International Journal of Fauna and Biological Studies
Available online at www.faunajournal.com

IJFBS
International Journal of Fauna And Biological Studies

ISSN 2347-2677
IJFBS 2017; 4(2): 91-96
Received: 13-01-2017
Accepted: 14-02-2017

Ugyen Tshering
1) Department of Forest and Park Services, Ministry of Agriculture and Forests, Territorial Forest Division, Sarpang, Nebraska
2) Indira Gandhi National Forest Academy, Dehradun, Uttarakhand India

Om Katel
College of Natural Resources, Royal University of Bhutan, Lobesa, Punakha, Bhutan.

Tshering Nidup
Department of Forest and Park Services, Ministry of Agriculture and Forests, Phibsoo Wildlife Sanctuary, Sarpang

Correspondence
Ugyen Tshering
1) Department of Forest and Park Services, Ministry of Agriculture and Forests, Territorial Forest Division, Sarpang, Nebraska
2) Indira Gandhi National Forest Academy, Dehradun, Uttarakhand India

Determining ungulate distribution and habitat utilization in royal Manas national park, Bhutan

Ugyen Tshering, Om Katel and Tshering Nidup

Abstract
Conservation of ungulates is vital to protect the viable population of tiger, leopard and dhole as ungulates are the principal prey species of carnivores of conservation importance. The objective of this study is to determine the distribution and habitat utilization by ungulates in Royal Manas National Park in southern Bhutan. The study area was stratified into four habitat types and a total of 53 sample plots of 20 x 20 m were surveyed to enumerate pellet groups and habitat variables such as canopy cover, ground cover, elevation, slope and aspect. A total of 80 pellet groups were recorded in 53 plots with a mean pellet of 1.51 per plot with a detection probability of 0.8. Among ungulates, Sambar pellet showed highest relative abundance (23.8%) and mostly ungulates detection probability is high in elevation zone less than 1000masl. The study concludes that RMNP could be one of the hotspot areas for tiger conservation through forest habitat conservation and protecting ungulates habitat.

Keywords: Habitat utilization, national park, prey, ungulate distribution, prey

1. Introduction
Conservation of ungulates is vital to protect the viable population of tiger, leopard and dhole. Tiger population is primarily a function of prey abundance [5] and are obligate carnivores preying upon the ungulates in all the ecosystems [14]. Depletion of prey population is one of the factors among others that led ot the present plight of tiger population around the world [6, 15, 17]. In Royal Manas National Park (RMNP), it is estimated about 25 -30 tigers [18] while there are 12 species of wild ungulates [21] in Bhutan but very few information is available about the ungulate species occurring in RMNP which is a prime habitat of tiger. Information in distribution and abundance on ungulates would help better understand the strategy for ungulate population monitoring and management, tiger conservation including other important predators and conservation of subtropical ecosystem and management.
Principle prey of tiger consists chiefly the ungulates under sub-order Artiodactyla. There are 12 species of ungulates under sub-order Artiodactyla in Bhutan of which nine species occur in RMNP [21]. Ungulates population in other parts of the world have declined severely both in abundance and distribution, due to the degradation and fragmentation of forest and grassland [17], competition for forage by domestic cattle in Nepal [15].
Currently, in the face of mounting threats to the populations of ungulates and predators in Bhutan from increasing habitat fragmentation, poisoning and trapping [21] are likely to deplete population of ungulates [15]. Therefore, there is an urgent need to establish baseline population data for this important prey species in all its habitat range for effective monitoring and management purpose.

2. Methods and Materials
2.1 Study area
RMNP is located in the central southern part of Bhutan covering jurisdiction of Pemagatshel, Sarpang and –Zhemgang districts and the first and oldest national park in Bhutan. It was established as a game sanctuary and changed to wildlife sanctuary in 1966. In 1993, it was notified to a national park. RMNP constitute an integral part of the protected areas in the country owing to its location. It is connected to the Phibsoo Wildlife Sanctuary (PWS) in the west, Jomotsangkha Wildlife Sanctuary (JWS) in the east and Phrumsengla National Park (PNP) in the north-east through biological corridors. Towards the north it is bordered by Jigme Singye Wangchuck National Park (JSWNP) (Figure 1). RMNP forms the contiguous belt of very rich forest with Manas National Park in Assam, India. It is the only park in Bhutan which covers wide range of habitats from tropical to temperate.

