



**RESPONSES OF WILD UNGULATES TO ANTHROPOGENIC  
PRESSURE AND PERCEPTION OF LOCAL COMMUNITIES  
TOWARDS CONSERVATION OF WILD UNGULATES IN  
DAMPA TIGER RESERVE, MIZORAM, INDIA**

*Thesis submitted for the award of the Degree of*

**MASTERS  
in  
WILDLIFE SCIENCE**

*by*

**JOONU CHAKMA**

*to*

**Saurashtra University  
Rajkot - 360005 (Gujarat)**

**Under the Supervision of**

**Dr. S. Sathyakumar (Scientist-G)  
Dr. Lallianpuii Kawlni (Scientist-C)  
Dr. Vishnupriya Kolipakam (Scientist-C)**



**भारतीय वन्यजीव संस्थान  
Wildlife Institute of India**

**JULY, 2021**



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DECLARATION

I, **Joonu Chakma**, hereby declare that the research work entitled "**Responses of wild ungulates to anthropogenic pressure and perception of local communities towards conservation of wild ungulates in Dampa Tiger Reserve, Mizoram, India**", carried out in partial fulfilment of M.Sc. (Wildlife Science) degree of Saurashtra University, Rajkot is an original piece of research work. This research work was carried out under the supervision of Dr. S. Sathyakumar, Dr. Lallianpui Kawlani, Dr. Vishnupriya Kolipakam, at the Wildlife Institute of India from January 2021 to July 2021. I hereby declare that this work has not been submitted for any other degree of any university.

Date: 6<sup>th</sup> August, 2021  
Place: Dehradun

(Joonu Chakma)  
XVII M.Sc. Wildlife Science



भारतीय वन्यजीव संस्थान  
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CERTIFICATE

This is to certify that Ms. Joonu Chakma has carried out original research titled “**Responses of wild ungulates to anthropogenic pressure and perception of local communities towards conservation of wild ungulates in Dampa Tiger Reserve, Mizoram, India**” in partial fulfilment of Master’s Degree in Wildlife Science from Saurashtra University, Rajkot. This study was carried out under our supervision from January 2021-July 2021. We hereby certify that this work has not been submitted for any other degree to any other university.

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## CONTENTS

Acknowledgements	i
Summary	iii
Chapters	Page no
1. Introduction	
1.1 Background	1
1.2 Literature review	1
1.3 Rationale of the study	7
1.4 Objectives	8
2. Study area	
2.1 Location	10
2.2 Topography	11
2.3 Elevation and Climate	12
2.4 Flora / Vegetation	12
2.5 Fauna	15
2.6 Fringe villages	15
3. Study Design and Methods	
3.1 General Methods	17
3.2 Design	17
3.3 Methods	17
3.4 Statistical analysis	28
4. Results	32
5. Discussions	43
6. Conclusions and Implications	47
References	49
Appendices	55

**List of Tables:**

Table 1 & 2	Deployment of camera traps in different Habitat type and elevation range of study area in Dampa Tiger Reserve, Mizoram	18-19
Table 3	Profile of the sampled villages in Dampa Tiger Reserve	25
Table 4	Types of questions asked during questionnaire survey in the surveyed villages of Dampa Tiger Reserve	26
Table 5	Site covariates from field sampling in Dampa Tiger Reserve for occupancy estimation	30
Table 6	Site covariates extracted from GIS for occupancy estimation in Dampa Tiger Reserve	30
Table 7	Pooled densities of ungulates in Dampa Tiger Reserve, February 2021 to May 2021	34
Table 8	Probability of site occupied by barking deer and sambar and total sites in Dampa Tiger Reserve	37-38
Table 9	Naïve occupancy, averaged Psi and P of ungulates in DTR, February 2021 to May 2021	38
Table 10	Significant models for Perception of local communities towards ungulates from multinomial logistic regression analysis	42
Table 11	Predictor variables influencing the ungulate conservation by local communities in DTR using Multinomial logistic regression	42

**List of Figures:**

Figure 1	A map showing the intensive study area, Dampa Tiger Reserve, Mizoram	10
Figure 2	Maps of elevation (2.a), slope (2.b), terrain ruggedness (2.c) and aspect (2.d) and vegetation Map of Dampa Tiger Reserve (2.e)	11, 12, 14
Figure 3	A map showing the locations of villages surveyed and cameratrap deployed for the study in Dampa Tiger	19

	Reserve	
Figure 4	Camera trap locations in High and Low human use areas of Dampa Tiger Reserve	22
Figure 5	Percentage of different age groups surveyed in the villages of Dampa Tiger Reserve	26
Figure 6	Activity plots of ungulates in Dampa Tiger Reserve, January to May 2021	32-33
Figure 7	Estimated detection function for ungulates in Dampa Tiger Reserve, January to May 2021	34
Figure 8	Change in RAI of ungulates between 2018 (AITM report) and 2021 (Present study)	35
Figure 9	Map showing predicted distribution of ungulates in Dampa Tiger Reserve, February to May 2021	36-37
Figure 10	Percentage of meat preference indicated by respondents from surveyed villages in Dampa Tiger Reserve	39
Figure 11	Percentage of wild ungulate meat preference by respondents from surveyed villages in Dampa Tiger Reserve	40
Figure 12	Frequency of wild ungulate meat seen in villages from Dampa Tiger Reserve	40
Figure 13	Perception of local communities towards conservation of wild ungulates from Dampa Tiger Reserve	41

Plates:

Plate 1	Vegetation type in Dampa Tiger Reserve	16
Plate 2	Types of signs encounters during sign survey in Dampa Tiger Reserve	21
Plate 3	Cameratrap deployment and calibration of distance for camera-based distance sampling in Dampa Tiger	23

	Reserve	
Plate 4	Semi-structured interview with local communities in Dampa Tiger Reserve	25

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## **Summary:**

With the increasing anthropogenic pressures, conservation of ungulates is ever more crucial as they help in maintaining the forest structure. The impact of anthropogenic pressures such as hunting of wild ungulates by local communities in Mizoram, India, is limited and lacks reliable information.

This study was conducted in Dampa Tiger Reserve (DTR), Mamit district, Mizoram from January-Mid May, 2021 to quantify the responses of wild ungulates to the anthropogenic pressures, as a measure of conservation efforts. This study focussed on the population and distribution of ungulates in Dampa Tiger Reserve (DTR), Mizoram and assessed how the ungulates responded to human use areas. Stratified systematic sampling was done in an intensive study area (40 km<sup>2</sup>) to assess the ungulate density, distribution and activity pattern. In addition to that, the perception and attitude of local communities towards wild ungulates were also assessed. Estimates of the distribution, population and activity pattern of ungulates were obtained using single season occupancy model and cameratrap based distance sampling method whereas the local people perception and attitude were analysed based on answers from the semi-structured interview.

The study was carried out on the Teirei and Phuldungsei range of the DTR. A total of 40 grids (1 km<sup>2</sup> each) were sampled following the above framework. The grids were sampled using Camera-based distance sampling for population estimation in which the cameras were placed at the centroid of the grid. The density of the ungulates in two areas (high and low human use) could not be compared as the anthropogenic disturbance was homogenous throughout the study area. However, the pooled density of wild pig (0.55±0.23) was the highest among the other species, followed by barking deer (0.28±0.06) and sambar (0.20±0.09). The activities of the ungulates were at the peak from the crepuscular period to early morning and late evening. Occupancy pattern showed that barking deer distribution was influenced by the food availability/ground cover including areas near human habitations whereas sambar occurrence was negatively influenced by non-forest and presence of anthropogenic disturbance. Perception survey revealed that villagers showed a

positive perception towards ungulate conservation, however, in contrast to these responses, conservation practices in DTR by the local communities still lacks as intensive hunting still prevails.

This study highlights the impact of anthropogenic pressure towards ungulates and how strengthen management interventions is necessary to ensure the conservation of ungulates in DTR.

**Key words:**

Ungulates, abundance, occupancy, activity pattern, human-perception, anthropogenic pressure

# **1.0 INTRODUCTION:**

## **1.1 Background**

Ungulates are important ecological species maintaining the dynamics in habitat as they maintain the terrestrial ecosystem and restore predator population (Lamichhane et al., 2020). However, with the increase in proximity between humans and wildlife, there are frequent interactions, affecting both. This proximity has also affected the habitat use and activity pattern of wild animals since co-existence is the only viable alternative. However, this change can affect the natural process of animals thereby, affecting their population. DTR has remained unexplored largely and is threatened by human activities such as poaching, NTFP collection and habitat degradation such as shifting cultivation. Lack of reliable information on ungulates or any other wildlife often has the conservation and management priorities of the protected area lagging.

So, this study aimed to generate reliable information on the effect of anthropogenic pressure on the wild ungulate populations in the Dampa Tiger Reserve and its effect on the ungulate population, distribution, activity pattern. This study also attempted to understand the local villagers' perception and attitude towards the wild ungulates of DTR.

## **1.2 Literature Review:**

### **1.2.1. Driver of Ungulate Abundance, Occupancy and Activity pattern:**

Various environmental factors, both density-dependent and independent, determine the abundance of herbivores-ungulates (Borowik et al., 2013). While the activity patterns may also change based on seasons (Ikeda et al., 2015), habitat use changes based on the availability of food resources (Dupke et al., 2017). A study by Carrillo et al., (2002) on the remnant White-lipped Peccary population in Costa Rica, showed that White-lipped Peccary is diurnal and movements of animals occurred with the change in seasons, but with the availability of food especially in

interspersed habitat, the movement reduced. The interspersed habitat showed a higher density of the animal, raising concern for the interspersed habitat for the conservation of the White-lipped Peccary. Changes in feeding habits and activity pattern among different species may also occur to avoid competition (Ferreguetti et al., 2015; Tobler et al., 2009). Therefore, the ecology of ungulates may depend on various factors. However, human disturbances can alter the behaviour of wild animals (Ikeda et al., 2015; Srivastava et al., 2020) exceeding those of natural predator, and these disturbances can lead to severe implications on wildlife populations (Ciuti et al., 2012).

Occurrence of disturbances may lead to changes in activity patterns of animals (Barrueto et al., 2014; Gaynor et al., 2018; Oberosler et al., 2017), and affect its relative abundance (Bitetti et al., 2004), studies showed that roads, hunting and human settlements are negatively associated with the relative abundance of ungulates (Altrichter and Boaglio, 2004; Bitetti et al., 2004; Laurance et al., 2006). However, some of the ungulate species may have a different tolerance response to hunting. A study by Reyna-Hurtado and Tanner, (2007) in Southern Mexico showed that Broussard deer, white-tailed deer and collared peccary persisted despite hunting pressure due to high adaptability in both secondary vegetation and primary forest and while White-lipped peccary was negatively associated with hunting, however it is worth noting that viability of the species could depend on the survival as a meta-population. A study found that the occupancy of prey species such as *Muntjac* spp and Mouse deer, decreased with the on-going human disturbance in Indonesian Borneo (Bersacola et al., 2019). Kays et al., (2017) revealed that human activities such as hunting and hiking, did have an impact on wildlife communities although, major activities such as housing density in the area, agriculture, habitat fragmentation had larger impact.

In a study from India, where occupancy and activity pattern was estimated using camera traps, it has been seen that detection probability in ungulates was negatively related to human presence (Bhattacharya et al., 2012). North-east India, an Indo biodiversity hotspot, faces several threats of human disturbances. Habitat fragmentation such as shifting cultivation accounts for 0.76 m ha in northeast India

(Panda et al., 2016). In protected areas where illegal activities such as the above-mentioned habitat fragmentation are absent or negligible, activities like hunting which is a strong tradition of the local tribes (Datta et al., 2008) and NTFP collection do persist. Major ungulate species such as the Sambar (*Rusa unicolor*), Wild pig (*Sus scrofa*), Barking deer (*Muntiacus muntjak*), Serow (*Naemorhaedus sumatraensis*) and Gaur (*Bos gaurus*) have been a target of the hunters in Arunachal Pradesh of northeast India (Aiyadurai et al., 2010; Datta et al., 2008). These affect the wildlife distribution and the activity pattern of the animals. The ungulates in Manas National Park were also found to have altered behaviour in their activity pattern, both spatially and temporally, with minimal overlap with humans (Lahkar, 2020).

A study from DTR, Mizoram revealed that, 26.3% of the total fauna (525 individuals/year) hunted by local people constituted of ungulates (Solanki, 2016). Unfortunately, studies on the responses of wild ungulates from anthropogenic pressure from this northeast region have not been addressed well and lack research.

### **1.2.2. Monitoring ungulate population:**

Ungulates are an important ecological species as they are important seed dispersers (Bhattacharya and Sathyakumar, 2011), and maintain the dynamicity of the forest (Pérez-Irineo and Santos-Moreno, 2016). They require management decisions based on ecological knowledge such as its behaviour and habitat needs (Carrillo et al., 2002). It is necessary to have reliable estimates of density and abundance (Howe et al., 2017) for making any conservation decisions. Ecological uses of ungulates have been widely studied from all over the world for quite some time now such as abundance estimation, habitat utilization and activity patterns were determined by observation from machans, elephants (Seidensticker, 1976), walking transects (Adhikari and Khadka, 1970; Gopalaswamy et al., 2012), drive count, pellet count and track count (Koster and Hart, 1988) but each method has its limitations depending on the type of terrain it is being applied on and other logistics. For hilly or

steep terrains, trails have been preferred to get the estimates (Bhardwaj et al., 2010; Sathyakumar, 1993; Sathyakumar, 1994).

For instance, in the north-eastern part of India, the gaur distribution has been studied based on the direct and indirect observations such as footprints, dung, consultation with forest department, villagers (Choudhury, 2002).

Distance sampling, a widely used method for estimating the abundance of a population is based on the direct sightings of the animals (Thomas et al., 2010), however, direct sightings or visual encounters are rare in areas having low animal densities or even in dense forests or difficult terrains (Bhattacharya et al., 2012; Bhattacharya and Sathyakumar, 2011; Corlatti et al., 2020; Singh and Milner-Gulland, 2011). So, the camera trapping method used for passive monitoring of animals is suitable not just in the difficult terrain where distance sampling and other methods seem difficult (Singh and Milner-Gulland, 2011; Srivastava and Kumar, 2018) but also, useful for studying the animal activity patterns (Gómez et al., 2005) at night with no or minimal disturbance. However, appropriate sampling efforts are crucial to achieving reliable results (Saito et al., 2015).

While camera trapping has shown to be reliable in estimating the population of animals with natural markings (Karanth and Nichols, 1998), animals like ungulates without natural markings require a different approach using camera traps. Several methods such as REM (Random Encounter Model) (Rovero and Marshall, 2009; Rowcliffe et al., 2008) are being used for population estimation of unmarked animals, Howe et al., (2017) used camera trap-based distance sampling, an extension of the distance sampling method to estimate the abundance of unmarked animals by remotely monitoring the species. For instance, this method has been tested on Chimpanzees by Cappelle et al., (2019) in Côte d'Ivoire, on Marmot population in Central Italian Alps by Corlatti et al., (2020).

In India, this method was used on mountain ungulates i.e., the group-living Blue sheep and the solitary Musk deer (Pal et al., 2021). These studies showed the potentiality of camera trap distance sampling in estimating density or abundance and

especially in areas where the terrain is rugged or is densely forested and direct sighting using distance sampling method with point and line transects are difficult.

