# MID-TERM REPORT: 18997-1

# Assessing Health Impact of Livestock Grazing on Two Ungulate Species in Kedarnath Wildlife Sanctuary: An Ecological Review

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## 1.0 Introduction

Ungulates are critical components of a healthy ecosystem as they control vegetative growth and provide a main source of protein for predators, and as such, it is vitally important to understand the ecology of ungulate species for effective conservation. The Kedarnath Wildlife Sanctuary (KWS), located in in the upper Mandakini valley of the higher Himalaya in Uttarakhand, India (see figure 1 below), is important habitat for ungulates, some of which are endemic (Betts & McCulloch, 2004; Negi, 2004). In addition to being valuable members of the ecosystem, ungulates in the area have a spiritual value to the local people, who strive to protect the wild populations. Unfortunately, the growing human population in the area is threatening the wild herbivore diversity, mainly through increased agro-pastoralist activity. (Shared Pastures 2015; Mishra et al., 2004; Mishra et al., 2001; Sathyakumar 1994; Paudel 2015; Kittur *et al.*, 2010). Although several protected regions are present across this mountain chain, many ungulates, like Himalayan musk-deer (*Moschus chrysogaster)*, sambar (*Rusa unicolor)*, Himalayan serow *(Capricornus tahr)*, Himalayan tahr *(Hemitragus jemlahicus)* and Himalayan goral *(Nemorhaedus gorai)* are still found outside of protected areas, resulting in territorial overlap with livestock herds (Giri *et al.* 2011). Livestock encroachment into protected-areas is high as well, and may pose a threat to wild ungulates. One of the major challenges in this area is to manage the agro-pastoralist lifestyle that many people rely on, as well as protecting the wild ungulates in the area; this cannot be done without a thorough knowledge of the ecology of ungulate species, much of which is unknown.

Himalayan serow (*C. thar*) and Himalayan tahr (*H. jemlahicus*) are particularly interesting owing to a lack of pre-existing biological and ecological studies. The Himalayan serow (hereafter serow) is similar to the other ungulates with respect to its predominantly solitary behavior, similar patterns of nocturnal and diurnal behavior, and preference for cover (Green, 1981; Haleem *et al.* 2014). On the other hand, the Himalayan tahr (hereafter tahr) are generally found in status dominated herds. Serow are primarily browsers, while tahr are predominantly grazers, but known to browse the leaves of shrubs, particularly in the winter (Schaller 1977; Green, 1987; Shrestha *et al.* 2005). These differences are important to keep in mind when assessing the potential impact of livestock on the health of these two wild ungulates.

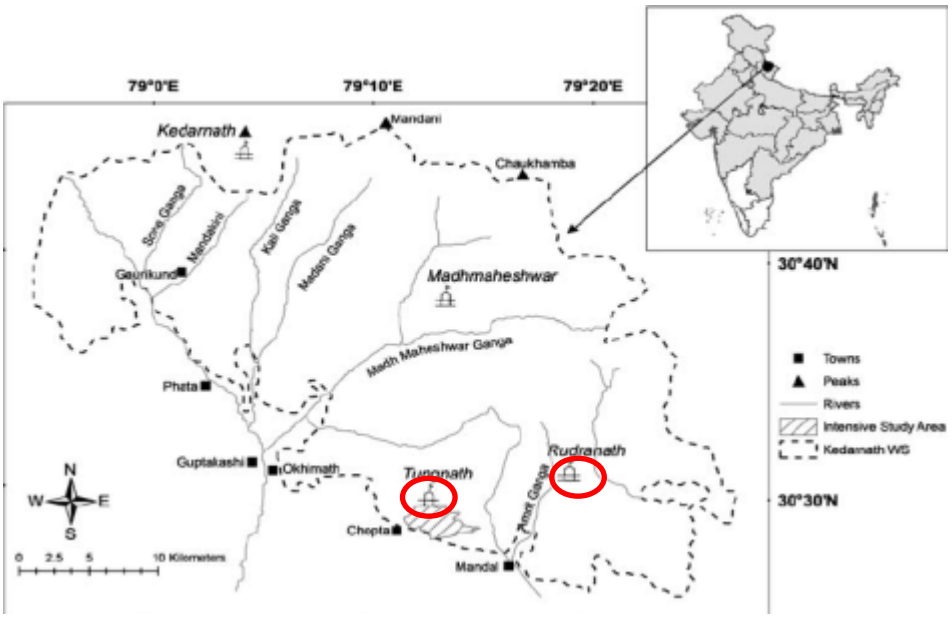


**Figure 1.** Map Showing the Study area. Inset: Map of India. Marked in Red circles at the two study areas; namely Rudranath and Shokarkh (below Tungnath) (Kittur et al. 2010)

# 2.0 Methodology

## 2.1 Field Site

### 2.1.1 Rudranath

The Rudranath site is located between 3000-3800m at N30.49702 E079.32834 (camp), along a pilgrimage trail to Rudranath temple that is frequently travelled in the summer months. Mainly the site is sparsely wooded, open, grassy slopes with patches of Rhododendron trees (mainly *Rhododendron arboreum*) at lower elevations. There too are a few small shops, serving the pilgrims, along the route that contribute to anthropogenic influence. The most notable anthropogenic disturbance in the area is livestock grazing. On average, there are at least two herds of livestock of 300 and 700 animals, respectively that overlap in grazing territory with tahr groups. This is considerable overlap; thus, Rudranath site is labelled as high overlap zone between wild ungulates and livestock.

### 2.1.2 Shokarkh

The camp at Shokarkh site is located at a lower elevation of about 3100m. The site encompasses heights between 2700-4000m and is primarily covered in old oak forests. Closer to 4000m, the area near the site is a mixture of grassy and rocky slopes. It has lower overlap between wild ungulates and livestock, as on one side(western) of the main peak, Chandrashila(N30.48619 E079.22159), there are three small livestock herds(<100 individuals in each group) at varying elevations, with tahr on the opposite side(eastern). It is unclear whether there is overlap between the higher elevation livestock and tahr (closer to the Chandrashila peak. There is a small temple community below Chandrashila (tungnath) that sees many visitors, however tahr do not seem to be affected by this disturbance and graze relatively nearby.