RMNP is home to varieties of wildlife including the species of global conservation significance such as Royal Bengal Tiger (*Panthera tigris*), Indian Rhinoceros (*Rhinoceros unicornis*), Pygmy hog (*Sus salvanius*), Asian Elephant (*Elephas maximus*), Asiatic water buffalo (*Bubalus bubalis*) and others.

The study of ungulate population abundance, structure, and habitat use was conducted in RMNP (Figure 1), starting from December 2014 to March 2015. We chose RMNP as research site, because several field reports and encounter rates suggested that this park is one of the richest not only in terms of flora but also fauna. Most importantly, RMNP is connected to Royal Manas National Park in India, which is mainly set aside to protect Royal Bengal Tiger. There are many reports of decreasing tiger population due to habitat fragmentation and decreasing population of main prey species and in RMNP many existence of many prey species are reported in field reports. This is the main reason for choosing park as the research site. The research was conducted in winter because in summer the thick forest in tropical and sub-tropical become inaccessible.

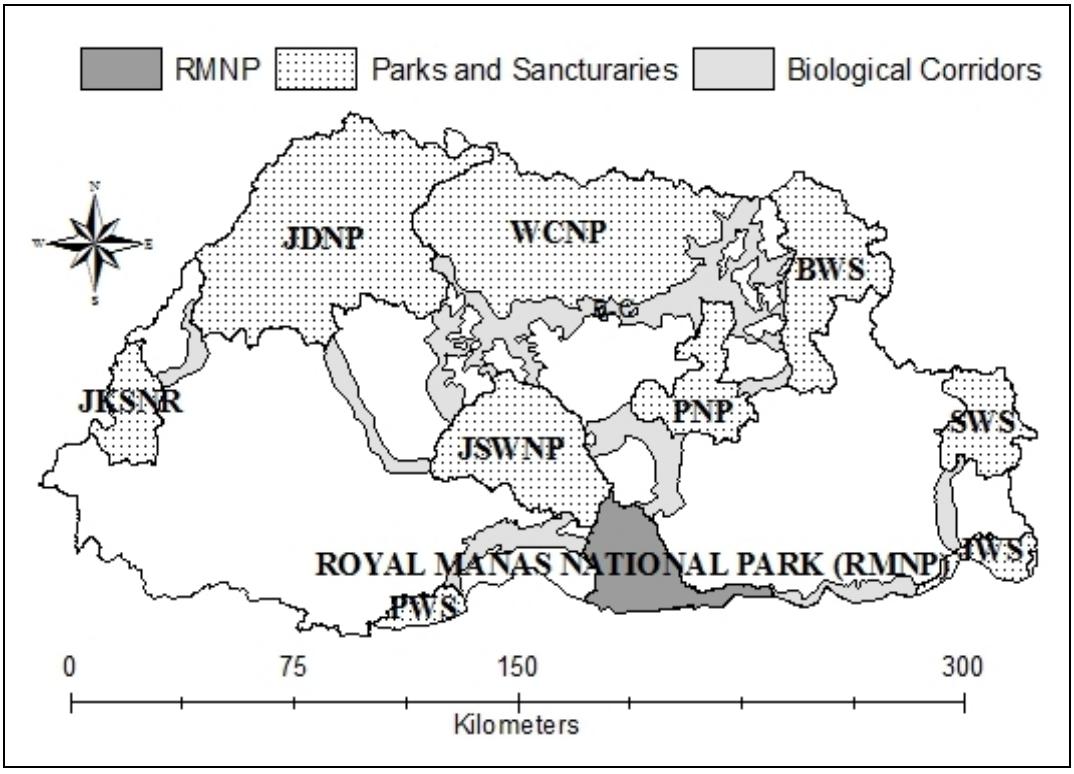

Fig 1: Location of study area

RMNP is a habitat to many prey species such as Sambar (*Cervus unicolor*), Gaur (*Bos gaurus*), Asiatic water buffalo (*Bubalus arnee*), Wild pig (*Sus scrofa*), Serow (*Capricornis sumateriensis),* Goral (*Naemorhedous goral*) Barking deer (*Muntiacus muntjak*), Golden Langur (*Trachypithecus geei*), Capped langur (*Trachypithecus pileatus*) and Macaques. In addition, it is also the habitat of many carnivorous species such as Tiger (*Panthera tigris*), Common Leopard (*Panthera pardus*), Clouded Leopard (*Neofelis nebulosa*), Marbled Cat (*Pardofelis marmorata*), Golden Cat (*Catopuma temminckii*), Jungle Cat (*Felischaus*), Leopard Cat (*Prionailurus bangalensis*), Himalayan Black Bear (*Ursus thibetanus),* Large Indian Civet (*Viverricula zibetha*), Small Indian Civet (*Viverricula indica*), Common Palm Civet(*Paradoxurus hermaphrodites*), Himalayan Palm Civet (*Paguma larvata*), Binturung (*Arctictis binturong*), Yellow-throated Marten (*Martes flavigula*), Ferret Badger and otter species [9]. As per the IUCN Red List of December 2014 version, the park has two critically endangered mammal species, eight endangered species, nine near threatened species and 11 species belong to vulnerable. In our research, we included the principle prey species of tiger such as gaur, sambar, barking deer, wild pig and serow.

The study area consists of tropical monsoon forest 354.74 km^2, subtropical forest 262.66 km^2, warm temperate forest 61.29 km^2, and cool temperate forest 3.44 km^2.In addition to rich biodiversity with various types of forest vegetation it also offers a spectacular landscape, lush green valleys and rivers, immense scenic beauty with unique culture and lifestyle.

2.2 Study methods

2.2.1 Stratification of habitat and Transect Survey

