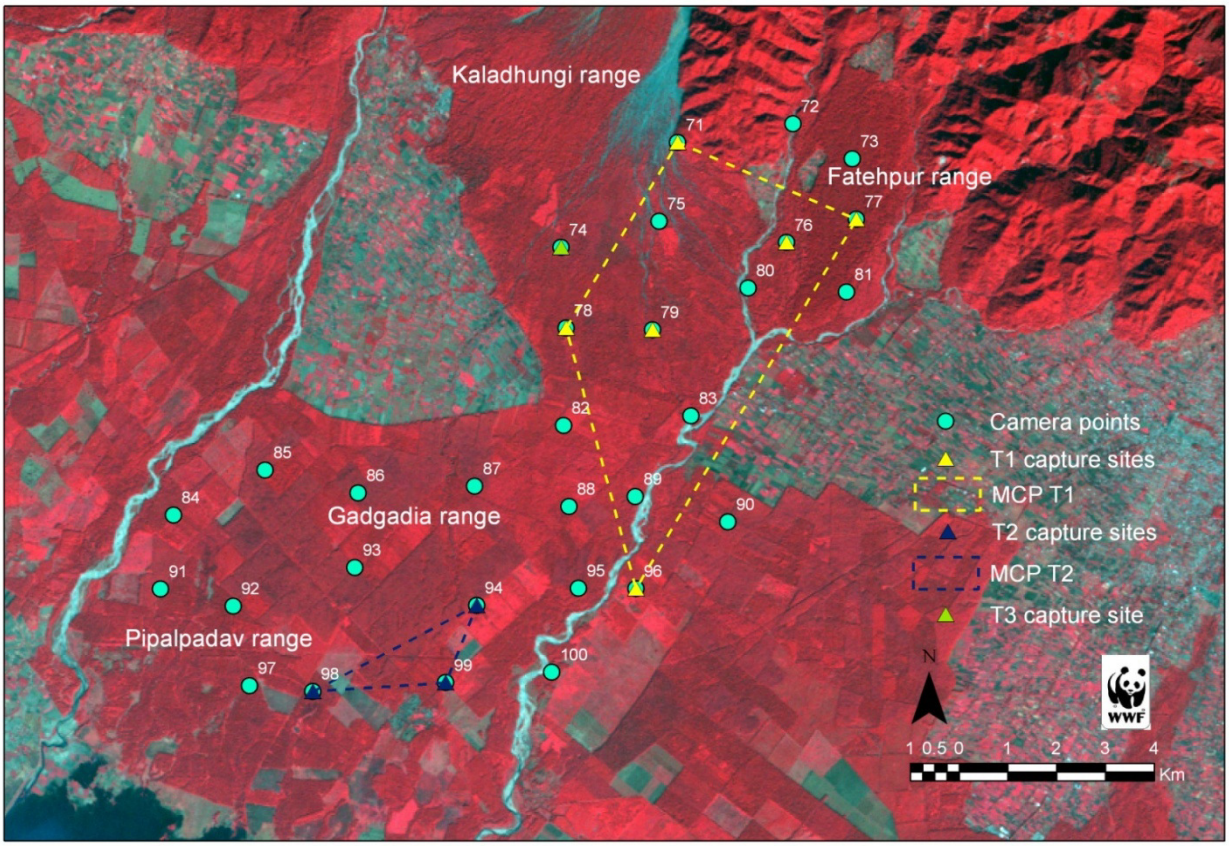

Figure-6: Capture sites and minimum convex polygon of individual tigers in Nihal-Bhakra corridor. Red shades depict forest cover.

Assemblage and abundance of mammals in the corridor: Camera trapping of the present study recorded16 species of wild mammals including charismatic tiger, leopard and Asian elephant in the Nihal-Bhakra corridor. Five species of 16 were of high global conservation significance and are categorized as endangered (2), vulnerable (2) and near threatened (1) on the IUCN Red list presenting this corridor as ecologically significant. Most of the recorded species are low land mammals. First time, rusty spotted cat (Figure-7) was recorded from this corridor area of Ramnagar as well as Terai Central forest divisions both. Rusty spotted cat was not one among the recorded 21 wild mammals from Kosi River corridor[23]. Among other lesser carnivores, grey mongoose, small Indian and common palm civets were recorded. Commonly found wild prey species recorded in the corridor were chital, sambar, muntjac, nilgai and wild pig. Two non-human primates (rhesus monkey and hanuman langur) were also photo-captured from the different parts of this corridor. Indian porcupine and Indian hare were recorded many times (19 and 9 respectively) from this corridor. Occasionally, tiger and leopard feeds on hanuman langur and India porcupine too.

