The Rufford Foundation
Final Report

Congratulations on the completion of your project that was supported by The Rufford Foundation.

We ask all grant recipients to complete a Final Report Form that helps us to gauge the success of our grant giving. The Final Report must be sent in **word format** and not PDF format or any other format. We understand that projects often do not follow the predicted course but knowledge of your experiences is valuable to us and others who may be undertaking similar work. Please be as honest as you can in answering the questions – remember that negative experiences are just as valuable as positive ones if they help others to learn from them.

Please complete the form in English and be as clear and concise as you can. Please note that the information may be edited for clarity. We will ask for further information if required. If you have any other materials produced by the project, particularly a few relevant photographs, please send these to us separately.

Please submit your final report to jane@rufford.org.

Thank you for your help.

Josh Cole, Grants Director

Grant Recipient Details	
Your name	Pelden Zangmo
Project title	Habitat use, Distribution and Conservation Threats of Gaur (*Bos gaurus*) in Royal Manas National Park, Bhutan
RSG reference	20701-1
Reporting period	March 2017-March 2018
Amount of grant	£5000
Your email address	pzangmo@moaf.gov.bt
Date of this report	04/04/2018

1. Please indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.

Objective	Not achieved	Partially achieved	Fully achieved	Comments
Estimate gaur distribution and abundance in RMNP.				True abundance was not able to derive because ungulates lack individual identification pattern
Study the habitat use of gaur and its interaction with other sympatric ungulates and major predators in RMNP.				The achievement scores are purely confined within the study area
Understand conservation threats of Gaur in RMNP				

2. Please explain any unforeseen difficulties that arose during the project and how these were tackled (if relevant).

Frequent encounter with wild animals such as gaur, elephant and the wild animals chasing the team was one of the fearful experiences. The fear of encountering the armed illegal loggers/hunters as per the past incidences along the porous Indo-Bhutanese border was also another fearful experience. However, the team was well armed and the full cooperation rendered by the staff of RMNP helped in tackling the problem.

3. Briefly describe the three most important outcomes of your project.

3.1 Capture success, abundance and distribution in RMNP.

Photographic capture success

In total, 5,763 images of gaur were captured during the effective sampling period from 35 camera station ranging from 97 – 2135 m asl. The highest photo capture was from Manas range with 1,387 photos and lowest was from Gomphu with only one picture from elevation of 2135 m asl. The highest elevation of gaur recorded was from elevation of 2256 masl and the highest elevation of camera set was at 2601 m asl.

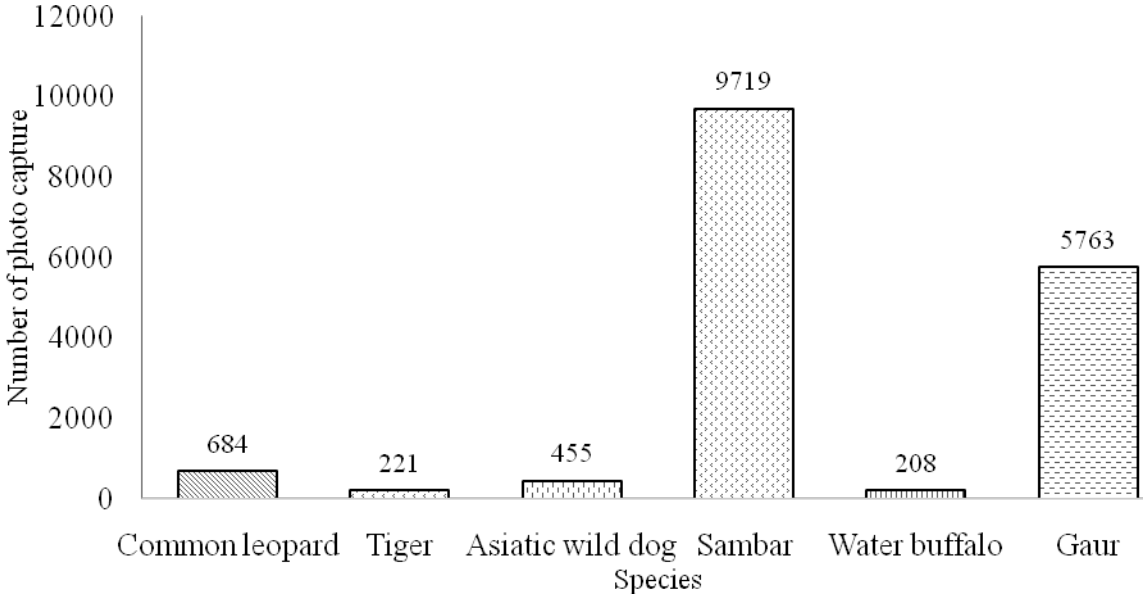


Photo capture details of major prey and predator species in RMNP

Estimation of Relative Abundance Indices (RAI)

