

Sheep grazing patterns for better land management: adjusting GPS tracking protocol

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Over centuries, the small ruminant systems of northeast Portugal evolved, utilising assorted farming remnants that made them resilient to changes throughout time. Local breeds of sheep and goats fit their productive niche constrained by the landscape and the main crops: cereals and cattle. Typically, the shepherds drive flocks of no more than two hundred head around five kilometers of the parish landscape to take advantage of a combination of agriculture by-products and natural vegetation: fallow and agroforestry patches, vegetable leftovers, orchard prunes, woods, and shrublands.



Shepherding routes became recorded by GPS-equipped collars, firstly with memory recording unit, nowadays with GSM and satellite data transmission. The team is now developing a technological solution to record ecosystem usage by the flocks of sheep and goats and integrate it with the CAP Portuguese map services. Readability and cost-effectiveness are crucial to success. This work's objective was to determine how many collars per flock and what positional data time-interval we need without losing shepherding recording precision.



Flock monitoring occurred from December 2020 to June 2021 solstices to cover all seasonal winter to summer variation in sheep diets and vegetation development. We followed the flock with three sets of DOMODIS IP67 GPS receivers and transmitters mounted on collars, housed in 115 x 65 x 40 mm plastic containers together with a DMS-Bat PLUS lithium. Each collar weighed 750 g, and the three selected sheep accepted them without any obvious irritation. We recharged and changed all batteries monthly to record and transmit the three GPS positions every five minutes, enough to trace a spatial grazing pattern of reference. Positional data includes Gauss-Krüger coordinates of latitude and longitude, date, time, and battery status, transmitted to, stored and uploaded from the DOMODIS web platform.



For 186 days, the collars transmitted 35509 positional records in total (reference dataset), 13811 at 15-minute intervals, and 9613 at 30-minute intervals: collar C1 registered 10170 positions in total, collar C2 11414 positions, and collar C3 13925 positions. It reveals a recurrent pattern on landscape patches utilized by the flock that is more accurate for 5-minute sub-datasets and 3-collar sub-datasets. The recording options' yearly costs range from €336 (3collars/5-minute intervals) to €78 (1 collar/30-minute intervals). The similarity with the reference dataset quickly drops when we extend the recording interval and not so quickly if we reduce the number of utilized collars.



Our results indicate that increasing registering intervals and decreasing collars number involve a decline in the flock positioning accuracy as expected. It means that flock displacement on the terrain requires a positioning refinement. According to the similarity declining, increasing registering intervals affects the positioning accuracy more than reducing the number of flock's collars. Nevertheless, the three collars reveal a differential behavior, and C1 and C2 performed worse than C3. Along with records amount, two main reasons could contribute to that: differences in equipment (components, battery life, manufacture) and differences in the animal character within the flock; further research needs to investigate both..



Shepherding practices provide important ecosystem services, and their cost requires reliability. Our study strengthens the GPS and similar systems function to evaluate landscape usage by shepherding in north-eastern Portugal accurately. It clarifies how the number of collars and the registration rates affects the system performance. According to our results, we can register the shepherding routes satisfactorily with just one collar if we get short positioning intervals. This means that we can reduce equipment costs significantly. So, the next step is to reduce the operating costs associated with the data transmission services. It demands renegotiating the web platform services agreement or researching alternative data transmission and logging systems to decrease costs in the future.

