Association of Domestic Sheep Flocks in the Presence of Livestock Guardian Dogs

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Abstract

This study examined the spatio-temporal association between individual sheep, how they are associated with other sheep within the flock, and how livestock guardian dogs (LGDs) influence that association. To accomplish this, we used global positioning system (GPS)-tracking of individual sheep and randomly selected times throughout the trial periods to compare the association between sheep in the presence and absence of LGDs. This study suggested that sheep accompanied by LGDs have a lower percent association between each other than sheep where LGDs are absent ($P < 0.001$). Results from this and other related studies may improve sheep grazing management and aid future studies interested in monitoring sheep movement and range utilization.

Introduction

In the U.S., sheep are primarily raised for meat, wool, and dairy products (American Sheep Industry 2012). In 2010, approximately 81,000 sheep producers existed in the US and by 2012 that number rose to just over 84,000. In 2004, US sheep producers spent $98 million on various non-lethal predator controls (American Sheep Industry 2012) with livestock guardian dogs (LGD) considered one of the most effective methods. Until relatively recently use of LGDs was not common in the US. However, LGD use has rebounded principally in response to increasing predator populations. Common LGD breeds include the Great Pyrenees, Akbash, and Komondor (Livestock Guardian Dogs 2012).

Understanding the indirect or non-lethal affects predators have on livestock is important to producers and the sheep industry (e.g., increased stress and decreased foraging efficiency). Similarly, understanding the affect LGDs have on sheep is also important. For these reasons, we sought to describe and compare flock

behavior in the presence and absence of LGDs within an environment where predators were common and determine if sheep exhibited different flock associations due to the presence of LGD.

Methods

Study site: U.S. Sheep Experiment Station

The USDA, Agricultural Research Service, U. S. Sheep Experiment Station (USSES) operates five separate range research locations totaling over 20,000 ha and manages approximately 3,000 adult sheep and their lambs. These sheep are primarily Rambouillet, Columbia and Targhee breeds. The latter two, which were the first major composite breeds developed in the US, were released to the public from the USSES in the 1920s . The USSES uses Akbash and Akbash/Great Pyrenees crosses for LGDs, with two dogs typically accompanying each flock into pasture.

Data collection:

Collars carrying global positioning system (GPS) receivers were fitted to a randomly selected subset of sheep grazing the USSES headquarters allotment near Dubois, Idaho from April 28 through May 10, 2010. In total, there were two groups of sheep with approximately 140 sheep within each group. Fifteen sheep were selected from each group (~10%) and fitted with GPS collars that recorded their position every second (± 4.41 m @95% CI). Each group grazed two different pastures (65 ha each) for two days each. The study pastures were enclosed with 2-m high predator-proof fencing. However, these sheep were not typically grazed in areas with predator-proof fencing and indeed, are regularly exposed to predation by coyotes, bears, mountain lions, and wolves. Hence, these sheep were accustomed to the presence of both LGDs and predators.

Beginning April 28, group one was located in pasture 30D (figure 1) along with two LGDs. Group one was then rotated into pasture 30C at which point the LGDs were removed. Group two was initially placed

in pasture 30A and then moved to pasture 30B and accompanied by the two LGDs at that time. The groups were grazed in diagonally adjacent pastures to keep interaction across the fence to a minimum.

Following the grazing periods, data stored by the GPS receivers were collected and saved in separate ASCII files for each sheep. The GPS data collected included collar number, date/time, and X, Y coordinates (± 4.41 m with 95 % CI).

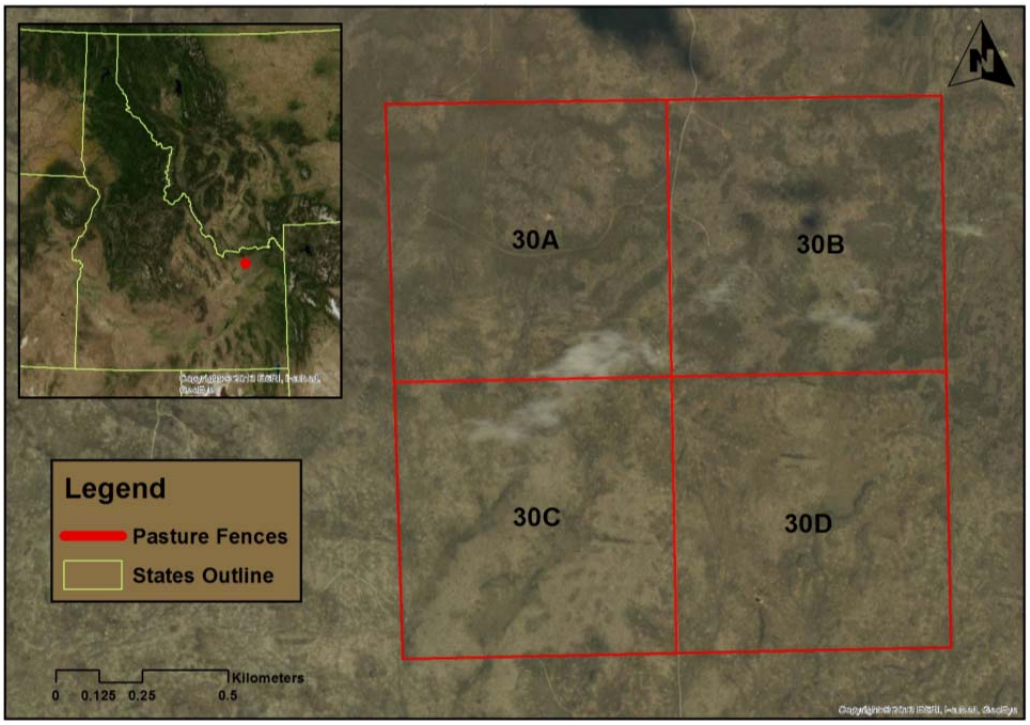

Figure 1. Pasture orientation and nomenclature used in this study.

