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Holistic Management: an approach to increase pasture sustainability and mitigate climate change effects

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Abstract. Improving grazing management could increase soil carbon sequestration and other goods and services in grazing lands and contribute to increase pasture sustainability. The objectives of the study were to compare two grazing management techniques, one of them referring to holistic management. Nine plots, located in three farms in the Southwest of Iberian Peninsula under an Adaptive Multi-Paddock (AMP) grazing were compared with nine control plots of neighbouring farms with similar vegetation and soil and under a rotational stocking method. The analysed indicators were: Rangeland Health Index (RHI), plants richness and biodiversity, and soil quality like bulk density, total carbon and nitrogen, availability of phosphorous, calcium and potassium, microbial diversity and enzymatic activity. The results reveal better values of all indicators analysed in the AMP grazing plots in relation to control ones. Significant differences were found in percentage of ground cover, species richness, and availability of phosphorus and potassium ($P<0,05$). Although more studies are needed, these preliminary results show a trend to better health ecosystem and soil quality in the farms under AMP grazing. These findings highlight the importance of researching and implementing sustainable grazing managements to keep and restore grasslands thanks to ecosystem services generated by livestock, including carbon sequestration and climate regulation.

Keywords. Holistic management – Adaptive Multi-Paddock (AMP) grazing – Ecosystem health – Soil quality.

Gestion holistique : une approche pour accroître la durabilité des pâturages et atténuer les effets des changements climatiques

Résumé. *L'amélioration de la gestion des pâturages pourrait augmenter la séquestration du carbone dans le sol et d'autres biens et services dans les pâturages et contribuer à accroître la durabilité des pâturages. Les objectifs de l'étude étaient de comparer deux techniques de gestion du pâturage, l'une d'elles faisant référence à la gestion holistique.Neuf parcelles situées dans trois exploitations situées dans le sud-ouest de la péninsule ibérique sous un pâturage adaptatif à plusieurs enclos (AMP) ont été comparées à neuf parcelles témoins de fermes voisines présentant une végétation et un sol similaires et une méthode de stockage en rotation. Les indicateurs analysés étaient les suivants : indice de santé des parcours (Richland Health Index, RHI), richesse des plantes et biodiversité, et qualité des sols comme la densité apparente, le carbone total et l'azote, la disponibilité de phosphore, de calcium et de potassium, la diversité microbienne et l'activité enzymatique. Les résultats révèlent de meilleures valeurs pour tous les indicateurs analysés dans les parcelles de pâturage AMP par rapport aux témoins. Des différences significatives ont été observées en termes de pourcentage de couverture végétale, de richesse en espèces et de disponibilité de phosphore et de potassium ($P<0,05$). Bien que d'autres études soient nécessaires, ces résultats préliminaires montrent une tendance à l'amélioration de la santé des écosystèmes et de la qualité des sols dans les exploitations soumises au pâturage AMP. Ces résultats soulignent l'importance de la recherche et de la mise en œuvre de pratiques de gestion durable des pâturages pour conserver et restaurer les prairies grâce aux services écosystémiques générés par l'élevage, notamment la séquestration du carbone et la régulation du climat.*

Mots-clés. *Gestion holistique – Pâturage adaptatif multi-paddock (AMP) – Santé de l'écosystème – Qualité du sol.*

I – Introduction

Grazing lands represent the largest resource in the world, occupying about a half of the world's land area and providing a wide range of important economic, environmental, and social goods and services (Ronald *et al.,* 2010). Also they are a large repository of soil C because of their high C density and the vast land area they occupy (Schuman G *et al.,* 2002).

In a global context of land degradation and climate change, improved grazing management strategies could greatly increase soil C sequestration, while greatly improving their production potential and other environmental benefits (Schuman G. *et al*., 2002).

Holistic Management ^{TM} (HM), is a whole-farm management process relying on holistic-goal setting and adaptive decision-making. The grazing management, an Adaptive Multi-Paddock (AMP) grazing, try to mimic the intense yet brief grazing pressure of large herds, through high intensity grazing pressure followed by long rest periods (Savory and Butterfield, 1999; Stinner *et al*., 1997). In a farm, a grazing planning is implemented, with long recovery times (120-60 days) and short grazing periods (3 days by paddock), and livestock densities are higher than in traditional managemet.

There is controversy on the benefits of Adaptive Multi-Paddock (AMP) grazing and its role in ecosystem sustainability, and, to our knowledge, there is not any research carried out in Mediterranean context. Some researchers have concluded that even rotational stocking method offers no significant benefit over continuous stocking (Holechek *et al.,* 2000; Briske *et al*., 2008). While others show evidences in productivity and profitability and ecosystem health under Adaptive Multi-Paddock grazing (Teague *et al*., 2009b; Hillenbranda *et al.,* 2019).

Our objective is to study, in a Mediterranean context, the effects of an Adaptive Multi-Paddock (AMP) grazing on ecosystem health, plants richness and biodiversity, and soil quality.

II – Materials and methods

1. Farms and grazing management

This study was developed in three farms located in the Southwest of Iberian Peninsula, in Retamal de Llerena (Spain, 38º34' N, 5º49'W; 467 m a.s.l.), Elvas (Portugal, 38° 47' N, 7° 10' W; 190 m a.s.l.) and Campo Maior (Portugal, 39° 06' N, 7° 03' W; 259 m a.s.l.). The climate is Mediterranean, characterized by dry summers and high variability rainfall with an annual average of 450 mm.