### **1.2.3. Local people perception and attitude:**

It is also necessary to look at local people's attitude and perception of wildlife for long term conservation (Choudhury et al., 2019; Ebua et al., 2011; Htun et al., 2012; Newmark et al., 1993). These depend on the direct and indirect interactions between human and wildlife (Karanth et al., 2019). In addition to that, (Fisher, 2016; Karanth et al., 2019; Redpath et al., 2015) revealed that the interactions can be negative, neutral or positive. However, the human-wildlife interaction is not the whole explanation to their perception, the perception and attitude of local people may depend on the livelihood strategies, cultural values, gender, age, educational qualifications, occupation (Jyrwa et al., 2020) and other values such as ritualistic hunting (Aiyadurai et al., 2010). Through this, one can also assess the resource use interest of people from the forest (Arjunan et al., 2006; Newmark et al., 1993). For instance, the tribals in and around DTR, Mizoram use wildlife in their therapeutic activities due to lack of healthcare facilities, however, there are no evidences of ethno-zoology (Solanki, 2016).

Htun et al., (2012) also revealed that the positive attitude of villagers towards protected area/ conservation was correlated to the socio-demographic characteristics and knowledge, whereas the negative attitude correlated to the economic loss. However, some studies reveal that sex, ethnicity, landholdings and occupations do not correlate with the resources used from the forests (Baral and Heinen, 2007). Newmark et al. (1993) also studied how people perceived poachers and 74% of the local people perceived poachers as law-breakers.

### **1.2.4. Importance of the proposed project in the context of current status:**

DTR is one of the protected area in the northeast which has remained largely unexplored (Sethy et al., 2016). The large carnivore populations has been in decline and often dependent on the abundance of the prey populations (Lahkar, 2020;

Vongkhamheng et al., 2013). Over hunting of large herbivore is a major problem in Southeast Asia (Steinmetz et al., 2010), (Muthamizh Selvan et al., 2014), including DTR. Furthermore, northeast India being a home to at least 145 tribes largely dependent on shifting cultivation, forest and on hunting particularly of ungulates, (Aiyadurai, 2011; Aiyadurai et al., 2010) faces huge challenge in conservation.

Singh et al., (2019) stated that for the conservation of the wild dogs in DTR, it is important to protect the prey populations. The recent photographic evidence of tiger presence from DTR (Desk, 2021) shows that the large predator that is dependent on the ungulates continues to thrive in this landscape. However, only a baseline information is given on the ungulates of DTR in Status of Tigers, Co predators and Prey in India (Javadekar, 2018). In addition, the reduction of the vegetation cover in Dampa over several decades, have led in reduction of the habitats for animals and the bamboo forest and scrubs have taken over and reduced the cover of evergreen, semi-evergreen and the deciduous forest (Devi and Sarma, 2011). The increasing urbanization such as intensification of agriculture and fragmentation has resulted increasing human-wildlife interface (Hassell et al., 2017). In a study by Dutta et al., (2019), 113 carcasses of wild red Serow were found in different districts of Mizoram due to the outbreak of goat pox in the year 2015-2016. This was also reported to have caused spillover to domestic goats (Bora et al., 2018). Similar outbreak and spillover was also reported from Arunachal Pradesh (Bora et al., 2021). Bora et al., (2021) mentions that, anthropogenic pressure and climate change, can establish diseases in areas earlier not known to be present.

The attitude and perception of local people on hunting and living near a protected area is necessary in the best conservation efforts (Choudhury et al., 2019; Ebua et al., 2011; Htun et al., 2012; Jyrwa et al., 2020; Karanth et al., 2019; Newmark et al., 1993). So, these are some of the gaps that need to be answered.

### **1.3 Rationale of the study**

Ungulates being important seed dispersers, also maintain the large carnivore populations in an area (Bhattacharya and Sathyakumar, 2011). Ungulates are known to be widely distributed and have high abundance across a broad geographic range (Jolles and Ezenwa, 2015). The abundance of ungulates may depend on several interconnected factors (biotic and abiotic) simultaneously across landscapes. Climate plays an important role in the ungulate life history and population dynamics, changes in temperature and precipitation affect the abundance of ungulates directly or indirectly (Malpeli et al., 2020). However, in the presence of anthropogenic pressure, the behaviour of ungulates and other wildlife is likely to vary more than that influenced in the presence of natural predators (Ciuti et al., 2012). Therefore, it is necessary, especially in areas of low abundance, to understand the influence of humans living nearby on the ungulate population.

Many of the protected areas in the Eastern Biodiversity Hotspot in India lack reliable data on ungulates (Muthamizh Selvan et al., 2014). Study of mammals like the ungulates species lack research not just in DTR but in other parts of Mizoram as well (Lalthanzara, 2017). Hilly terrains with dense forests are often inaccessible and surveys through transect lines are rarely done.

DTR, a part of the Indo-Burma biodiversity hotspot, faces threats of habitat degradation due to shifting cultivation, and poaching (Solanki, 2016). With a very small population of Wild dog acting as an apex predator and tiger, and several other species such as Asian elephant being at the brink of extinction, the ecological balance of the system could be dismantled. Studying ungulates is important for wildlife management as in the absence of overhunting/poaching, ungulates help in maintaining the populations of large carnivores as well as are an important part of the ecological process (Muthamizh Selvan et al., 2014). In addition, the core of DTR is surrounded by villages in the buffer. The local peoples' use of wildlife resources has been studied in DTR (Solanki, 2016) however, there is paucity of copious information on the impact of anthropogenic disturbances in ungulates.

So, in this study attempt has been made to answer questions on ungulate distribution, activity patterns and how people in villages of DTR perceive wild ungulates and their conservation.

#### **1.4 Objectives:**

##### **Objective 1:**

To assess the distribution and activity pattern of ungulates with reference to human use (low use area and high use area) in DTR

##### **Hypothesis:**

A high human use area is expected to have lower occupancy, abundance, and differences in activity pattern in comparison to a low human use area.

##### **Research question:**

- a) Is there any significant variation in the activity pattern and abundance of ungulates in high and low human use area?
- b) Is there any variation in the occupancy of the ungulates across the study area?

##### **Objective 2:**

To understand people's perception and attitude towards wild ungulates in DTR

##### **Hypothesis:**

Villagers are expected to have a cultural association with the hunting of ungulates and a positive attitude towards conservation, linked to their livelihood strategies (hunting) and religio-cultural values.

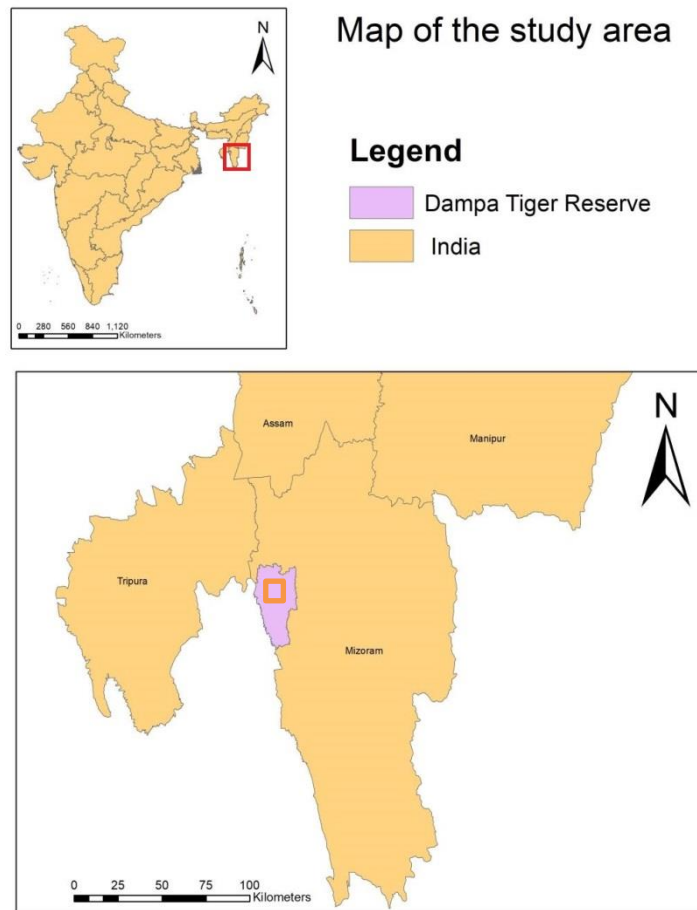
##### **Research questions:**

- a) How do local villagers associate with ungulates in the study area?
- b) How do villagers perceive the conservation of wild ungulates?

- c) What are the personal, cultural and socio-economic attributes that affect peoples' perception and attitude towards wild ungulates and their conservation?

## 2.0. STUDY AREA:

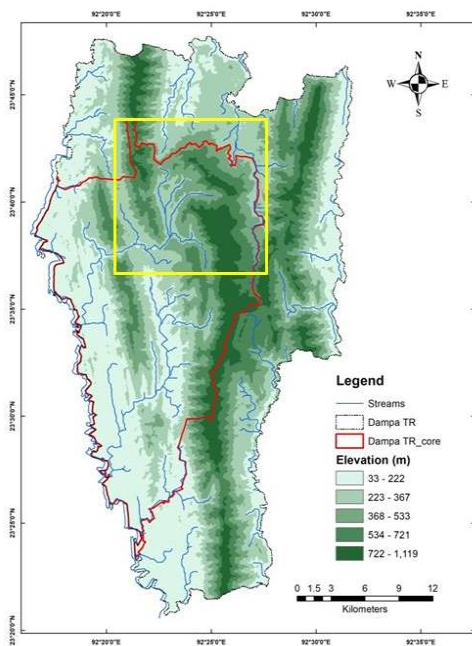
**2.1. Location:** The study was conducted in the Teirei and Phuldungsei range of the Dampa Tiger Reserve. DTR is a part of the Indo-Burma Biodiversity Hotspot, located in the Lushai Hills, Mamit District of Mizoram (23°20'- 23°47' N and 92°15'- 92°30' E). It is situated on the western part of Mizoram bordering the Chittagong Hill Tract region of Bangladesh on the west whereas the east, north and south part of DTR is surrounded by villages consisting of three tribal groups namely- Mizo, Chakma and Bru. The total area of DTR is 500sq.km.



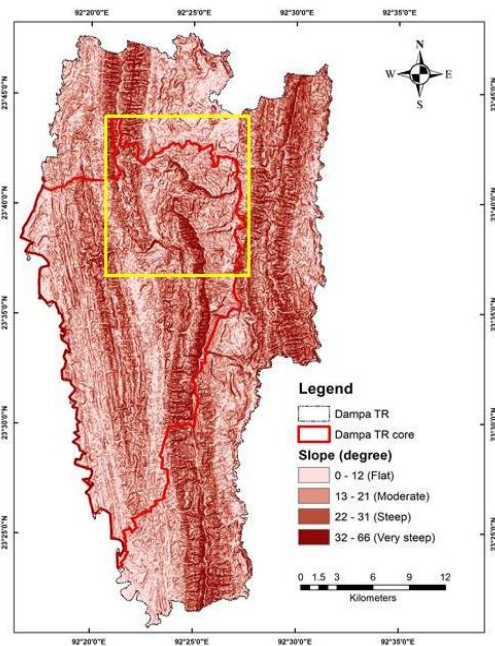
**Figure 1: Map showing Dampa Tiger Reserve, Mizoram, India**

**2.2. Topography:** The terrain in DTR is hilly and steep for the most part (Figure 2.b and 2.c), while there are undulating and valley areas too with streams and perennial rivers like Sialring, Seling and Tuichhar flowing in the Reserve. This diverse topography provides a variety of habitats to a vast number of generalist and specialist species, both flora and fauna. Part of the north-eastern part of DTRs has been selected to conduct the study, as the Southern part of DTR has cliffs and very steep terrain in comparison to the northern part of the DTR. Also, the north-eastern DTR has proximity to human settlement, making it logistically feasible to conduct the study.

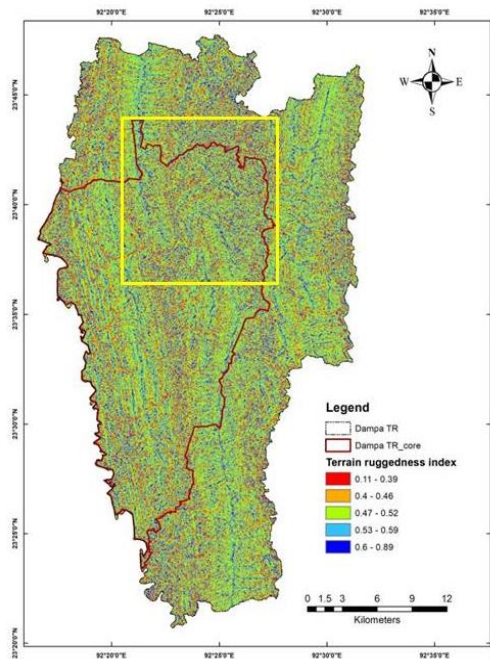
**2.a Elevation Map of DTR**



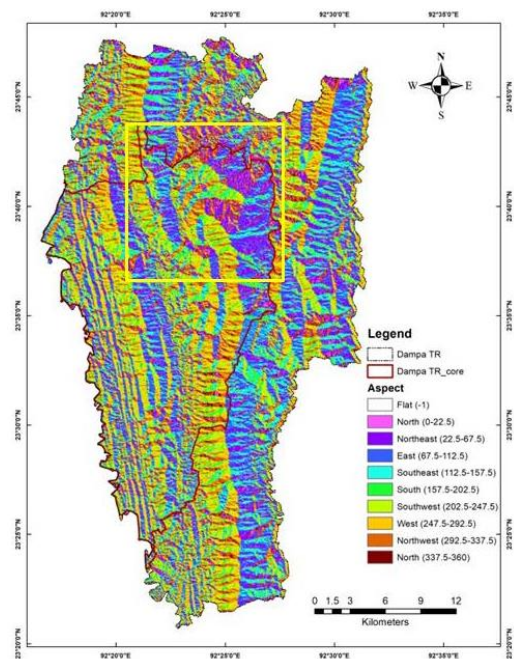
**2.b Slope Map of DTR**



**2.c Terrain Ruggedness Map of DTR**



**2.d Aspect Map of DTR**



**Note: Yellow outline (Box) shows intensive study area**

**2.3. Elevation and Climate:** The TR lies in the elevation ranging from 250-1,119 MSL (Figure 2.a) with an average precipitation of 2,150 mm, mainly from the southwestern monsoon between May to October (Raman et al., 1998) while the pre-monsoon starts from the end of March. The minimum temperature in winter is 3.5°C and the maximum temperature in the summer is 36°C. The winter in DTR usually lasts till February.

**2.4. Vegetation:** The vegetation of DTR mainly comprises moist deciduous forest, tropical wet evergreen forest, tropical semi-evergreen forest and tropical grassland at higher altitudes. According to the forest classification of (Champion and Seth, 1968), the vegetation in DTR is classified as (Figure 2.e)-

2B/C2 Cachar Tropical Semi-Evergreen Forest

2/251 Secondary Moist Bamboo Brakes

3C/C3 b East Himalayan Moist Mixed Deciduous Forest

The forest in DTR is largely dominated by bamboos, with the dominating species being *Melocana baccifera*, with a sparse growth of *Hibiscus macrophylla* within the bamboo forest while some of the other bamboo species found are *Bambusa tulda*, *Dendrocalamus longispathus* and *Bambusa dampaeana*. The tree species compositions in the mixed deciduous forest are *Cinnamomum spp*, *Pterygota alata*, *Calliandra ambrosa*, *Tetrameles nudiflora*, *Sizygium spp*, *Knema spp*, *Duabanga grandiflora*, *Leah indica*, *Wrightia coccinea*, *Terminalia spp*, *Lagerstroemia spp*, *Canarium strictum*, *Ficus spp*, *Castanopsis spp*, *Acrocarpous fraxinifolius*, *Quercus spp*, *Lithocarpous spp*, *Trevesia palmata*, *Caryota urens* etc with different species of canes. The undergrowth vegetation is composed of shrubs like *Ardissia spp*, *Phrynium spp*, *Clerodendron spp*, *Setaria palmata* and others.