Under big cats category, leopards were most abundant (3.56 ± 0.87 (SE) captures / 100 trap days) and for getting a photo of leopard only 21.13 trap days were required while tigers took 64.29 trap days to get captured once (Table-1). The corridor is surrounded by a number of villages which probably impacts on the occurrence of tigers here as the tigers need undisturbed habitat in addition to prey base[24, 25, 26]while leopards are more adapted to survive on livestock and domestic dogs adjoining human settlements[27].RAI_2 for tiger was higher than that of leopard. RAI_2 of lesser carnivores was low, probably due to the study design which focused mainly tiger as target species. Grey mongoose and common palm civet were captured only once while rusty spotted cat and small Indian civet were captured twice and six times respectively. Rusty spotted cat photo-captured from this corridor and other areas too[29] after it was reported from Terai[30] for the first time.

Figure-7: Rusty spotted cat photo-captured in Nihal-Bhakra corridor.

Among ungulates, chital were found to be most abundant (22.56 ± 4.08 captures / 100 trap days ± SE) followed by sambar, wild pig, nilgai and lowest relative abundance index was of muntjac (1.11 ± 0.43). Based on RAI, nilgai in Nihal-Bhakra corridor were more abundant (Table-1). For a photograph of chital, 4.43 trap days were required and muntjac needed 90 trap days to get captured once in the study duration. Hanuman langur were relatively less abundant than rhesus monkeys. Asian elephant were captured 27 times in the corridor. Mainly, tuskers were found using this corridor area.

People and Livestock: Anthropogenic disturbance was recorded from the Nihal-Bhakra corridor which was mainly contributed by presence of humans themselves (104.22 ± 16.21 (SE) captures / 100 trap days).Humans needed less than a trap day to get captured once in the camera traps deployed in the corridor (Table-2). They were captured when involved in fuel wood and fodder collection from the forest as well as traversing through forest. At two different instances they were captured with country made firearm and knives probably prowling for prey species hunting in the corridor. Camera traps from three different locations of the corridor were also stolen during the study which is an indication of anthropogenic disturbance. RAI_2 for the cattle was also higher (16.00 ± 4.64) they produced a photo in 6.25 trap days. Dogs supposed to be carrier of dreaded disease such as Canine distemper virus[28], were also recorded at least 20 times in the Nihal-Bhakra corridor (Table-2). Increasing human population and ever increasing their dependency on the forest is putting more pressure from eastern and western side at the bottleneck of this corridor. Encroachments in the form of Khatta (unauthorized land plot) are also exerting pressure on the habitat. They clear the area for agriculture by drying of trees with the help of girding. Snares on the edges of crop fields adjoining forest were also encountered during the study.

Table 1: Relative abundance index (RAI_2) and number of trap days required to capture a wild mammal species (RAI_1) and associated information of wild mammal species recorded in Nihal-Bhakra corridor

Fauna	IUCN category	Order	Family	# of captures	Mean (RAI_2) ± SE (RAI_2)	Trap days /capture (RAI_1)
Tiger	EN	Carnivora	Felidae	14	1.56 ± 0.41	64.29
Leopard	NT	Carnivora	Felidae	32	3.56 ± 0.87	21.13
Rusty spotted cat	V	Carnivora	Felidae	2	0.22 ± 0.15	450
Grey mongoose	LC	Carnivora	Herpetidae	1	0.11 ± 0.11	900
Common palm civet	LC	Carnivora	Viverridae	1	0.11 ± 0.11	900
Small Indian civet	LC	Carnivora	Viverridae	6	0.67 ± 0.34	150
Nilgai	LC	Artiodactyla	Bovidae	37	4.11 ± 1.58	24.32
Chital	LC	Artiodactyla	Cervidae	203	22.56 ± 4.08	4.43
Muntjac	LC	Artiodactyla	Cervidae	10	1.11 ± 0.43	90
Sambar	V	Artiodactyla	Cervidae	67	7.44 ± 1.60	13.43
Wild pig	LC	Artiodactyla	Suidae	47	5.22 ± 1.27	19.15
Rhesus monkey	LC	Primates	Cercopithecidae	42	4.67 ± 1.76	21.43
Hanuman langur	LC	Primates	Cercopithecidae	13	1.44 ± 0.69	69.23
Indian hare	LC	Lagomorpha	Leporidae	9	1.00 ± 0.48	100
Indian porcupine	LC	Rodentia	Hystricidae	19	2.11 ± 0.72	47.37
Asian elephant	EN	Proboscidea	Elephantidae	27	3.00 ± 0.81	33.33

