PLANT FUNCTIONAL TRAIT VARIATION ALONG ALTITITUDE AND ALPINE TREELINE LIMITATION IN QILIAN MOUNTAINS

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Abstract - The dynamics of the alpine forest boundary and the mechanisms behind have long been the ecological research hotspots. Growing season temperature (T_{gs}) decreases along with altitude gradients limiting alpine treeline has become the widely accepted mechanism among various theories. However, the physiological process amid T_{gs} limitation of the alpine treeline is still not well understood. Here, we measured leaf hydraulic conductance (K_l), stem hydraulic conductance (K_s), leaf and stem anatomic structures, and leaf saturated photosynthetic rate (A_{sat}) of 11 tree and shrub species naturally distributed along the altitude gradients towards the typical alpine treeline in the north face of Qilian Mountains. We found, irrespective of interspecies or intraspecies, K_l and K_s both significantly decreased along the altitude gradients, and the species distributed in the high altitude with rather low K_l and K_s. The decrease of leaf midvein and stem xylem vessel diameter were the anatomical cause of the decreases of K_l and K_s. Further analysis proved that the decreased T_{gs}, not growing season precipitation (P_{gs}), was closely coordinated with the decrease of K_l and K_s along altitude gradients. The path analysis showed that the decreased T_{gs}, K_l, and K_s along the altitude gradients negatively influenced A_{sat}, and thereby limits the species survival in high altitudes. The findings proposed the physiological constraints of the alpine forest treeline and provided the physiological insights for alpine forest management and conservation. Plant functional traits are the measurable characteristics of plants in adaption to habitats, which mainly dependent on inner genetic variety and external environmental factors. Qilian Mountains is a major mountain located in the dry land of northwest China and the north face with an elevation range from 1500 to 3800 m, where naturally distributed 10 ~ 20 woody species. Exploring the woody plant functional traits variation along the altitude is key to understand the adaption and the vertical zone distribution of alpine plants. In this study, we selected 11 naturally distributed woody plants, which include 9 shrubs (Potentilla glabra, Potentilla fruticose, Ilex pernyi, Cotoneaster multiflorus, Salix gilashanica, Caragana jubata , Lonicera hispida, Spiraea alpina, Berberis diaphana) and 2 trees (Picea crassifolia, Sabina przewalskii). Six shoot and leaf traits were investigated, sapwood density, huber value, leaf water content, leaf dry matter content, leaf specific leaf area, respectively. The result shown: (1) sapwood density, huber value, leaf water content and specific leaf area of shrubs were significantly greater than trees, and leaf area and leaf dry matter content of shrubs were significantly lower than trees; (2) sapwood density and leaf dry matter content declined along the altitudes gradients and other traits changed insignificantly. (3) growing-season temperature positively correlated with leaf dry mater content and negatively correlated with huber value and leaf water content, furthermore, no obvious relationships between growing-season precipitation and plant functional traits were observed. The results imply tree species adopt a more conservative resource strategy compared with shrubs; the decreased structure carbon investment along the altitude gradients might limit the upshift of alpine plants; growing-season temperature is the key environmental factor, not the only one, tuning woody plant functional traits variation along altitudes gradients.

Keywords - Plant Functional Trait, Alpine Forest, Qilian Mountains, Altitudes Gradients.

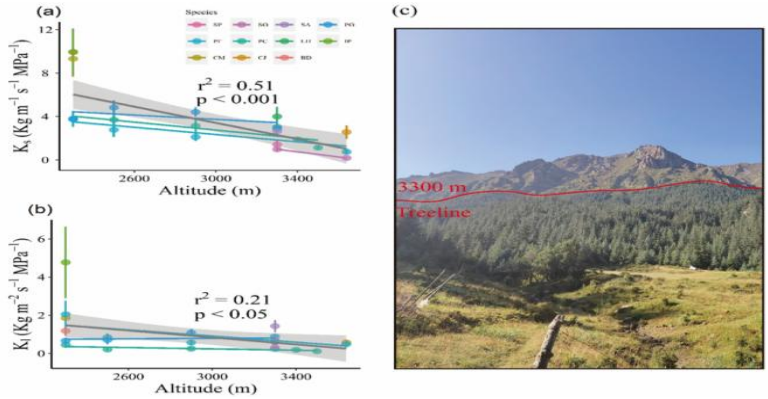


Figure 1 The change trend of plant hydraulic conductance along altitude gradients towards alpine treeline. (a) Interspecies and intraspecies analysis both showed that stem hydraulic conductance decreased along the altitude gradients. (b) A similar decreasing trend of leaf hydraulic conductance along altitude among interspecies and intraspecies was showed. (c) The typical alpine treeline in the north face of Qilian Mountains. The different color represents different species and the species codes could be found in Table S1. K_s, stem hydraulic conductance; K_l, leaf hydraulic conductance; standard error bar, significant differences, and coefficient of determination were showed above the curved lines.

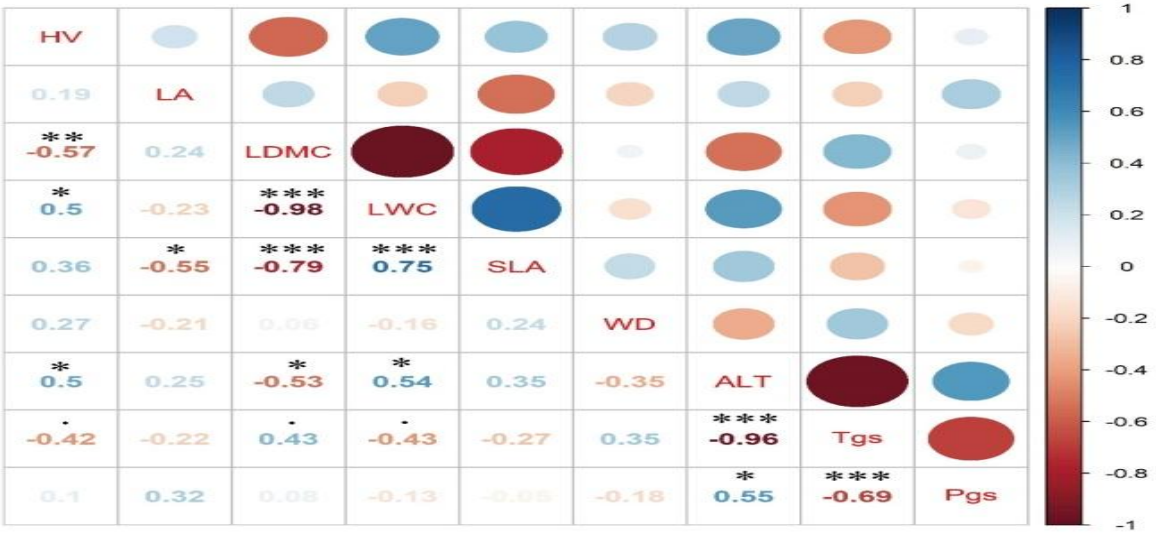


Figure 2 Pearson coefficients of main woody plant functional traits and environmental factors on the north face of Qilian Mountains. The abbreviation of functional trait and environmental factor showed in the Results and Analysis. WD, Sapwood density; HV, huber value; LA, leaf area; LDMC, leaf dry matter content; LWC, leaf water content; SLA, specific leaf area; ALT, altitude; Tgs, growing-season temperature; Pgs, growing-season precipitation.

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