Sparse growth of grasslands in higher elevation in rocky mountains are also seen in the reserve.

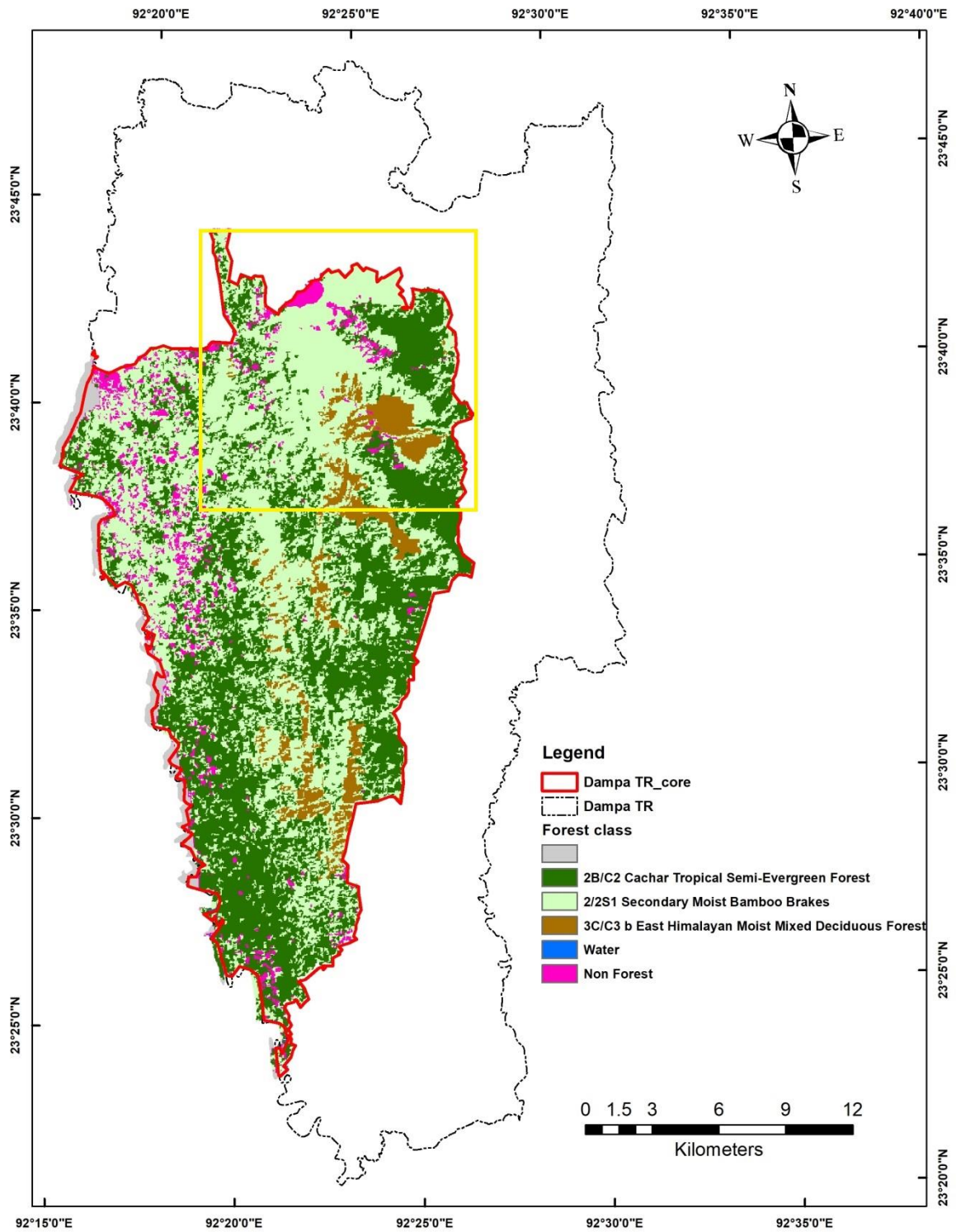


Figure 2.e: Vegetation Map of DTR

**2.5. Fauna:** DTR supports several mammalian species (Singh et al., 2019) including ungulate species such as Gaur (*Bos gaurus*), Sambar (*Rusa unicolor*), Red serow (*Capricornis rubidus*), Barking deer (*Muntiacus vaginalis*), Wild pig (*Sus scrofa*) (Singh and Macdonald, 2017). Felids found in DTR are Tiger (*Panthera tigris*) (Desk, 2021), Clouded leopard (*Neofelis nebulosa*), Leopard cat (*Prionailurus bengalensis*), Marbled cat (*Pardofelis marmota*), Golden cat (*Catopuma temmincki*). Ursids found in DTR are Malayan sun bear (*Helarctos malayanus*) and Himalayan black bear (*Ursus thibethanus*). Other carnivores such as the Binturong (*Arctis binturong*), Hog badger (*Arctonyx collaris*), Yellow-throated marten (*Martes flavigula*), and others are also found. A small population of Dhole (*Cuon alpinus*) is also present. Primates such as the Western Hoolock gibbon (*Hoolock hoolock*), Phayre's leaf monkey (*Trachypithecus phayrei*), Pig-tailed macaque (*Macaca leonina*), Assamese macaque (*Macaca assamica*), Capped langur (*Trachypithecus pileatus*), Rhesus macaque (*Macaca mulatta*) are found. DTR is also rich in avifauna and the Grey Peacock pheasant (*Polyplectron bicalcaratum*) is frequently seen and heard in this region.

**2.6. Fringe Villages:** Villages on the buffer of DTR are W. Phaileng, Teirei, Damparengpui, Tuipuibari, Rajivnagar, Lallen, Saithah, Serhmun, Phuldungsei, Pukzing, Khawhnai, W. Phulpui and Silsuri. The local communities in these villages are dependent on the forest resources such as NTFP collection for their economic subsistence and several wildlife products (Solanki, 2016).

Plate 1: Vegetation Types of DTR



a. Bamboo forest



b. Semi evergreen forest



c. Grassland patches



d. Moist deciduous forest

## **3.0 STUDY DESIGN AND METHODS**

### **3.1. General Methods**

The study was conducted in Teirei and Phuldungsei ranges of DTR from January 2021 to May 2021. Based on the reconnaissance survey, a 40 km<sup>2</sup> area was selected as the intensive study area. The Field hostel in Teirei Forest, DTR was used as a basecamp. The Teirei, Damparengpui, Malpui, Chikha and Lallen road provided access to the study area using vehicles and by foot. Basic field equipment such as binoculars, compass, GPS, measuring tape, bamboo poles and cameratraps were used during the study area.

### **3.2 DESIGN:**

Stratified systematic sampling was used based on the sampling of regular grids of the size of 1 km<sup>2</sup> which were superimposed using fishnet in ArcGIS. Centroids in each grid were also generated on a processed vegetation map which has been acquired from the GIS laboratory of Wildlife Institute of India. The image provides 3 classes of forest types (Champion and Seth 1968) and other non-forest classes. This was adopted to proportionately sample the area based on the habitat type. The sampling regime was to identify one block in the study area based on distance from the village, consultations with local villagers and walking transect and collecting data of disturbance/signs.

### **3.3. FIELD METHODS:**

The 1 km<sup>2</sup> grids with the centroids were then imported into Locus Map, an application used in mobile phones, which was then used for searching the centroids in the study area.

A total of 40 grids (Figure 3) were chosen in the entire study area upon reconnaissance and a camera trap was deployed in the centroid of each grid depending on the accessibility of the terrain. However, in six out of the forty 1 km<sup>2</sup> grids, at least two camera traps each were deployed on the basis of presence of signs of the target species. One camera trap in the centroid whereas the other inside the 1

km<sup>2</sup> grid for the density and occupancy estimation respectively. This was done for the occupancy estimation because although animals may be present in the area, they may not necessarily be detected or captured and whichever camera trap out of the two (in the same grid) that the animals were detected in, that camera was selected for the analysis. Therefore, a total of 46 camera traps in 40 grids were deployed (Figure 3). Centroids in inaccessible areas could not be used for deploying the camera traps. However, the closest accessible location to the centroid was used. This was focused in the two ranges of DTR, namely- Teirei and Phuldungsei range.

### **Vegetation Sampling:**

The data sheet for vegetation sampling from the Field Guide Monitoring Tigers, Co-predators, Prey and their Habitats (Jhala et al., 2017), was used. Vegetation plots were made in the camera trap locations. A 10m circular plot was used for trees, 5m plot for shrubs and a 1m plot for herbs/ ground cover. Canopy cover percentage was also sampled.

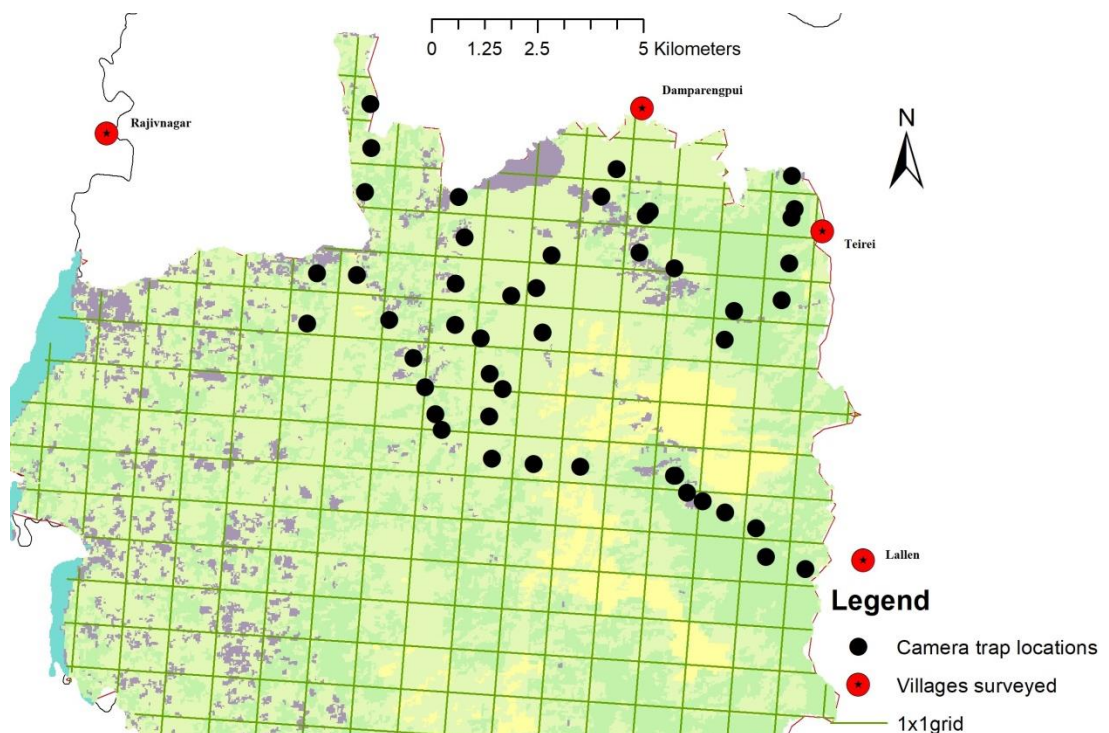
The camera traps were deployed in various habitat type and elevation-

**Table 1: Deployment of camera traps in different Habitat type in DTR**

<b>Habitat Type</b>	<b>No. of camera traps</b>
<b>Tropical Semi evergreen</b>	17
<b>Moist Bamboo Brakes</b>	24
<b>Mixed Deciduous forest</b>	0
<b>Non Forest</b>	5

**Table 1: Deployment of camera traps in different elevation ranges in DTR**

Elevation (m)	No. of Camera traps
200-400	18
400-600	9
600-800	13
800-1000	4
>1000	2



**Figure 3: A map showing the locations of villages surveyed and cameratrap deployed for the study in Dampa Tiger Reserve**

### **Identification of Low and High Human use areas:**

Since the study was conducted inside the core, there was no fixed demarcation to identify high and low human use area. Therefore, visual assessment of use of the areas by humans through signs and direct encounter of humans was done. Sign survey was conducted every 200m by walking an average of 1.7 km per 1 km<sup>2</sup> grid within which opportunistic encounters of signs were used. Line transect was not possible due to the steep slopes and rugged terrain (Figure 2b and 2c). A 10m circular plot was also used in the camera trap location to collect disturbance data such as lopping, NTFP collection and presence of livestock. This was replicated at least 3 times in each grid. Further, encounter rates of signs in each grid were used to classify high and “comparatively” lower use areas. However, since the disturbance/signs were homogenous, there was no distinct difference between high and low human use areas in the study area. So, the distance from village was taken as a factor to determine the two areas. Although, this does not indicate fixed distinction and only implies comparative differences between grids closer to human habitations and away from human habitation.

