Article

Social Behaviour of Domestic Yaks in Manang, Nepal: An Etho-ethnographic Study

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Abstract: Herdsmen use different techniques, as per varying geographies and cultures, to keep the cohesion within herds and avoid animals getting lost or predated. However, there is no study on the social behaviour of yaks and on herdsmen management practices. Therefore, this ethology study was initiated by ethnographic inquiries. In Manang, the success of the shepherd is dictated by his personal attribute of "Khula man" or open-heartedness. This attribute refers to good intentions and emotions such as empathy that allows the shepherd to focus more on others than on ownself. This cultural method of assessing the skills required to become a successful and knowledgable shepherd guided us to study the effect of cultural values on the herd's social behavior. We collected data from two herds living at the same settlement (Yak kharka, 4,100 m altitude, Nepal) by equipping them with loggers. One of the herdsman used the tether rope while other did not. Moreover, the Thaku herd had a more proactive shepherd than the Phurba one. In each herd, 17 animals were equipped with one actigraph wgt3x-BT to measure activity using accelerometer and spatial associations using proximity recorder. One of the herds was equipped with GPS (N=11) as well. Using GPS locations and activity, we showed that the two herds were cohesive and synchronised their activities but the herd with the tether rope was more cohesive. The shepherds also have personal knowledge of the social relationships of their herds and use these relationships to keep the group cohesive and to well manage cattle.

Keywords: Anthropozoology; social network; human-animal bond; herd synchronization; biologging

1. Introduction

The domestic yak (*Bos grunniens*), a descendent of wild yak (*Bos mutus*), is domesticated in the Himalayan region and in Siberia for its milk, wool, and meat but mainly for its tolerance to harsh climatic conditions at high altitude [1]. Central Asia and yak domestication is also known as a lactase gene locus of apparitions [2]. Approximately 94% (13.3 million) of the estimated total yak population are found in China (Food and Agriculture Organization of the United Nations, 2003), therefore, most of the studies on yak's grazing behaviour, livestock management, and ecological systems were conducted in China [3–5]. Few studies were also done on its social behaviour because it is important not only as a fundamental knowledge but also as a practical one. Herd management is crucial particularly in places where there is an increase in the number of predator incidents. As in most cattle species, yaks also live in herds mostly comprising females and juveniles [6]. There is a sexual segregation, where males leave the herd in adulthood, and revisit only in the mating season. Himalayan inhabitants kill these isolated males for their meat. Contrastingly, female yaks are protected for producing milk, wool, and calves [7,8]. As the herds were bigger with 50-60 animals in it, owners employ herdsmen to keep a watch on the herd and milk them. Maintaining such big herds (fig.1a) is unnatural because wild cattle live in smaller group size of 20, however in plains the number can be over 200

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individuals/group [6]. Therefore, the herdsmen had to employ different techniques, varying as per geographies and cultures, to keep the herd cohesive and avoid animals from being lost or predated (fig.1b).

