Use of pastures by cattle in a Pyrenean ski station: Diagnosis and recommendations for improved preservation of natural resources and snow condition

Casasús I.[1*], Rodríguez-Sánchez J. A.[1], Sanz A.[1], Ferrer C.[2], Reiné R.[2], Barrantes O.[2]

[1] Centro de Investigación y Tecnología Agroalimentaria de Aragón (CITA), Zaragoza, Spain.
[2] Dpto. Ciencias Agrarias y Medio Natural, Universidad de Zaragoza, Zaragoza, Spain.

***E-mail: icasasus@aragon.es**

Abstract

Ski stations are commonly located in alpine pastures where livestock graze during part of the year, providing a synergy in which animals benefit from the grazing resources while their consumption guarantees the stability of the snowpack during the winter. The current study was conducted on a 297-ha ski station grazed by 314 cows during the summer and early autumn. The patterns of space use were studied on 8 days throughout the grazing season, by scan-sampling at 30-min intervals during daylight hours. The number of heads, activity and position of the different groups were recorded and entered into a Geographic Information System (ArcGis Desktop 9.3). For each observation polygon a vegetation class and pastoral value, altitude, slope, exposure, distance to tracks, station infrastructures, water points and salt areas where calculated or assigned. Abiotic factors where compared between grazed and non-grazed areas, Ivlev's electivity index was calculated for the different vegetation types and land use categories (n=12). Cattle grazed on 190 ha (64% of the total area) and rejected areas of lower pastoral value (16.4 *vs.* 24.3 points in non-grazed and grazed areas), with higher slope (23 *vs.* 16%), located at higher altitude (1895 vs. 1695 m), and farther from salt supply (1004 *vs.* 461 m), buildings (402 *vs.* 237 m) ($P<0.001$) and roads, but unexpectedly closer to water (381 vs. 442 m, $P<0.05$), therefore water availability was not a limiting factor for pasture use in this area. Ivlev's electivity index was negative for rocky areas (-0.60), lower forests (-0.24) and *Festucion eskiae* pastures (-0.24), while preferences were observed for *Festucion gautieri, Nardion strictae, Caricion nigrae* and *Bromion erecti*, related either to their pastoral value or to their geographical location. After a diagnosis of current use, recommendations were made for a more homogeneous distribution of livestock on the area, either by modifying temporal and spatial management or by providing infrastructures (fences, salt distribution areas) to ensure a proper use of each vegetation type.
Keywords: livestock, ski resort, space use, management.

Introduction

Ski stations are commonly located in high alpine pastures where livestock graze during part of the year, providing a synergy in which animals benefit from the grazing resources while their consumption guarantees the stability of the snowpack during the winter. Livestock can therefore be used as a tool for environmental management in these areas, provided their pasture use is adequate for this purpose. This may not be the case in free-ranging herds, which is now the common management in many mountain areas.

Several studies have shown that spatial use of unguarded animals is not homogeneous, because livestock select their grazing sites according to different biotic and abiotic factors (Bailey, 2005). This can lead to high stocking density in some areas while others are underutilized, both having negative effects on pasture preservation, i.e. overgrazing may lead to soil compaction or excessive accumulation of dejections, while too low grazing pressure can result in pasture invasion by shrub species and reduction of herbage quality (Casasús *et al.*, 2007).

In the case of cattle, slope, distance to water sources and vegetation community, which affects the amount and quality of available herbage, are among the most important factors conditioning pasture use (Senft *et al.*, 1985). Several studies have also highlighted the role of distance to salt or mineral supply, to roads and fences, the existence of shadowed or protected areas, or exposure to dominant winds (Pinchak *et al.*, 1991; Bailey *et al.*, 1998). Moreover, livestock patterns of space use are not constant throughout the grazing season; preferences change according to pasture characteristics and animal nutritional needs, thermoregulation and well-being (Casasús *et al.*, 2009).

Knowledge of livestock patterns of pasture use is crucial to determine if interventions are needed to enhance a more adequate use of the available resources, in order to optimize their utilization and to obtain the expected positive outcome from grazing, particularly when other land uses concur (Casasús *et al.*, 2013). Therefore, the objective of this study was to determine the factors influencing pasture use by livestock in the area of a ski station, and to suggest correcting measures where needed.

Material and methods

The study was conducted in Aramón-Panticosa ski station, in the Spanish Pyrenees. A herd of 314 adult cows and their offspring grazed during 71 d in the early summer (14/6 to 28/7) and early autumn (30/9 to 27/10) of 2011 on the 297 ha occupied by the ski station. During the rest of the summer they were transferred to other alpine pastures according to the traditional practice in the valley.