**Figure 2.0:** Above: Rudranath camp. Below: Field cottage at Shorkh. Photo Credit: Ilke Geladi

## 2.2 Field Methods

### 2.2.1 Ecological Data

Ecological data was collected in Rudranath throughout the months of May, June and August, and in Shokarh during July, and August. A team of two to four people would locate a group of tahr, and upon sighting they would record the group composition: how many males and females, pregnant females, juveniles and new-borns. After the group was characterized, there were two kinds of observational methods used to record behaviour of the group and individuals. Focal sampling involved tracking the movements of one individual in the group for fifteen minutes, or until visibility allowed, noting exact times for changes in behaviour (types of behaviour can be found in annex 1). Multiple people would take different individual focals (of individuals of different age-sex classes), if possible, to maximize the data collected. Group scan sampling was the other method used, where one researcher would describe the activities(same as the ones in annex 1) of all members of the group at one point in time, then mark down changes in that activity throughout a minimum fifteen minute period; although if visibility allowed the time was extended. Activities of the individuals and group were characterized as the following: foraging, resting, jumping, walking, grooming, fighting, being vigilant, and playing (juveniles). Additional information, such as unusual behaviours or specific habitat, was included when possible. The method suggested by Altmann (1974) formed the basis for the scan and focal sampling

### 2.2.2 Parasitological Analysis

Tahr, serow and livestock (sheep and goat) faecal samples of 5mL each were collected at both sites, and processed for parasitic egg counts, the same day of collection. Only samples one day old or less were collected in order to avoid larvae hatching. Number of samples per site per species varied as a result of scarcity in serow faecal matter, especially in Shokarh, and smaller livestock herds in Shokarh; Table 1 below shows the number of samples collected and analysed from each site

| **Site** | **# Tahr Samples** | **# Serow Samples** | **# Livestock Samples** |
|---|---|---|---|
| Rudranath 1st leg | 20 | 7 | 21 |
| Shokarkh 1st leg | 34 | 2 | 17 |
| Rudranath 2nd leg (on going) | 6 | 3 | 5 |
| **Total** | 60 | 12 | 43 |

**Table 1.0**: Table showing the break-down in numbers of faecal samples collected and analysed across the two study sites in Kedarnath Wildlife Sanctuary

The FLOTAC method (Cringoli *et al.* 2010) was used to analyse parasite eggs in faecal matter. It involves mixing the 5mL sample with 45mL of saturated salt solution in a fill flotact device, then pouring a small amount of the mixture into a miniflotac and waiting for 10 minutes. The wait raises the eggs to the surface due to osmotic pressure. After the 10 minutes, the miniflotac is turned and the parasite eggs of interest are separated from debris and can be easily seen under a microscope (at 5x or 10x power), where they are counted within two slides of 12 columns each. Parasites were identified to functional groups (strongyles, marshallagia, etc.) as resolution was too poor to further identify species. Unidentifiable items that were considered more than debris were also noted.

## 2.2.3 Location Data

At each point of faecal collection, a GPS point was taken as evidence of tahr or serow presence in that area. In addition, GPS points were taken at points of tahr sightings if within 500m, even if faecal matter was unable to be acquired. This was done to understand

distribution. Tahr data was only for fresh faecal matter and sightings in order to accurately depict their spatial distribution at one specific point in time (e.g. June) on a map. Serow were more difficult as there were no sightings of serow; thus, faecal matter, tracks, and hairs were all considered location markers, despite their age. The objective for the serow map is different than that of the tahr because at this point in time, such little research has been done on the serow and its habitat preference is still unclear, and thus displaying all areas with evidence of serow, a better idea of habitat preference may be possible.

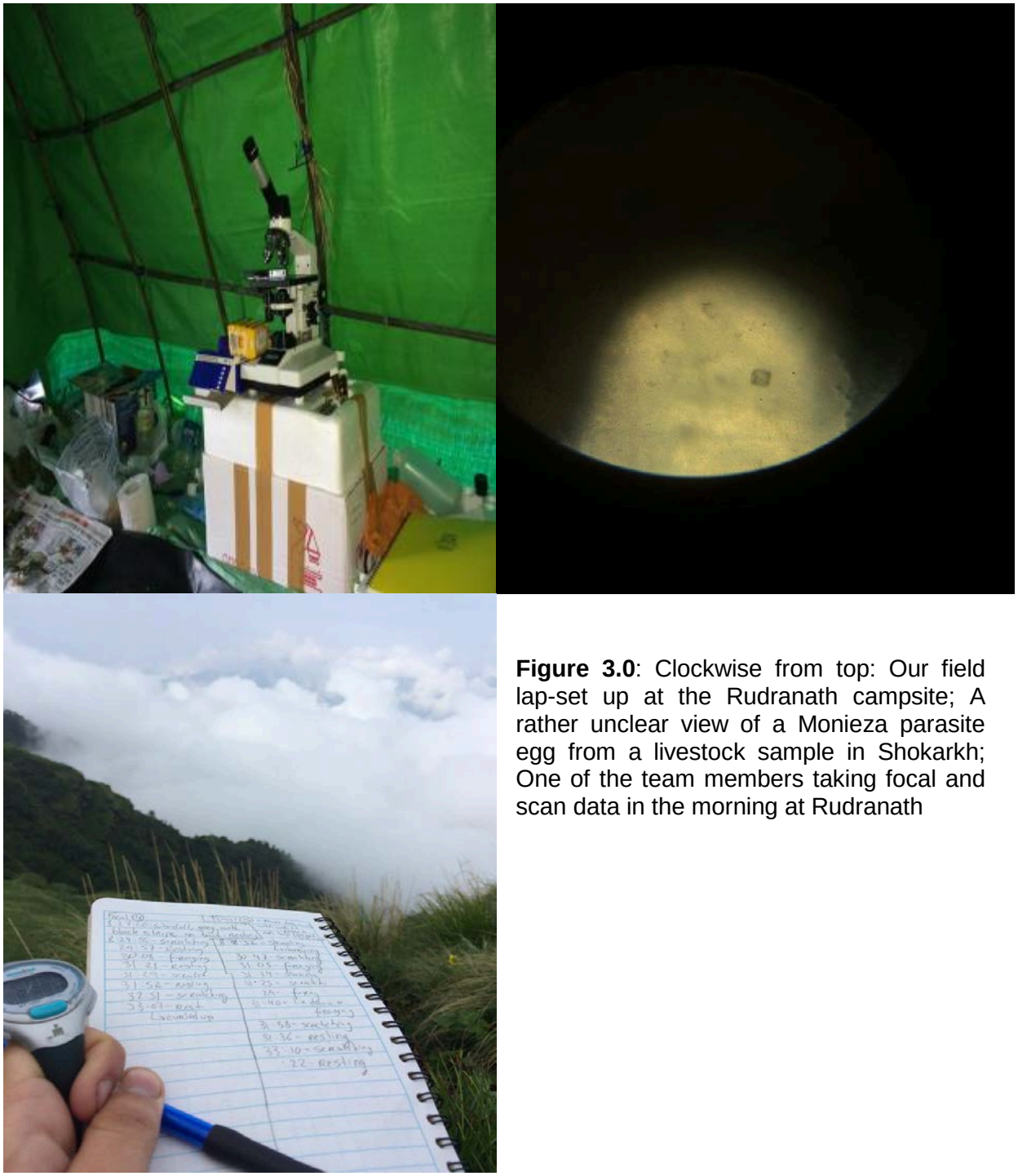

**Figure 3.0**: Clockwise from top: Our field lap-set up at the Rudranath campsite; A rather unclear view of a Monieza parasite egg from a livestock sample in Shokarkh; One of the team members taking focal and scan data in the morning at Rudranath