Table 1.1: Relative abundance of major prey and predators of RMNP

Species	Total Station	Total Photo	Sampling Occasions	Sampling Efforts	Total IE	RAI-I	RAI -II
Common leopard	68	684	18	5386	115	46.83	2.14
Tiger	68	221	18	5386	57	94.49	1.06
Asiatic wild dog	68	455	18	5386	90	59.84	1.67
Sambar	68	9719	18	5386	709	7.60	13.16
Water buffalo	68	208	18	5386	21	256.48	0.39
Gaur	68	5763	18	5386	342	15.75	6.35

***** Relative Abundance Indices (RAI_1: Number of days required to get single photo capture and RAI_2: Number of photos per 100 trap-days) for major predators and co-prey species recorded in camera traps from RMNP.

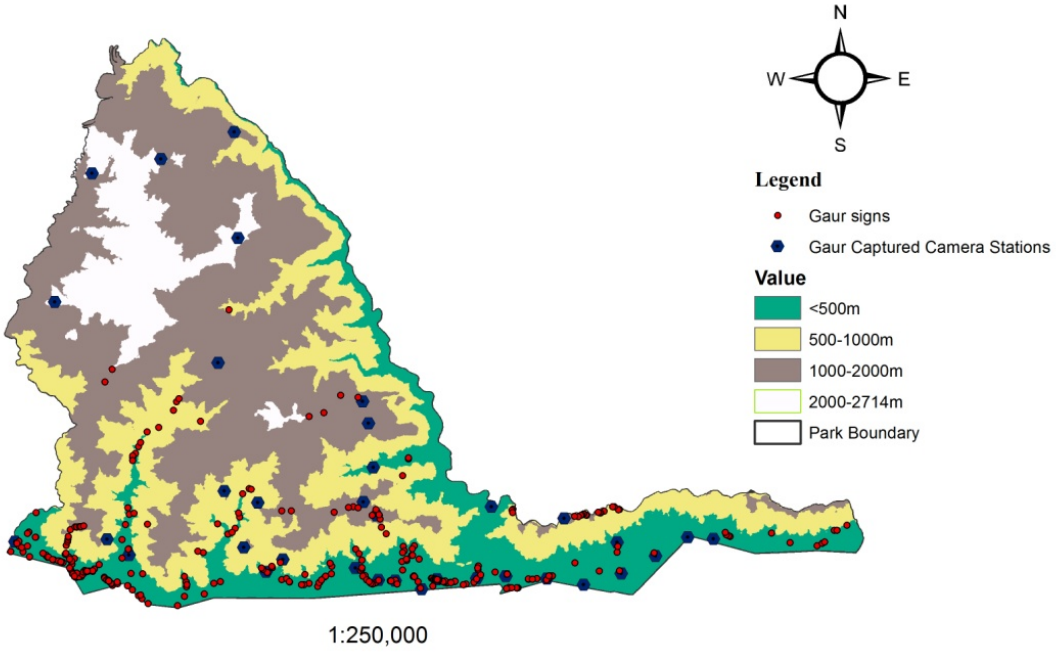
Sambar was the most abundant ungulate species (*RAI* = 13.16) while water buffalo was the least (*RAI* = 0.39) among major ungulates in RMNP. Gaur was relatively abundant (*RAI* = 6.35). Common leopard is the most abundant (*RAI* = 2.14) among major predator species and tiger (*RAI* = 1.06) and Asiatic wild dog (*RAI* = 1.67) were equally abundant in RMNP (Table 1.1).

Gaur distribution

Gaur distribution was determined through 68 camera traps set across various elevation zones. Thirty five camera stations out of 68 functional cameras captured Gaur pictures ranging from 97 to 2256 m asl.

