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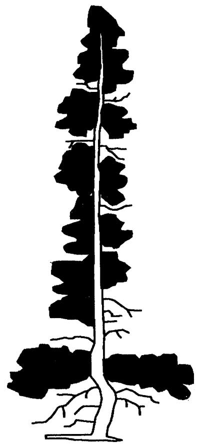

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Abstracts

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A millennium-long tree-ring chronology of *Sabina przewalskii* in the Tianjun area of eastern Qinghai-Tibet Plateau

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Introduction

There have been great progresses in the studies of long time-series of tree-ring chronologies across the world in the past several decades (Briffa, 2000). In comparison to other high mountainous forests of the world, the forests of the Qinghai-Tibet Plateau have received considerably less dendroclimatological research. The trees of *Sabina przewalskii* in this region bear a great potential for dendroclimatological studies because of their unique characteristics, such as high longevity, sensitivity, and growth on sites of low latitude and high elevation (Zhang, Kang & Huang, (unpubl.)). Tree-ring samples of this species were collected in the Tianjun area of eastern Qinghai-Tibet Plateau for the purpose of developing long proxy record of past climate variation. This study will add new tree-ring data for this poorly understood area and will facilitate comparisons with records from other areas so as to increase the spatial resolution of past climate reconstruction in the eastern Qinghai-Tibet Plateau.

Materials and Methods

Tree-ring samples were collected from trees of *Sabina przewalskii* in the Tianjun area (37° 40′ N Lat., 98° 40′ E Long.) of Qinghai province, northwest of China. The mean annual total precipitation in this area ranges from 200 mm to 250 mm, and the mean annual air temperature is 1.6° C. Increment cores were extracted from trees located at the elevation between 3000-3500 m on the south-facing mountain slopes. A total of 117 increment cores were collected from 69 trees.

The tree-ring samples were mounted and polished before measurement. The ring-width series were crossdated and quality checked using the software COFECHA (Holmes, 1983). The age-related growth trend in ring-widths was removed by fitting either negative exponential curves or linear regression lines using the software ARSTAN (Cook & Holmes, 1996).

The standard tree-ring chronology was used to conduct climate-growth response function analysis. The climatic data of mean monthly temperature and total precipitation were obtained from three nearest meteorological stations (Tianjun, 3417 m in elevation, Chaka, 3088 m in elevation, and Delingha, 2982 m in elevation). The averaged data from these stations provide a continuous record back to the year 1958.

Results and Discussion

The annual growth rate of *S. przewalskii* was low and sensitive to environmental changes (Table I). Tree-rings from different samples contained common signals, most probably of climate, as reflected by the high mean serial correlation. The high value of first-order autocorrelation indicated that the growth in the previous year had an influence on the growth of the following year.

The longest living tree had an age of about 1150 years. Here we only presented the 1101-year chronology interval (A.D. 893 to A.D. 1993) that had at least five sample replications (Fig. 1). Preliminary analysis of the relationships between ring-width indices and a variety of climatic variables showed that the total precipitation in May and June had the highest correlation with the ring-width indices ($r = 0.60$; the 95% significance level for $n = 40$ is 0.30). This suggested that the growing season precipitation may be a major limiting factor for the radial growth of *S. przewalskii* trees in this area.

TABLE I. Chronological characteristics of *Sabina przewalskii* for the Tianjun area of eastern Qinghai-Tibet Plateau.

Chronology length (calendar year)	Mean ring-widths (mm)	Mean serial correlation	Mean sensitivity	First-order autocorrelation
893-1993	0.30	0.76	0.37	0.69