The total park area is stratified based on forest types. Forest type definition is mainly based on the elevation and presence of specific species as described by Ohsawa [7]. We found that vegetation types were classified with reference to elevation gradients as < 1000 masl as Tropical Monsoon Forest (TMF), 1000 – 2000 masl as Sub-Tropical Forest (STF), 2000 – 2500 masl as Warm Temperate Forest (WTF) and > 2500 masl as Cool Temperate Forest (CTF). The lowest elevation recorded was 97 masl and the highest was 2710 masl within the study area. The habitat stratification along altitudinal gradient was done by ArcGIS version 9.3 using Digital Elevation Model (DEM). Henceforth, the forest types will be referred in this paper as Habitat types.

First, the transects were laid on a map GIS and Google Earth then transects to be surveyed were chosen randomly from those laid on the map. Along the laid transects, vegetation sampling plots were established to assess the habitat utilization by ungulates. A total of 53 plots were surveyed along five transects. The plots to be laid were first plotted on maps and then located in the field by using GPS. Presence of ungulates was assessed by direct sighting and indirect signs with detection of pellets and counting them by traversing along the sampled transects. Observation of every sign of ungulates along transects were recorded. The parameters for habitat assessment included were slope, aspect, elevation, vegetation species and undergrowth including threats from human related activities.

2.2.2 Habitat utilization assessment

Forest types, canopy cover, ground cover, elevation, aspect and slope were considered as six different variables to determine habitat utilization by ungulates. The habitat selection was evaluated by comparing habitat availability with number of pellet groups in each habitat (Table 1).

Table 1: Habitat variables and their sampling method

Habitat variables	Sampling methods
Habitat types	Habitat types based on elevation zones of <1000, 1000-2000, 2000-2500 &>2500 masl as TMF, STF, WTF & CTF respectively
Canopy cover	Coverage of overstory vegetation estimated from visual observation
Ground cover	Plants <1.3 m were measured as ground cover. Height of the tallest plant of individual species and estimate percent coverage within 2 x 2 m quadret
Elevation	Elevation was recorded from the center of sample plot by an altimeter
Aspect	Determined aspect from the center of sample plot by compass as N, NE, E, SE, S, SW, W, NW
Slope	Measured slope in degrees from the center of the sample plot

2.2.3 Vegetation plot Sampling

Sample plots of 20 x 20 m were laid every 100 m rise or fall of elevation along transects. Five transects were randomly selected on map which covered all the representative habitats of the study area. In order to sample ground cover 2 x 2 m plot was laid in the center of the sample plots. Plant species of less than 1.37 m in height were recorded as ground covered. Canopy cover was determined by visual observation from the center of the sampling unit. Pellet group within the sample plot was recorded.

2.2.4 Distribution and abundance of ungulates

At the outset, all possible areas of ungulate habitats and their occurrence in RMNP were identified and listed through staff interview and consultation with local communities who are adjacent and even inside of the park. The first and corresponding authors' familiarity of the Park Range was also helpful in identifying some more possible areas of ungulate occurrence.