Gaur distribution along elevation and forest types

RMNP in general holds a great potential habitat for gaur. Its distribution is found in all three ranges (Manas, Umling, and Gomphu range) at various elevation zones with varying density.



Gaur distribution along elevation and forest types in RMNP

Gaur distribution assessed through both camera traps and direct and indirect signs found higher abundance in lower elevations <500 m (*n* = 20, *IE* = 292) showing its preference towards tropical plains at lower elevations. It was found that the presence of gaur decreases with increasing elevation. Only four of the seven camera traps (*IE* = 9) set up above the elevation of 2000 m asl captured gaur (Figure above). Highest elevation that captured gaur picture was at 2256 m asl. Owing to the contigious habitat across the borders, the transboundary landscape harbours many globally significant and threatened species providing free movement and safe habitat for those species. Gaur, along with other animals are said to trespass the border based on resource availability and habitat compatibility. They take refuge in thick forests of RMNP when the MNP plains gets waterlogged with rain in summer while MNP provides best habitat for gaur during the early spring season feeding on grass shoots (T. Dendup, personal communication, 16 January, 2017). The ground interspersed by minerals are the prime habitats found mostly in tropical monsoon forest <500 m in RMNP. Gaurs are said to visit those saltlick spots in early

morning and late evening (T. Dendup, personal communication, 20 January 2017), which could be the reason that gaur population is concentrated in lower elevations.

Gaur distribution based on management zones

Table 1.2: Gaur distribution in core zone and multiple use zone

Range	**Total Camera Stations**		**Functional Camera Stations**		**Gaur Captured Stations**	
Zones	Core	Multiple	Core	Multiple	Core	Multiple
Manas	30	7	28	6	20	3
Gomphu	8	22	2	17	0	4
Umling	23	2	11	4	8	0

Functionally, RMNP is divided into two zones, core zone and multiple use zones. A total of 41 functional cameras were located in core zone out of which 28 stations captured gaur images (Table 1.2). The management plan of RMNP (2015) reflects that the core zone constitutes major portion of the park with representation of diverse ecosystem. The park management delineated the core zone based on the presence of prime habitats of endemic, rare and endangered species, area with high biological diversity, existence of pristine sub-tropical and tropical forest with interspersion of grasslands and prevalence of saltlicks and waterhole sites.

Contrary to this, multiple use zones was delineated based on the presence of settlements and resource areas for local residents, ecotourism trails and campsites, areas having road network and power lines and existence of individual and communal grazing areas. In accordance with delineation functions, only seven cameras out of seven stations captured gaur pictures in multiple use zones. Thus, the core zone spanning over an area of 653 km^2, and with the capture of highest gaur pictures, it could be said that zonation based on functions under RMNP is correctly delineated.

Due to security reason, the east zone of the park was left out from camera trapping survey. Thus, the areas were covered through direct sightings and indirect sign collection for distribution. In line with camera trap records, the sign and sightings of gaur was abundant in core zone areas while signs were lesser to absent in multiple use zones.

3.2 Habitat use

Presence of gaur is largely determined by the availability of food and geographic range they dwell in (Imam and Kushwa, 2013). However, gaur are known as generalist feeders (Pedrono, 2008) grazing and browsing a wide variety of grasses, herbs, shrubs and tree species. Gaur's characteristics of being a general feeder, having a travelling range of 3.2 – 4.8 km/day (Ashokkumar *et al*., 2011) and RMNP's pristine habitat in core zone spanning over 653 km^2, provide safe habitat for feeding and existence of gaur.

However, looking into field reality, the scarce and season based resources, human encroachment due to population rise, insurgent problems and illegal felling of trees which would affect its prime habitat are seen as some of the real habitat parameters that need to be considered in determining its habitat use.

Distance to water bodies

Water is one of the fundamental requirements of life therefore animals' water requirements have implications for all aspects of its ecology and conservation (Hayward and Hayward, 2012). Remote cameras are an ideal tool for determining waterhole use (Wakefield *et al*., 2008). Of the 35 camera stations that recorded gaur, 94% were found within a distance of 2,500 m from the nearest river/stream or waterhole with only two camera stations being located between 2,500 – 4,500 m. Majority of the cameras that captured gaur were nearby water bodies or within the average walking range of 3.2 – 4.8 kms/day of gaur (Ashokkumar *et al*., 2011; Paliwal and Mathur, 2012; Imam and Kushwa, 2013; Nayak and Patra, 2015). The shortest distance that the gaurs travel from water bodies reveals gaur's dependency on water every day.