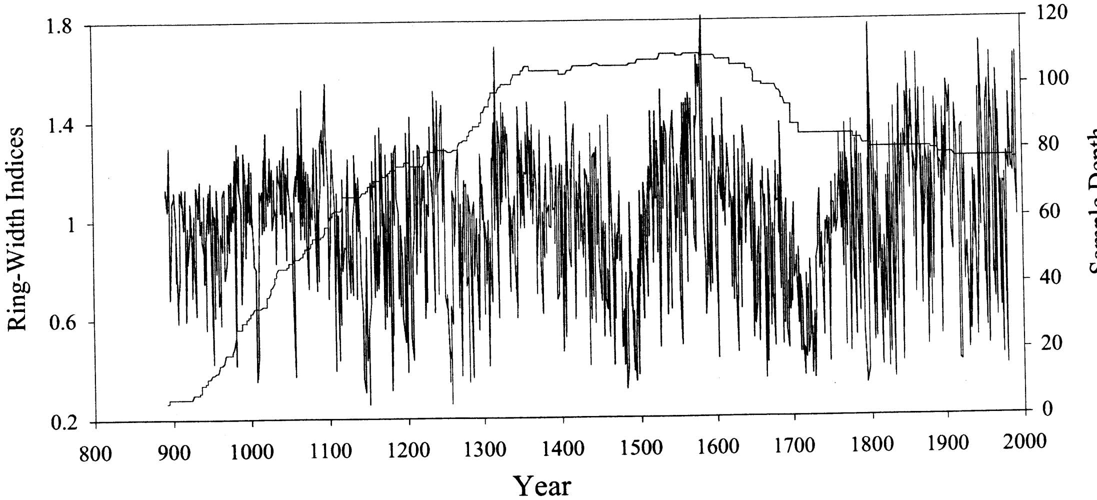

FIGURE 1. Ring-width chronology of *Sabina przewalskii* for the Tianjun area of eastern Qinghai-Tibet Plateau.

The tree-ring variations in this study area (Figure 1) showed a similar pattern with those developed in Qilian, Wulan, and Dulan areas in the eastern Qinghai-Tibet Plateau (Kang et al., 2000, 2002; Huang, Zhang & Kang, (unpubl.)), suggesting that the chronology in the Tianjun area contained information of large-scale climatic variability. For example, the tree-ring indices were below the average for at least two decades around A.D. 1500 and 1710, and above average around A.D. 1550. By comparison with other proxy records, such as ice core from the Qinghai-Tibet Plateau (Yao, Yang & Huang, 1996) and historical documents (Zhang, 1993), a more detailed picture of the past climate variation can be obtained. Further work will be carried out to interpret the chronology and to address the major climatic events (such as the medieval warm period, the little ice age, and the current global warming) in the past millennium.

References

Briffa, K.R., 2000. Annual climate variability in the Holocene: interpreting the message of ancient trees. Quaternary Science Reviews, 19: 87-105.

Cook, E.R. & R.L. Holmes, 1996. Guide for computer program ARSTAN. Pages 75-87 in H.D. Grissino-Mayer, R.L. Holmes & F.C. Fritts (ed.). The International Tree-Ring Data Bank program library version 2.0 user's manual. University of Arizona, Tucson, Arizona

Holmes, R.L., 1983. Computer-assisted quality control in tree-ring dating and measurement. Tree-Ring Bulletin, 43: 69-75.

Kang, X.C., Q.H. Zhang, L.J. Graumlich & P. Sheppard, 2000. Reconstruction of a 1835a past climate for Dulan, Qinghai province, using tree-ring. Journal of Glaciology and Geocryology, 22: 65-72.

Kang, X.C., G.D. Cheng, E.S. Kang & Q.H. Zhang, 2002. Runoff from mountain outlet in the Heihe region for the past one thousand years as reconstructed from tree-rings. Science in China (series D) (in press).

Yao, T., Z. Yang & C. Huang, 1996. High resolution record of paleoclimate and environment for the past 2000 years. Chinese Science Bulletin, 41:1103-1106.

Zhang, D., 1993. A study on the medieval warm period in China. Quaternary Research, 1993(1): 7-15

A dendroclimatic study of Qilian Juniper in the northeast Qinghai-Xizang (Tibet) Plateau

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Introduction

One of the long-lived trees reported in China is Qilian juniper (*Sabina przewalskii* Kom.) growing on the mountains of the eastern extreme of the Qaidam Basin in northeast Qinghai-Xizang Plateau (Kang et al., 1997, Wang et al. 1983). To investigate the dendroclimatic potential of the species and to develop the reliable tree-ring chronologies with 1000-years long, tree-ring cores from several sites in the region have been sampled in 2000 and 2001. Here we report the results from two sites.