## 3.0 Preliminary Results

Although the fieldwork is still in progress, through field data collected during the months of May, June, July and August, we have a basic understanding of the ecology of both the Himalayan Tahr and the Himalayan Serow. Our main observations are presented below.

### 3.1 Ecological Data

In total, across all age-sex classes 24317(6.75 hours) seconds and 13074(3.63 hours) seconds of scan data were collected from Rudranath and Shokarkh respectively. A total of 40 focals (each or at least 15 minutes) were taken from Rudranath and only 5 focals were taken from Shokarkh. Shokarkh has lower focals as we haven't done the second round of data collection there yet(scheduled for September and October) and most of the July month(the first period of data collection) was misty and wet, which made it hard for focals. These are all for Himalayan Tahr, as no Serow were spotted. The break-up of the focals can be seen below in figure 1.0

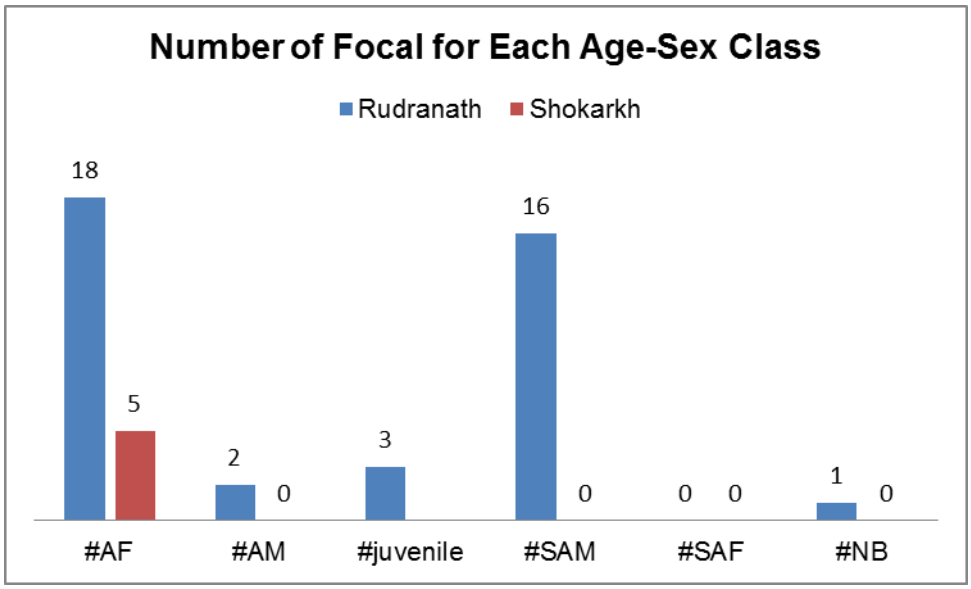


**Figure 4.0**: Bar-graph displaying the distribution of focals across different age-sex classes of Tahr across the two sites

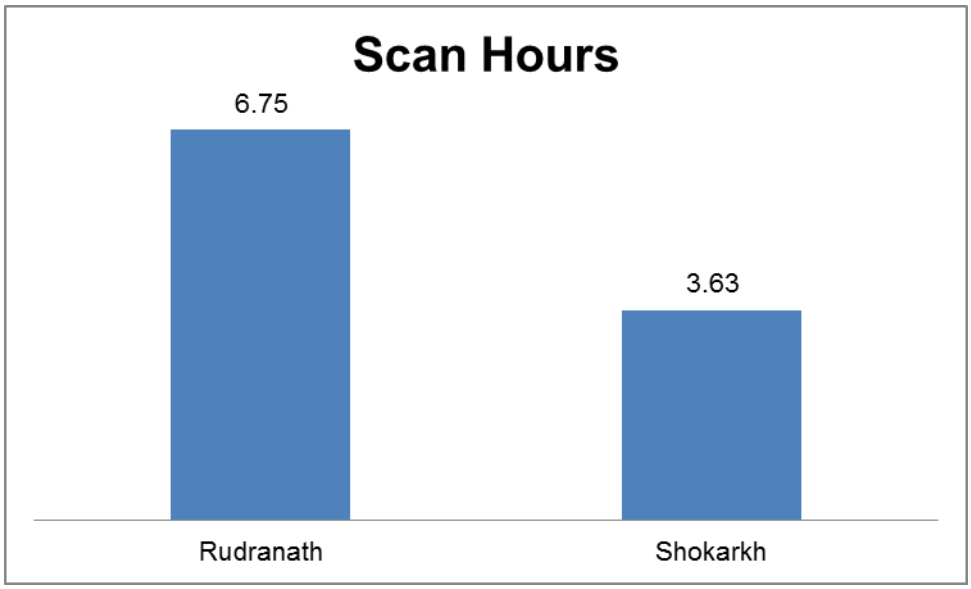


**Figure 4.1**: Bar-graph displaying the number of scan hours of data obtained from each sight

### 3.1.1 Scan Ecological Data

From the scan data, their seem to be subtle difference in the activity budget of the tahr groups across the two sites. Figure 2.0 compares the activities across the two sites. As seen, in Rudranath, tahr spent 58% of their time (14144 seconds) foraging/feeding, 32% resting (7719 seconds) and 10% with other activities such as but not restricted to scratching, moving, vigilance, etc. Alternatively, in Shokarkh, the herds comparatively spent more time foraging, 65 %( 8510 seconds), than resting 11 %( 1427) and other activities, 24%.