Distance to saltlicks

The present study found that gaur inhabits habitats as far as 25 km from the saltlicks. However, majority of the camera stations (*n* = 25) that captured gaur were within the distance of 4,000 m from the nearest saltlick. The stations having the highest elevations were located furthest from the saltlicks. The number of camera stations increased from (*n* = 1) at distance of 25 km to (*n* = 30) at 5,500 m indicating high occurrence of gaur near saltlick spots. Natural saltlicks are one of the mineral sources for such animals and studies reveal mammals have higher preference for areas having greater concentrations of minerals at saltlicks (Moe, 1993; Matsubayashi *et al*., 2006; Edwards *et al*., 2012; Duckworth *et al*., 2016; King *et al*., 2016). Numerous natural saltlicks are mapped in RMNP, which enables the researches to assess the dependence of animals on the saltlicks as use of licks influences the movements and distribution of ungulates (Ayote *et al*., 2008).

Elevation and forest types

The forest types were classified based on elevation ranges as per RMNP (2015) and Oshawa (1987). Elevation was one of the determining factors in gaur occurrence. Only two camera stations out of 35 gaur captured stations were located above 2000 m asl.

Table 1.3: Number of gaur captured stations along elevation and forest types

Elevations	**97-500**	**500-1000**	**1000-2000**	**2000-2714**
Total functional stations	30	9	21	7
Manas	18	1	5	0
Umling	2	3	1	1
Gomphu	0	0	3	1
Gaur captured stations	**20**	**4**	**9**	**2**

Over 57% (*n* = 20) (Table 1.3) of the camera stations that captured gaur were between the elevation of 97 to 500 m, in the southern part of the national park. As the elevation increases, numbers of camera traps capturing the images of gaur were found decreasing. Following the tropical monsoon forests, the warm broad leaved forest (500 –1000 m) saw more camera traps capturing gaur (*n* = 9). Only two cameras captured gaur in cool broadleaved forest (2000 – 2714 m) and both of them captured solitary gaurs.

Gaur in RMNP are found to be feeding on diverse plant species. During inspection of feeding site, gaur were found feeding on plants such as *Thysanolaena maxima, Cymbopogon* sp., *Imperata cylindrica, Paspalum vaginatum, Saccharum spontaneum, Themeda* sp., *Vetivera* sp., *Opliminus* sp., *Digitaria* sp. They were also found browsing on *Phlogocanthus* sp., *Bauhinia purpurea, Mallotus philippensis, Elatostema* sp., *Ficus* spp., *Sterculia villosa, Strobilanthes* spp., and *Dendrocalamus strictus* (Appendix 1). They were also found feeding on bark and flowers of *Bombax ceiba* and fruits of *Dillenia pentagyna.* Most of the bulls in RMNP are found solitary and the heard consisted only of one or two bulls depending on heard sizes. The forest officials of Manas range who had been serving the area for minimum of five years observed inferior bulls being separated from the herd once they attained maturity by the dominating bulls.

Distance to settlement and human presence

Out of 35 camera station that captured gaur, only five camera stations were located within the distance of 1,500 m from settlement. Twenty five camera stations are located 3,000 m away from settlement which indicates gaur inhabit away from settlements and human occurrence. Similar to this study, various researchers reported gaur avoiding areas where there is human presence. Choudhury (2002) and Duckworth *et al*. (2008) defined habitat loss due to increase in human population as the large scale decline of gaur range indicating it as a major threat to gaur conservation in Asia. Similarly, Ashokkumar *et al*. (2011) pointed the physical disturbance caused by people such as wood cutting, forest fire and loss of food availability due to extensive cattle grazing as the main causes of habitat degradation and fragmentation. Imam and Kushwaha (2013) also pointed that continuous anthropogenic pressure created disturbances to the area and affect the entire herbivore population which led to low density/number of gaur in CTR. Paliwal and Mathur (2012) also reported about gaur avoiding areas where there are human presences in Tadoba Andhari Tiger Reserve in central India.