**Plate 2: Types of sign encounters during sign survey in DTR**



a. Fire made by poachers



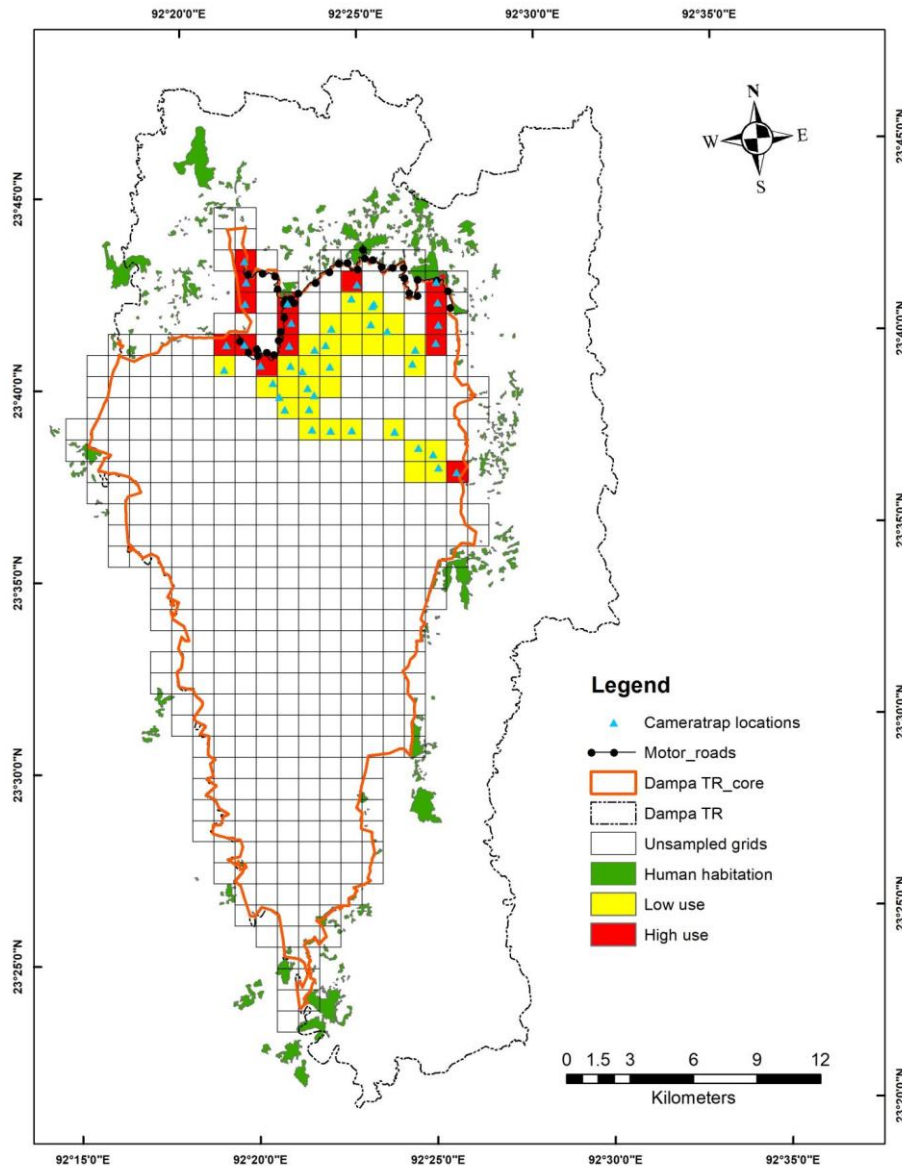
b. Fishnet used by local villagers



c. Bottles/Plastics



d. Resting place for poachers



**Figure 4: Camera trap locations in High human use and Low human use areas of DTR**

### **3.3.1. Population estimation using Camera based distance sampling:**

For the population estimation, camera trap based distance sampling was used (Howe et al., 2017). As mentioned above, a total of 40 grids were sampled. The camera traps were mounted at a height of 40cm-1m height because of the steep and undulated terrain and set in a way in which upon any movement detection, the camera triggers in a burst mode with 5 images. The camera traps were deployed from mid-February to mid-May (3 months). Since distance sampling was used using camera traps (point transect), the distance from the camera traps were measured in

both the sides and centre of camera's FOV (Pal et al., 2021). Sticks of 1.5m were used at every metre to determine the average height of the animals and the distance in front of the camera. These measurements were done for all the 40 camera traps. However, one camera (camera 12) malfunctioned and another camera (camera 10) was stolen during the field work. So these cameras were excluded from the analysis. So, for the final analysis, a total of 38 camera traps were used.

**Plate 3: Photographs of cameratrap deployment and calibration of distance for camera-based distance sampling in the study area, DTR**



**a. Cameratrap deployment in DTR**



**b. Calibration of distance in DTR**

### **3.3.2. Occupancy for determining the distribution pattern:**

Sampling for occupancy requires the presence or absence of the target species from the sites or at the given spatial scale. By combining the data from the sites, the measure of occupancy is obtained (MacKenzie, 2006). However, it is not always possible to detect the target species within the sampling unit, so to account for the “false absences”, repeated surveys is done. In sites where the target species is detected, repeated surveys provide the chances of detection or detection probability of target species. But in our study, a total of 78 days (camera deployment) were used to account for the false absences. Stratified systematic sampling has been used to represent the entire population from this study area. A total of 38 camera traps were selected for the occupancy sampling. In addition, covariates data such as elevation, slope, canopy cover, disturbance, etc. were defined from each site to represent the areas or each stratum.

### **3.3.3. Human perception:**

A preliminary survey was done to look for the villages in the fringe (Choudhury et al., 2019) of DTR. A total of 4 villages were selected to conduct the study based on the-

- 1) Tribes- Mizo, Chakma and Bru,
- 2) Distance from the forest,
- 3) The villages being closer to the study area inside the core

The four villages are Damparengpui ( $23^{\circ} 42' 57''\text{N}$  and  $92^{\circ} 24' 50''\text{E}$ ), Teirei ( $23^{\circ} 41' 23''\text{N}$  and  $92^{\circ} 27' 08''\text{E}$ ), Rajivnagar ( $23^{\circ} 42' 38''\text{N}$  and  $92^{\circ} 18' 1''\text{E}$ ) and Lallen village ( $23^{\circ} 37' 12''\text{N}$  and  $92^{\circ} 27' 39''\text{E}$ ). Though, all four villages are dominated by their respective tribes, they are not entirely homogenous. Damparengpui is dominantly inhabited by the Bru tribe, with small population of Mizos in the village, meanwhile the dominant inhabitants in Rajiv nagar is the Chakma tribe and Lallen, is dominantly inhabited by the Mizo tribe. The Teirei village is dominated by both Mizos and Brus. The villages being closer to the other study area inside the core made it logistically feasible to conduct both the studies simultaneously. The preliminary survey was followed by formal and informal meeting with the village heads. Since the last population census was conducted in 2011, the most recent population census available was the Mizoram Village Council Level Baseline Survey Report 2013 conducted by LAD, Mamit, in 2013 ("Department of Local Administration Department, Government of Mizoram, India - Mamit," n.d.). The total population in all the four villages from this census is shown in Table 3. In addition to that, on informal discussions with the Village heads, it was found that the population has increased in over 10 years. So, sampling was done in such a way that, at least 10% of the household from the latest population data from village heads and above 10% households from the 2013 report was surveyed. Once the basic information about the village was collected from the village heads, the semi-structured interview with questionnaires and informal discussions with the local villagers was done from February to April. Survey was done using simple random

sampling with one member representing one household. A proportionate representation of the gender was also attempted.

**Plate 4: Semi-structured interview with local communities in Dampa Tiger Reserve**



**Table 3: Profile of the sampled villages in DTR**

Sl.no	Village	Total population	Total no. of househ old	No. of individuals surveyed	Male	Female	% of household surveyed
1.	Teirei	274	109	40	23	17	37%
2.	Damparengpui	1287	540	80	43	37	14%
3.	Rajiv Nagar	1261	904	107	68	39	11%
4.	Lallen	592	146	40	22	18	27%
	TOTAL			267	156	111	

**Basic Information included-**

1. Name/Respondent no.
2. Age
3. Tribe
4. Religion
5. Education
6. Occupation

7. No. of family members

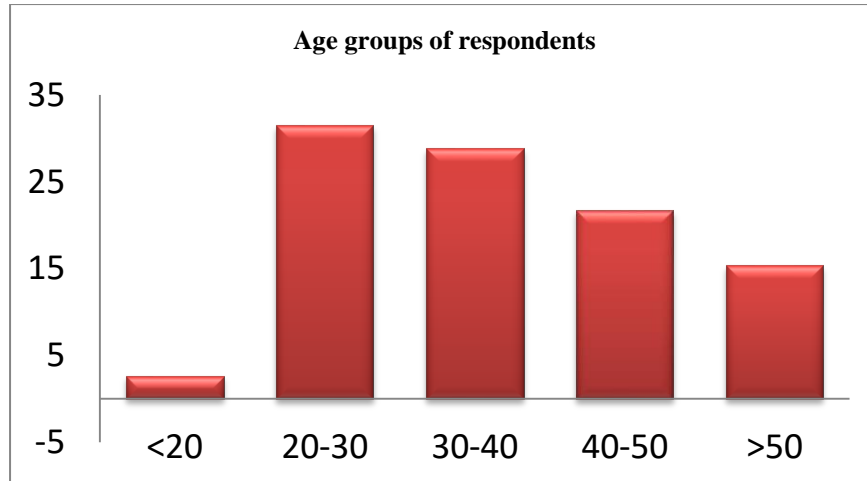


Figure 5: Percentage of different age groups surveyed in the villages of DTR

Table 4: Types of questions asked during questionnaire survey in the surveyed villages of Dampa Tiger Reserve

Questions	Responses/Ranks
<b>Do you think conservation of ungulates is necessary?</b>	Yes / No /To some extent / Not sure
<b>How frequently do you see wild ungulate meat in the village?</b>	Very high (Once or twice a week) High (Once or twice a month) Fair (Once or twice in 6 months) Low (Once or Twice a year or above) Never
<b>Do you prefer Wild or Domestic Meat?</b>	Wild/Domestic
<b>If wild meat, which animal?</b>	Birds Snakes

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	Deer/Wild Pig/Serow/Gaur
	Frogs
	Fish
	Primate
	All wild
<b>Do you think hunting should stop?</b>	Yes
	No
	Not sure
	To some extent
<b>What kind of changes has DTR brought to your village? Elaborate</b>	Positive _____
	Negative _____
	None/No change
<b>Do you think Human-Wildlife can co-exist?</b>	Yes
	No
	Not sure
<b>Value of ungulates?</b>	Aesthetic
	Medicinal
	Delicacy
	Religious
<b>How often do you go to the forest to collect NTFP or other resources?</b>	Very high (Everyday )
	High (Once in one or 2 weeks)
	Fair (Once or twice in a month)

---

Low (Few times a year)

Never

### 3.4 STATISTICAL ANALYSIS:

#### 3.4.1. Activity Pattern:

The camera trap data of the ungulates from each location were sorted for the activity pattern. The activity plots of the ungulates were then generated using camtrapR package (Niedballa et al., 2016) in R software. One capture every 30 minute was taken to plot the activity pattern to avoid bias due to the repeated capture of the same animal.

**3.4.2 Density estimation:** The distance data was analysed using the Distance 7.3 software. As mentioned by Howe et al., 2017; Pal et al., 2021, only the animals available for detected can be estimated for density. So, the period or the proportion of time where the animals were available for detection was used for the density estimation. The peak period was generated from the activity plots. If, however, the entire sampling period was taken including the period when animals were not available for detection, the temporal sampling would be overestimated leading to negatively biased density estimates (Cappelle et al., 2019; Pal et al., 2021). The distance data included the animals detected in the selected sampling window along with their radial distances, effort and the area.

The equation for density estimation used by (Cappelle et al., 2019; Howe et al., 2017; Pal et al., 2021) is given as follows-

$$\hat{D} = \frac{\sum_{k=1}^K n_k}{\pi w^2 \sum_{k=1}^K e_k \hat{p}_k}$$

Where at point k,  $n_k$  is the number of observations,  $e_k = \frac{\theta T_k}{2\pi t}$  is the temporal effort,

$\frac{\theta}{2\pi}$  is the fraction of the circle covered by the camera and  $T_k$  is the period (in

seconds) in which the camera trap was deployed or the proportion/peak period in which the animals were available for detection and  $t$  is the unit of time (in seconds) between each consecutive snapshots.  $W$  is the truncation point where any distance beyond this point was discarded,  $\hat{P}_k$  is the estimated probability of obtaining an image of an animal that is within  $\theta$ .

Pooling data for each species was done to fit the global detection function curve in the Distance software. The models used were Uniform function with cosine adjustment, Hazard-rate function with cosine adjustment and Half-normal function with Hermite-polynomial adjustment. The lowest AIC values are used for choosing the best fit model, however, this tends to choose complex models due to over-dispersed data it chooses complex models (Howe et al., 2019; Pal et al., 2021). So, two steps model selection given by Howe et al., (2019) was used. The first step requires selection of the best model on the basis of QAIC within each key function in which the ratio between the chi square statistics of the most parameterized model for each key function and its degree of freedom ( $\frac{\chi^2}{df}$ ) calculates the over-dispersed parameter  $\hat{C}$ . Secondly, the smallest value of  $\chi^2$  GOF statistics divided by its df (across QAIC- selected models, one from each function) gives the best model.

For Sambar density estimation, two of the camera traps made up for more than 60% of all the captures, as the camera traps were deployed in along a stream which was used by the animal and an another intensively used Sambar trail in a bamboo forest. To reduce this bias, the Sambar data from these two camera traps were not included for the final analysis.

**3.4.3 Occupancy estimation:** The presence-absence data of the ungulates or the detection history matrix for each ungulate was generated from the camera trap information in Excel. The detection history matrix had 38 sites (rows) and 78 occasions (column). However, due to low captures and high absences, 78 occasions was pooled into 13 occasions. Therefore, there were total 13 occasions in 38 sites in the detection history matrix. A Single-season model was run to estimate the proportion of area occupied ( $\Psi$ ) and detection probability ( $p$ ) along with site covariates (Table 5 and 6). Due to low captures, Occupancy for Wild pig, Serow and

Gaur could not be analysed. Therefore, the analysis was only done for Barking Deer and Sambar.

**Table 5: Site covariates from field sampling in DTR for occupancy estimation**

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<b>Elevation (m)</b>
<b>Canopy Cover (%)</b>
<b>Tree Density (ha)</b>
<b>Shrub cover (%)</b>
<b>Ground Cover (%)</b>
<b>Human signs/Disturbance (Encounter rate)</b>

**Table 6: Site Covariates extracted from GIS (ASTR DEM, 30m resolution) for occupancy estimation in DTR**

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<b>Distance from Stream (km)</b>
<b>Distance from Village (km)</b>
<b>Bamboo forest (%)</b>
<b>Deciduous forest (%)</b>
<b>Non Forest (%)</b>
<b>Semi evergreen forest (%)</b>
<b>Slope</b>
<b>Terrain (TRI)</b>

**3.4.4 Social survey:** A total of 267 individuals were surveyed from the four villages. Data was analysed using bar plots in Excel showing the responses of the villagers and a multinomial logistic regression using mlogit package (Croissant, 2020) in R

software to look at the relationship between Peoples' perception towards ungulate conservation as dependent variable and their personal, cultural and socioeconomic factor as independent variable such as- Age, Gender, Tribe, Occupation and Education. Other variables includes, resource dependency of local people from forest, perception of local communities towards DTR, attitude towards hunting, frequency of seeing wild meat in the village, wild meat preference, attitude towards coexistence of wild animals and value of ungulates according to the local communities.

## 4.0 RESULTS:

During the study, five ungulates were photo-captured. Based on the 2969 camera trap nights effort we got 277 images ungulates, of which there were 11, 12, 116, 87 and 51 captures were of gaur, serow, barking deer, sambar and wild pig respectively, 1160 blanks (including edited), 405 images of other mammals such as clouded leopard, wild dog, marbled cat, Malayan sun bear, Himalayan black bear, Pig tailed macaque, Assamese macaque Hog badger, Binturong, etc., and 138 images of birds such as peacock pheasant, khali j pheasant, jungle fowl, 81 images of humans including villagers and forest department staffs.

### 4.1 Activity Plots of Ungulates in DTR:

Barking deer, Sambar and Red serow showed similar activity, showing a bimodal peak (Figure 5 a, b, d) with peak activity during the crepuscular period to early morning (4:00 am to 7:00 am) and late evening (5:00pm-8:00pm), when the villagers in and around DTR are less active. Although active throughout the day, Wild pig and Gaur, however showed peak activity between 6:00pm-8:00pm (Figure 6.c and 6.e).