The patterns of space use in the study area were analyzed on 8 days throughout the grazing season, at weekly intervals. The number of heads, activity and position of the different groups were visually registered by instantaneous scan-sampling (Lehner, 1996) each 30 min during daylight hours. This method involves collecting data of the entire herd at regular intervals and extrapolating for the time separating two successive scans. Data were recorded on-site on a map and database and later entered into a Geographic Information System (ArcGis Desktop 9.3) (n=278 observations). Previously, a Digital Elevation Model had been derived from a georeferenced map, and by the combination of photo-interpretation and field research the available pastures had been classified into 8 vegetation types according to the phytosociological method (Braun-Blanquet, 1965) *(Bromion erecti* (37% of the area), *Festucion eskiae* (22%), *Nardion strictae* (8%), *Primulion intrincatae* (4%), *Festucion gautieri* (3%), hygronitrophylous pastures (1%), dense forest pastures (2%), open forest pastures (1%); 230 ha), the rest being other land use categories (bare rock areas, lakes, roads/ski tracks and buildings (Barrantes *et al.*, 2013)). Salt and drinking troughs were located on the map.

For each polygon, stocking rate (livestock units (LU)*month/ha) was calculated from field data. The original 278 polygons were merged into a single layer, resulting in 217 cells with a given stocking rate, for which vegetation type, pastoral value, altitude, slope, exposure, distance to roads, buildings, water and salt areas where assigned or calculated from the coordinates of the polygon centroid. The same parameters were calculated for non-grazed vegetation types/land use polygons (n=73).

Ivlev's electivity index (Jacobs, 1974) was calculated for the different vegetation types and land use categories (n=12), in order to detect which were preferred or avoided relatively to their availability (values from +1: highly preferred to -1: completely avoided).

Abiotic factors were compared between used and avoided areas by variance analysis (proc GLM, SAS 9.1), where livestock use (grazed vs. non-grazed) was the fixed effect. The patterns of use through the grazing season were compared by proc GLM, with season (summer vs. autumn) as fixed effect. Within grazed areas, Pearson correlations were established between stocking rate and pastoral value and site abiotic characteristics. These aspects were compared among vegetation types (proc GLM, vegetation type as fixed effect). Least Square means (± SE) are presented, with differences tested with a t-test.

Results and discussion

Cattle used 190 of the 297 ha of the ski station (64% of the area), at an average stocking rate of 0.646 LU*month/ha on 190 ha during 2.3 months. Therefore, 282 LU used these pastures in the grazing season, which is exactly the carrying capacity proposed by Barrantes *et al.* (2013) for the pastures of the ski resort. This is the result of a long grazing tradition and reflects an accurate knowledge by local farmers, who have adjusted animal needs and censuses to pasture offer (Casasús *et al.*, 2013).

Grazed and non-grazed areas were different in many aspects related to terrain characteristics and pastoral value (Table 1). Grazed sites were in lower areas of the station, with lower slope, mostly of W exposure, and closer to salt placements, buildings and roads, and with higher pastoral value. Surprisingly, non-grazed areas were closer to water troughs or lakes, therefore this was not a factor limiting pasture use here, differing with other areas (Bailey, 2005; Putfarken *et al.*, 2008).

Ivlev's electivity index differed among vegetation types and land use categories: some of them were preferred (*Festucion gautieri +0.23, Nardion strictae +0.19, Caricion nigrae +0.16, Bromion erecti +0.14*) while others were avoided (*Primulion intrincatae* -0.14, *Festucion eskiae* -0.24, open forest -0.24, and especially bare rock -0.6). This agrees partly with the quality and carrying capacity of each pasture type (Barrantes *et al.,* 2013), although some high quality areas (*Primulion intrincatae*) seem to be underutilized due to their higher altitude and distance from salt.

Table 1: Characteristics of grazed and non-grazed areas.

	Grazed	Non-grazed	Sign.
Altitude, m	1695 ± 127	1895 ± 209	***
Slope, %	16 ± 7	23 ± 10	***
Aspect, º from N	254 ± 114	156 ± 120	***
Distance to salt, m	461 ± 402	1004 ± 563	***
Distance to water, m	442 ± 233	381 ± 215	*
Distance to buildings, m	237 ± 175	402 ± 213	***
Distance to roads, m	63 ± 67	88 ± 73	**
Pastoral value, points	24.3 ± 10.1	16.4 ± 14.1	***