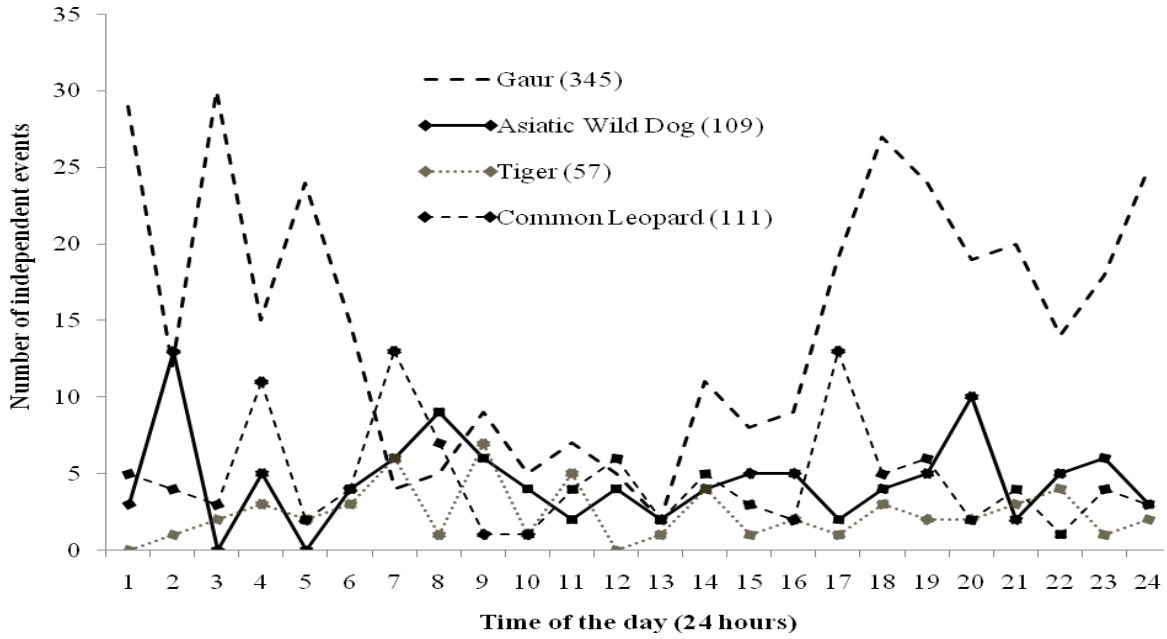
3.3 Temporal activity of Gaur and its interaction with other sympatric ungulates and major predators

Spatial and temporal habitat overlap of gaur with its major predators

The study found that gaurs in general were active throughout day and night as their activity curve never dropped to zero (Figure below). However, their peak activeness was recorded during the dusk (19:00 to 20:00 hours) and early morning (04.00 to 07.00 hours).

They also remained active in the mid-night (22.00 to 01.00 hours) making them crepuscular while their movements were less during the days (07.00 to16.00 hours). Gaur is considered as one of the major prey species of tiger and other large felids. The other prey species includes sambar and water buffalo. Tiger was found only in 20 stations out of 68 stations distributed spatially across the elevations of Manas. The 18 stations out of 20 where tiger was found overlapping with the gaur captured station depicts tiger as one of the major prey species of gaur. Asiatic wild dog was found in 17 stations mostly concentrated in the higher elevations and 10 stations were found to be overlapping with gaur. Common leopard was found in 28 stations concentrated mostly in lower elevations and 20 stations were found to be over lapping with gaur captured stations.

Gaur, common leopard and Asiatic wild dog had same activity pattern indicating high predator based threat for gaur. Tiger was seen active throughout the day though its activity peaked from dusk to noon.