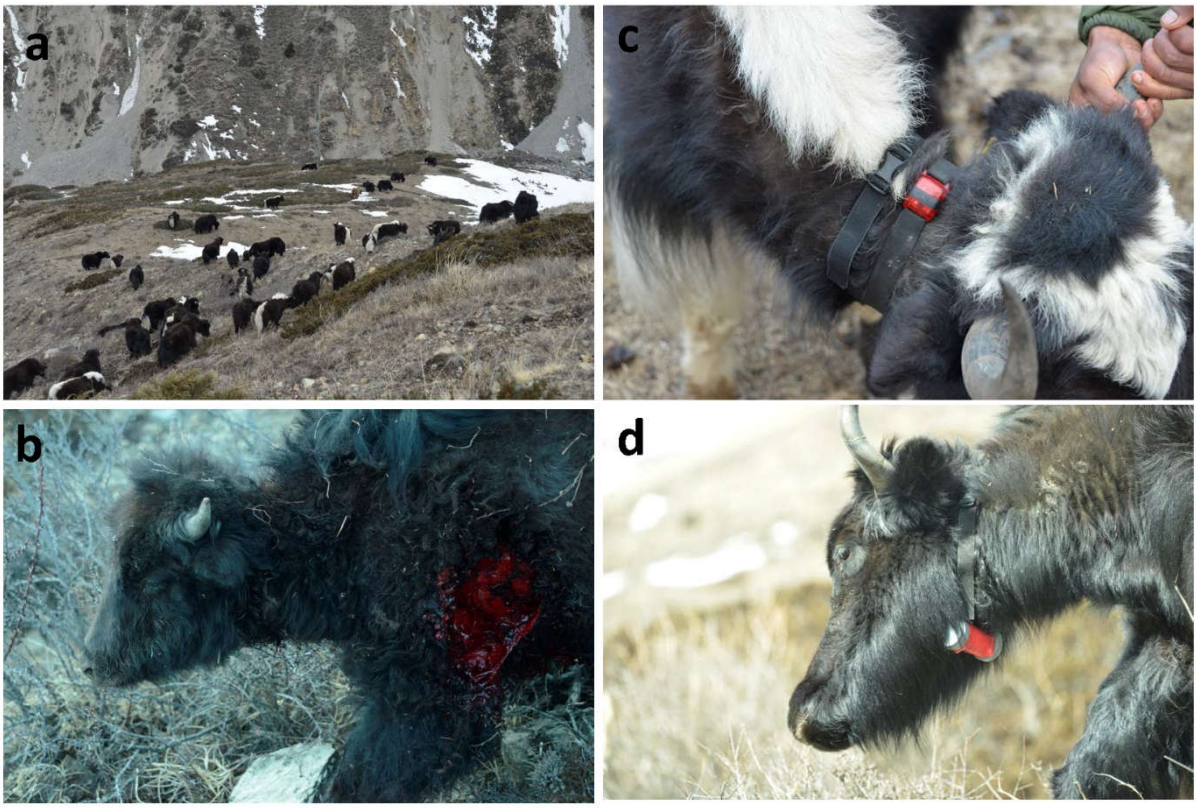

Figure 1. Domestic yaks. a. Herd of yaks. b. Juvenile yak injured by a snow leopard. c-d. Yaks tagged with an actigraph and a GPS to measure activity, proximity and locations.

Manang is a village situated at 3,500 m of altitude in the Annapurna Valley, Nepal [9]. Its inhabitants earn by practicing agriculture, rearing livestock, and trading with the tourists [10]. Due to the change of seasons, the herdsmen practice transhumance in search of greener pastures where cattle graze freely but are brought back to the camp due to the fear of predators. This is rarely combined with some corals for the juveniles in winter next to the village, but more usually with a system called tether rope. During night, the calves are tied close to their mothers to promote cohesiveness at the camp. Interestingly, the herdsmen also choose to tie the calves together and keep the mothers close to each other to keep the herds cohesive [11]. However, until now there is no study on the social behaviour of yaks and the coping strategies that herdsmen use. This ethology study was initiated by ethnography inquiries, without these inquiries it is difficult to formulate a hypothesis on the impact of herders on social behavior of the yaks.

Ethnographic study

The shepherd's discourses about their herds are always focused on the relations they have with each yak. Irrespective of the shepherd's culture and geography he comes from, the source of knowledge comes from sharing lives. In Manang, the success of the shepherd is dictated by his personal attribute of "Khula man" or open-heartedness. This attribute refers to good intentions and emotions such as empathy that allows the shepherd to focus more on others than on ownself. This cultural method of assessing the skills required to become a successful and knowledgable shepherd guided us to study the effect of cultural values on the herd's social behavior.

