Dry/wet variation recorded by shrub tree-rings in the central Badain Jaran Desert of northwestern China

S.C. Xiao [a,*], H.L. Xiao [a], Z.B. Dong [b], X.M. Peng [a]

[a] Key Laboratory of Ecohydrology of Inland River Basin, Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences (CAS), 320 Donggang West Road, Lanzhou 730000, China
[b] Key Laboratory of Desert and Desertification, Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences (CAS), Lanzhou 730000, China

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ABSTRACT

The dendrochronological study of shrubs is a new field, particularly with respect to desert areas. Using a dendrochronological perspective, we studied the radial growth and the climatic response model of the common beancaper (Zygophyllum xanthoxylum Maxim) in three sampling sites in the Badain Jaran Desert of northwestern China. The results showed that the radial growth of the common beancaper was primarily affected by precipitation during the pre-growing and growing seasons, especially during July. Variation in wet/drought periods over the last 160 years in the study area was analyzed using a radial growth climatic response model and data on regional chronology. Using decadal time scales, three wet periods were identified in the Badain Jaran Desert: the 1840s to early 1850s, the early 1890s to the 1900s and the late 1970s to the mid-1980s. Similarly, transitions from dry to wet periods over the last 160 years occurred in the late 1850s, mid-1870s, early 1880s, early 1900s, mid-1920s, early 1950s, early and late 1970s and early 1990s. These results are helpful for understanding regional climate change and the desertification process in arid desert regions.

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1. Introduction

Studies of regional climate change and ecosystem response are important components of global climate change research, especially in arid desert regions (Wei, 2000). The arid areas of China are significant repositories of climatic changes in central and eastern Asia. Located within the zone of westerlies and on the northern fringe of the Asian summer monsoon, the Alashan Plateau records the history of these two different climate systems (Yang et al., 2003). The Alashan Plateau is a typical and sensitive ecological zone located throughout western Inner Mongolia, northwestern China and the eastern Asia desert region. This plateau is also a major dust source and region of dust storms in central and eastern Asia (Fig. 1) (Wang et al., 2006). The scrub and shrub vegetation in this extremely arid desert experiences moderate to warm temperatures. Desert plants stabilize the ecological environment and play an important role in preventing soil erosion and in controlling desertification.

Previous research on climatic and environmental changes in and around the Badain Jaran Desert has focused mainly on dune (Gates et al., 2008; Ma et al., 2009; Yang, 2000) and lake deposits (Herzschuh et al., 2004, 2006; Jin et al., 2004) and loess (Dong et al., 1996; Li et al., 2005) and has been conducted primarily at a decadal resolution on scales from hundreds to thousands of years. Studies at higher resolutions have been limited.