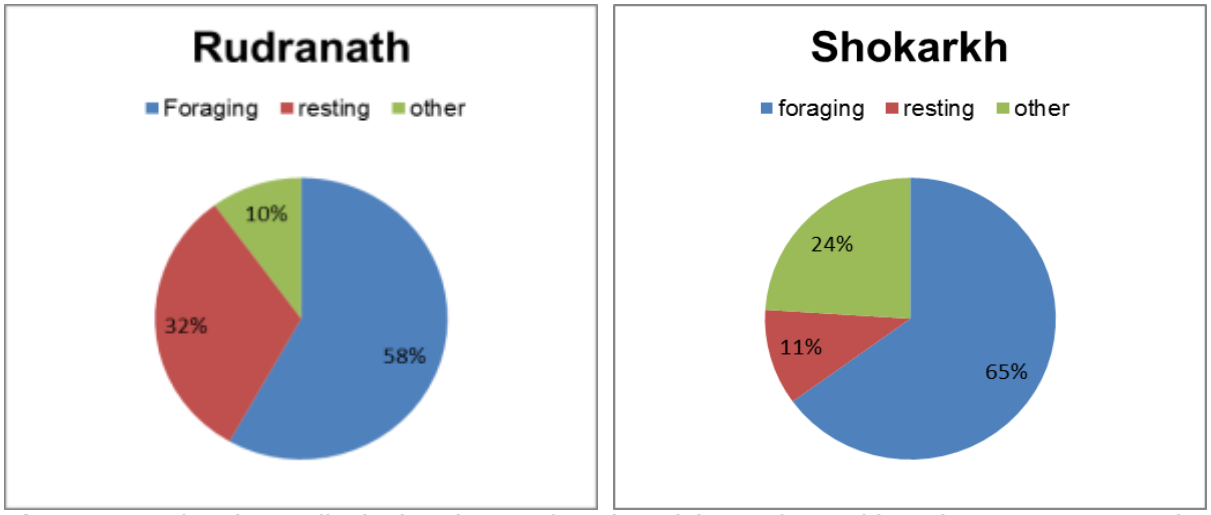


**Figure 5.0:** Pie-Charts displaying the % of each activity performed by tahr groups across the two study sites

To understand this data better we performed the Kruskall-Wallis test. We obtained a statistically significant difference in the amount of time allocated to feeding (H=228.28110 > p=3.84146, df = 1) and resting (H =19494 > p=3.84146, df = 1), by tahr across the two study areas.

### 3.1.2 Focal Ecological Data

To better understand trends across sites of different age-sex class behaviour of tahr, we analysed the focal data with the filter of age-sex categories. Upon performing the Kruskall-Wallis test, we found a statistically significant different in the time allocated by adult females for foraging (H=2812.5555 > p=3.84146, df=1). From the total focal seconds observed for adult females, only about 12% of the time(1487 seconds out of 12941 seconds) was spent foraging in Rudranath, whereas a much higher 68% of the time(3898 seconds out of 5766 seconds) was spent foraging in Shokarkh.

A similar difference was noticed in the resting data for adult females across the two sites. We found a statistically significant difference in the time allocated for this across Rudranath and Shokarkh (H = 2903.42526 > p = 3.84146, df = 1). Thus, in Rudranath, individuals spent about 8% of their time (997 seconds out of 12941 seconds) resting, whilst in Shokarkh they spent about 12% of their time (695 seconds out of 5766 seconds) resting. This is interesting, as the individual data for adult females suggests they spent more time resting in Rudranath than Shokarkh, which is opposite from the scan results seem in section 3.1.1 for tahr groups as a whole.

Furthermore, having had data set for Rudranath across two time periods (May/June and August) we did a comparison on the amount of time spent foraging by a group of Sub-adult and Adult males found at N 30.49329 E 079.32622 (a group of about 23 individuals). . Interestingly, we found a statistically significant difference between the time spent foraging in initial months and latter month (H = 1287.390764 > p = 3.84146, df = 1). In May/June they

spent only about 12% of their time (1087 seconds out of 9207 seconds) foraging/feeding, whilst a significantly higher 45% of their time (1126 seconds out of 9207 seconds) foraging/feeding in August. This increased foraging could be related to the approaching mating season that sees male tahr sparring with rivals as early as September and actual mating happens sometime from October/November (Lovari *et al.* 2009).

Another interesting result we found was that the amount of time spent scratching by females and male wasn't statistically different ($H = -85.49 < p = 3.84146$, $df = 1$). Males have longer, thicker hair, which possibly makes them more susceptible to catching parasites like ticks, mites, etc. This causes increased irritation that is expressed by the individual scratching themselves. For example, Sarcoptic mange is also prevalent in the area (a skin disease caused by mites), which expresses itself in terms of profuse scratching and hair loss. But, a lack of statistically difference between the two sexes suggests that there is no visual evidence of a health stress that could be sex linked.

Lastly, though we have very restricted data on juveniles (only from Rudranath), figure 3.0 below helps us visualize their activity budget. Interestingly, they seem to be spending a lost more timing moving (28%) than other age categories such as Adult females and males. More data needs to be collected though, across the sites, to arrive at statistically significant results.

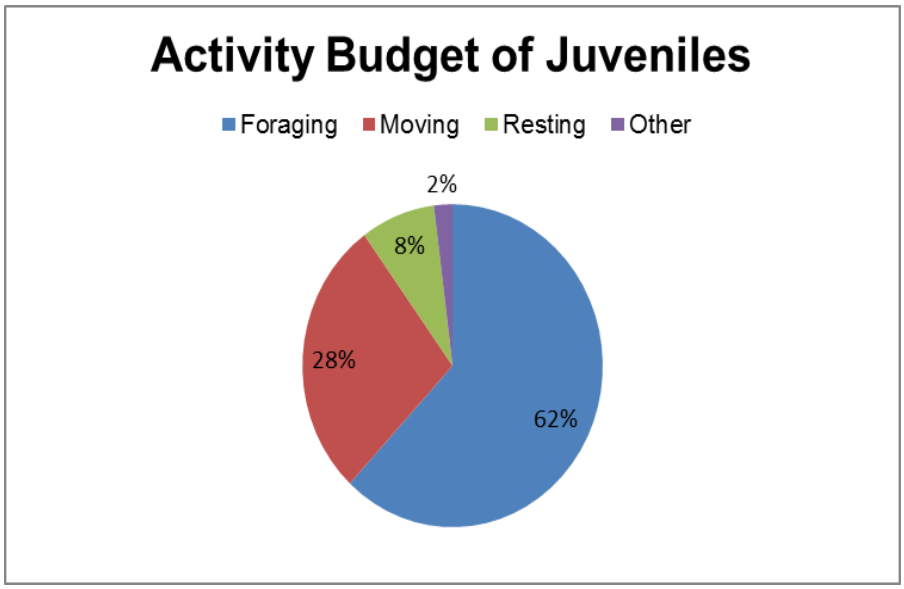


**Figure 6.0:** Pie-Chart displaying the % activity performed by Juveniles in Rudranath

**Figure 7.0**:
A part of sub-adult and adult male group we sighted and got focal/scan data of, at Rudranath (see map below)

