Nonlinear responses of Picea crassifolia needle structures to different elevations in Plateau and soil as the main driver

Huizhong Hu[a,b], Dengwu Li[a,b*],Xinru Lia[b],Na Luoa[b],Duozhen Zhonga[b],Jinyan Yanga[b]

（a.College of Forestry, Northwest A & F University, Yangling 712100, Shaanxi, China；b.Shaanxi Key Laboratory of Economic Plant Resources Development and Utilization, Yangling 712100, Shaanxi, China）

Abstract: Within towering canopy, structural diversity at the leaf level is easily visible. Altitude is an important factor affecting plant growth and development. Understanding how coniferous plants transcend plateau and survive successfully at different altitudes is of great significance for predicting their response to future climate change. As the dominant tree species in the plateau forest ecosystem, Picea crassifolia needles were gathered to test morphological, anatomical, and phenolic traits at five different altitudes from the northeastern Tibetan Plateau using a combination of paraffin section, freehand section and histochemical localization. The findings revealed typical xerophilous phenotypic characteristics of needles, such as smaller, thicker and larger vascular bundles. The morphological structure, anatomical structure and phenolic content of needles varied with altitude, and most indices demonstrated a trend of "w". Among the five elevations, the needles at 2 923 m showed the strongest forces to dodge the hostile climate by developed primary protective tissues, vascular bundles and phenolic substances. Needle characters markedly differed between geographical groups and most indices revealed a strong positive correlation and a coevolutionary relationship. Total phenols, vascular bundle perimeter, mesophyll cell area, stomatal length, stomatal width, vascular bundle diameter, vascular bundle area, and subcutaneous layer thickness all had significance values greater than 1, making them the key traits of P. crassifolia for long-term monitoring wild populations in response to global change. Environmental variables could account for 73.82% of the structural variations between different elevations, according to research on the influence of these environmental factors on needle structure. The most important impact of soil factors on the needle characters was ascribed to high explanation degree present in the variables of available P, total K, alkali-hydrolyzable N, total N, soil organic C and so on at different elevation.

Keywords: Leaf traits；Morphological structure；Anatomical structure；Histochemical localization；Low temperature；Xerophilous characteristic；Soil factors

Foundation Support: This work was supported by the special fund for Northwest Surveying and Planning Institute of National Forestry and Grassland Administration (201803010236, TG20220118).

***Corresponding author:** Dengwu Li. E-mail: dengwuli@163.com. Tel/fax: 029-87082230