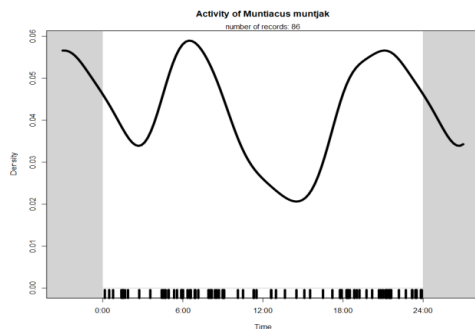


Figure 6.a Barking deer (*Muntiacus muntjak*)

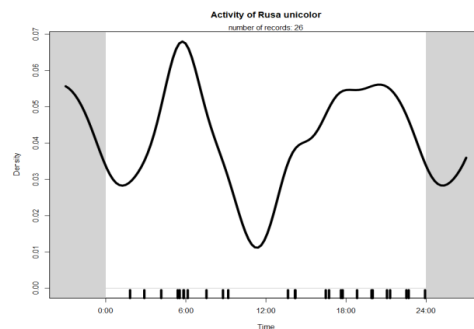
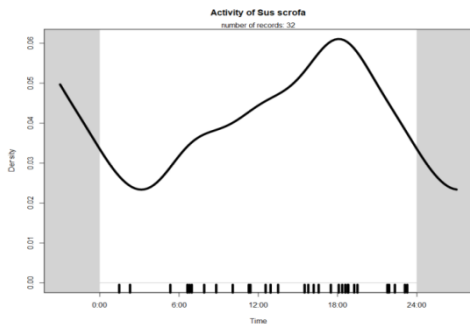
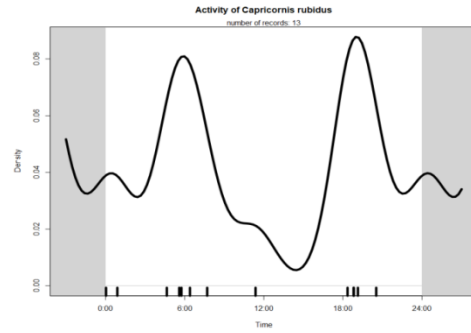


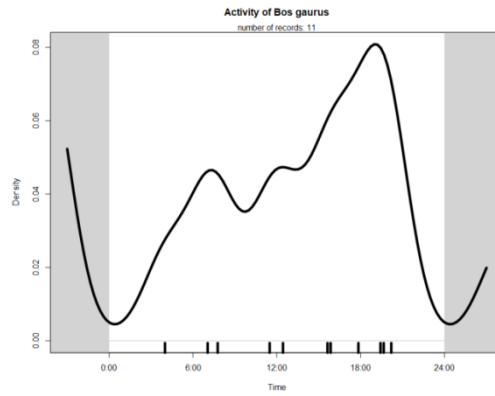
Figure 6.b Sambar (*Rusa unicolor*)



**Figure 6.c Wild pig (*Sus scrofa*)**



**Figure 6.d Serow (*Capricornis rubidus*)**



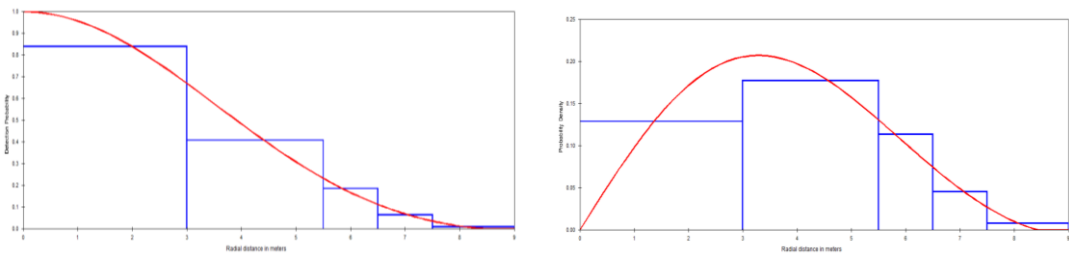
**Figure 6.e Gaur (*Bos gaurus*)**

#### **4.2 Density estimate of ungulates in DTR:**

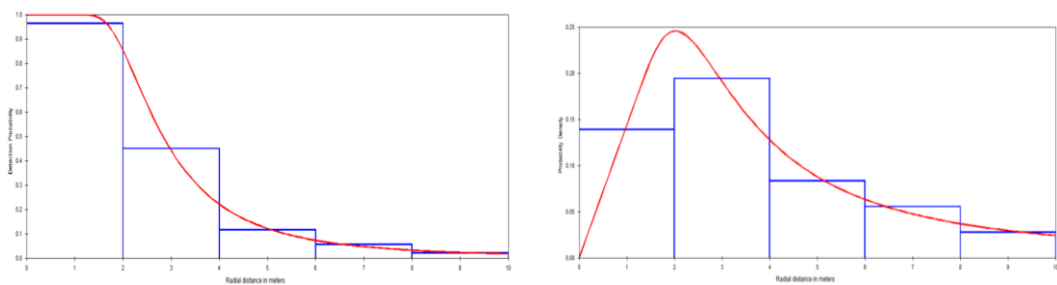
Barking deer was photo-captured in 27 camera traps out of the 38, while, Sambar, Wild pig, Serow and Gaur were photo-captured in 17, 15, 5 and 3 camera traps respectively. Due to the low capture rates of Serow and Gaur, density could not be estimated.

**Table 7: Pooled densities of ungulates in Dampa Tiger Reserve, Feb 2021 to May 2021**

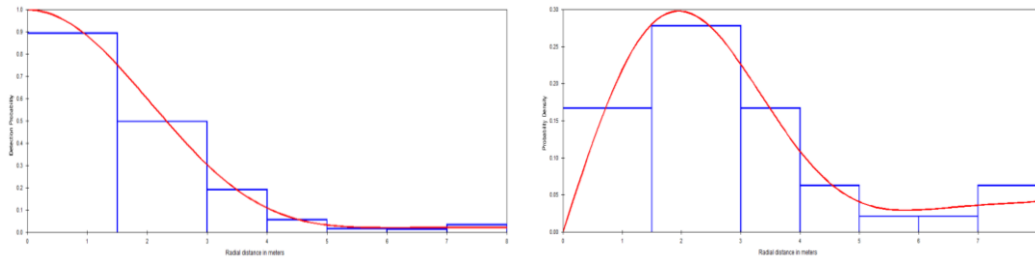
Species	Key	Adjustment	Order	$\hat{C}$	QAIC	D	SE	CV
<b>Barking Deer</b>	Uniform	Cosine	1	0.171	1202.2	0.28	0.06	21.78
	Hazard-rate	Cosine	-	1.843	117.4	0.23	0.04	20.38
	Half-normal	Hermite-polynomial	4	0.637	327.63	0.33	0.06	19.12
<b>Sambar</b>	Uniform	Cosine	2	1.442	40.63	0.15	0.04	26
	Hazard-rate	Cosine	-	0.033	1557.3	0.20	0.09	48.09
	Half-normal	Hermite-polynomial	4	0.748	73.165	0.15	0.04	28.69
<b>Wild Pig</b>	Uniform	Cosine	1	0.163	903.17	0.61	0.23	37.66
	Hazard-rate	Cosine	0	1.071	258.28	0.55	0.23	42.22
	Half-normal	Hermite-polynomial	2	0.588	147.68	0.45	0.16	36.87



**Figure 7.a: Estimated detection function for Barking Deer, with chi-square goodness of fit (df)=0.17(1)**

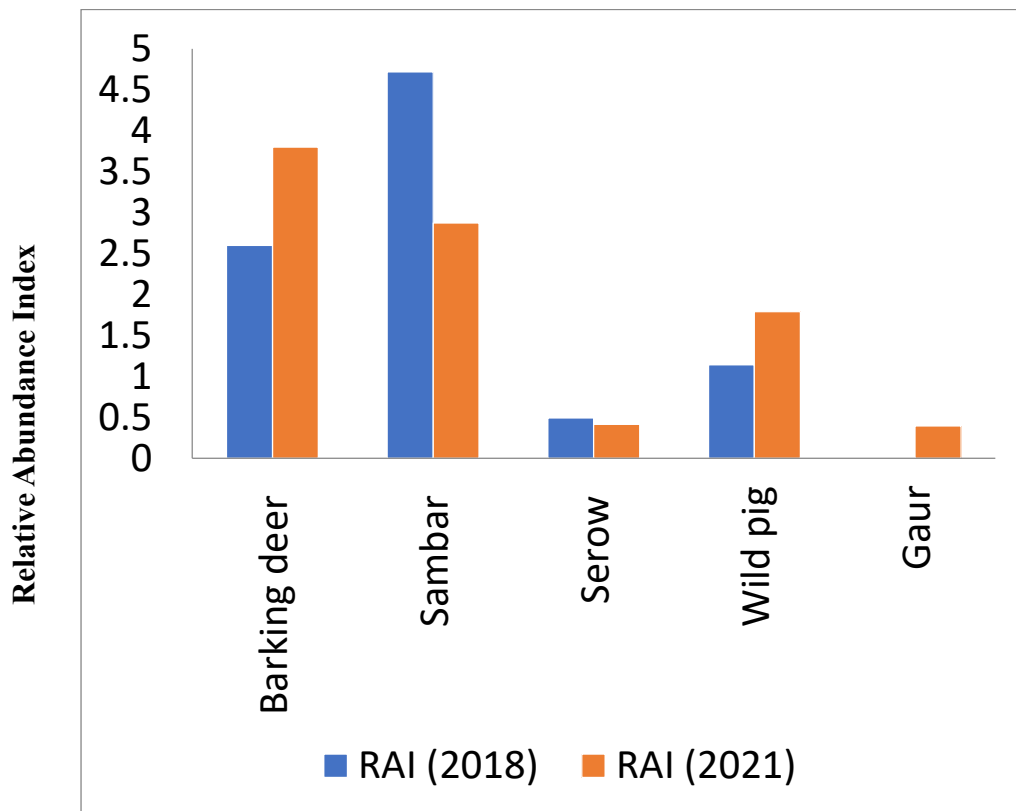


**Figure 7.b: Estimated detection function for Sambar, with chi-square goodness of fit (df)=0.03(1)**



**Figure 7.c: Estimated detection function for Wild Pig, with chi-square goodness of fit (df)= 0.327(2)**

The Relative abundance index (RAI) of the present study (2021) and from 2018 (AITE) was compared (Figure 8)



**Figure 8: Change in RAI of ungulates between 2018 (AITM report) and 2021 (Present study) in DTR**

There is an increase in RAI of barking deer, and wild pig whereas there is a decrease in the RAI of sambar and serow. In addition to that, the gaur has also been photo-captured in the present study.

### 4.3 Occupancy:

The proportion of site occupied (Psi) and Detection probability (P) was estimated for Barking deer and Sambar (Appendix 1 and 2). Different models were compared to choose the best model. Model with the least AIC value was chosen as the best model. However, models with delta AIC value less than 2 were selected as equivalent with the best model. These were then averaged and Psi and P were computed and listed in Appendix 1 and 2. However, due to the low sample size of the other ungulates- Wild Pig, Gaur and Serow, only the Naïve estimate was computed.

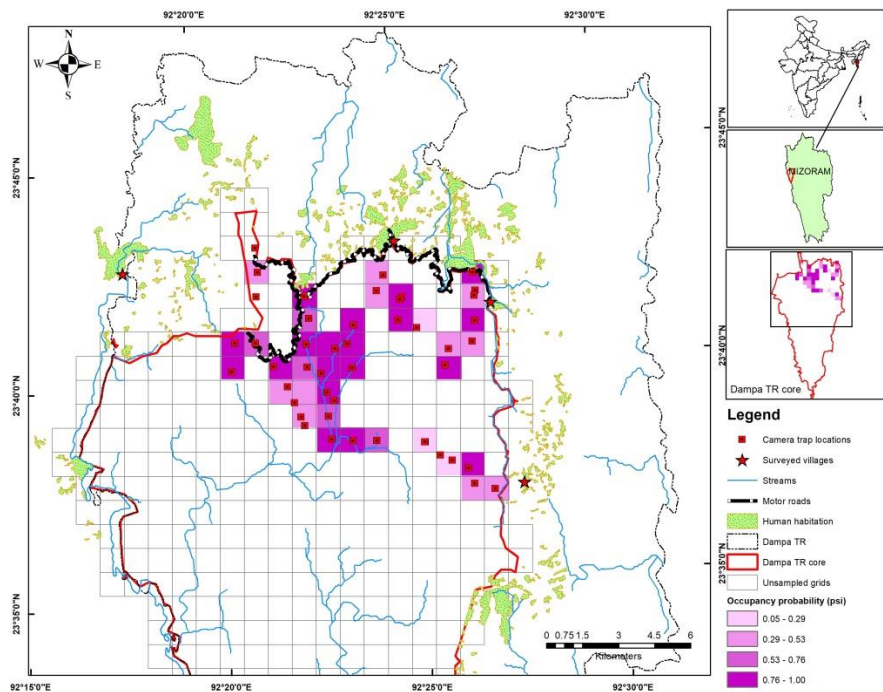
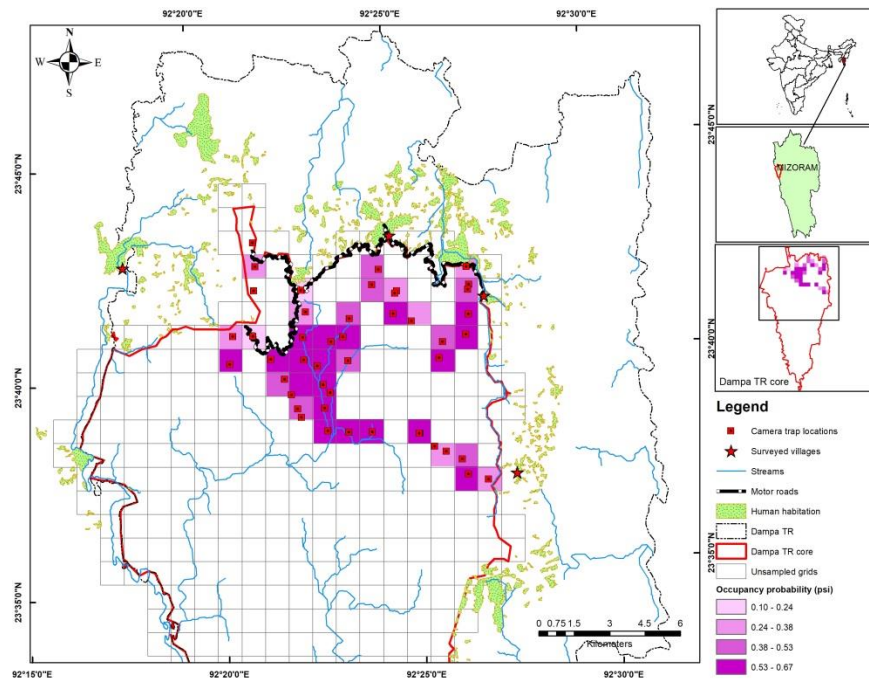


Figure 9.a: Map showing predicted distribution of barking deer in DTR, Feb to May 2021



**Figure 9.b: Map showing predicted distribution of Sambar in DTR, Feb to May 2021**

In case of Barking deer, (Elevation + Ground cover) was found to be the best model (Appendix). Elevation showed to have a negative influence on the occurrence of Barking deer ( $\beta = -1.2219 \pm 0.83$ ). Whereas, ground cover had a positive influence on the occurrence of this species ( $\beta = 2.698 \pm 1.34$ ).

Meanwhile, Sambar was negatively influenced by presence of disturbance/human signs ( $\beta = -0.807 \pm 0.53$ ) and a weak influence of non-forest ( $\beta = -2.086 \pm 2.07$ ) and stream ( $\beta = -0.5304 \pm 0.44$ ).