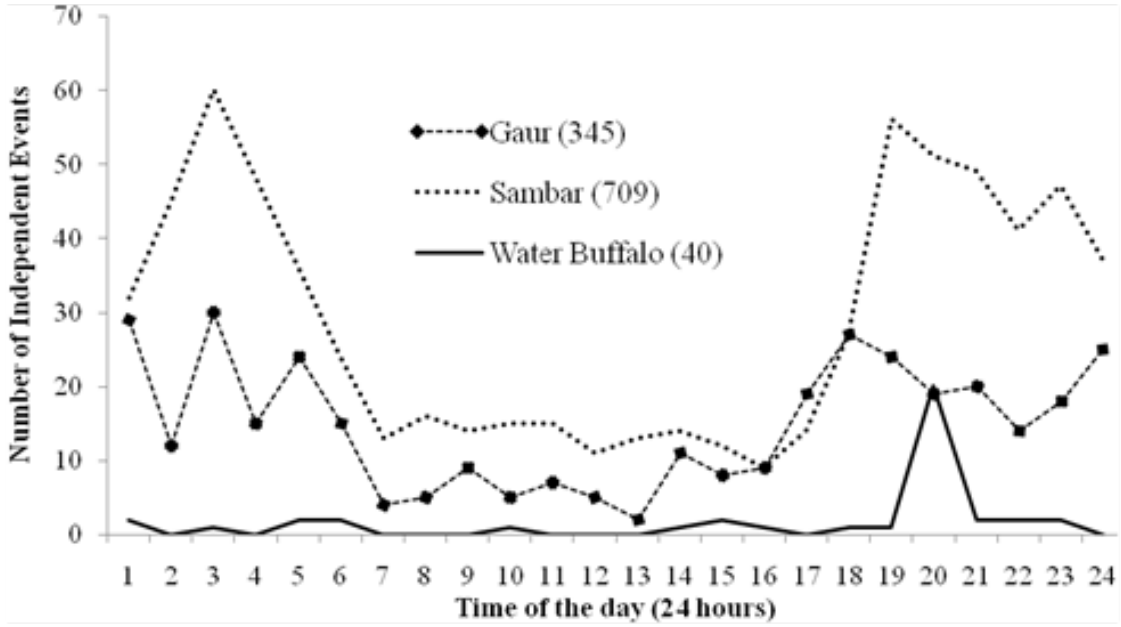


Temporal activity of gaur and major predators in RMNP

The universal assumption of gaur as one of the important prey species for flagship species (tiger) can be agreed in case of RMNP as well, considering higher habitat sharing and similar activity pattern. Predation sighted (Appendix2A) during the camera trap survey also indicates tigers preference for gaur.

Spatial and temporal habitat overlap of gaur with its sympatric species

Sambar and water buffalo were considered as gaur's sympatric species because of their similarity in resource use pattern. Water buffalo was captured only in four camera stations out of 68 stations but gaur was recorded in all the four camera stations, thus indicating the habitat overlap. Sambar was found in 42 camera stations out of which 21 stations were found in same stations where gaur occurred.



Temporal activity pattern of gaur and its sympatric species

Sambar had similar activity pattern with gaur with its peak activity from dusk to early morning, however, water buffalo, because of its less detection (*IE* = 40) were seen active only towards dusk. They remained inactive throughout day and late night. Water buffalo, though less in number (*IE* = 40) had same activity pattern with gaur and sambar (Figure above). Similar feeding habit and timing showed resource competition for gaur especially in winter season when resources are very scarce. Salt or mineral licks are must factors for gaur, sambar and water buffalo that are mostly distributed in the lower areas. Such licks are regarded as spatially-limited resources (Klaus and Schmid, 1998). Sambar population has been rising tremendously in RMNP and they are sighted everywhere. Its increasing population (*IE* = 709) poses direct threat in terms of resource competition.

3.4 Threats

Anthropogenic threats

Human disturbances like fishing, illegal felling and hunting evidence were spotted at 15 camera stations. Gaur was spotted only in three stations that had human interference. The camera trap team of this study also found hunting shed (Appendix 2B) on Norbugang top located in east zone of park. The illegal activities related to wildlife poaching and hunting were mostly reported from that area in Manas range. A casual interview with local residents indicated that the local residents are known to hunting since ancient times and that they are well skilled in tracking wild animals and knew their activities and behavioural well. A hunting shed found on Norbugang hill indicated that they are still hunting animals for meat. Few years ago, a gaur calf was also rescued from Norbugang area (Appendix 2B). The calf along with other gaur herd was found interacting with domestic cattle of Norbugang area where the calf failed to join gaur herd. However, during the time of camera trap survey, the team did not find any sign of gaur occurrence in that area. Illegal logging leading to

habitat degradation and wildlife poaching were reported as the key increasing threats leading to conservation in RMNP (RMNP, 2015). Habitat loss and degradation is ranked under high risk category among other threats. Patrolling team has also come across a number of makeshift machans used by poachers for hunting wild animals (J. Lhendup, Personal communication, 18 January, 2017). Human wildlife conflict with change in agricultural patterns and land use systems is medium ranked in RMNP (2015). Outside Bhutan, an anthropogenic pressure is reported to have affected the density/number of gaur in Chandoli Tiger Reserve (CTR) in India (Imam and Kushwaha, 2013) while habitat loss and disturbance is regarded as the second most serious threat in Vietnam (Ashokkumar *et al*., 2011).