## 3.2 Parasitic Data

In total 123 faecal samples have been analysed till date. 70 in Rudranath and 53 in Shokarkh; the breakdown of samples in shown in figure 4 below. The category “Others” included parasites such as Toxacara, Monieza and Strongyloides, depending on the sample

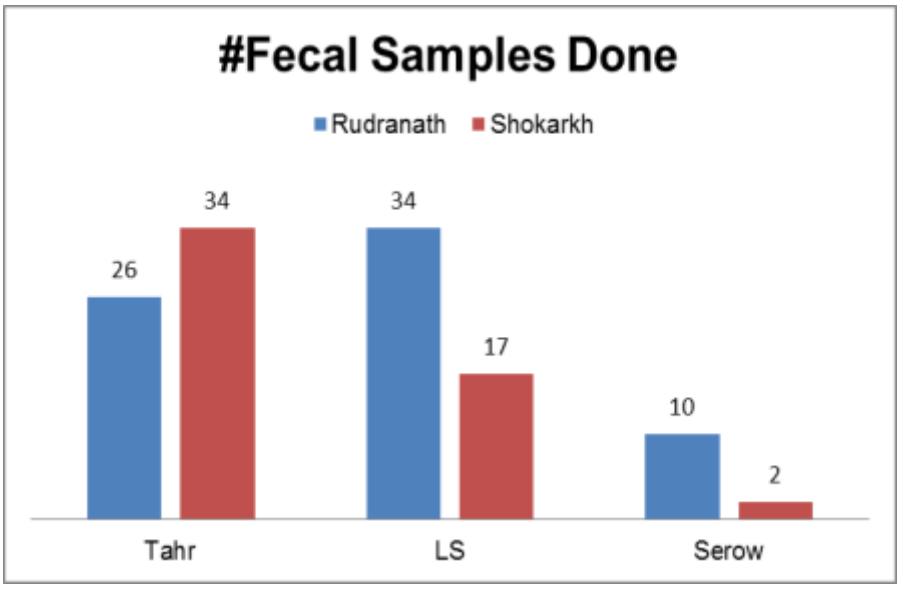


**Figure 8.0**: Bar-graphs displaying the number of faecal samples collected and analysed at each site and animal group

Below in figure 4.1, 4.2 and 4.3, we can see the breakdown of parasite types and number in tahr, livestock and serow in Rudranath and Shokarkh

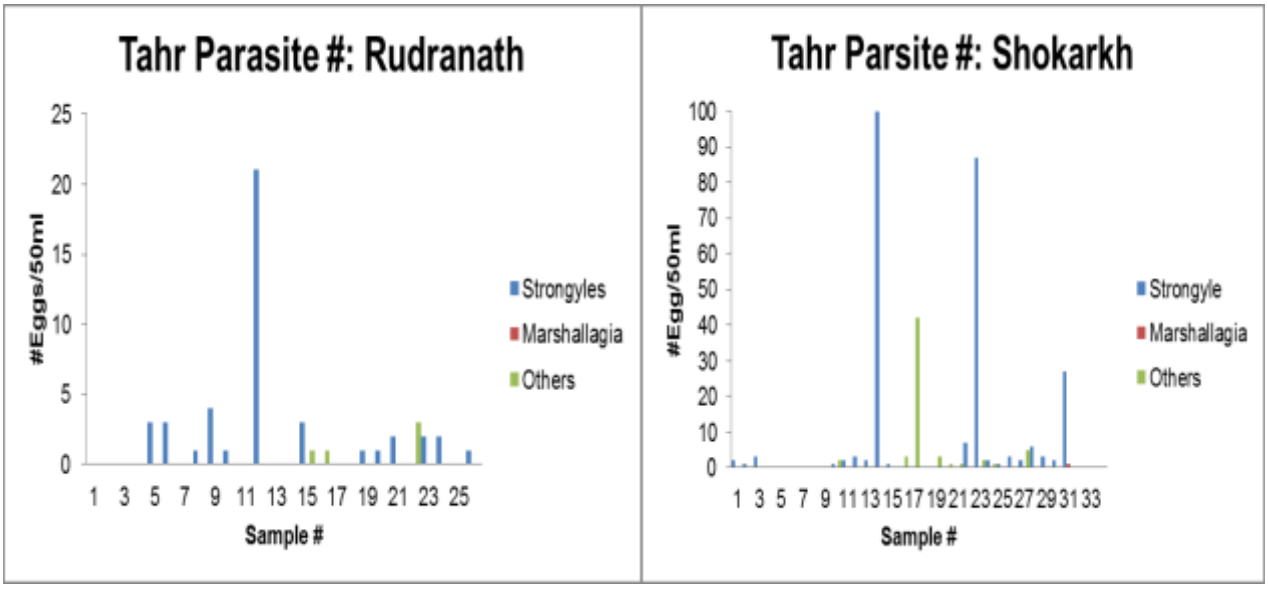


**Figure 8.1**: Bar-graphs displaying the number of difference kinds of parasites in tahr across the two study sites. Sample 13 for Shokarkh actually has a strongyle count of 280, but needed to shrunk down for display purposes.