Data analysis:

We used the geospatial location of individual sheep relative to other monitored sheep to describe flock behavior. These data were analyzed using Association software (Weber 2012). Association Software aids in understanding the spatio-temporal association observed among herd animals. In addition, this software addresses independence of animal locations by producing matrices that describe observed independence/association. To prepare the GPS data for use in Association Software, several formatting changes were performed within MS Excel spreadsheet software. Specifically, since Association software recognizes and requires five data fields (ID, date, frequency, X, and Y coordinates) the source data

needed to be arranged to follow this format. The ID field contained each sheep's unique identification number, the date field contained the date and time of the observation, frequency was the same as the ID field, and the X and Y fields represented the geospatial easting and northing in Idaho Transverse Mercator (NAD 83). Association software was originally developed for use with radio telemetry data where the frequency of the collar was one way to track individuals. However, over a period of years, a given animal may be outfitted with different collars having different frequencies. This allows users to identify the individual (ID) plus maintain records of specific radio collars used on that animal. The date field was particularly important in this study and because locations were recorded each second a tremendous amount of data was available for analysis. Hence, the date field uniquely identified each recorded observation. One spreadsheet was completed for each sheep and exported to a comma separated values (CSV) file for use within Association software.

Due to the volume of data collected and slight second/millisecond variability in recorded timestamps, all data were filtered to identify the first record collected during each minute of the study. This subset was used for the remainder of the analysis. Using this subset, 30 randomly selected timestamps were chosen and animal association comparisons made between flocks of sheep in the presence/absence of LGDs.

Association Software requires both a temporal and spatial threshold for analysis. The spatial threshold describes the maximum Euclidean distance two individual sheep can be apart and still be considered associated with one another. The temporal threshold asks for the minimum amount of time two individual sheep must be observed together to be considered associated.

Association software provides output in four individual files. The first is named Assoc1.txt, and contains the raw summary matrix detailing the frequency count for each pair of individual sheep that met the spatial threshold criteria. The second file, Percent.txt, contains a matrix with percent association (a conversion of Assoc1.txt). The only difference between the two is that values in Assoc1.txt are expressed

as frequency (count) while Percent.txt values are expressed as percent. The third output file is called Similar.txt and contains a matrix with Boolean or binary indicators describing both the spatial and temporal association for each pair of individual sheep. The association of each pair of sheep is indicated with a 1 (yes) or 0 (no). The fourth output file is named Herds.txt and lists all individuals and their herd assignment if adequate associations (the spatial and temporal thresholds were satisfied) were observed during the analysis. This file also identifies the template individual (cf. herd cow concept) best able to designate herd assignments. The last entry in this text file identifies how similar the pattern of association was between individual sheep and the template individual. For this study, data from the percent output file was used and all analyses were completed using a temporal threshold of 50% along with four spatial thresholds (25, 50, 75, and 100 meters). A statistical comparison of association was made using analysis of variance (ANOVA) ensuring both consistent sample size and that individual sheep records were correctly paired for statistical analysis across the duration of the study. This improved confidence in test results and removed individual variability from the overall study.

Results and Discussion

In several cases, the GPS collars failed before the end of the trial and as a result, we were able to include only seven individual sheep from group one (47%) and 11 sheep from group two (72%). To ensure even sample sizes for ANOVA testing we analyzed and reported results for the same seven individual sheep.

Average percent association was calculated for all sheep using results from Association software analysis. The higher the percent value the more associated the flock of sheep were considered. Results illustrate lower percent association for sheep accompanied by LGDs relative to sheep where LGDs were absent (table 1). Statistical comparisons of mean percent association were significant in all cases ($P < 0.001$). This suggests flocks behave more spatially dispersed when LGDs are present and may be the result of decreased individual vigilance activity. An indirect result of this change in behavior may be a concomitant difference in pasture utilization, however this study can only speculate upon this at this time.

Table 1. Results of sheep association analyses showing mean percent association at various spatial thresholds.

	Mean flock association (%)	
Spatial threshold	**LGD Present**	**LGD Absent**
25 meters	3.9	18.3
50 meters	9.7	36.0
75 meters	14.8	56.5
100 meters	19.0	65.8

Results of the association analysis are unique and illustrate that once sheep are placed in a herd, they tend to stay together in that herd instead of breaking into separate sub-herds or simply acting as individuals grazing the landscape. This differs from numerous other studies using association analysis where elk (Weber et al., 2001) and cattle herds (Harris et al., 2007) were shown to exhibit far less herd fidelity. Overall, this study suggests the presence of LGDs does affect sheep behavior.

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