MONITORING GRAZING GOATS' BEHAVIOR USING SENSORS AND SATELLITE REMOTE SENSING

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ABSTRACT

The recent development of new methods for remotely observing animal behavior using electronic sensors such as global positioning systems (GPS) and three-axis accelerometers to monitor and record behavior at different spatial and temporal scales presents real opportunities to better understanding and interpreting behaviors of grazing animal. The goal of this study was to distinguish different behavioral categories of grazing goats by combining GPS collars, accelerometers, and satellite remote sensing. It was conducted in the mountainous forest rangeland of Beni Arouss (Northern Morocco) from an extensive local goat's farm. Eight experimental goats were fitted with GPS collars and leg sensors to monitor their seasonal grazing activities. A calibration study and classification tree analysis were used to predict the grazing activities of goats. According to the results, goats spent most of their time searching for forage in the spring and autumn. Goats prolonged their resting time in summer ($p<0.001$) at the expense of grazing time. The number of steps was numerically similar and significantly higher in both seasons of summer and autumn ($p<0.001$). Goats spent 48% of their feeding time grazing (foraging) during the spring season, in contrast to the summer (27%) and autumn (31%). Analysis of GPS collar data showed a significant effect of the season on the measured parameters ($p<0.001$). Monitoring grazing activities by using GPS collars and sensors provides useful and accurate information, which could be used to manage grazing strategies and optimize animal performance

INTRODUCTION

In Northern Morocco, forest rangelands ensure abundant and free fodder production for grazing animals. Livestock in this region is concerned with grazing goats in forest pastures, guaranteeing free animal feed all year round (Chebli et al., 2023). Grazing in mountainous forest rangelands generates additional physical activities for the vertical locomotion of goats (Chebli et al., 2022). These altitudinal motions increase the time and energy required to travel a given distance. This information is difficult to obtain only through direct observation because observers cannot accurately measure individual animal behavior, such as movement and activity patterns. Data on an animal's behavioral activities are critical to understand feeding behavior and interactions with the environment, and to identify optimal management intervention strategies. The recent developments in Global Positioning Systems (GPS) and the increasing number of accelerometers used to monitor and record behavioral activities offer real opportunities to expand databases and understand animal grazing behavior. Previous studies using sensors and GPS technology to track animal grazing activities have focused on grazing cattle and sheep (Barbari et al., 2006; González-Pech et al., 2015; Ungar et al., 2018). The aim of this research is to ensure the sustainability of goat farming in extensive production systems using GPS collars, sensors, and remote sensing to better

understand the grazing behaviour of goats to make targeted decisions for management and grazing strategies.

MATERIALS AND METHODS

This work was carried out in the forest pasture of Beni Arouss in Northern Morocco. Eight experimental local meat goats of the Beni Arouss breed (local goat, 30 ± 2.6 kg live weight (BW) and 36 ± 6 months of age) were chosen to conduct this study, during the three-grazing seasons (spring, summer, and autumn). Goats spend most of their day in the studied forest pasture. At the end of the grazing day, the animals are confined to a closed and semi-open shed inside the farm. In winter, access to forest rangelands is very limited and corresponds to the calving period. To ensure that goats are fed during winter season, herders delimb the branches of evergreen trees in the forest as fodder and bring them to the goat farm (Chebli et al., 2023). Each experimental goat was fitted with a GPS collar and an IceTag sensor on the left hind leg for three days during each studied season. Several days before the actual experimentation, these goats were fitted with GPS collars and IceTag sensors to accustom them to the devices attached to their bodies. GPS data was used to estimate location, speed, and horizontal and vertical traveled distances. The data were analyzed by the GPS3000 Host software. Coordinates were converted from UTM WGS84 to Moroccan Transverse Mercator using ArcGIS 10.X. Coordinates (x and y) in meters were calculated for each fixed record using ArcMap. The vertical distance (VD) was derived from the altitude difference between successive positions 1 (z1) and 2 (z2). IceTag data was analyzed by IceManager software. The variables provided are the goat is lying (sitting to rest or ruminating), standing (standing without eating and ruminating), number of steps, and movement index (a proprietary metric of overall leg activity measured in three dimensions).

Data analyzes were performed using SAS software. The grazing activity data were analyzed according to the SAS PROCMIXED procedure. Parameters were compared across seasons (i.e., spring, summer, and autumn). For all analyzes, the level of significance was declared at $p < 0.05$. In case of significance, means were compared using Tukey test.

RESULTS AND DISCUSSION

Figures 1 and 2 represent the seasonal variation of grazing goat activities. Goats spent most of their time searching for palatable species in the spring and autumn. Goats prolonged their resting time in summer ($p<0.001$) to the detriment of resting time. The number of steps was numerically similar and significantly higher in both seasons of summer and autumn ($p<0.001$).