**Table 8.a: Probability of site occupied by barking deer and total sites in Dampa Tiger Reserve**

<b>Psi- Probability of site occupied:</b>	<b>Total no. of sites</b>
<b>0-0.29</b>	<b>3</b>
<b>0.29-0.53</b>	<b>10</b>
<b>0.53-0.76</b>	<b>5</b>
<b>0.76-1</b>	<b>20</b>

**Table 8.b: Probability of site occupied sambar and total sites in Dampa Tiger Reserve**

<b>Psi- Probability of site occupied:</b>	<b>Total no. of sites</b>
<b>0.10-0.24</b>	2
<b>0.24-0.38</b>	14
<b>0.38-0.53</b>	22
<b>0.53-0.67</b>	0

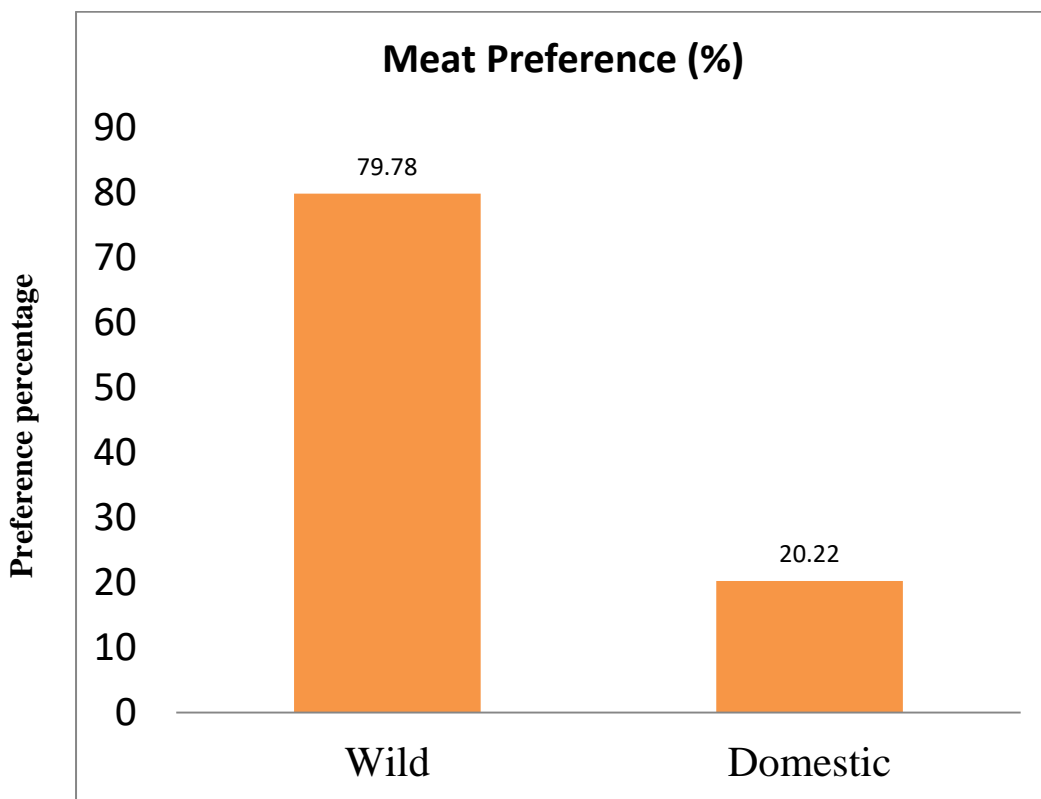
**Table 9: Naïve occupancy, averaged Psi and P of ungulates in DTR, February 2021 to May 2021**

Species	Naïve estimate of $\Psi$	Proportion of site occupied (Psi)	SE (Psi)	Detection probability (P)	SE (P)	Model
Barking Deer	0.6579	0.6755	0.2965	0.6755	0.4570	Averaged
Sambar	0.4211	0.4826	0.1461	0.4826	0.4490	Averaged
Wild Pig	0.4474	-	-	-	-	-
Serow	0.1250	-	-	-	-	-
Gaur	0.0750	-	-	-	-	-

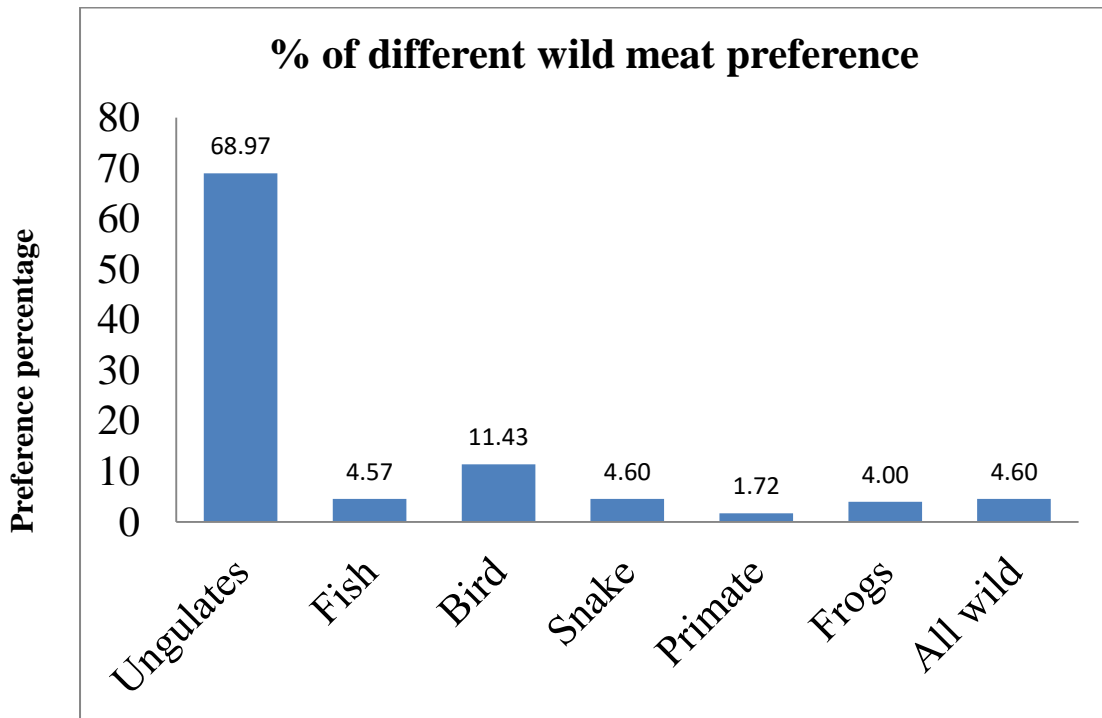
#### **4.4 Peoples' Perception:**

Data from survey showed that 79.78% of the respondents still prefer wild meat over meat of domestic animals, out of which the 68.97% respondents preferred ungulate meat. In addition to that, 0.75% of the respondents have seen wild ungulate meat at least once every one or two weeks. And 10% of the villagers admitted to seeing wild ungulate meat at least once a month whereas 49.8% of the respondents have seen wild ungulate meat at least once or twice a year. Although, hunting still prevails, 90% of the people have a positive perception towards conservation of ungulates.

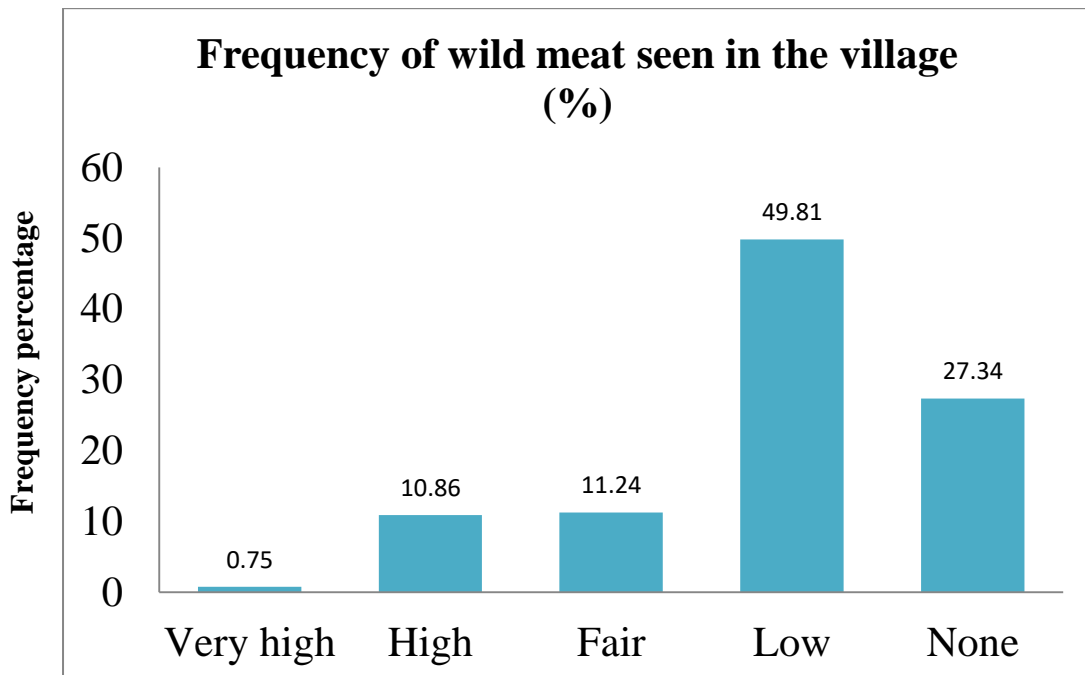
However, 47.6% Chakma communities (mostly farmers) in Rajiv nagar showed a negative perception towards DTR, as the respondent do not have land for practicing agriculture as well as using resources from the forest. Whereas the Mizo community in Lallen, showed 100% positive attitude (among the 40 individuals surveyed), and more than 80% of the Bru communities and 90% of the Bru and Mizo communities in Teirei village showed positive attitude towards DTR (Appendix 7).



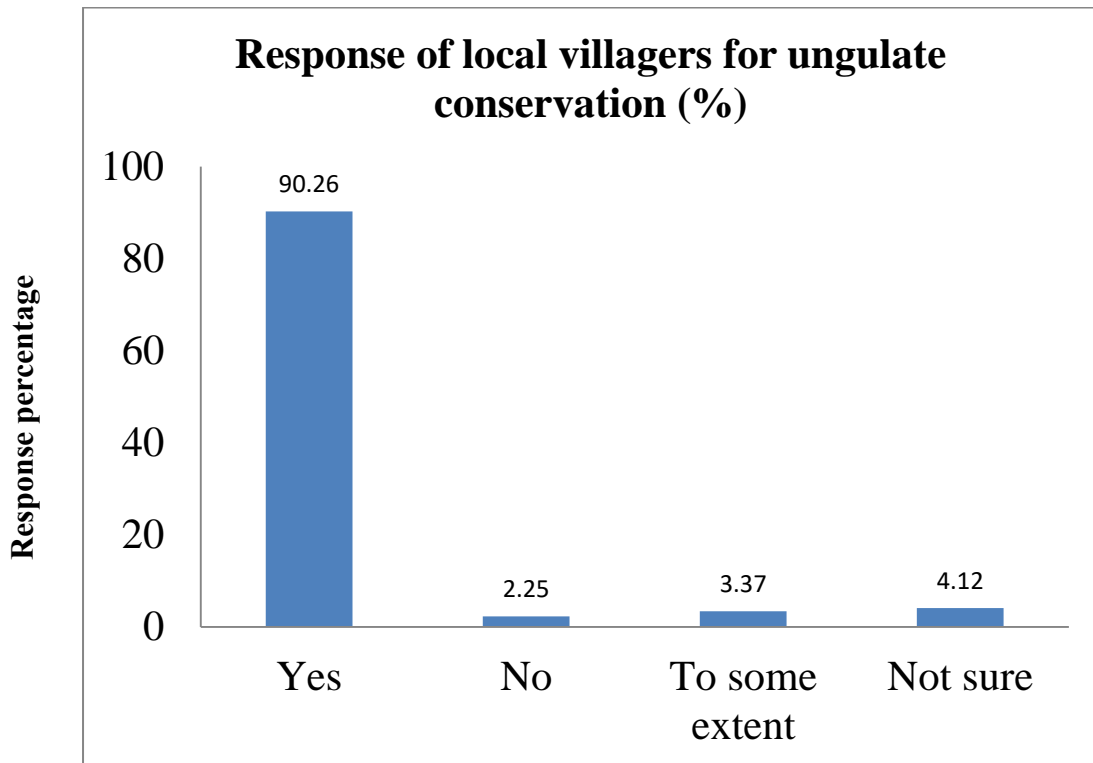
**Figure 10: Percentage of meat preference indicated by respondents from surveyed villages in DTR**



**Figure 11: Percentage of wild ungulate meat preference indicated by respondents from surveyed villages in DTR**



**Figure 12: Frequency of wild ungulate meat seen in villages, DTR**



**Figure 13: Conservation of ungulates by respondents in DTR**

To look at the factors that affects people’s perception and attitude towards ungulate conservation, a multinomial logistic regression analysis was used and several models were run (Appendix 4), however only four models (Table 10) were found to have parameters with significant p-value  $\leq 0.05$ , of which the model with the lowest AIC value was considered as the best model which means that the additive effect of predictor variables i.e., “Age” and “Changes brought by DTR to the villages” influences the conservation of ungulates by local communities. Our result shows that with increase in age, the local communities have positive responses towards ungulates conservation (Table 11); however, there is also a weak influence of local villagers having a negative response with increase in age. On the other hand, negative perception of people could be due to the cultural association of hunting ungulates both in rituals and as a traditional culinary delicacy.

**Table 10: Significant models for Perception of local communities towards ungulates from multinomial logistic regression analysis**

Model	AIC	$\Delta$ AIC	-log-likelihood	Chi sq	p-value
Ag+Chg	183.634	0.00	-82.817	8.4067	0.0383
Ag	185.645	2.01	-86.823	12.321	0.0006
Chg	189.559	5.92	-88.78	8.4067	0.0383
Co	193.66	10.02	-90.834	4.299	0.230

Note: Ag=Age of respondents, Chg= Changes brought by DTR in village, Co= Human-Wildlife Coexistence

**Table 11: Predictor variables influencing the ungulate conservation by local communities in DTR using Multinomial logistic regression**

Conseravtion of ungulates in DTR	Predictor variables	Estimate	SE	z-value	p-value
<b>Yes</b>	Age	1.431	0.56	2.53	0.01136 *
	Change	-0.665	0.876	-0.75	0.44
<b>No</b>	Age	1.329	0.689	1.928	0.05.
	Change	-2.036	1.019	-1.99	0.04582 *
<b>Not sure</b>	Age	0.799	0.693	1.153	0.248
	Change	-1.132	1.016	-1.115	0.264

## **5.0 Discussions:**

### **5.1 Temporal patterns of ungulates:**

The activity pattern of ungulates may depend on factors like anthropogenic pressure or the presence of sympatric species or even the presence of predators. Barking deer, sambar and serow showed high activities when the humans were less active. Similar activity of Himalayan Serow has been seen elsewhere (Srivastava et al., 2020). Sambar showed least activity during noon in comparison to the barking deer, which could be due to the fact that sambar is negatively influenced by disturbances like the presence of humans (Appendix 2a) whereas the reason barking deer showed slightly higher activity during noon could possibly be due to its better adaptations to anthropogenic pressure (Srivastava et al., 2020) or the species could be occupying areas where humans are less (Pokharel and Chalise, 1970). In addition to that, there is lesser overlap between activities of the forest department along with few captures of local villagers from the camera trap data and ungulates (Appendix 5a, 5b, 5c).

