Shrub and tree growth in southeast Tibet: new information for dendroclimatology

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High-elevation Tibetan Plateau provides an excellent platform to investigate responses of tree or shrub growth to extreme environments. However, little is known about their adaptation to climate change across a large latitudinal scale. Along two latitudinal transects across the eastern and central Tibetan Plateau, variations in growth of timberline trees and shrubs and their responses to climate were investigated. Along the eastern Tibetan Plateau, timberline tree growth was, in general, controlled by summer temperature as well as winter temperature. In particular, timberline tree growth was limited by summer minimum temperature, as reported for *Juniperus przewalskii* on the northeastern Tibetan Plateau, *Picea likiangensis* var. *balfouria*na in southern Qinghai, *Abies georgei* var. *smithii*, *Picea likiangensis* var. *balfouria*na and *Rhododendron nivale* in southeastern Tibet [1-4]. We should mention that the growth of rhododendron shows a climatic signal to those of *Abies georgei* var. *smithii* at timberline.

However, along another transect ranging from central Nepal via Nam Co Lake in central Tibet and the middle of Qaidam to the Qilian Mountains, the responses of tree growth to climate are different from those along the eastern Tibetan Plateau. Despite its high elevation (4000 m a.s.l.), the radial growth of *Betula utilis* shows strong signals (positive) of pre-monsoon precipitation, while March-May temperature is negatively correlated with tree growth due to the fact that high temperature can increase evaporation [5]. Unlike dwarf shrubs in the circum-arctic tundra ecosystem which positively respond to above-average temperature in the growing season, moisture turned out to be growth limiting for the dwarf shrub *Juniperus pingii* var. *wilsonii*, particularly the loss of moisture caused by high maximum temperatures in May–June [6]. *Populus euphratica* is a key species of Tugai forests in the central Asian deserts. In the Qaidam Basin, its growth was persistently positively correlated with temperature from previous September to current August although not significant throughout. The annual precipitation of around 41 mm can not exert any significant effect on Euphrates poplar growth in view of the extremely high annual evaporation of 2150 mm. Water in the nearby Tuolahai River is limited to the period from June-September. The positive correlation of tree growth with spring/early summer temperature indicates that the riparian Euphrates poplar trees may benefit from an increasing river runoff due to an advanced and accelerated snow and glacier melting [7]. In the central Qilian Mountains, the growth of *Picea crassifolia* was strongly limited by precipitation or moisture in May-June, being similar with *Juniperus pingii* var. *wilsonii* around the Nam Co Lake. In spite of the high elevation on the central Tibetan Plateau, the growth of trees or shrubs was primarily controlled by moisture. These studies provide useful information for understanding the adaptation of trees and shrubs to extreme environments.

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