To determine distribution and abundance of ungulates, pellet count was preferred over other methods because rugged terrain and dense forest obstructed low visibility for direct sighting. We referred [8, 11] for pellet group count method and this confirms that this method is widely used method as an index of ungulate abundance. Further the relative abundance of ungulates was determined from the number of pellet groups in different habitat types.

Abundance of species =

$$\text{Abundance of species} = \frac{\text{Total number of pellet groups present in all sample plots}}{\text{Total number sampling plots in which pellet occured}}$$

2.2.6 Occurrence of ungulates in different aspect and slope

The environmental variables such as aspect and slope were classified based on [25]. The classification of slope was; gentle slope (<15°), moderate slope (15-30°) and steep slope (>30°). The aspect was classified into eight categories such as, East (67.5-112.5°), North (337.5-22.5°), Northeast (22.5-67.5°), Northwest (292.5-337.5°), South (157.5-202.5°), Southeast (112.5-157.5°), Southwest (202.5-247.5°), and West (247.5-292.5°).

3 Result and Discussion

3.1 Relative abundance of ungulates

Out of 53 plots, 26 plots were sampled in tropical monsoon forest, 19 in subtropical forest, 6 in warm temperate forest and 2 in cool temperate forest. A total of 80 ungulate pellet groups were encountered within the sampled area of 21200 m^2 and no pellets were detected in 32% of the sampled plots. A highest relative abundance of sambar were estimated with 23.8% pellets recorded while lowest was of serow with 15.4% (Table 2).

Table 2: Relative abundance of ungulates

Species	Total pellet	RP	UP	Abundance	RA
Gaur	18	13	40	1.38	21.3
Sambar	17	11	42	1.55	23.8
Barking deer	31	23	30	1.35	20.7
Wild pig	11	9	44	1.22	18.8
Serow	3	3	50	1.00	15.44

*RP= Pellet presence plot, UP= Pellet absence plot, RA= Relative abundance

3.2 Abundance of ungulate pellets by habitat type and elevation

The TMF has the highest overall pellets count (M = 9, SD = 4.7, followed by STF (M = 5.8, SD = 7), WTF (M = 1.2, SD = 1.1) and no pellet detection in CTF (Table 3). The absence of pellet in CTF may not be indicative of ungulates not using habitat but the detection of pellet was hampered by snow cover during the time of data collection. Habitat type could be the key factor affecting ungulate distribution in TMF as it has abundant grass and shrub as component of ungulates diet [3]. Apart from grass and shrub, relatively more fruits and seeds were observed within TMF which may indicate the frequent presence of ungulates. Ungulates feed on fruits and seeds of forage tree species during dry winter and in absence of grasses. This also means that ungulates play important role in forest ecosystem by dispersing seeds and changing forest structure and composition.

Most of the areas of TMF covered in this study is relatively away from settlement so human disturbance was not expected. This could be one of the reasons of having relatively higher aggregation of ungulates than other vegetation zones. For example, sambar avoids disturbed and open forests as it is highly sensitive to human disturbance [19].

The pellet group of barking deer was detected higher in STF and WTF relative to other ungulates. Barking deer being smallest in size, it might have outcompeted from TMF by larger ungulates resulting higher abundance in STF and WTF.

Table 3: Occurrence of pellet groups among forest types in percent

Habitat	Gaur	Sambar	Barking deer	Wild pig	Serow	Total
TMF	26.7(66.7)	31.1(82.4)	22.2(32.3)	15.6(63.6)	4.4(66.7)	100
STF	17.2(27.8)	6.9(11.8)	62.1(58.1)	10.4(27.3)	3.5(33.3)	100
WTF	16.67(5.6)	166.7(5.9)	50.0(9.7)	16.7(9.1)	0.0	100
CTF	0(0)	0	0	0	0	0
Total	(100)	(100)	(100)	(100)	(100)	0

* TMF = tropical monsoon forest, STF = subtropical forest, WTF = warm temperate forest, CTF = cool temperate forest

The occurrence of pellet group showed decreasing with increasing elevation for gaur (r = -.356, p<.05) and sambar (r = -.337, p<.05). With exception to barking deer, the mean abundance of pellet group of other ungulates was higher in the TMF. Similar result was reported in Nepal that ungulates preferred low land areas [15]. The favorable temperature of winter and available fodder in the low lying habitat of TMF might have favored gaur and sambar. Low lying areas seem to comprise optimal habitat for gaur in India [2] as gaur generally prefers sub-humid foothill tracks [24]. The undergrowth in TMF is mainly grass and the coarse grass covered areas were observed as the habitat for gaur in India [13].