Materials and Methods

The two sites reported here are identified as WL3 and WL4 and located in 36° 45'N, 98° 13'E and 36° 41'N, 98° 25'E respectively. According to Zheng (1996), the study area is situated in arid region in Plateau's temperate belt with the annual precipitation of less than 200mm at the ground (2900-3000 m above sea level). Qilian juniper is growing at the altitude from 3600 to 4000m on the mountains and is the only dominant timber species. The two sites are located both on the slopes of Yak Mountain, but in different slope aspect. WL3 is on northern aspect with 15° to the east and WL4 is on southern aspect with 25° to the west. Tree-ring cores were taken by increment bores at the altitude of tree growth. A total of 97 cores were extracted from 43 trees for WL3 and 105 cores from 50 trees for WL4. For most sampled trees, two cores were taken from one tree. In a few cases, one or three cores were taken from one tree.

All cores were mounted, sanded, and visually cross-dated using skeleton plot (Stokes and Smiley, 1968). The ring widths in each sample were measured under a microscope on a sliding stage micrometer accurate to the nearest 0.01mm, and recorded in computerized data files. The cross-dating and measurement were verified with computer program COFECHA (Homes, 1983). All flagged segments by the program were visually rechecked and corrections were made if errors occurred. The placement of missing rings was also rechecked. Some of cores that showed low correlation coefficients with other cores were excluded from the site. The ring-width chronologies were developed using program ARSTAN (Cook, 1985). A cubic smoothing spline with 50 percent variance reduction function at 250 years is used to describe the growth trend for each series. Quotient was used to eliminate the aging trend. The dimentionless series were then average together by a method of bi-weight robust mean to form the standard ring-width chronologies. The two chronologies were also cross-dated each other using program COFECHA.

The growth-climate relationships were approached by correlation function (Blasing, et al., 1984). The climate data used is from the grided data set of China (Wei and Cao, 1994). The nearest grided site to the chronologies', i.e. 37°N by 98 °E, was selected. Both monthly mean temperature and monthly total precipitation for the available period (1951-1997) were used in correlation analyses. Partial correlation analysis was also utilized in this study to distinguish the effect of temperature from precipitation.

Results and Discussion

Figure 1 shows the ring-width chronologies and their replication depth of the two sites. The mean sensitivity is 0.351 for WL3 and 0.355 for WL4. The mean correlation coefficient between trees in the 351-years (1400-1750) common interval is 0.57 for both sites. It is clear that Qilian junipers at Yak Mountain were characterized by "sensitive" ring patterns, with large year-to-year variability and relatively large amount of common variance. The agreement with population chronology (Wigley et al, 1984) is 0.97 for WL3 and 0.98 for WL4, and the date for the subsample signal strength (Wigley et al, 1984) reaching to 0.90 is AD 900 for WL3 and AD 994 for WL4. The chronologies may therefore be considered statistically reliable and homogeneous time series over