4. Briefly describe the involvement of local communities and how they have benefitted from the project (if relevant).

Local communities were involved and benefited both directly and indirectly. Five local people from Tanzima under Pemagatshel district were involved permanently during the entire survey period. They were paid the highest wage considering the high risk posing porous border and heavy field work.

Simultaneously, the local people involved in questionnaire survey were also paid the daily wage for taking time to respond us from their busy field works. Communities benefitted most from the project since they were informed on the importance of conserving the species and also informed them on the existing rules with regards to the *Bos gaurus.*

5. Are there any plans to continue this work?

Yes. This is just the first study on Gaur in Bhutan. Internationally, we don't find any latest literature on gaur and its ecology, threats and definitely there lies many opportunity to cover up those gaps.

6. How do you plan to share the results of your work with others?

The results of this work were already shared at with the students and faculty of my previous college. It was done as a part of academic course and introductory to camera trapping methods. The copy of my findings was also shared with management of Royal Manas National Park so that the management can incorporate my findings in their management plan. For larger audience, the manuscript of this work has been submitted to a journal to be published.

7. Timescale: Over what period was The Rufford Foundation grant used? How does this compare to the anticipated or actual length of the project?

The project was planned for 1 year [January 2017 to February 2018] and the objectives of the projects were met within the planned period of 1 year. However, the data processing and analysis took more time due to more number of camera traps and sorting other miscellaneous pictures captured.

8. Budget: Please provide a breakdown of budgeted versus actual expenditure and the reasons for any differences. All figures should be in £ sterling, indicating the local exchange rate used.

Item	Budgeted Amount	Actual Amount	Difference	Comments
Stationary and other equipments including lithium battery and banners	1000	650	+350	Camera trap and GPS battery costed more than projected amount
Vehicle rental during field surveys	450	450	0	The projected amount covered as I had to pay just for the fuel
Daily allowance for field survey team	1050	1675.6	-1620.6	I had to break down the expenses for meal and survey as field survey incurred much more amount than project jointly for meals and field survey
Daily meal expenses for field survey team		995		
Refreshment and subsistence allowance for local community	1350	865	+485	The refreshment items costed much as the study is located far from actual town
Questionnaire survey and work charge during field survey	700	245	+455	
Refreshment for Seminar and presentation for college students	550	120	+430	Only refreshment was served over initial estimate of lunch to the students instead of park staff
Total	5100	5000.6	-0.6	Difference is for actual grant amount received and expenses incurred.

9. Looking ahead, what do you feel are the important next steps?

As mentioned in the proposal, i believe that the next important step to understand the gaur distribution is through DNA study. The gaur movement based on radio collar is important to determine and understand its ecology at depth. A study on its transboundary movement is also felt important to determine the actual population of gaur in Bhutan.

10. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the RSGF receive any publicity during the course of your work?

A big YES! The Rufford Foundation logo has been used in any presentations I made and shall continue to use whenever a talk resulted from this project is delivered. RF is now known by many Bhutanese the people who are working for conservation in Bhutan remains highly indebted to all the contributions made by RF this far in the area of conserving floral and faunal diversity of Bhutan.

11. Please provide a full list of all the members of your team and briefly what was their role in the project.

1. 5 local people as guide and potter
2. 8 Foresters for camera setting
3. 2 Mohaut for elephant services
4. 4 college student for questionnaire survey

12. Any other comments?

RF has played a very important role in conservation of flora and fauna in Bhutan. It has helped many conversationalists to reach their goals in educating people and particularly in conservation of species that are in verge of extinction or threats. In a way Bhutanese people have been able to contribute many baseline information at world's conservation forum which otherwise has remained least unexplored.

Thus, the Bhutanese conversationalists remain grateful to RF for your continued support in making our dream come true and i hope that the foundation keeps supporting the Bhutanese conversationalists so that we can explore further and contribute to the conservation field more.

Appendix 1: Diets preferred by Gaur in RMNP

Appendix 2: Gaur predation and hunting shed encountered during field survey

Appendix 1: Gaur rescued in RMNP

Appendix 4: Questionnaire survey and awareness program