Serow was not detected within the elevation range of above 2001 masl (Table 4) while in Nepal serow was detected only within 2500-3500 masl [1]. This difference could be attributed to the difference in the habitat type and range as probability of occurrence of serow in Bhutan is reported to be within the elevation range of from 150-3500 [21].The low detection of pellet of serow might be due to the lack of samples from rugged terrain because serow generally prefers steep rugged terrain and dense forested areas [1].

Table 4: Summary of ungulate abundance in different elevation range

	Elevation category			
	<1000m	1001-2000m	2001-2500m	>2500m
No. of plots	26	20	5	2
Gaur	12	5	1	0
Sambar	14	2	1	0
Barking deer	10	18	3	0
Wild pig	17	3	1	0
Serow	2	1	0	0
Average pellet	9	5.8	1.2	0
Max (Min)	14(2)	18(1)	3(0)	0(0)
SD	4.7	7.0	1.1	0
Total pellet	45	29	6	

3.3 Abundance of ungulates in relation to slope, forest cover and aspect

The number of pellet occurrence indicated that ungulates prefer mostly gentle slope with slope gradient of 0° to15° (Table 5) and barking deer mostly found to prefer steep slope (>30^0). Gaur and sambar recorded about 83.3% and 88.2% respectively in gentle slope. Gaur usually use flat and gentle slope and this finding is consistent with the findings in Bandhavgrah Tiger Reserve [11], India and in western Thailand [16] while barking deer shows wider ecological niche with occurrence of 64.5%in moderate slope (15^0-30^0). The avoidance of gentle slope could be that deer avoids habitat over lapping with large ungulates. The pellet group of sambar, wild pig and serow was not detected in steep slope (>30°) and the absence of serow pellet in steep slope contradicts with the preference of steep slope habitat by serow. This is not clearly known but one of the plausible explanations could be that survey of habitat in steep slope is not be representative in our case. It could also be that since the habitat types and the slope gradient was positively correlated (r = .450, p<.01) the habitat type may be affecting to occur limited number of ungulates in steep slope.

Table 5: Occurrence of pellet group in different slope in numbers

	Slope category			
	Gentle slope	Moderate slope	Steep slope	Total
Gaur	15 (M=.65, SD=.83)	1 (M=.04, SD=.20)	2 (M=.33, SD=.82)	18
Sambar	15 (M=.65, SD=1.07)	2 (M=.08, SD=.28)	0 (M=.00, SD=.00)	17
Barking deer	8 (M=.35, SD=.57)	20 (M=.83, SD=.92)	3 (M=.50, SD=.55)	31
Wild pig	6 (M=.65, SD=.54)	5 (M=.21, SD=.51)	0 (M=.00, SD=.00)	11
Serow	2 (M=.09, SD=.29)	1 (M=.04, SD=.20)	0 (M=.00, SD=.00)	3
Total	46	29	5	80

*M= mean, SD= Standard deviation

Sambar was observed highest in south aspect but avoided northwest, southwest and west (Table 6) indicating that sambar favour warmer habitat mostly open landscape [20, 22]. However, the pellet of serow was observed only in east and south aspect with dense forest and bamboo thicket indicating serow prefer even warmer areas than sambar [1, 21].

The highest mean pellet group of ungulates was observed in the low cover (<25%) but relatively less in canopy cover of >61% (Table 6). This result was affected due to the higher record of pellet from two samples in managed grassland (M = 3.5, SD = 0.4) compared to other sample plots (M = 0.6, SD = 0.7). It was argued that opening up the canopy is likely to facilatate growth of grass and other vegetative feed which in turn has a positive effect on ungulate densities [15]. However, a certain degree of canopy cover may be important to ungulates as concealment from predators and human disturbances.

The maximum pellet group of gaur (33.3%), sambar (41.2%) and barking deer (42.0%) was observed in the canopy cover of 26% to 40% indicating that mostly ungulates prefer moderately dense forest. In the dense canopy the growth of forest floor could be very less because canopy density affects light, temperature and moisture condition which in turn determines the presence of various forest floors. Certain undergrowth is necessary for ungulate for foraging and bedding. This is consistent with report [4] that ungulate relative abundance is negatively correlated with dense tree cover and positively correlated with cover of small shrubs.