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This study was done over a period of 10 months, beginning in 2017 and ending in 2018. For 10 months, we observed that by strategizing facilitating habits or daily rites, the shepherds nurtured the cauri (female yak) to form a good herd. Shepherds emphasized on the quality of relationship they had with every yak in the herd as it was crucial for daily milking. The quality of the relationship was tested over milking as milking was interpreted as the cooperation of the cauri that "give her milk" to the shepherd. To acheive this, the shepherd tied all the young ones to the tether rope in a particular spots, irrespective of the season. The calves of same age were grouped together to "make friends." Until three years of age, the calves were tied to the tether rope as they nursed on their mums, and the older ones took their places by themselves. The placement of each calf was chosen, to prevent the mother yaks from fighting with each other. This helped the shepherd to find his herd in the morning, have a harmonious relationship at the milking station by reducing stress, improve the milk quality, and build cohesiveness amongst his herd. If not done this way, it would become impossible to get the herd back from the pastures as they would not stay together or refuse to come back to the settlement and not cooperate. The daily movements of the herds in the pastures are implicitly related with the shepherd's work and personality. If the shepherd is considerate, takes care of his cattle by giving *tsangba* or *kho* (mixture prepared with salt and barley flour), and doesn't take punitive action, the herd stays around and comes back to the settlement. These shepherding skills impact the herd behaviour and it is important to study the effect of human actions shaping social behaviour in yaks.

The shepherds also have personal knowledge of the social relationships of their herds. They don't automatically assimilate mother yak's personality to her calf. The calves develop their own personalities with time. Friendships between the calves were frequent and beyond shepherd's control for e.g., two calves were too slow and always stayed together at the end of the herd, next to the shepherd. As often loneliness is a criteria of personal complexity or non-subjaction and a sign of intelligence, yaks may need the cohesiveness that can be improved by the shepherds. In 2022 winter, the data were collected from the two herds living at the same settlement (Yak kharka, 4,100 m altitude) by equipping them with loggers. One herdsman used the tether rope in his herd (named Thaku) whilst in the other herd (named Phurba) rope was not used. Moreover, the Thaku herd's shepherd was proactive than the Phurba one. In each herd, 17 yaks were tagged with an actigraph wgt3x-BT to measure the activity using accelerometer and spatial associations using proximity recorder [12]. The proximity recorders helped us in measuring the cohesiveness of the herd during day time and to check the effect of the tether rope on spatial associations among the cattle. One herd was equipped with GPS (N=11) (fig.1c-d) as well that helped in assessing the cohesiveness and synchronicity of motion and behaviours of the yaks.

The shepherds were excited and participated actively in fitting the loggers. They were curious at the possibility of observing their herd onscreen and to see if the cauri were staying together or dispersed on the pasture. The equipped cattle were chosen by the shepherds, who categorized the animals in groups such as mother and calves, good or the bad ones, or two inseperable friends. The calves could not be equipped with the GPS as the loggers were heavy and few cauris could not be equipped because they were uncooperative. As a result, only the cauri that were closest to the shepherd were equipped.

2. Materials and Methods

Ethical statement

This study did not require any ethical approval as no invasive handling or experiment were done on yaks. Yaks were equipped with the consent of herdsmen and when logging an specific animal was considered dangerous for it, it was not done (explanations in the next paragraph).

Ethological study methods

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Study subjects

Two herds were shepherded by two different herdsmen at Yak kharka and Annapurna Valley, Nepal (28.722992730245295, 83.97359502534931). During the study, at least four snow leopards were observed in the valley (from March 10 to 24, 2022). Moreover, a month before and after the study, four yaks ware killed by the predator. A dog was used to keep the snow leopard away from the village. At night, the dog stayed in the village and during the day it could roam between the village and the pastures. In each herd, 17 yaks were euipped with actigraphs [12,13] but GPS tagging was done to 11 yaks of Phurba herd only. The herdsmen along with the dog were equipped with a GPS and an actigraph not only to measure their activity, spatial associations, and locations with animals but also to act as a control or reference point for the yaks. As the shepherds failed to wear the loggers all the time, the data were insufficient to analyse the relationships between the shepherds and their yaks. The two selected herds were not linked to eachother and were not grazing on the same pasture, most of the time. In each herd, the 17 equipped yaks were chosen to balance the sex and the age variable. However, revisiting male adults were excluded from tagging as they were too aggressive. Similarly, some female yaks too were excluded for being aggressive, though they could have been good candidates to study. In the Phurba herd, actigraphs were fitted to eight males aging from one to three years and nine females aging from five to thirteen years. Additionally, GPS were fitted on eleven cattles (two males and nine females). Similarly in the Thaku herd, four males aged one to two years and thirteen females aged one to eleven years were fitted with actigraphs. For reasons beyond the control, only male juveniles survived the 2022 winter. During the study, Phurba herd did not use the tether rope but Thaku group used it from March 21 after three days of logging. The animals in the two herds left the village each morning around 6 am and were brought back to yak Kharka at around 5 pm.

