Environmental constraints and species adaptive strategies drive plant longevity in Himalayan high-mountain plants

Thinles Chondol[1], Adam Klimeš[1], Jan Altman[1], Katerina Capkova[1], Miroslav Dvorsky[1], Inga Hiiesalu[2], Veronika Jandova[1], Martin Kopecký[1], Martin Macek[1], Klara Rehakova[1], Pierre Liancourt[3], and Jiri Dolezal[1]

[1]Institute of Botany Czech Academy of Sciences
[2]University of Tartu Institute of Ecology and Earth Sciences
[3]Stuttgart State Museum of Natural History

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Abstract

Plant lifespan has important evolutionary, physiological, and ecological implications related to population persistence, community stability, and resilience to ongoing environmental change impacts. Although biologists have long puzzled over the extraordinary variation in plant lifespan and its causes, our understanding of interspecific variability in plant lifespan and the key internal and external factors influencing longevity remains limited. Here, we demonstrate the concurrent impacts of environmental, morphological, physiological, and anatomical constraints on interspecific variation in longevity among >300 vascular dicot plant species naturally occurring at an elevation gradient (2800-6150 m) in the western Himalayas. First, we show that plant longevity is largely related to species' habitat preferences. Ecologically stressful habitats such as alpine and subnival host long-lived species, while productive ruderal and wetland habitats contain a higher proportion of short-lived species. Second, longevity is influenced by growth form. Small-statured cushion plants with compact canopies and deep roots, most found on cold and infertile alpine and subnival soils, had a higher chance of achieving longevity. Third, plant traits reflecting plant adaptations to stress and disturbance modulate interspecific differences in plant longevity. Importantly, we show that longevity and growth are negatively correlated. Slow-growing plants are those that have a higher chance of reaching a maximum age. Finally, changes in plant carbon, nitrogen, and phosphorus content in root and leaf tissue were significantly associated with variations in longevity. We discuss the link between the longevity and productivity and stability of studied Himalayan ecosystems and the intrinsic growth dynamics and physiological constraints under increasing environmental pressure.

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