LETTER

REPLY TO HU ET AL.:

Whether grazer diversity or grazing intensity really accounts for grassland functioning

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Hu et al. (1) question the robustness that livestock diversity is that causally influential in shaping biodiversity and ecosystem multifunctionality (EMF), in our recent published paper (2) entitled "Diversifying livestock promotes multidiversity and multifunctionality in managed grasslands," on the basis that maintaining all of the plots at an anticipated same grazing intensity level was a tough challenge due to the spatially unequal vegetation and livestock foraging, which thus could confound the effects of livestock diversity and grazing intensity.

We welcome the interest shown by Hu et al. (1) regarding whether grazer diversity or grazing intensity really account for the promotion of biodiversity and EMF in our research. Firstly, we fully agree that it is impossible that the absolutely same grazing intensity was controlled across all of the grazing treatments just as Hu et al. considered, because the grazing intensity was controlled at a moderate level only, based on the estimation of food intake of livestock and plant biomass before the grazing. However, we believe that the possible minor difference in intensity should not bring obvious influences on grasslands. For example, in a continuous grazing study with 6 levels of intensity (1, 1.5, 2, 2.5, 3, and 3.5 sheep per ha), a clear difference in plant composition was observed only between the plots with the lowest stocking rate vs. the plots with higher stocking rates, and there was no significant difference in the grazing effect between 2 adjacent grazing intensities (3). We believe that the effects brought by large differences in livestock species will far outweigh the impact of minor differences in grazing intensity among the grazing treatments. Different livestock species, such as cattle and sheep, have distinct foraging modes, foraging parts at individual plants, diet preference, trampling effects, traveling behavior, and also quantity, distribution, and chemical composition of excreta returning to grassland, etc., which undoubtedly will bring the diversifying disturbance to grassland if adopting the diversifying livestock grazing, and thus will create high environmental heterogeneity. According to the classical niche theory (4), a variety of resource conditions will promote the coexistence of a variety of species, which differ sufficiently in niches from one another. Thus the diversifying disturbance from different livestock species will greatly benefit maintaining ecosystem biodiversity and thus EMF.

Secondly, we believe that, in general, effects of livestock grazing on grassland functioning depend more on grazing intensity than livestock diversity. As we know, continuous high-intensity livestock grazing will severely affect ecosystem functions and even result in grassland degradation. However, here, we emphasize, diversifying livestock grazing management at moderate level may have important ecosystem service benefits.

1 L.-J. Hu, W. Wang, Y. Cheng, Y. Guo, Effects of grazing livestock on grassland functioning may depend more on grazing intensity than livestock diversity. *Proc. Natl. Acad. Sci. U.S.A.* **116**, 18762–18763 (2019).

2 L. Wang *et al.*, Diversifying livestock promotes multidiversity and multifunctionality in managed grasslands. *Proc. Natl. Acad. Sci. U.S.A.* **116**, 6187–6192 (2019).

3 A. del Pozo, C. Ovalle, M. A. Casado, B. Acosta, J. M. de Miguel, Effects of grazing intensity in grasslands of the Espinal of central Chile. *J. Veg. Sci.* **17**, 791–798 (2006).

4 R. H. MacArthur, R. Levins, The limiting similarity, convergence and divergence of coexisting species. *Am. Nat.* **101**, 377–385 (1967).

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