Data collection

All loggers of yaks were synchronised and every herd started at the same time.

Activity: Activity was measured using accelerometer with the actigraph wGT3X-BT [12,13]. Accelerometer sensors measure the change in speed (velocity) per unit time (M/s^2). To measure and assess behaviour of animals, we did not calibrate the three axes of the accelerometer and used one axis to measure the global activity as the measures on the three axes had high correlation cofficient ($R^2 > 0.7$). The frequency was set at 0.1Hz (one measure every ten seconds). Owing to some battery issues, the activity was measured for seven days for Phurba herd and for five days for Thaku herd.

Spatial associations: Proximities between individuals were measured using blue-tooth technology with the actigraph wGT3X-BT. A received signal strength indicator (RSSI) [14,15] was recorded between two identified loggers every minute (60 Hz). The signal between two loggers was strong at <1 m (-45 RSSI), beame weak at 2-3 m (-90 RSSI), and recording stopped when the distance was >3 m indicating that the actigraphs do not work with greater distance. Moreover, shorter distance fulfilled our purpose because studies usually consider a distance of <3 m between cattles to have positive or affiliated relationships. Due to unresolved battery issues, the proximities between yaks were measured for seven days in Phurba herd and for five days in Thaku herd. Due to difference in the battery life, the absolute frequencies of RSSI were corrected by acknowledging the minimum recorded time for a pair of yaks, which provided a relative frequency of proximities for a pair named as spatial relationship.

Matrices of spatial associations were available for every day and every night for the duration of the study.

GPS locations: GPS locations of the 12 Phurba herd yaks were scored from March 10 to 24, every minute during the day and every ten minutes during the night. With the help of D*plyr* [16], *lubridate* [17] and *moveHMM* [18] R packages, the aberrant GPS points were eliminated by applying a speed threshold of 6 km/h between two locations. To obtain the trajectories with regular time intervals of 2 minutes between two GPS locations, R package

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AdehabitatLT [19] was used with the function *SetNa* and *Sett0*. Animated graphs with maps as background were obtained by using the R package *ggplot2* [20], followed by *gganimate* [21]; 2 000 gif per day were chosen for a graph. The map was added to the figure using the package *GGmap* [22] with API Maps Static (The Maps Static API Service creates a map based on URL parameters sent through a standard HTTP request and returns the map as an image). This allowed us to analyse movements and cohesion of the yaks. All these animated gif images are available on Zenodo (https://doi.org/10.5281/zenodo.7281214).

Data analyses

Activity: Kruskal-Wallis tests were used to test the difference in the activity distribution between the two herds and between juveniles and adults in the two herds.

Social Network Analyses: Firstly, we calculated the mean number of signals exchanged between loggers during the day and at night for each group and for each cattle (as indicated above, this mean number was corrected according to the time of the recording). Secondly, the spatial association matrices were uploaded on Gephi 0.92 [23], which were transformed into social networks. From these networks, we calculated the maximum modularity [24], which measured the strength of division of a network into subgroups. We analysed the effect of groups, their nictemeral rhythm, and presence of tether rope using Wilcoxon tests based on the mean number of exchanged signals and the modularity. However, as the modularity was rarely superior to 0.3, indicating groups could not be further divided into communities, we did not assess which animal belonged to each community. We used a spearman correlation test to correlate the mean received number of signals per individual with age.