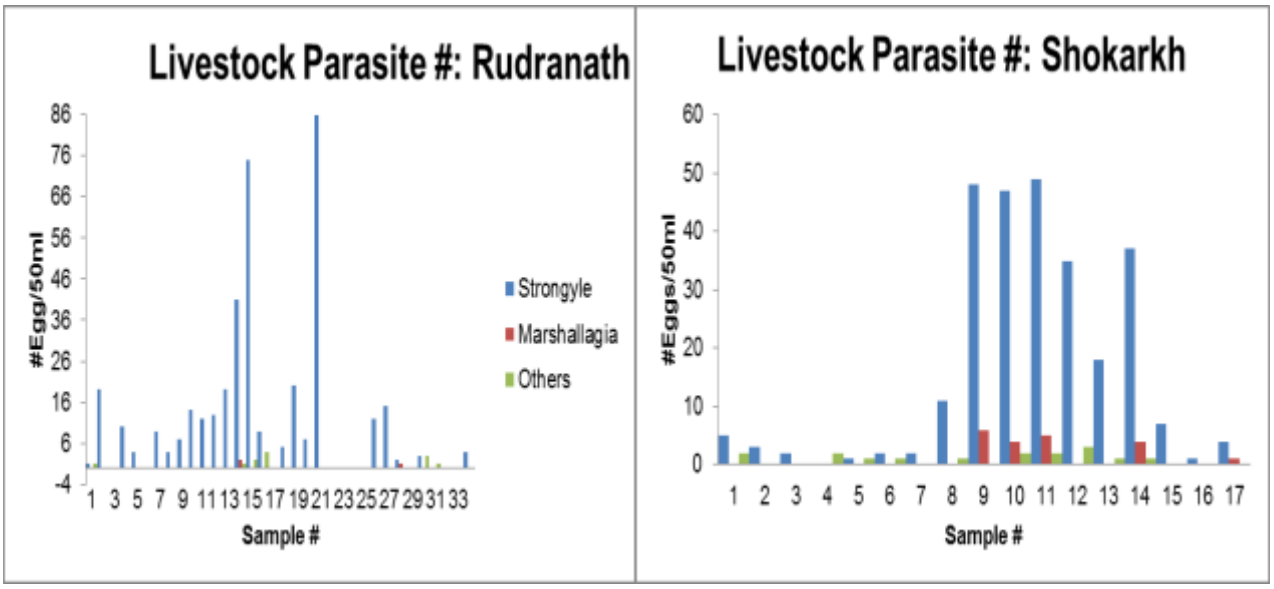


**Figure 8.2**: Bar-graph displaying the number of different kinds of parasites in livestock across the two study sites.

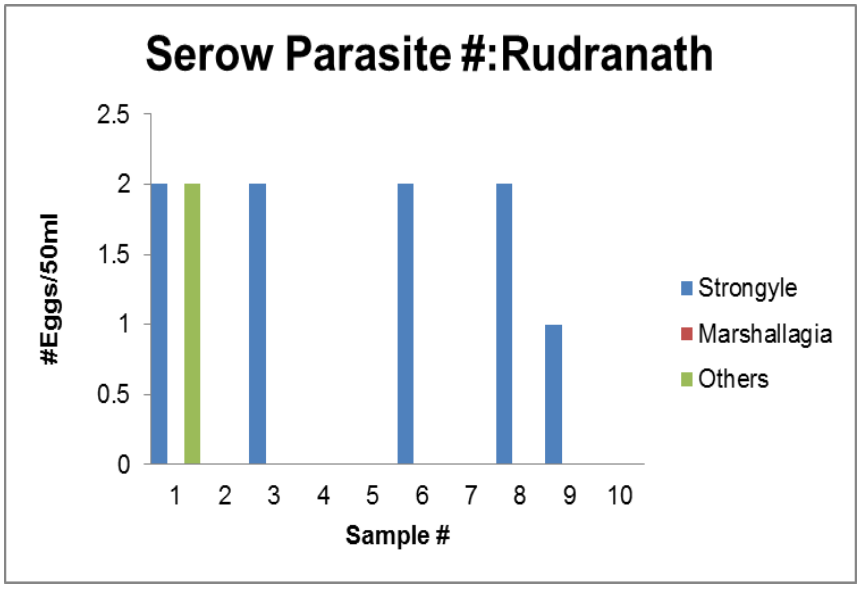


**Figure 8.3**: Bar-graph displaying the number of different kinds of parasites in Serow across the Rudranath site. No graph for Shokarkh is show, as we only obtained two fresh serow samples, of which only sample 1 had 1 parasite("other"),

### 3.2.1 Prevalence of parasites

We, initially performed the Chi-squared test to compare the prevalence of different parasite in species across the two study sites. When considering the tahr faecal samples, we obtained a non- statistically significant difference in parasite prevalence between the two study sites ($p=0.062243 > \alpha=0.05$). For livestock, we obtained a statistically significant difference in the prevalence of parasites across the two sites($p=2.20025E-05 < \alpha=0.05$), wherein Shokarkh had an average total parasite count of 18 eggs/50 ml, for each sample, while Rudranath registered a much lower 11 eggs/50 ml.

Interestingly, we also found a statistically significant difference between prevalence of parasites in tahr and livestock in both Rudranath ($p=1.11446E-07 < \alpha=0.05$) and Shokarkh ($p= 8.48074E-10 < \alpha=0.05$). In both areas on average the livestock had much higher parasite prevalence. Per sample in Rudranath, tahr had about 1 egg/50ml, whereas livestock had about 11egss/50ml. In Shokarkh, tahr had a much higher 14egg/50ml (this is particularly, which was still lower than the 18 eggs/50ml parasite prevalence in livestock.

Collectively, we also found a statistically significant difference in prevalence of parasite across the two sites irrespective of species ($p=0.002655 < \alpha=0.05$), where in Shokarkh averaged around 14eggs/50ml and Rudranath, a lower 7eggs/50ml. This includes serow, tahr and livestock data.

### 3.2.2 Intensity of parasites

We, subsequently performed the MannWhitney U test to compare the intensity of parasites challenge across study sites. When considering tahr samples, we found there to be no statistically significant difference between Rudranath and Shokarkh in terms of the intensity of the parasite challenge faced by the tahr ($U=389.5$, $Z =0.77572 > p = 0.4354$). This is interesting, as one may hypothesise that increased proximity to livestock (as in Rudranath) may contribute to a higher parasite challenge to tahr, due to communicability.

The trend is the same when we dwell deeper into the tahr data and consider the strongyle parasites (as they are the most prevalent) ($Z =0.73096 > p = 0.4654$).

Interestingly, when comparing intensity between tahr and livestock, we obtained statistically significant differences in both Rudranath ($U=246$, $Z=3.04075 > p=0.00236$) and Shokarkh ($U=133$, $Z=3.1071 > p=0.00188$). To add to this, there was no statistically significant difference in the parasite challenge intensity in livestock across the two sites ($U=246.5$, $Z=-0.98511 < p = 0.32218$)

**Figure 9**: Clockwise from top: A local team member and conservation ambassador. Harish Maithani, collecting fresh tahr poop for analysis; A livestock herd grazing near the camp at Rudranath; A Serow latrine within a Rhododendron patch at Rudranath

## 3.3 Location and Habitat

In order to better understand the habitat use and particularly the spatial spread of our study species, while trying to understand overlap with livestock, we made using the GPS obtained.