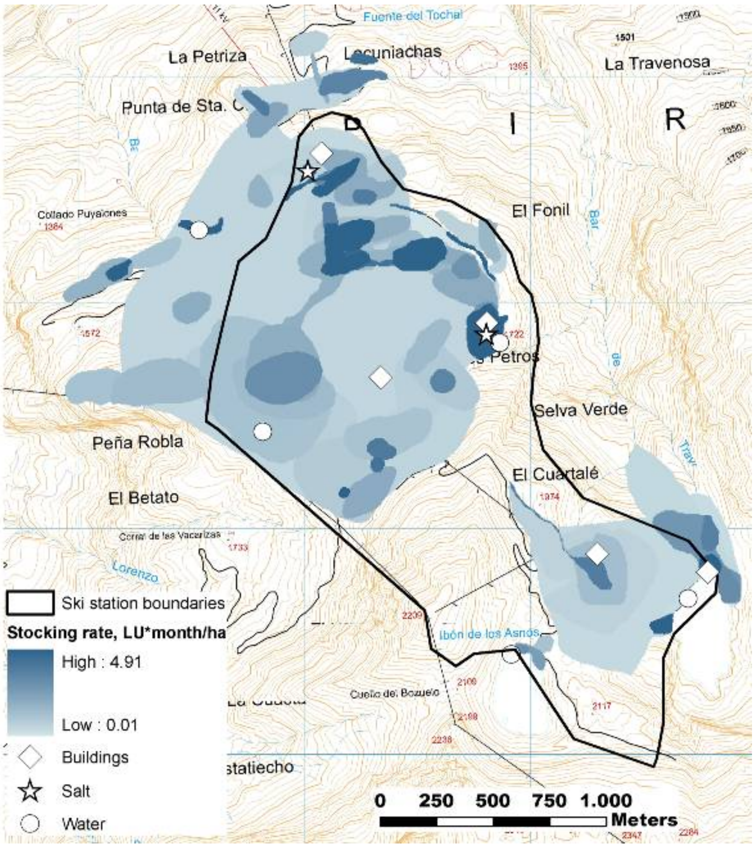

Figure 1: Cattle distribution and stocking rates.

Within grazed areas, cattle distribution was not homogeneous (Figure 1). Stocking rate was negatively related ($P<0.001$) to slope ($r=-0.23$), distance to roads (-0.32), buildings (-0.34), salt (-0.35), altitude (-0.38) and, surprisingly, to pastoral value (-0.38). The later was associated to the fact that the higher quality vegetation type (*Primulion intrincatae*, 34 points) was less used due to the aforementioned abiotic aspects, while cattle were often concentrated at very high stocking rates (average 1.86 LU*month/ha) close to roads or bare areas close to ski infrastructures with null pastoral value. Average stocking rates on the different vegetation units and other categories of land use ranged between 0.01 and 0.51 LU*month/ha. When cattle activity was considered, rest areas were more conditioned by topographic factors than grazing areas, as observed by other authors (García-González *et al.*, 1990; Aldezábal *et al.*, 2012).

Table 2: Livestock use and characteristics of the main vegetation types and land use categories in the sites where cattle was located.

	Bromion erecti	*Festucion eskiae*	*Nardion strictae*	*Primulion intrincatae*	*Festucion gautieri*	*Caricion nigrae*	*Roads, infrastruct.*	Sign.
Stocking rate, LU*month/ha	0.428 ^{b}	0.291 ^{b}	0.519 ^{b}	0.172 ^{b}	0.013 ^{b}	0.162 ^{b}	1.857 ^{a}	***
Altitude, m	1675 ^{de}	1992 ^{ab}	1857 ^{bc}	2080 ^{a}	1786 ^{cd}	1764 ^{cde}	1619 ^{e}	***
Slope, %	17.2 ^{a}	8.5 ^{b}	18.2 ^{a}	15 ^{ab}	11 ^{ab}	6.8 ^{b}	12.1 ^{ab}	***
Aspect, º from N	249	252	233	308	311	227	285	NS
Pastoral value, points	29 ^{a}	20 ^{b}	21 ^{b}	34 ^{a}	3 ^{c}	16 ^{b}	5 ^{c}	***

$^{abcd:}$ within the same row, means with different superscript differ at $P < 0.05$.

Cattle showed distinct seasonal patterns of site use, as observed by Senft *et al.* (1985). In the summer the herds were concentrated in smaller areas, with higher stocking rates than in the autumn (0.747 vs. 0.362 LU*month/ha in summer and autumn, respectively, P<0.001); closer to salt (406 vs. 615 m, P<0.001) and tracks but farther from water (482 vs. 329 m, P<0.001) and buildings, and of higher slope (16.6 vs. 14.4%, P<0.05) but lower altitude (1672 vs. 1759 m, P<0.01).

Barrantes et al. (2013) suggested the best grazing management for each vegetation type in the ski station, considering both livestock performance and an adequate consumption of pasture that would not compromise the permanence and security of the snowpack in the winter. The actual use indicates that *Bromion erecti* pastures are grazed according to those recommendations (at the start and end of the grazing season), and *Festucion eskiae* and particularly *Festucion gautieri* pastures are naturally avoided (as suggested, to prevent from soil erosion). On the opposite, the high quality *Primulion* pastures should be grazed throughout the summer, and *Nardion* pastures, that are grazed at an early development stage (at the start of the grazing season) should also be grazed at the end of the summer, in order to avoid biomass accumulation and, hence, to improve the permanence of the snowpack in the ski runs in winter. The use of both pasture types could be forced by supplying salt in the target areas, and temporally fencing access to others. Although distance to water did not have a major influence on pasture use, in order to avoid the establishment of hygronitrophylous pastures, detected by a leaking water trough, these should be placed in steep areas, float valves should be used and periodic maintenance should be done.

In conclusion, the current stocking rates on pastures in the ski station are adjusted to their carrying capacity. However, the use of space by livestock is not homogeneous but conditioned by different biotic (vegetation type) and abiotic factors. Among the abiotic ones, some are natural (altitude, slope), but others, such as location of salt supply, are of anthropic origin, and could be easily improved for enhanced livestock performance and ecosystem preservation.

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