NT=Near threatened, LC=Least concern, V=Vulnerable, EN=Endangered, **RAI_1**: Number of trap days required to get one photo of a species-an index of effort required, **RAI_2**: number of captures of a species/100 trap days-an index of relative abundance. Both indices reflect relative commonness or rarity of a species.

Table-2: Relative abundance index (RAI_2) and number of trap days required to capture a disturbance regime (RAI_1) in Nihal-Bhakra corridor

Disturbance regime	Order	Family	# of captures	Mean (RAI_2) ± SE (RAI_2)	Trap days /capture (RAI_1)
Human	Primates	Hominidae	938	104.22 ± 16.21	0.96
Cattle	Artiodactyla	Bovidae	144	16.00 ± 4.64	6.25
Domestic dog	Carnivora	Canidae	20	2.22 ± 0.56	45

RAI_1: Number of trap days required to get one photo of a species-an index of effort required. **RAI_2**: number of captures of a species/100 trap days-an index of relative abundance. Both indices reflect relative commonness or rarity of a species

Conclusion

By investing an effort of 900 trap days, three tigers were recorded from the Nihal-Bhakra corridor however only one tiger (T1) was found crossing the corridor once in 30 days of the study period. This tiger (T1) was forced to negotiate the traffic on the Kaladhungi-Haldwani road to access the forest of Terai Central Forest Division. Global conservation significance was high for the five out of 16 wild mammals recorded in the corridor. These are categorized as endangered (Tiger and Asian elephant), vulnerable (sambar and rusty-spotted cat) and near threatened (leopard) on the IUCN Red list presenting this corridor as ecologically significant. Rusty-spotted cat was photo-captured for the first time from this corridor which is an addition to the list of wild fauna of both the forest divisions. Cattle grazing in this corridor were found high and a photo of cattle required approximately 6 trap days in the corridor. Based on the study in Nihal-Bhakra corridor following recommendations would be helpful in ensuring functionality of this corridor for the long term conservation of tigers in this landscape.

Inclusion of Corridor Management Plan: There is a need to bring and manage wildlife corridors under an umbrella of legal protection body. Forest divisions of Ramnagar and Terai Central need to develop Corridor Management Plan (CMP) by incorporating infrastructure developmental issues and threats affecting the status as well as functionality of the Nihal-Bhakra corridor. CMP can be included in the divisions' working/management plan for implementation. As long as corridor remains functional along with suitable habitat, tiger population will flourish in this landscape.

Strategies for reclaiming forest land and awareness in villages around the corridor: The forest land of the corridor which was encroached upon should be reclaimed on priority basis by taking decision at state level. Encroachments in the form of khatta are exerting anthropogenic pressure enormously on the habitat and making it less suitable for tigers and other wildlife.

Awareness to the villagers of surrounding villages on the conservation of tiger in this landscape and importance of this corridor can bring a big change in their understanding of saving corridors for tigers and other wildlife.

Regulation on open grazing in the corridor: Forest of this corridor is under heavy grazing by cattle of surrounding villages and pastoralists residing in the corridor. They need to be regulated and block wise grazing pattern can be adopted by forest divisions. Heavy grazing by cattle in particular areas would degrade the forest beyond its carrying capacity.

Regulation of traffic on Kaladhungi-Haldwani road: Night time traffic movement on the 4 km section of Kaladhungi-Haldwani road passing through the corridor need regulation to safeguard wild animals using this corridor.Deployment of wildlife detection and alarm sensors on the main crossing points along the road passing though the corridor will be helpful in minimizing road kills.For longer term, this stretch can be brought under over pass for traffic to zero down road kills and maintain the functionality of the corridor.

Enhancing Protection in the corridor: Protection is one of the biggest challenges in this corridor due to porous boundary of the forest from all directions. People have easy access in day and night and round the year to the forest of this corridor therefore, protection level needs to be enhanced. There is a need of strengthening of anti-poaching camps with equipment and better informer network.

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