The farms managed under AMP have an average area of 450 ha of agroforestry system (*Quercus Ilex*). The herds are composed of 1400 merino sheep's in one farm, and 100 and 250 angus cows in the others farms.

Since 2015 a Holistic Management has been implemented, under an Adaptive Multi-Paddock (AMP) grazing with relative high stocking density, with mean values of 25 Animal Units/hectare (AU/Ha), where one Animal Unit is equivalent a one mature, non-lactating bovine weighing 500 kg and fed at a maintenance level for zero gain. AMP is also characterized by using short grazing periods in each paddock, with mean values of three days and adequate resting periods during the growing season, with mean values that oscillate between 100 days when the plants growth is slow- autumn and winter- and 40 days when the plants growth is fast- spring-.

Closer farms were chosen as control, having similar soils, vegetation, livestock (cattle/sheep) and stocking rates. These farms followed a conventional management consisting in a rotational stocking method with lower stocking density, larger grazing periods and shorter rest periods.

2. Sampling and analysis

The sampling was carried out during the spring of 2018 in three plots per AMP farm and three in their respectively controls, in total nine plots under AMP grazing and nine control plots under a rotational stocking method.

In each plot the Rangeland Health Index (RHI) was measured according to Borreli *et al.* (2012). Also floristic inventories to determinate biodiversity and species richness were made in each plot identifying all species in 100 m^2. Three square of 1m^2 each were used to determinate the abundance of each taxon considering Braun-Blanquet scale (1979). Shannon-Wiener Index and Simpson's Index were calculate to determinate plant biodiversity.

Furthermore, two total soil samples were taken per plot, one under the canopy of trees and another outside the tree. The sieved soil samples (> 2mm) were divided in 3 aliquots, one was used to calculate bulk density and total carbon and nitrogen and phosphorus, potassium and calcium availability. The second was kept refrigerated until enzymatic activity analysis were done using Biolog Plate technique and the third aliquot was stored at -80 ºC for analysis of phospholipid fatty acids analyses (PLFAs) to determinate microbial structural and functional diversity.

For the statistical analyses, the SPSS Statistics v24 program was used. Student's T test was used to evaluate if there were significant differences among treatments.

III – Results and discussion

The RHI was higher in farms under AMP grazing, but with no significant differences respect to control farms. However, the biological indicator of percentage of ground cover was statistically higher in 10 average points (the score according to ground cover ranged from +20 to -20) in AMP farms in contrast to control farms. These results agree with Teague *et al.* (2011) that found that the percentage of bare ground was statistically significant lower on pastures under holistic grazing. Vegetation cover is likewise an important ecological indicator related to pasture sustainability as greater bare ground results in increased run off and soil loss.

In relation to plant biodiversity, no significant differences were found between treatments. However, farms under AMP grazing presented higher level of species richness in contrast to control plots, with mean values of 47,22 and 39,33 species respectively ($P < 0.05$).

Hillenbranda *et al.,* 2019 also found positive results in a holistic planned grazing (similar to AMP grazing) with bison compared to continuous grazing with cattle, including increase fine litter cover, herbaceous biomass, plant composition, plant importance value, and decrease in bare ground and improve water infiltration rate.

The nutrients and physical soil indicator measured (Table 1) were better under AMP grazing, but only the value of phosphorus and calcium presented statistically significant differences. In relation to enzymatic activity and microbial biodiversity in soil samples outside the tree higher values were found under AMP grazing, without significant differences (p= 0.875 and p = 0.088 respectively). Teague *et al*. (2011) found that land grazed holistically presented better soil quality in higher ratio of fungi and bacteria and higher contents of calcium, magnesium, and sodium.

On the other hand, Stanley *et al.* (2018) comparing the life cycle analysis (LCA), including soil carbon sequestration, in two different beef systems – AMP grazing and feedlot-finished cattle (FD) – suggest that AMP grazing has the potential to offset greenhouse gases (GHG) emissions through soil carbon sequestration, and therefore not only improving grazing management can facilitate carbon sequestration, but that the finishing phase could be a net carbon sink.

Table 1. Soil indicators measured, units and method applied and results

Soil indicators	Method/technique	AMP	Control
Bulk density (g/cm^3)	Steel cylinders (Coile, 1936)	1.52 ± 0.37	1.60 ± 0.40
Total carbon (%)	Dry combustion (Dumas method)	1.78 ± 0.66	1.48 ± 0.44
Total nitrogen (%)	Dry combustion (Dumas method)	0.22 ± 0.07	0.18 ± 0.06
Phosphorus (mg/kg soil)*	Colorimetry	89.82 ± 81.67	0.18 ± 0.41
Potassium (mg/kg soil)*	Flame spectrometry	1593.01 ± 877.36	915.60 ± 3344.99
Calcium (mg/kg soil)	Flame spectrometry	1098.57 ± 1203.97	750.04 ± 704.73

AMP: Adaptive Multi-Paddock grazing; Control (Soil samples taken outside the tree);
* Statistically significant differences P value < 0.05.

IV – Conclusion

Although further studies are going on, which means more farms and long-term trials, these preliminary results suggest that AMP grazing in a whole-farm Holistic Management can be a tool for improving environmental pasture sustainability and soil health and contributing to mitigate climate change.

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