### 3.3.1 Himalayan Tahr


**Figure 10.0:** Maps displaying tahr group's sites at Rudranath (above) and Shokarkh (below). Different coloured pins indicate different groups/herds

#### 3.3.1(a) Rudranath

We have come across at least 3 different defined tahr herds. In yellow, labelled "above camp" in a group of roughly 110 individuals, that are mainly adult females, of which around 30-40 were pregnant in May. This group also included new-borns, juveniles (born the previous year) and sub-adults, whose sex we couldn't determine. They overnight, generally at the point labelled "Cave". Interestingly, we observed that the pregnant females and most of the new born and juveniles, tended to forage nearer to the caves, whilst the non-pregnant females wandered to the pastures much closer to camp and the males. The Male group

consists about 23 individuals that were seen in months of May, June and August in those areas and are said to stay there all year rough as per anecdotes by shepherds. The points labelled “Above Temple” refer to two groups, one an adult male group of around 20-25 individuals and another a group of around 30 adult females that are found in the valley just above the temple. What is striking here is the proximity of the male groups to the female groups and a lack of temporal movement of all groups.

### 3.3.2(b) Shokarkh

In Shokarkh, as well we found around 3 definable herds of tahr. Marked in light blue is a herd that primarily is divided into two parts, a small (~20) group of pregnant females (in the month of July) along with new born and juveniles and another group of about 25 sub-adult and adult males. They forage close to the Tungnath temple, below the Chandrashila peak. We did see a lot of tahr movement from this area to the point marked in purple, above “Tungnath” and on towards non-labelled red marker. Thus, we aren’t sure if the individuals are from the same group or distinct groups, with overlap. Marked, below in red as “males” is group of about 87 adult males that were seen foraging on top of the mountain across the Chandrashila peak and in the below behind it. Lastly, marked in dark blue is a group of females with young (new born and juveniles) that stayed in close proximity to rocky slopes and wooded areas near our camp.

**Figure 10.1:** A part of the “Male & Pregnant females” group marked with light blue of Shokarkh map in figure 10.0. Seen here are females that have given birth this year, followed by their young (both from this year and the past)

### 3.3.2 Himalayan Serow


**Figure 11:** Maps displaying serow presence sites at Rudranath (above) and Shokarkh (below)

Most points displayed on the above maps of serow presence, were either old poop piles or had some indirect serow presence indicator such as hair or hooves prints. Interestingly, in the Rudranath site all serow points were located on the eastern slope, which was descending and more wooded (mainly oak and Rhododendrons). The western slope either was quiet precipitous, ascending and mainly just Rhododendrons thickets. Clearly, the serow preferred the eastern slope. Most serow points both in Rudranath and Shokarkh, were in old growth Oak or Rhododendron forests. At many points such as 3 and 4 in Shokarkh, we found very shallow caves, which the serow were using as latrines. The majority habitat in Rudranath can be defined as Rhododenron thickets mixed with a little Oak forest, whereas in Shokarkh it was primarily Oak forest. The range of altitude in Rudranath was between 3400m-3800m, where in Shokarkh was between 2600m-3700m.

### 3.3.3 Livestock Overlap

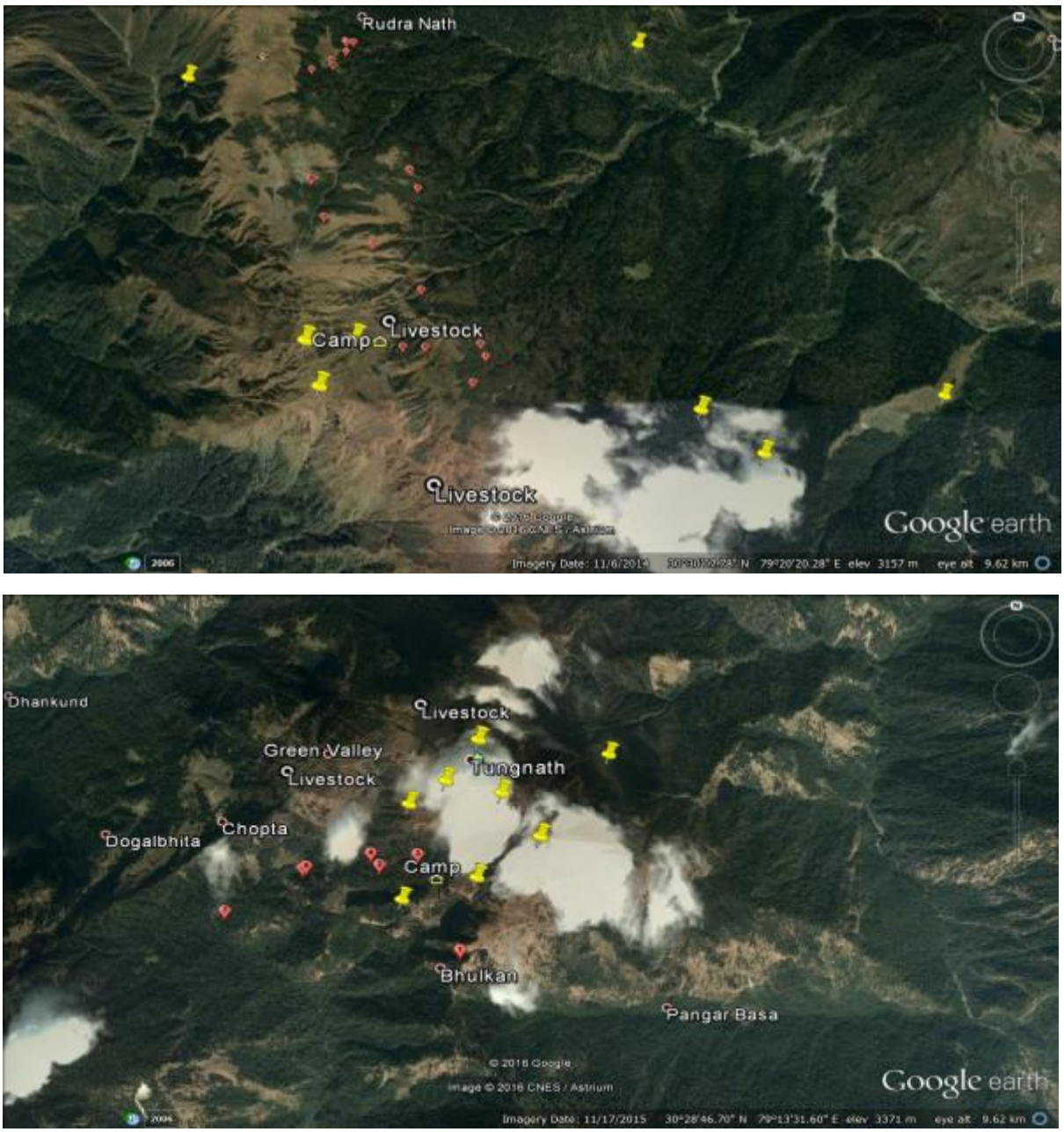


**Figure 12:** Maps displaying livestock overlap/proximity with tahr and serow in Rudranath and Shokarkh (red=serow, yellow=tahr and black/white=livestock; with each label indicating a different livestock group (i.e. Different individual animals, herders and their owners)