Spatial cohesion: Using the GPS locations of yaks, after every 30 m we analysed the number of subgroups. We defined a cluster comprised of one or several cohesive individuals (less than 0.5° longitude or latitude of separation) separated from other individuals (or subgroups) by at least 0.5° longitude or latitude).

All analyses were made using RStudio 2022.02.2 [25]. α=0.05. We summed the values for the two groups for some tests and indicated the statistical differences between the two groups. Data are available at Zenodo: https://doi.org/10.5281/zenodo.7281214.

3. Results

Activity: The activity distribution was same between the two herds (p = 0.92, fig.2A and B). Moreover, the activity profile was not different between adults and juveniles, within the Phurba herd (p = 0.16, fig.1C), and Thaku herd (p = 0.17, fig.1D). At 5 am, the activity increased as the animals left the camp. Grazing was classified as resting period and an activity was observed again at 5 pm when the yaks returned to the camp. The activity was lowest at night, but interestingly around midnight the activity increased except in Thaku herd juveniles because they are attached to the tether rope.

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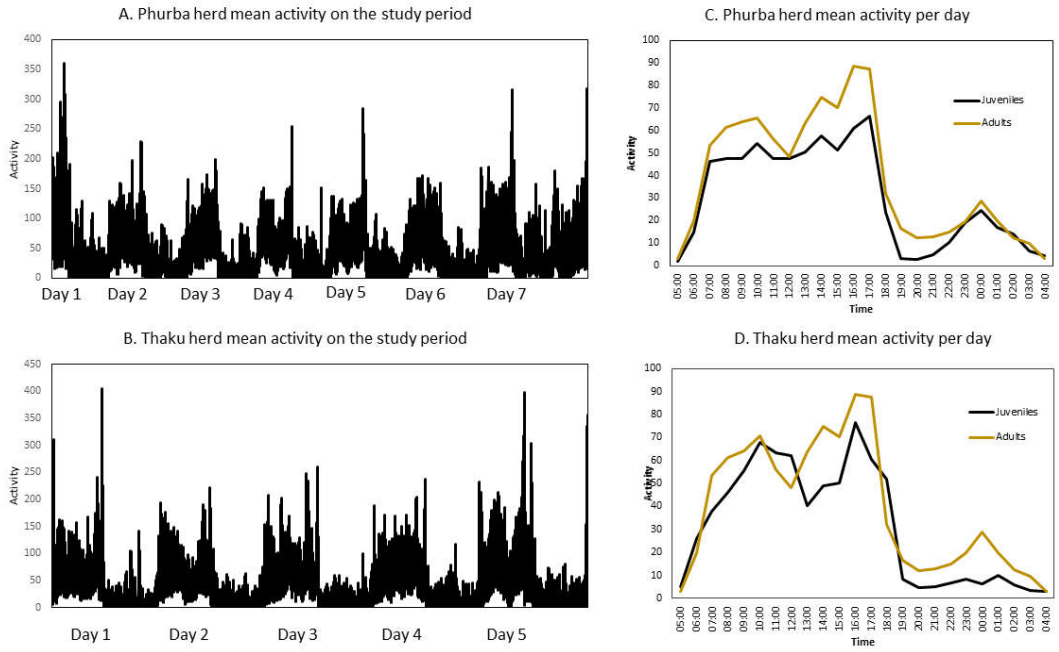

Figure 2. Activity rate of herd yaks measured using actigraph. A. Phurba herd mean activity during the study period. B. Thaku herd mean activity during the study period. C. Phurba herd mean activity per day. D. Thaku herd mean activity per day.