Table 6: Occurrence of ungulates on different crown cover and aspects

	Crown cover percent class				Aspect							
Ungulate species	**<25**	**26-40**	**41-60**	**>61**	**E**	**N**	**NE**	**NW**	**S**	**SE**	**SW**	**W**
Gaur*	4(14)	6(14)	2(14)	6(14)	1(14)	1(14)	0(14)	3(14)	1(14)	6(14)	0(14)	2(14)
Sambar	2(17)	4(17)	7(17)	4(17)	1(12)	1(12)	2(12)	0(12)	0(12)	8(12)	0(12)	0(12)
Barking deer	11(31)	13(31)	5(31)	2(31)	2(29)	6(29)	6(29)	4(29)	0(29)	9(29)	1(29)	1(29)
Wild pig	4(11)	2(11)	3(11)	2(11)	3(11)	1(11)	1(11)	0(11)	1(11)	2(11)	1(11)	2(11)
Serow	0(3)	1(3)	1(3)	1(3)	1(2)	0(2)	0(2)	0(2)	1(2)	0(2)	0(2)	0(2)
Total pellet**	21(80)	26(80)	18(80)	15(80)	8(80)	9(80)	9(80)	7(80)	15(80)	25(80)	2(80)	5(80)
Total observation plots***	15(53)	21(53)	9(53)	8(53)	6(53)	7(53)	9(53)	5(53)	6(53)	13(53)	3(53)	4(53)

*pellets recorded per species, ** total pellets and ***total plots observed in parenthesis

Overall abundance of pellet group was recorded maximum in southeast, south and east aspects with relative abundance of pellet groups of 32%, 20% and 15% respectively. The analysis of species wise abundance of pellet group showed that the pellet group of barking deer was recorded in all aspects with higher preference at north, northeast, northwest and southeast aspect (Table 6). Based on the abundance of pellet group, the aspect preferred by gaur was northwest (38.82%) and southeast (30.24%). The preference of northwest aspect in winter by gaur may be due to the presence of bamboo forest that was common in this aspect. This is because gaur mostly prefers bamboo forest in winter [11].

4. Conclusion

Ungulates abundance and distribution is related to elevation, slope gradient, aspect, vegetation structure and species composition, ground cover and canopy cover. The distribution and abundance of ungulates were concentrated in the elevation zone below 1000 masl corresponding to TMF indicating that this elevation zone has higher preference by ungulates. The highest relative abundance of sambar is a positive sign of favourable tiger habitat as sambar is the most preferred prey for tiger. A proper planning and management of habitat below elevation zone of 1000 masl may be considered in future planning to protect ungulates in RMNP. As tiger also uses the habitat below 1000 m elevation more frequently than others therefore conserving habitat below 1000 m elevation range help protect ungulates ultimately providing conducive environment for tiger conservation.

This study however suffers from low sample size in high elevation zone of >2500 masl coupled with presence of snow cover during data collection which is insufficient to explain the non-preference of this zone by ungulates. Therefore more research covering all season is highly recommended.

5. Acknowledgement

Authors would like to thank Mr. Tenzin Wangchuk, Chief Forestry Officer and the staffs of RMNP for their help during field work and logistics. This research is supported by research grants Rufford Small Grants Programme and without this support research would not have been materialized. I sincerely thanked all the staff of Manas Range for their support during data collection.