As seen, by comparing the maps, both tahr and serow seem to be closer to livestock herds in Rudranath. Livestock and wild ungulates seem to be clearly separated on two sides of ridge in Shokarkh, as Easter solve (with livestock) in a patch of land, defined as 'multiple use' by the local authorities and Forest department, allowing for livestock grazing, whereas the area west of the ridge(with most of the tahr sites) is a protected area. Shokarkh is interesting as the highest and northern most tahr site is very close to a livestock group (near the Tungnath temple) and potentially there is proximity between tahr and livestock there. Interestingly, there are no sheep and goat in the region of the serow in Shokarkh, though we found a lot of grazing buffalo's belonging to the Gujjar nomads in areas 5, 6, 7 of serow. The gujjar sell milk from buffalo in local markets (Mandal and Gopeshwar) and head to their winter homes near Rishkesh, around November.

## 4.0 Additional Observations

### 4.1 Himalayan Tahr

One of the most interesting observations about the Himalayan Tahr is that during this time of the year, which is prior to mating season, the species subdivides into different groups. From our observations, we have classified at least four different groups with particular compositions: (1) Non-Pregnant Adult Females with sub adults and some Juveniles, these groups tend to be much bigger in number and are often found in open spaces; (2) Pregnant Adult Females (who tend to be lighter in colour) with Juveniles, these are usually found in more sheltered areas and in vicinity of Group 1; (3) Sub adult Male Group with males of different ages, where most are sub adults from different years but there is also one or multiple older males (who tend to be darker in colour and have longer horns) which seem to be the leaders of the herd; (4) Adult Male Group with some juveniles, usually found a lot further away from any female group and known to travel long distances. Groups 1-3 were observed in both field sites, and Group 4 in the first field site, Rudranath. Furthermore, in multiple cases we have observed pregnant females separating from their group when it is time for them to give birth, and remain separated for a few days until the mother and young are fit enough to re-join the group.

In both field sites, foraging bouts lasting longer than one hour were observed, especially in the mornings. Also, tahr in both field sites were often found near caves which were used for shelter and licking for minerals; this was principally observed in female tahr.

### 4.2 Himalayan Serow

Direct observations of the Himalayan Serow were not obtained as we have yet to spot an individual, nevertheless we were able to infer some information from indirect observations and informal interviews. The most alarming finding is that Himalayan Serow populations are suffering big losses this year as they are being affected by sarcoptic mange disease, a skin disease caused by a mite (species unknown). Affected serow have been found on both sides of the Mandal valley. This was further reinforced when we found a diseased and deceased serow near Mandal village (base for trek to Rudranath), as well as by the lack of serow spotted this year which according to our local guide, is very unusual.

Despite these difficulties, we found some evidence of serow (mainly in the form of faeces) from which we were able to make inferences. We found that in the months of June and July, there is presence of young as in both sites as faeces of infant Serow were found near faeces of adult female Serow. Furthermore, Himalayan Serow were often found to return to the same site for multiple rounds of defecation (latrines). There seemed to be a preference for these sites to be near big boulders. An interesting recurring observation, was the finding of singular pellets of male Serow faeces along a path. We are not sure as to what the meaning of this is but there are multiple possibilities such as for the marking of territory. We are still working on classifying their habitat, however so far we have mainly found evidence of Serow in areas including rhododendron and/or oak trees.

Significant observations specific to the Rudranath site include that there was more evidence of Serow presence below the main road used by pilgrims, as well as that Serow in this area often used pathways made by Sambar Deer (*Rusa* unicolor) to move around.

**Figure 13.0**: Photos of freshly deceased Himalayan Serow, on the 29th of June 2016 at 0653 hours, found near the Mandal village, along the road to Siroli village. Seen clearly on the skin is evidence of Sarcoptic mange disease, characterized by hair loss, due to drying and scratching of skin.

## 5.0 Lessons learnt from first leg of fieldwork

The beginning of a new project and first immersion into the field always yields room for improvement, which is important to reflect upon so that the project can always develop and advance. Firstly, as a team we learnt we need to improve our overall record keeping skills by at the end of every day recording all the areas searched that day(in particular distance and area estimates) and what was found in a general sense. On a similar note, we realized a better characterization of the habitats searched could be beneficial to the project, including vegetation, closeness to road, presence of water, forest density, altitude, presence of other species, etc. Additionally, a goal for next field session is to prepare ahead of time to spend entire days in the field (rather than chunks of days, especially for ecological data) to get a fuller picture of long-term behaviour to answer questions such as, how long is a bout of foraging? Also, our daily scheduled usually involved taking focals and scans in the morning and parasite work in the evening; however we realized that collection of scans and focals should be spread out over all hours of the day and our schedule should be more varied to get develop a more thorough understanding of ungulate behaviour.

Furthermore, we focused a lot on taking presence data but need to improve in taking absence data as well. To do so, we thought it could be interesting to use aerial photographs prior to field immersion and draw out transects of areas to search and hereby quantify area searched and record both presence and absence of species. It would be important to take GPS points in all patches searched, regardless of findings. This would also be a way to standardize and keep a good record of the patches searched.

Whilst in the field, the weather conditions seemed very sporadic which raised an intriguing question: does the weather affect ungulate behaviour, or more specifically the spread of parasites? We thought it would be interesting to obtain meteorological data perhaps through a data logger or from satellites, and study if certain weather conditions (such as increased precipitation) facilitate disease transmission.

**Figure 14.0**: Higher reaches of Kedarnath Wildlife Sanctuary, beyond Rudranath

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## ANNEX 1: Types of Activities Recorded for Scan and Focals

1) **Foraging:** feeding at any height which might include movement

2) **Vigilance:** scanning, observing

3) **Resting:** standing and lying idle

4) **Moving:** directional movement, including walking, jumping, running

5) **Vocalizing:** grunting or producing a sound (generally audible) with their mouth

6) **Other:** Including but not limited to activities like suckling, mating, grooming and fighting