Wild pig and Gaur, though diurnal, showed peak activity during the late evening hours which could possibly be to avoid humans. Similar activities has been seen in Manas NP, Assam, in which the ungulates (sambar, gaur, wild pig and barking deer) showed minimal overlap with humans that were active during the day (Lahkar, 2020). The activity through-out the day could mean spatial segregation if not temporal with humans.

The activities of ungulates in areas near human habitation and far from human habitations could not be compared as on doing human disturbance survey, we found that the human presence signs were present all throughout the study area. So, we could not make a definitive differentiation between the two areas for comparison.

### **5.2 Population size of ungulates in DTR:**

As mentioned above, comparison between ungulates in high human use areas and low human use areas (Figure 4) was not possible. In addition to that, the capture rates of these ungulates were low. Therefore, densities of three ungulates i.e., barking deer, sambar and wild pig that had few but enough observations to be

analysed were pooled together from one continuous area. The Wild pig was found to be the most abundant i.e., 0.55 individual/km<sup>2</sup> among all ungulate species in DTR, followed by Barking deer with 0.28 individual/km<sup>2</sup> and Sambar having a density of 0.20 individual/km<sup>2</sup> (Table 7). This is relatively lower than the densities elsewhere in northeast India (Lahkar, 2020; Muthamizh Selvan et al., 2014). Although, no reliable data on the ungulates population from DTR and other parts of Mizoram or from similar habitat or landscape is available, anthropogenic pressure could be the one of the drivers behind low densities in DTR. In addition to that, the results from the questionnaire survey revealed that hunting of wild ungulates still prevails among the local communities (Figure 11) and about 69% of the respondents (Figure 10) revealed their preference over consumption of wild ungulate meat. During the study period, we encountered several poaching signs such as animal remains, gunpowder remains, incidence of hearing gunshot and chainsaw deep inside the forest.

Habitat characteristics, elevation, and ruggedness of the DTR may also have influenced the lower capture rates of these animals as different species have different requirements. Our method of camera based distance sampling required us to deploy camera traps at the centroid of every grid to reduce the bias of overestimating the population. However, the undulated and steep terrain may have a negative influence of ungulates such as barking deer, sambar and wild pig whereas; serow was photo-captured above an elevation of 550 msl. Gaur was photo-captured only after the onset of rains at the end of April, which shows Gaur may be seasonally migrating to different location in DTR depending on the availability of food.

### **5.3 Distribution of Ungulates:**

The distribution pattern of barking deer revealed that it occurred all throughout the DTR except for higher elevation (above 1000 MSL), where the proportion of site occupied was low. The limiting factor of this could be the unavailability of food (Pokharel and Chalise, 1970). Also, the study was conducted from January-Mid may, and the grassland patches growing on rocky mountains at higher elevation in DTR gets dry and could probably have better food availability at the lower elevations. Barking deer occurrence was positively influenced by the presence of ground cover

such as herbs, grasses and also shrubs as revealed in our study; the species being a nibbler and a browser (Nagarkoti and Thapa, 2007.) is highly dependent on the ground cover for its diet. Occurrences of three ungulate species- Wild pig, barking deer and sambar were higher in a location called Old Chikha, where the Chikha village was abandoned many decades ago leaving behind fruit trees and palatable plants (Gouda et al., 2020). Barking deer did not seem to be influenced as much by the human disturbances and non-forest areas. Results of questionnaire survey and informal discussions with the local communities, it was found that this species also raids the agriculture/Jhum fields at night in the villages apart from the wild pig. This could explain the high occurrences of the species near human habitations (Figure 8.a). In addition to that, their occurrences near human habitation could also possibly be the presence of a source-sink meta population in low humans use areas (Reyna-Hurtado and Tanner, 2007).

Meanwhile sambar, was negatively influenced by disturbances and non-forest. Although high occurrences of sambar is seen in areas near the streams (Figure 8.b), the results showed that the species has a weak negative influence of stream, as opposed to the study on factors influencing sambar abundance and distribution (Simcharoen et al., 2014). This behavior could be to avoid humans because of the fact that poachers are using the stream. Most of the disturbances and poachers' signs were encountered along the streams. Also, pre-monsoon rains starts in March and monsoon continues till October, so there could be no scarcity of water in the tiger reserve. Also, the animals could be getting their water requirements from plants and waterholes.

#### **5.4 Peoples' Perception towards ungulate conservation:**

These communities have a close association with the forest in their day to day life, however, overexploitation of the resources and habitat degradation through intensive shifting cultivation has posed a threat to the wild ungulate communities as it continues to be dominant economic activity (Bhuyan, 2019). Although, most villagers showed positive perception towards conservation of ungulates due to its drastic decline, respondents did however give their views on how the establishment

of DTR has barred them from their rights of using forest resources. However, in contrast to these responses, conservation practices in DTR by the local communities still lacks as intensive hunting still prevails.

The three major tribes in and around DTR consume wild meat. Figure 9 shows that majority of the local villagers in these 4 villages still prefer wild meat over domestic meat. This showed that villagers are associating with hunting of ungulates and consumption of wild meat is a part of their lifestyle. Apart from that, more than 60% sampled households are still dependent on the forest for resources like NTFP (Appendix 6.a).

The contradictory results in having a positive and negative perception towards conservation with increase in age could be due to the observance of abundance decline in ungulate species over the years which could have led to a positive perception to conserve the species. On the other hand, negative perception of people could be due to the cultural association of hunting ungulates both in rituals and as a traditional culinary delicacy.

A perception shift towards conservation of ungulates is observed with increase in changes in the form of benefits brought by DTR (Table 11). These include tangible benefits such as providing LPG cylinder and stoves as substitute for firewood, establishment of roads and intangible benefits include aesthetic values, as responded by 58% of the local communities (Appendix 6.b).

## **6.0 Conclusions and Implications:**

This study shows that DTR has diverse habitat characteristics that support the wild ungulates populations. However, anthropogenic pressure poses negative influence to the sambar population leading to lower abundance and distribution as revealed in our findings whereas barking deer showed to be less influence by anthropogenic pressure, it could probably due to its adaptability to hunting pressure or the presence of source-sink meta-population in less human use areas.

DTR despite having a diverse species of flora and fauna has lower abundances of wildlife including ungulates in comparison to other north eastern states. Ungulates are important ecological species and are required to maintain the dynamicity of the forest. In addition to that, DTR is the only region in Mizoram that supports the tiger, and is a home to other predators such as the wild dogs, common leopards and clouded leopards. These major predator species are highly dependent on the ungulates for its diet, and the on-going situation of intensive hunting of ungulates is alarming. Although management practices to conserve the wildlife are done by the forest department, it is imperative to further strengthen management interventions as DTR's core spans up to 500 km<sup>2</sup> and rugged terrains only prevents proper investigations. It is crucial to involve local communities in conservation practices and alternative subsistence such as tourism and skill developments programmes may be provided to reduce its dependency on the forest. Value addition of NTFP such as handicrafts made of bamboo, pickles made out of bamboo shoot and banana flowers, etc. can be marketed at a larger scale. The interest of the local communities can be identified and accordingly skill development programmes may be provided. For instance, weaving clothes is a skill among women of the Chakma tribe, this can not only reduce dependency but also preserve the cultural heritage. As observed in the questionnaire survey, conservation education and awareness will go a long way in shifting perceptions and practices towards conservation.

Keeping in view the ecological and cultural significance of DTR, the environmental and livelihood challenges must be met to preserve the reserve. The paucity of

scientific research must be filled to better inform conservation management measures.

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## APPENDICES:

### Appendix 1:

#### a. List of models used for predicting barking deer occurrence

Model	AIC	deltaAIC	AIC wgt	Model Likelihood	no.Par.	2*LogLike
psi(Elevation + Ground cover),p(.)	380.03	0	0.5451	1	4	372.03
psi(Terrain + Elevation+ Ground cover),p(.)	382.03	2	0.2005	0.3679	5	372.03
psi(Elevation +Ground cover +Shrubs +Canopy),p(.)	383.85	3.82	0.0807	0.1481	6	371.85
psi(Ground cover),p(.)	384.7	4.67	0.0528	0.0968	3	378.7
psi(Bamboo +Ground cover +Elevation),p(.)	385.8	5.77	0.0304	0.0559	4	377.8
psi(Signs +Ground cover),p(.)	386.22	6.19	0.0247	0.0453	4	378.22
psi(Elevation),p(.)	386.35	6.32	0.0231	0.0424	3	380.35
psi(Ground cover +Terrain),p(.)	386.68	6.65	0.0196	0.036	4	378.68
psi(Elevation +Shrub),p(.)	388.26	8.23	0.0089	0.0163	4	380.26
psi(Elevation +Tree density +Shrub),p(.)	390	9.97	0.0037	0.0068	5	380
psi(Elevation +Canopy+ Terrain),p(.)	390.07	10.04	0.0036	0.0066	5	380.07
psi(.),p(.)	391.62	11.59	0.0017	0.003	2	387.62
psi(Ground cover +Stream +Bamboo +Deciduous +Non forest +Semi evergreen +Signs +Elevation +Slope +Terrain +Canopy),p(.)	391.78	11.75	0.0015	0.0028	16	359.78
psi(Shrub),p(.)	392.15	12.12	0.0013	0.0023	3	386.15
Psi(Non-forest).p(.)	392.25	12.22	0.0012	0.0022	3	386.25
psi(Distance +Signs),p(.)	392.84	12.81	0.0009	0.0017	4	384.84
psi(Semi-evergreen+ shrub.),p(.)	393.1	13.07	0.0008	0.0015	4	385.1
psi(Terrain),p(.)	393.35	13.32	0.0007	0.0013	3	387.35

**b. Proportion of site occupied and detection probability of barking deer for each site**

Species	Naïve estimate of $\Psi$	Sites	Proportion of site occupied (Psi)	SE (Psi)	Detection probability (P)	SE (P)	Model
Barking Deer	0.6579	site1	0.8818	0.0894	1	0	Averaged
		site2	0.3744	0.1409	1	0	
		site3	0.3138	0.1651	1	0	
		site4	0.9619	0.0479	1	0	
		site5	0.5072	0.1532	1	0	
		site6	0.8625	0.1381	0.1406	0.154	
		site7	0.8054	0.1834	1	0	
		site8	0.3654	0.1527	0.0148	0.0118	
		Site11	0.4661	0.1708	1	0	
		site13	0.3905	0.1747	0.0216	0.0185	
		site15	0.9529	0.057	1	0	
		Site 16	0.9919	0.0155	1	0	
		site17	1	0.0001	1	0	
		site18	0.9715	0.0524	1	0	
		site19	0.9981	0.005	1	0	
		site20	0.7603	0.1378	1	0	
		site21	0.9909	0.0167	1	0	
		site22	0.7237	0.1283	1	0	
		site24	0.7035	0.174	1	0	
		site25	0.8229	0.1321	0.1382	0.1222	
		site26	0.7076	0.183	1	0	
		site27	1	0	1	0	
		site28	0.8016	0.1266	1	0	
		site29	0.9636	0.0445	1	0	
		site30	0.9701	0.039	1	0	
		site31	0.9893	0.0231	1	0	
		site32	0.4669	0.1262	0.0385	0.0243	
		site33	0.3272	0.1395	0.0217	0.016	
		site35	0.3933	0.1495	1	0	
		site36	0.7794	0.1551	0.1391	0.1202	
		site37	0.9362	0.063	1	0	
		site38	0.6242	0.131	0.0705	0.0462	
		site39	0.3231	0.1479	0.0281	0.0211	
		site40	0.292	0.1547	0.0243	0.0198	
		site41	0.9115	0.1471	1	0	
site44	0.1243	0.1504	0.0085	0.0121			
site45	0.051	0.0671	0.0032	0.0046			

site46	0.164	0.135	0.0204	0.0204
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**Appendix 2:**

**a. List of models used for predicting Sambar occurrence**

Model	AIC	deltaAIC	AIC wgt	Model Likelihood	no.Par	-2*LogLik
psi(Non-forest+Signs),p(.)	235.36	0	0.1328	1	4	227.36
psi(stream+signs+non forest),p(.)	235.81	0.45	0.1061	0.7985	5	225.81
psi(signs),p(.)	235.92	0.56	0.1004	0.7558	3	229.92
psi(stream),p(.)	236.17	0.81	0.0886	0.667	3	230.17
psi(non-forest),p(.)	236.28	0.92	0.0839	0.6313	3	230.28
psi(signs+Elevation),p(.)	236.59	1.23	0.0718	0.5406	4	228.59
psi(terrain+Signs),p(.)	237.1	1.74	0.0557	0.419	4	229.1
psi(bamboo+Signs),p(.)	237.45	2.09	0.0467	0.3517	4	229.45
psi(bamboo+Signs+stream),p(.)	237.56	2.2	0.0442	0.3329	5	227.56
psi(Semi evergreen),p(.)	237.87	2.51	0.0379	0.2851	3	231.87
psi(Bamboo+Stream),p(.)	238.06	2.7	0.0344	0.2592	4	230.06
psi(Stream+Semi evergreen),p(.)	238.17	2.81	0.0326	0.2454	4	230.17
psi(canopy),p(.)	238.21	2.85	0.032	0.2405	3	232.21
psi(Deciduous+signs),p(.)	238.36	3	0.0296	0.2231	4	230.36
psi(terrain),p(.)	238.59	3.23	0.0264	0.1989	3	232.59
psi(distance),p(.)	238.95	3.59	0.0221	0.1661	3	232.95
psi(Bam+Str+Signs+Semi+Slop),p(.)	239.15	3.79	0.02	0.1503	7	225.15
psi(Bamboo+canopy),p(.)	239.42	4.06	0.0174	0.1313	4	231.42
psi(signs+elevation+bamboo+terrain),p(.)	239.43	4.07	0.0174	0.1307	6	227.43

**b. Proportion of site occupied and detection probability of barking deer for each site**

Species	Naïve estimate of $\Psi$	Sites	Proportion of site occupied (Psi)	SE (Psi)	Detection probability (P)	SE (P)	Model
Sambar	0.4211	site1	0.5875	0.1298	1	1	Model average
		site2	0.5547	0.1264	1	1	
		site3	0.4616	0.1511	1	1	
		site4	0.295	0.25	0.0478	0.047	
		site5	0.514	0.1249	1	1	
		site6	0.2815	0.1865	0.0398	0.0398	
		site7	0.5296	0.1561	0.1015	0.1015	
		site8	0.4078	0.1839	0.0648	0.0648	

Site11	0.3176	0.1782	0.0454	0.0454
site13	0.4169	0.1795	0.0836	0.0836
site15	0.4731	0.2118	1	1
Site 16	0.6334	0.1406	1	1
site17	0.6408	0.1479	0.1756	0.1756
site18	0.5416	0.1735	0.127	0.127
site19	0.6444	0.1437	1	1
site20	0.6445	0.1423	0.1522	0.1522
site21	0.664	0.1479	1	1
site22	0.2864	0.2276	0.0439	0.0439
site24	0.6046	0.1402	0.1522	0.1522
site25	0.652	0.1487	1	1
site26	0.6446	0.147	1	1
site27	0.5827	0.1883	0.1468	0.1468
site28	0.6666	0.1492	1	1
site29	0.4345	0.2154	1	1
site30	0.216	0.2321	0.0471	0.0471
site31	0.5289	0.1454	1	1
site32	0.4544	0.1934	1	1
site33	0.6072	0.1386	0.179	0.179
site35	0.507	0.1343	1	1
site36	0.5923	0.1485	0.1714	0.1714
site37	0.3758	0.1937	0.0809	0.0809
site38	0.1006	0.1363	0.0171	0.0171
site39	0.2946	0.2185	0.0728	0.0728
site40	0.5274	0.1531	0.16	0.16
site41	0.5087	0.1579	0.1511	0.1511
site44	0.5306	0.1845	0.1672	0.1672
site45	0.359	0.1956	1	1
site46	0.2561	0.2822	0.1105	0.1105