Social networks: More actigraph signals/individual were exchanged (W=54, p = 0.02) in Thaku group (mean = 77.5±38.4), indicating that the cattle in Thaku group were more cohesive than the Phurba (mean = 66.4±32.2) herd. The groups were more cohesive during night than during the day (W=256, p<0.0001, $mean_{night}$ = 67.8±30.8, $mean_{day}$ = 37.6±40.3, fig.1) and the cohesion was higher in the presence of tether rope (W=3, p=0.025, $mean_{with}$ = 108±17, $mean_{without}$ = 34±19). In Thaku group, more signals were received in young individuals due to the tether rope (W=0, p=0.001, fig.3e). Contrastingly, the modularity was same between the two groups (W = 36, p = 0.713, $mean_{thaku}$ = 0.26±0.09, $mean_{phurba}$= 0.24±0.08); groups were more clustered at night than during day (W = 54, p = 0.02, $mean_{night}$ = 0.26±0.09, $mean_{day}$= 0.24±0.08) and the tethering rope increased the modularity (W = 3, p = 0.03, $mean_{with}$ = 0.35±0.08, $mean_{without}$= 0.23±0.07). The modularity was significant in case of tether rope (Q>0.03) as the young individuals clustered together. Finally, the mean number of signals received per individual negatively correlated with age; younger members being more closer to other members than old females (r=-0.52, S=8343, p = 0.002).

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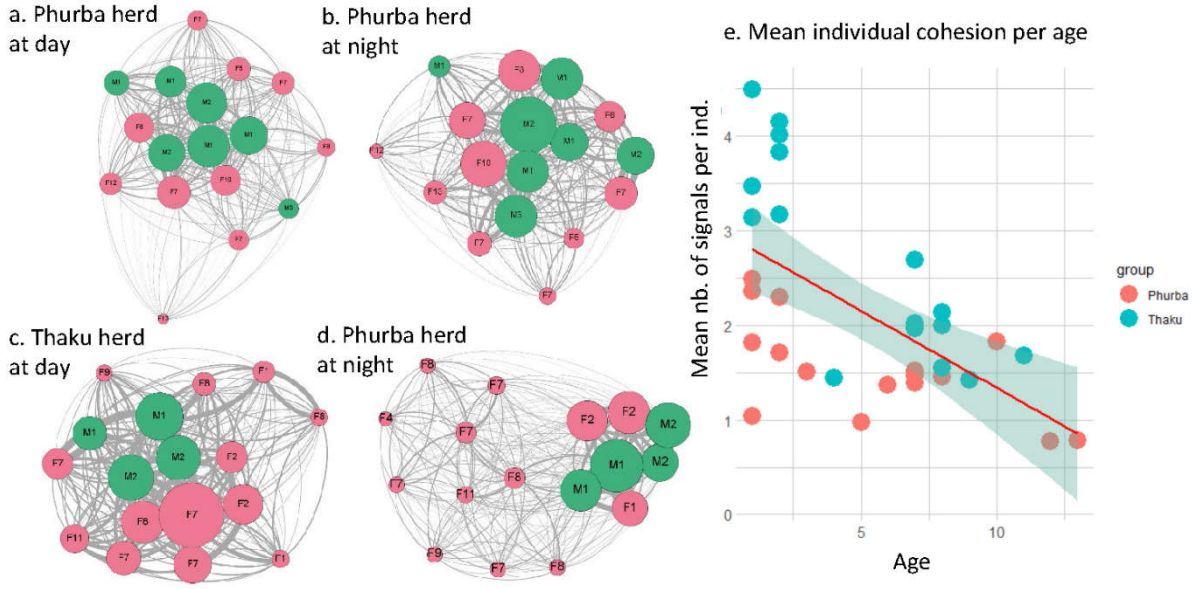

Figure 3. Social networks of Thaku and Phurba herds during day and at night (from a. to d.). e. Mean number of actigraph signals/individual according to age. Pink refers to female and green to male.

