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Soil compaction related to grazing and its effects on herbaceous roots frequency and soil organic matter content in rangelands of SW Spain

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Rangelands in SW Spain occupy a total surface area of approximately 6 million ha and constitute the most representative extensive ranching system of the Iberian Peninsula gathering more than 13 million livestock heads. They are characterised by an herbaceous layer, mostly composed of therophytic species, with a disperse tree cover, mainly holm oak and cork oak (Quercus ilex rotundifolia and Q. suber), interspersed with shrubs in many places. This type of land system is of ancient origin and experienced frequent changes in land use in the past, since agricultural, livestock and forestry activities have coexisted within the same farms. In recent decades, livestock farming has become dominant due, in part, to the subsidies of the Common Agriculture Policy. Since Spain joined the European Union in 1986 until the year 2000, the number of domestic animals doubled, particularly cattle, and consequently animal stocking rates have increased on average from 0.40 AU ha-1 up to 0.70 AU ha-1.

This increase in animal stocking rates, along with a progressive substitution of cattle instead of sheep in many farms, has led to the occurrence of land degradation processes such as the reduction of grass cover or soil compaction in heavily grazed areas. Previous research has evidenced higher values of soil bulk density and resistance to penetration as well as larger bare surface areas in spring in fenced areas with animal stocking rates above 1 AU ha-1. However, a better understanding of how increasing bulk density or resistance to penetration influence the frequency of herbaceous roots and how a reduction in the frequency of roots affects soil organic matter content in rangelands is still unknown. Therefore, the main goal of this study was to determine possible relationships between the frequencies of herbaceous roots and soil organic matter content in order to understand the effect of excessive animal numbers on the depletion of soil fertility by reducing progressively the quantity of roots.

The study was carried out in 22 fenced areas belonging to 10 privately-owned farms grazed under different intensities (range: 0.19 – 15.76 AU ha-1 year-1). A total number of 597 undisturbed core samples and 311 bulk samples were collected in order to determine bulk density and soil organic matter content, among other many properties. Resistance to soil penetration was quantified using Eijkelkamp Penetrologger in 890 random points at different depth (0-80 cm) and soil moisture content (dry and wet). The frequency of herbaceous roots was estimated for each soil horizon in 47 soil profiles, described according to FAO and categorized in 4 classes: none-few, common, abundant and many. All variables were pair-wise correlated and their mean values were compared between the different classes of root frequency.

Results showed an inverse relationship between soil resistance to penetration and the frequency of herbaceous roots, i.e. the amount of roots lower in soils with high resistance to penetration. Soil horizons with none or few, common, abundant and many roots averaged 0.74%, 1.27%, 2.23% and 2.70% of SOM, respectively, showing significant differences between groups. Furthermore, SOM showed negative coefficients of correlation with resistance to penetration under dry ($r=-0.34$, $p<0.05$) and under wet conditions ($r=-0.11$, $p<0.05$) and bulk density ($r=-0.31$, $p<0.05$). The values herein observed confirm that soil compaction provoked by an excessive number of animals can decrease the content of soil organic matter by reducing the quantity of herbaceous roots although further research is still needed.