Tree-ring series have served as a high-resolution proxy and an important tool to reconstruct environmental processes for climate and ecology throughout the world (Fritts, 1976; Schweingruber and Poschlod, 2005; Shao et al., 2003; Zhang et al., 2003). In recent years, dendrochronological studies of shrubs and dwarf shrubs in various parts of the world have increased, investigating phenomena such as climate change (Au and Tardif, 2007; Bar et al., 2007; Cherubini et al., 2003; Huang et al., 2004; Liang and Eckstein, 2009; Srur and Villalba, 2009; Woodcock and Bradley, 1994; Xiao et al., 2006), water sources for plants (Chen, 1996; Yang et al., 1996), changes in the water levels of lakes (Begin and Filion, 1995; Xiao et al., 2005), movement of glacial material (Schmidt et al., 2006; Xiao et al., 2007), significant rainfall events (Florentine and Westbrooke, 2005), changes in river runoff (Zalatan and Gajewski, 2006), soil erosion (Chartier et al., 2009) and forest community succession (Schweingruber, 1996). These studies have revealed the potential of shrub species for extending existing dendrochronological networks into extreme environments that exceed the survival limits of trees (Ferguson, 1959; Liang
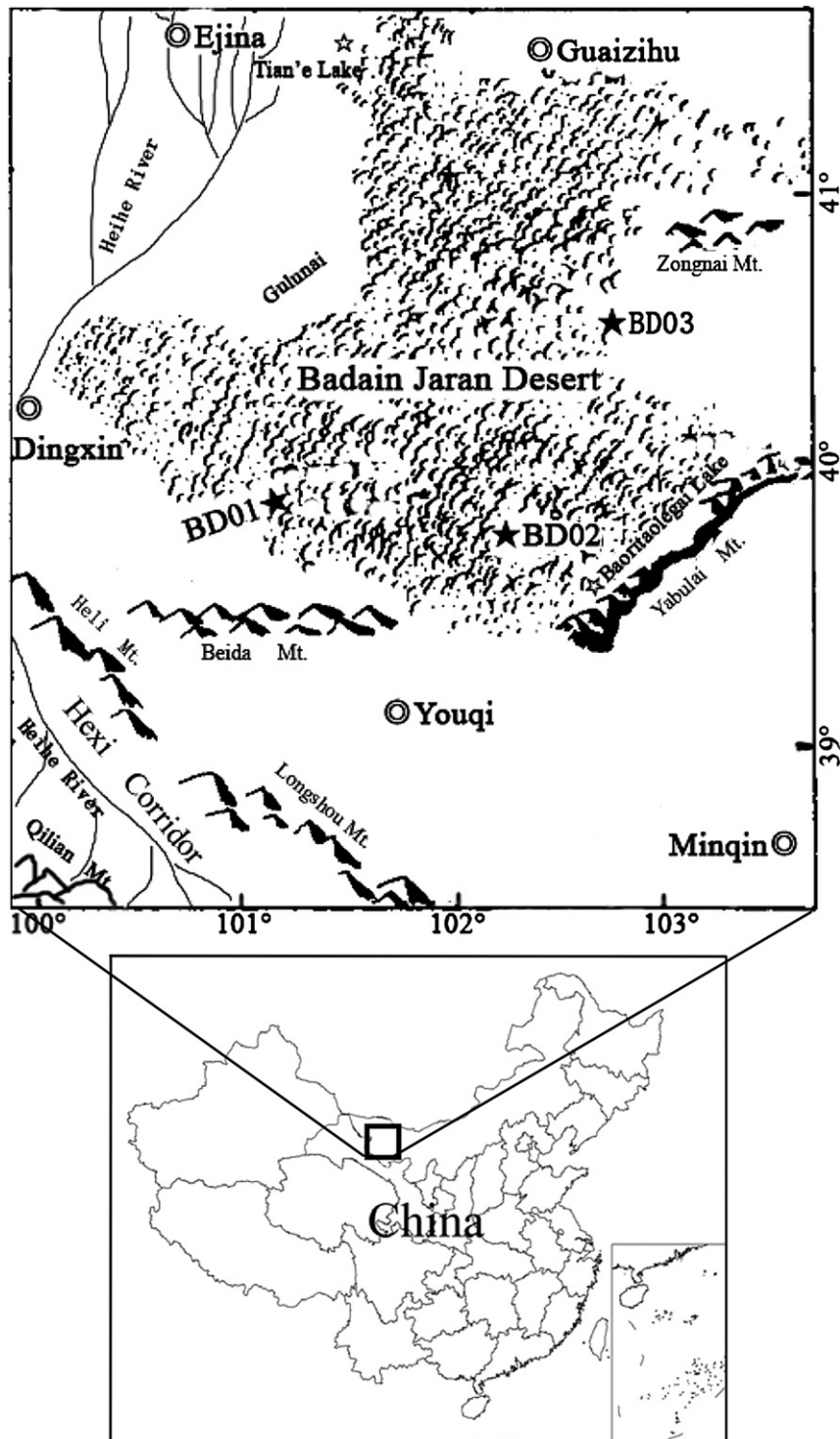

Fig. 1. Location of the study area and sampling sites. (★Sampling sites; ⊚Meteorological station).

and Eckstein, 2009; Rayback and Henry, 2005; Schweingruber and Dietz, 2001; Schweingruber and Poschlod, 2005; Verheyden et al., 2004).

This study investigates the radial growth of the common beancaper (*Zygophyllum xanthoxylum* Maxim), the dominant shrub species in the desert region, and its response to climate change. Our aims were to provide a high-resolution proxy record for understanding climate change in the Badain Jaran Desert in Alashan

Plateau and to compare this proxy with other climate proxies in and around the study area, such as records of sand dune and lake deposition, tree-ring records and local historical documents.

2. Study area

The Badain Jaran Desert lies in the northwest portion of the Alashan Plateau in western Inner Mongolia, Northwestern China.