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Cushion plants and herbivory drive the water-holding capacity of the high Andean peatlands in Bolivia

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In the South American tropics above 4000 m a.s.l., the high Andean peatlands (HAP) are an endemic form of peat production ecosystem shaped by vascular, cushion-forming plants. They provide outstanding, inter-connected ecosystem services, the most important of which being water retention, biomass production for livestock, carbon retention and biodiversity. Global warming and land use changes are responsible for an alteration and an upward migration of the HAP, questioning the long-term of these keystone ecosystems. We hypothesized that shifts in dominant cushion plants, under the effects of global changes and the glacial retreat, might modify the superficial water-holding capacities of the HAP, which in turn can impact their biomass production for livestock, the central income source for local people. We aimed at characterizing to what extent the type of dominant plant, can drive the water-holding capacities of HAP (H1). In a context of rapid global changes in the tropical high Andes we aimed at testing how the presence of domestic herbivores influences this interaction between plants and water (H2). Finally, we tested how the upward migration of peatlands, resulting from global warming, influences the water-holding capacities of peatlands (H3).

To test H1, we quantified the superficial volumetric water content (VWC) of the soil at different depths and the leaf dry matter content (LDMC) of the dominant plants – a functional trait taken as a proxy of plant growth rate- in five HAP (109 plots). In two of these HAP (H2) we excluded experimentally domestic herbivores during 3.5 years in half of the plots to test how herbivory influenced the water-holding capacity of cushion plants (36 plots). Finally, (H3) we measured VWC and LDMC of cushion-dominated plots along a 350 years post-glacial chronosequence in order to characterize the modalities of the upward migration of the HAP (39 plots) due to the progressive glacier recession.

We show that cushion life forms had significantly a better water-holding capacity than tussock grasses. The cushion plant Distichia spp. had the higher VWC and a great biomass production response to superficial water content whereas Oxychloe andina, another cushion, was a more stress tolerant species displaying a stable biomass production over a remarkable range of superficial water content. Herbivory action increased humidity, species compaction and relative cover sustaining thus cushion life forms dominance. Young HAP had a greater superficial humidity but were significantly shallower than old HAP, resulting in a weaker total water-holding capacity.

We demonstrated that the cushion species Distichia spp. created the wettest HAP, seemingly enhancing biomass production and carbon storage of HAP in comparison with other species (H1). The positive effects of extensive herbivory on cushions –through higher compaction and competition release by predation on other plants- resulted in a virtuous circle between plants and animals, which can be interpreted as an alternative stable state responsible for the presence of HAP over centuries (H2). However, the upward migration of HAP resulting from global warming should alter this relationship and reduce drastically the average depth of HAP (H3).