Analysis of GPS collar data showed a significant effect of the season on the measured parameters ($p<0.001$). During the summer, the forage availability is very limited, which obliges the goats' herder to move during this season and to settle in another forest pasture in the region (Figure 2). The horizontal distance traveled by goats was similar and significantly higher in autumn and summer. A similar trend was observed for the vertical distance. Conversely, goat speed was significantly higher in spring compared to other seasons ($p<0.001$). Foraging day length (time spent grazing) was prolonged ($p<0.001$) in summer compared to autumn and spring. According to CART (Classification and Regression Tree) analysis, the time spent grazing (eating) was longer in spring and similar in summer and autumn ($p<0.001$). Standing rest was similar between seasons ($p = 0.191$). Time spent walking without grazing (eating) is classified as fall > summer > spring. The

findings of this study correlate with seasonal variations in grazing behavior of goats in similar forest pastures (Chebli et al., 2022). In other regions of Africa, Safari et al. (2011) reported that goats in the semi-arid zone of Tanzania increased their grazing (eating) time (57–68%) and decreased their resting time (6.8–1.4%) between rains and late summer, while their time spent walking was similar (27%). In a similar region of Zimbabwe, goats spent most of their time eating during the rainy season (52–75%) in contrast to the summer (29–50%) (9. Nyamangara et al., 1995). Like the current results, goats spent 48% of their feeding time grazing (eating) during the green season, in contrast to the summer (27%) and autumn (31%) seasons [2]. This result could be explained by the high abundance of preferred shrubs (*Cistus spp*. and *Lavandula stoechas*) and herbaceous plants during the spring season. In the semi-arid zone of Tanzania, Safari et al. (2011) reported that goats extended the length of their grazing day in the summer compared to the rainy season to meet their intake requirements.

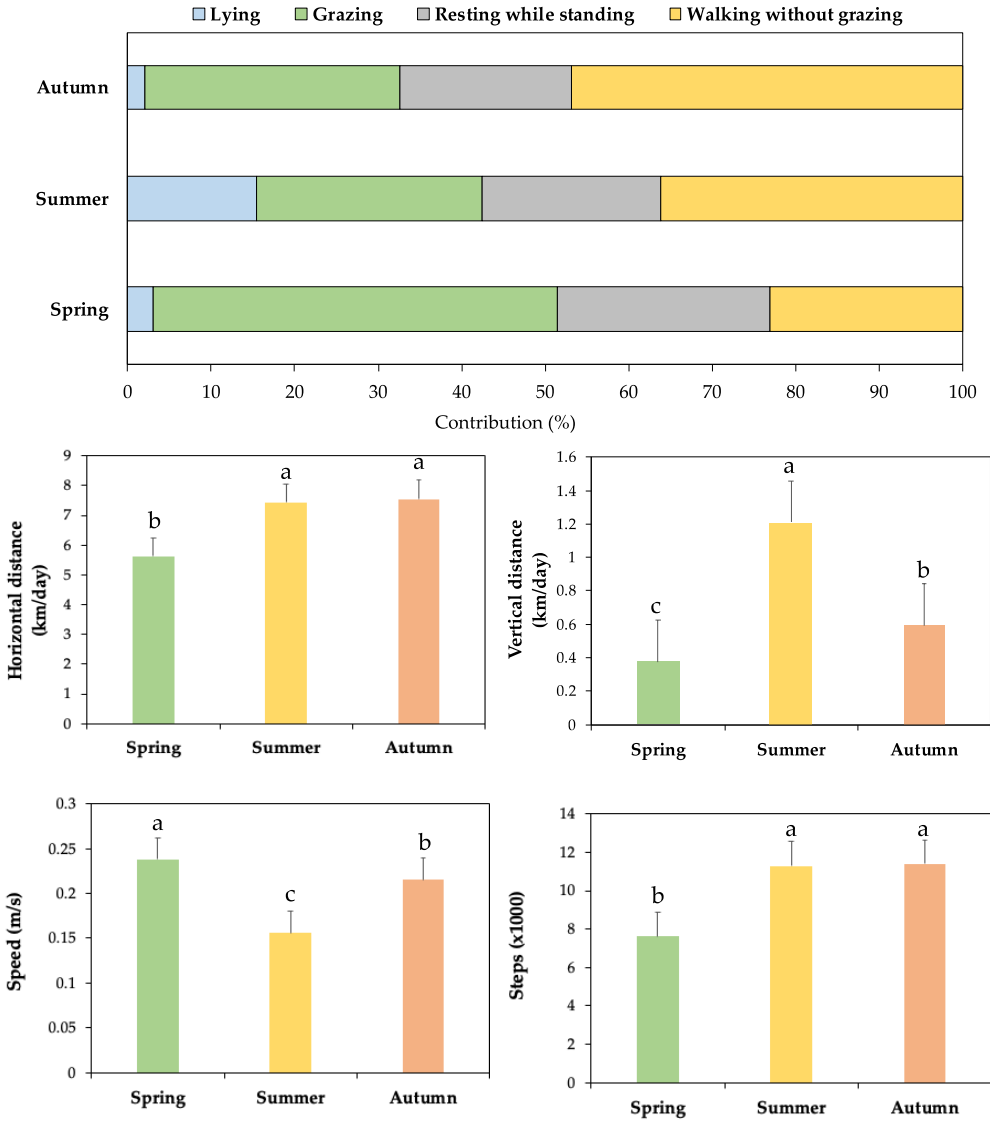

Figure 1. Seasonal variation in grazing activities of experimental local goats browsing in Beni Arouss pasture (Northern Morocco).

CONCLUSIONS

The combination of GPS collar, accelerometer, and remote sensing to monitor and record the grazing activities of goats has provided useful data for understanding the grazing behavior of goats in a complex forest rangeland of Northern Morocco.

Data on individual animal behavior, such as movement and activity patterns, are often important for their management on pasture. It would be more interesting to extend this type of study to other livestock systems and other types of animals to develop a guide on the use of forest pastures in Morocco.

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