Spatial cohesion: The mean number of subgroups observed using GPS was 1.22±0.46. The herd was cohesive (one group) in 78.7% of the scans and two subgroups were observed in 20% of the cases. Three and four subgroups were observed in 1.2% and 0.1% of the scans, respectively. The 24h period analysis suggested that cohesion varies temporally (Kruskal-Wallis test: $\chi^2 = 47$, df=23, p=0.002) but the pairwise comparison tests did not reveal difference between each hour (p>0.1). So, a day was divided into six periods of four hours each and the degree of cohesiveness differed during the periods (Kruskal-Wallis test: $\chi^2 = 29$, df=5, p<0.0001). Higher cohesiveness was observed between 1 a.m. and 4 a.m. than other periods (P<0.002) except for the period between 5 a.m. and 8 a.m. (p=0.09). The mean number of clusters between 1 a.m. and 4 a.m. were 1.05±0.23 whilst in other periods the number was around 1.26±0.58. A lower spatial cohesion was observed around 5 p.m. when yaks returned to the village (1.34±0.58).

4. Discussion

This study is preliminary to a deeper research required on the social behaviour of yaks and impact of domestication on this behaviour. This is the first study to highlight the social behaviour in yaks.

First, whilst the herds had different herding management, animals in the two herds were cohesive and synchronised their activities. Though the herds were rarely seen on the same pasture, but their activity distribution was same during the day. This distribution was punctuated by the phases of leaving the village (yaks were doing this on their own, which is well known in domestic and wild bovines as collective moves or activity synchronization [26–29]) and the phases of returning to the settlement, led by the herdsman. Interestingly, there is a peak of activity during the night and its reoccurence suggested that it was not due to the presence of predators but more because of yaks going for grazing in the close by village. Environmental conditions such as cold may dictate the animals for a night activity such as grazing or mating [30–32], but it was not the mating season and we do not beleive that yaks were cold (the temperature at night was about minus 10°C) [33,34]. However, calves may wanted to nurse, which can explain the activity peak. Herd synchronisation was confirmed by the spatial cohesion of Phurba herd. Eleven animals were fitted with GPS, animals were chosen according to their age and personalities where few animals were identified as independent or not social by the

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herdsman. Results show that 80% of the time the herd was cohesive, especially at night. So, the results indicate that with different herd management practices, domestic yaks stayed cohesive in small groups of females with juveniles and didn't live as wild yaks or as wild bovine species [1,33,35]. However, we noticed that few individuals in both the herds were independent and at four years of age, the cohesiveness with the herd reduced in males. This observation needs confirmation even though it seems coherent in the pastoral system that males are more independent and live separately from the herds. It would be interesting to assess if this cohesion was due to genetic selection during domestication or behavioural that can be lost. We also observed that in the near by valley the yaks were kept feral by the villagers. It was interesting to study their behavior further but it was a challenge to fit these animals with loggers.

When observing individual cohesion, young yaks were more cohesive and exchanged more actigraph signals amongst them and with mature females, but less with the older ones. Usually, in bovids, wild or domesticated, old individuals are more socially central than younger ones (e.g. Highland cattle [36]) or both have similar social centralities (e.g. European bison [35]). Younger ones get their centrality not only by sharing strong links with their mother, but also by forming a crèche (or nursery) and staying together [35]. This was observed in the Phurba group, but another force ruled the Thaku group, which used the tether rope. In the Thaku group, young individuals were very cohesive and clustered at night, but the effect seems to be prolonged during the day as Thaku group was more cohesive during the day than the Phurba group.

This study had two limitations- a). the duration of the study, b). the number of cattle equipped with loggers. Technological advances can mitigate the constraints met at this altitude that affected data scoring (extreme cold and lack of electricity affecting batteries). However, this study shows the importance of herd management on yaks social behaviour, particularly with the resurgence of the snow leopard [37,38] and the climate changes that can dramatically modify the relationships between the predators and wild and domesticated ungulates [39,40]. These results suggest that more studies are needed to understand how herdsmen use social relationships in yaks facing the environmental pressures [41].

Conflicts of Interest: The authors declare no conflict of interest.

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