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Causes for variable greening responses to warming detected in alpine grasslands on the Tibetan Plateau

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The alpine meadow and steppe on the Tibetan Plateau are the highest pasture in the world, and their formation and distribution are strongly controlled by Indian summer monsoon effects. However, little is known about whether monsoon-related cues may trigger spring phenology of the vast alpine vegetation, and how the cues can influence the greening response to warming. Based on the 7-year phenological observation data at 7 altitudes (4400-5200m) in the central plateau during 2007-2013, we found that leaf unfolding dates of dominant sedge and grass species in alpine meadows synchronized with monsoon rainfall onset, advancing with increasing precipitation regardless of air temperature. Similar results were also found in a 22-year observation data set from two stations in the northeast plateau. In the monsoon-related cues for leaf unfolding, the arrival of monsoon rainfall is crucial, while seasonal air temperatures are already continuously above 0°C. In contrast, the cushion plants in the same community generally leafed out earlier (30-40 days earlier than sedge and grass species) in warmer years regardless of precipitation. We further used meteorological data from 73 weather stations over the plateau and MODIS remote sensing data to calculate both monsoon rainfall onset and vegetation green-up dates during 2001-2013. We found that the onset dates of monsoon rainfall generally controlled the spatiotemporal variations in the satellite-derived green-up dates in alpine grasslands over the plateau consistent with the site observations. Our data provide evidence that leaf unfolding of dominant species in the alpine meadows and steppes senses the arrival of monsoon-season rainfall. Such a phenological pattern suggests a strategy to prevent damage of pre-monsoon drought and frost in alpine plants. These findings also provide a basis for interpreting the fan-shaped distribution pattern of the Kobresia meadow and Stipa steppe as well as the spatially variable greening responses to warming detected in the world's highest pasture.

Biography

Tianxiang Luo completed his PhD from Chinese Academy of Sciences. He has been interested in alpine ecosystems and their response to climate change. He has published more than 100 papers in peer review journals and has been serving as Editorial Board Members of *Journal of Arid Environments, Chinese Journal of Plant Ecology, Acta Ecologica Sinica* etc.

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