6. References

1. Aryal A. Habitat Ecology of Himalayan Serow (Capricornis sumatraensis ssp thar) in Annapurna Conservation Area of Nepal Tiger paper, 2009, 12-20.
2. Choudhury A. Distribution and conservation of the Gaur *Bos gaurus* in the Indian Subcontinent Mammal Review, 2002; 32(3):199-226.
3. Gill R.M.A. A review of damage by mammals in North Temperate Forests: 1. Deer Forestry 1992; 65(2):145-169.
4. Heinze E, Boch S, Fischer M, Hessenmoller D, Klenk B, Muller J *et al*. Habitat use of large ungulates in northern Germany in relation to forest management. Forest Ecology and Management 2011; 261:288-296.
5. Karnath K.U, Chundawat R.S. Ecology of the tiger: Implications for population monitoring: In Monitoring tigers and their prey: A mannual for Researchers, Managers and Conservationists in Tropical Asia, eds. K. Ullas Karanth and James D. Nichols, WWF, USGS & Wildlife Conservation Society, 2002, 9-21.
6. Karanth K.U, Stith B.M. Prey depletion as a critical determinant of tiger population viability. In Riding the Tiger: Tiger Conservation in Human-dominated Landscapes, eds. J Seidensticker, S. Christie & P. Jackson, Cambridge University Press, Cambridge, UK, 1999, 100-113.
7. Oshawa M. Vegetation zones in the Bhutan Himalaya. In Life Zone Ecology of the Bhutan Himalaya, ed. M. Oshawa, Yayoicho: Chiba University, Japan, 1987, 1-71.
8. Pokhrel S, Thapa T.B. Relative Abundance and Distribution of Wild Ungulates in Suklaphanta Wildlife Reserve Nepal Ecocity World Submit Proceedings, 2008, 1 -12.
9. Rai D.S. Report on mammals and their habitat, Royal Manas National Park. Thimphu: Nature Conservation Division, Department of Forests, 2006.
10. RMNP [Royal Manas National Park]. *Conservation* Management Plan. Gelephu: Nature Conservation Division, 2009.
11. Sankar K, Pabla H.S, Patil C.K, Nigam P, Qureshi Q, Navaneethan B *et al*. Home range, habitat use and food habits of re-introduced gaurin Bandhavgrah Tiger Reserve, Central India Tropical Conservation Science 2013; 6:50-69.
12. Sarkar P, Sharma A.A, Hazarika A.K, Chaudhry S. Survey on abundance of carnivores and their prey in Kalesar NP and WLS in Haryana, India The Clarion. 2013; 2:41-51.
13. Schaller B.G. The Deer and the Tiger Dehra Dun: Natraj Publishers, 1998.
14. Seidensticker J, Christie S, Jackson P. Riding the Tiger. Cambridge: Cambridge University Press, 1999.
15. Shrestha M.K. Relative Ungulate Abundance in a Fragmented Landscape: Implications for Tiger Conservation. University of Minnesota: Thesis, 2004.
16. Simcharoen A, Savini T, Gale G.A, Chimchome V, Smith J.L. Ecological factors that influence sambar (*Rusa unicolor*) distribution and abundance in western Thailand: implications for tiger conservation Raffles Bulletin of Zoology. 2014; 62:100-106.

17. Sunquist Mel, Karanth K Ullas, Sunquist Fiona. Ecology, behaviour and resilience of the tiger and its conservation needs. In Riding the Tiger, Tiger conservation in human-dominated landscapes, eds. J. Seidensticker, S. Christie, & P. Jackson, Cambridge: The Press Syndicate of the University of Cambridge, 1999, 5-18.
18. Tempa T, Norbu N, Dhendup P, Nidup T. Result from a Camera Trapping Excercise for Estimating Tiger Population Size in the Lower Foothills of Royal Manas National Park. Lami Gompa, Bumthang: UWICE and RMNP, 2011.
19. Timmins R.J, Steinmetz R, Sagar B.H, Samba K.N, Duckworth J.W, Anwarul Islam Md *et al*. Rusa unicolor. In IUCN 2013. IUCN Red List of Threatened Species. Version www.incuredlist.org. Retrieved on 25 March, 2014, 2008.
20. Trisurat Y, Pattanavibool A, Gale G.A, Reed D.H. Improving the viability of large-mammal populations by using habitat and landscape models to focus conservation planning Wildlife Research 2010; 37:401-412.
21. Wangchuk T, Thinley P, Tshering K, Tshering C, Yonten D, Pema B. A Field Guide to the Mammals of Bhutan. Thimphu: Royal Government of Bhutan, 2004.
22. Wani M.A, Telang S, Bhat S.A, Khursheed A.S. Habitat utilization of sambar (*Rusa unicolor*) in Van Vihar National Park, Bhopal, Madhya Pradesh, India. Indian Journal of Applied & Pure Biology. 2012; 27:25-29.
23. WCD [Nature Conservation Division]. Tiger Action Plan fot the Kingdom of Bhutan 2006-2015. Thimphu: Ministry of Agriculture, Royal Government of Bhutan, 2005.
24. Wharton C.H. Man, Fire and Wild Cattle in Southeast Asia. Proceedings of the annual Tall Timbers Fire Ecology Conference 1968; 8:107-167.
25. Zhou X, Jiao H, Dou Y, Aryal A, Hu J, Hu J *et al*. The winter habitat selection of red panda (*Ailurus fulgens*) in the Meigu Dafengding National Nature Reserve, China Current Science. 2013; 105(10):1425-1429.