**Appendix 3: Population data from Village Heads/Village Council Presidents on informal discussions:**

Sl.no	Village	Total population	Total no. of household	No. of individuals surveyed	Male	Female	% of household surveyed
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1.	Teirei	500	120	40	23	17	33%
2.	Damparengpui	1300	800	80	43	37	10%
3.	Rajiv Nagar	5595	1064	107	68	39	10%
4.	Lallen	1030	175	40	22	18	22%
	TOTAL			267			

#### Appendix 4: Predictor/Independent variables

##### a. Model= Tribe

###### Coefficients :

Estimate	Std. Error	z-value	Pr(> z )	
(Intercept):No	16.74744	1840.813	0.0091	0.992741
(Intercept):Not sure	1.54798	1.27321	1.2158	0.224055
(Intercept):Yes	3.01044	0.90771	3.3165	0.0009115 ***
Tribe: No	-16.1214	1840.813	-0.0088	0.993012
Tribe: Not sure	-1.00819	0.7754	-1.3002	0.193523
Tribe: Yes	0.28149	0.44158	0.6375	0.523824

##### b. Model= Age

Coefficients :	Estimate	Std. Error	z-value	Pr(> z )
(Intercept):No	-3.81751	1.75917	-2.1701	0.030002
(Intercept):Not sure	-2.04292	1.64217	-1.244	0.213487
(Intercept):Yes	-0.20529	1.25496	-0.1636	0.870061
Age: No	1.47392	0.68995	2.1363	0.032658
Age: Not sure	0.90594	0.70087	1.2926	0.196153
Age: Yes	1.507	0.5837	2.5818	0.009829

c. Model= Gender

Coefficients :	Estimate	Std. Error	z-value	Pr(> z )
(Intercept):No	0.28768	0.76376	0.3767	0.7064
(Intercept): Not sure	-0.40543	0.91287	-0.4441	0.657
(Intercept):Yes	3.89182	0.58321	6.6731	2.505e-11 ***
Gender: No	-0.98083	1.1547	-0.8494	0.3956
Gender: Not sure	0.62858	1.13284	0.5549	0.579
Gender: Yes	-0.67294	0.77468	-0.8687	0.385

d. Model= Occupation

Coefficients :	Estimate	Std. Error	z-value	Pr(> z )
(Intercept):No	0.18232	0.60553	0.3011	0.7633
(Intercept):Not sure	0.33647	0.58554	0.5746	0.5655
(Intercept):Yes	3.66356	0.45291	8.0889	6.661e-16 ***
Occupation: No	-16.8321	2916.945	-0.0058	0.9954
Occupation: Not sure	-16.9862	2916.945	-0.0058	0.9954
Occupation: Yes	-0.40547	0.85109	-0.4764	0.6338

e. Model= Wild meat preference

Coefficients :	Estimate	Std. Error	z-value	Pr(> z )
(Intercept):No	-17.62	1658.389	-0.0106	0.9915
(Intercept):Not sure	-15.136	1658.389	-0.0091	0.9927
(Intercept):Yes	-12.065	1658.388	-0.0073	0.9942
Meat: No	16.773	1658.388	0.0101	0.9919
Meat: Not sure	14.981	1658.388	0.009	0.9928
Meat: Yes	15.402	1658.388	0.0093	0.9926

f. Model= Frequency of seeing wild meat in the village

Coefficients :	Estimate	Std. Error	z-value	Pr(> z )
(Intercept):No	-1.13546	1.24317	-0.9134	0.361056
(Intercept):Not sure	-0.41487	1.19471	-0.3473	0.728397
(Intercept):Yes	3.40541	0.87913	3.8736	0.0001072 ***
Frequency: No	0.67405	0.77101	0.8742	0.381989
Frequency: Not sure	0.30663	0.79341	0.3865	0.699147
Frequency: Yes	0.12064	0.61477	0.1962	0.844427

g. Model= Resource dependency

Coefficients :	Estimate	Std. Error	z-value	Pr(> z )
(Intercept):No	-42.0856	4987.263	-0.0084	0.9933
(Intercept):Not sure	-1.34996	1.374403	-0.9822	0.326
(Intercept):Yes	3.735664	0.827482	4.5145	6.347e-06 ***
Resource: No	14.27514	1662.421	0.0086	0.9931
Resource: Not sure	0.627416	0.57872	1.0841	0.2783
Resource: Yes	-0.09498	0.395409	-0.2402	0.81

h. Model= Human-Wildlife Co-existence

Coefficients :	Estimate	Std. Error	z-value	Pr(> z )
(Intercept):No	0.81635	0.75315	1.0839	0.2784
(Intercept):Not sure	0.31785	0.77827	0.4084	0.68298
(Intercept):Yes	3.75262	0.57579	6.5173	7.16E-11
Co: No	-1.51125	0.8949	-1.6887	0.09127.
Co: Not sure	-0.32028	0.57282	-0.5591	0.57607
Co: Yes	-0.17931	0.37771	-0.4747	0.63497

i. Model= Attitude towards Hunter

Coefficients :	Estimate	Std. Error	z-value	Pr(> z )
(Intercept): No	-0.53441	0.70664	-0.7563	0.4495
(Intercept):Not sure	-0.26265	0.6543	-0.4014	0.6881

<b>(Intercept):Yes</b>	<b>3.61974</b>	<b>0.44024</b>	<b>8.2223</b>	<b>2.22e-16 ***</b>
<b>Hunters: No</b>	<b>0.44872</b>	<b>0.49637</b>	<b>0.904</b>	<b>0.366</b>
<b>Hunters: Not sure</b>	<b>0.34007</b>	<b>0.48689</b>	<b>0.6984</b>	<b>0.4849</b>
<b>Hunters: Yes</b>	<b>-0.10839</b>	<b>0.381</b>	<b>-0.2845</b>	<b>0.776</b>

**j. Model= Perception towards DTR**

<b>Coefficients :</b>	<b>Estimate</b>	<b>Std. Error</b>	<b>z-value</b>	<b>Pr(&gt; z )</b>
<b>(Intercept):No</b>	<b>0.56664</b>	<b>0.78708</b>	<b>0.7199</b>	<b>0.4716</b>
<b>(Intercept):Not sure</b>	<b>-0.31255</b>	<b>0.87862</b>	<b>-0.3557</b>	<b>0.722</b>
<b>(Intercept):Yes</b>	<b>3.25703</b>	<b>0.61838</b>	<b>5.2671</b>	<b>1.386e-07 ***</b>
<b>Perception: No</b>	<b>-1.40261</b>	<b>1.08901</b>	<b>-1.288</b>	<b>0.1978</b>
<b>Perception: Not sure</b>	<b>0.39922</b>	<b>0.89333</b>	<b>0.4469</b>	<b>0.655</b>
<b>Perception: Yes</b>	<b>0.39209</b>	<b>0.67585</b>	<b>0.5801</b>	<b>0.5618</b>

**k. Model= Changes brought to local villagers by DTR**

<b>Coefficients :</b>	<b>Estimate</b>	<b>Std. Error</b>	<b>z-value</b>	<b>Pr(&gt; z )</b>
<b>(Intercept):No</b>	<b>3.03558</b>	<b>1.73786</b>	<b>1.7467</b>	<b>0.080684</b>
<b>(Intercept):Not sure</b>	<b>2.08756</b>	<b>1.82938</b>	<b>1.1411</b>	<b>0.253816</b>
<b>(Intercept):Yes</b>	<b>5.05074</b>	<b>1.634</b>	<b>3.091</b>	<b>0.001995</b>
<b>Changes: No</b>	<b>-2.21147</b>	<b>1.00261</b>	<b>-2.2057</b>	<b>0.027404</b>
<b>Changes: Not sure</b>	<b>-1.24439</b>	<b>0.99994</b>	<b>-1.2445</b>	<b>0.213331</b>
<b>Changes: Yes</b>	<b>-0.8505</b>	<b>0.8571</b>	<b>-0.9923</b>	<b>0.321047</b>

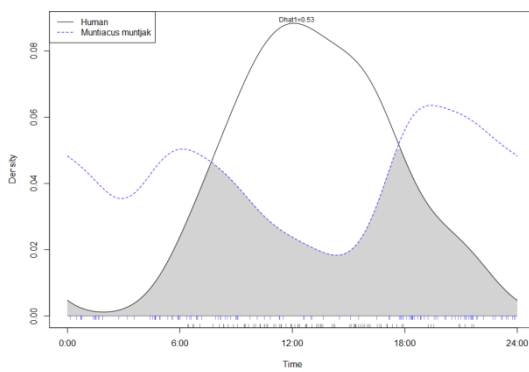
**l. Model= Change brought to local villagers + Age of respondents**

<b>Coefficients :</b>	<b>Estimate</b>	<b>Std. Error</b>	<b>z-value</b>	<b>Pr(&gt; z )</b>
<b>(Intercept):No</b>	<b>-0.54487</b>	<b>2.532139</b>	<b>-0.2152</b>	<b>0.82963</b>
<b>(Intercept):Not sure</b>	<b>0.093133</b>	<b>2.523529</b>	<b>0.0369</b>	<b>0.97056</b>
<b>(Intercept):Yes</b>	<b>1.133224</b>	<b>2.114338</b>	<b>0.536</b>	<b>0.59198.</b>
<b>Changes: No</b>	<b>-2.03608</b>	<b>1.019559</b>	<b>-1.997</b>	<b>0.04582*</b>
<b>Changes: Not sure</b>	<b>-1.13298</b>	<b>1.016159</b>	<b>-1.115</b>	<b>0.26487</b>

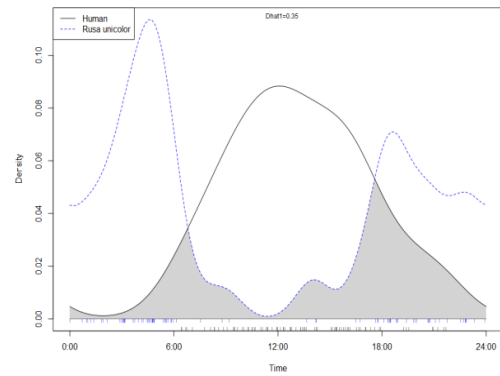
<b>Changes: Yes</b>	<b>-0.66577</b>	<b>0.876728</b>	<b>-0.7594</b>	<b>0.44762</b>
<b>Age: No</b>	<b>1.329003</b>	<b>0.689098</b>	<b>1.9286</b>	<b>0.05378.</b>
<b>Age: Not sure</b>	<b>0.799451</b>	<b>0.693119</b>	<b>1.1534</b>	<b>0.24874</b>
<b>Age: Yes</b>	<b>1.431249</b>	<b>0.565405</b>	<b>2.5314</b>	<b>0.01136*</b>

**Appendix 5: Overlap between Humans (Forest dept and loacl villagers) and Ungulates**

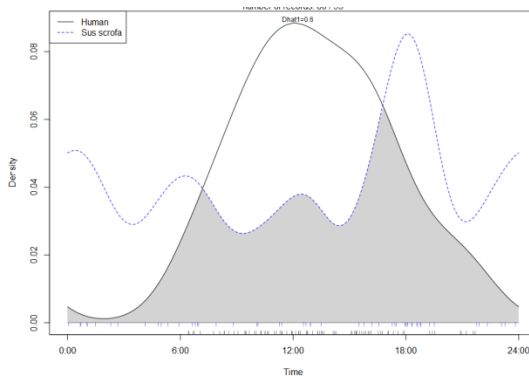
a. Overlap between Humans and Barking deer



b. Overlap between Humans and Sambar deer



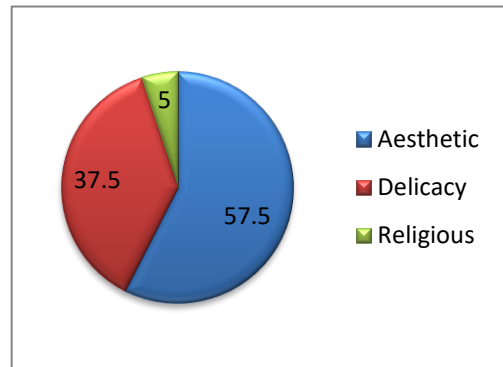
c. Overlap between Humans and Wild Pig



**Appendix 6: Pie charts of the responses from villagers-**

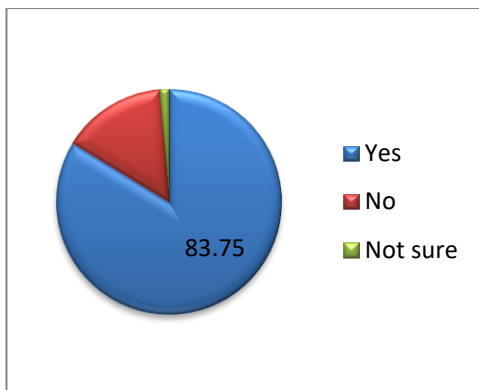


a. Resources dependency of villagers from value

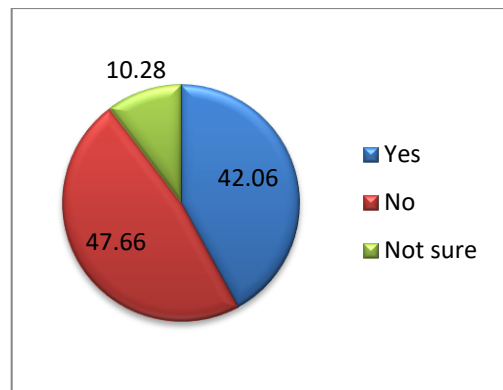


b. Value of ungulates according to villagers

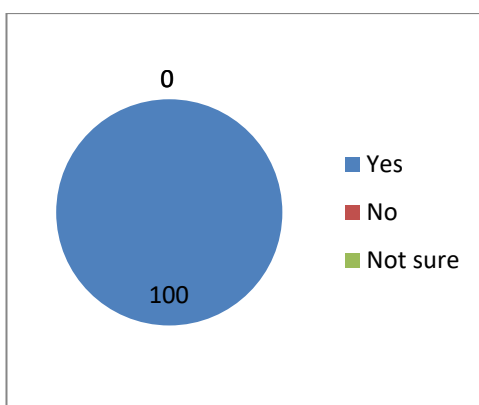
**Appendix 7: Perception of Villagers towards DTR- Q. Do you like DTR?**



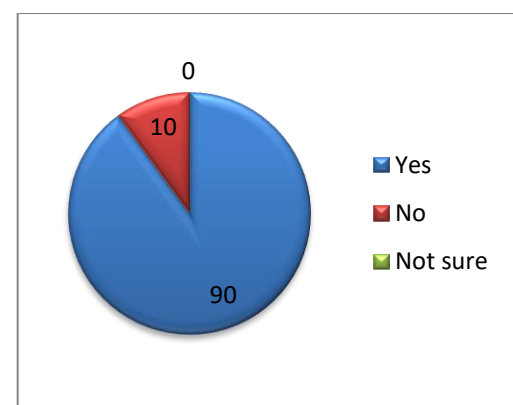
a. Village: Damparengpui



b. Village: Rajivnagar



c. Lallen



d. Teirei