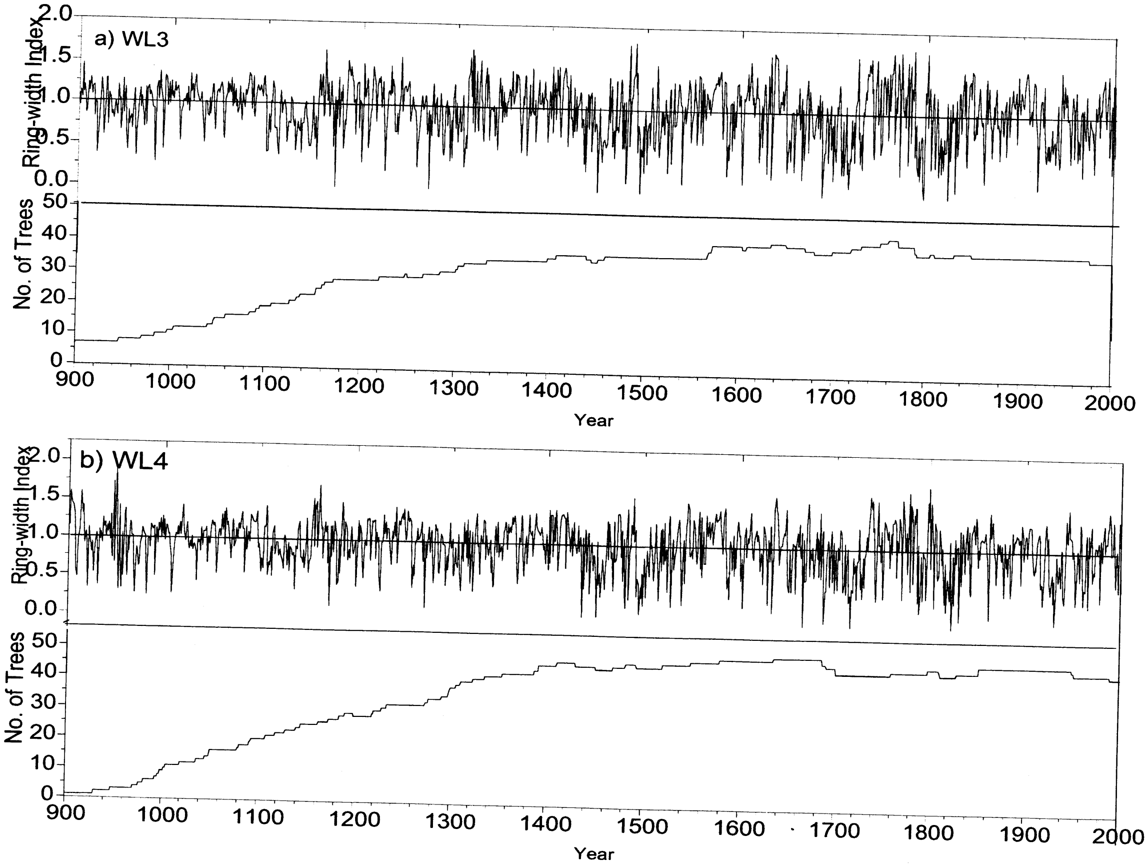

FIGURE 1 Ring-width chronologies and replication depth of Qilian juniper from WL3 and WL4

the last millennium. The COFECHA results of the two chronologies suggested that the two sites could be cross-dated each other. The high agreement of variations in ring-width indices between the two sites separated by 23 km and located in different aspects of slope implies that the information in chronologies represent a large-scale signal.

The correlation function analyses indicate that the radial growth is positively related to precipitations from previous December to current June with the highest correlation occurred in current May and June. The radial growth is also significantly and negatively related to temperatures in June and August. However, the partial correlation analysis shows that the negative correlation between ring-width index and June temperature is not significant and only the negative effect of August temperature on growth is still significant when the effect of May precipitation to growth is fixed. It is clear that the soil moisture is the limiting factor to radial growth during winter, spring and early summer. In August the water stress in tree caused by high temperature is the limiting factor. When August is hot, this water stress may terminate the growing season earlier than usual.

Acknowledgements

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References

Blasing, et al., 1984. Response function revisited. Tree-Ring Bulletin. 44:1-5

Cook, E., 1985. A Time Series Analysis Approach to Tree-Ring standardization, Ph.D. dissertation, university of Arizona, Tucson, USA

Homes, R.L. 1983. Computer-assisted quality control in tree-ring dating and measurement. Tree-Ring Bulletin 43: 69-78.

Kang, X, L.J. Graumlich & P. Sheppard, 1997. The last 1835 years climate changes inferred from tree ring records in Dulan region, Qinghai, China. Quaternary Sciences (in Chinese), 1:70-75.

Stokes, M.A. and T.L. Smiley, 1968. An Introduction to Tree-Ring Dating. Then University of Chicago Press, Chicago.

Wang Y, et al. 1983. The relationships of tree rings of Qilianshan Juniper and climatic change and glacial activity during the past 1000 years in China, Kexue Tongbao, 28(12): 746-750.

Wei, F and H. Cao, 1994. Grided Processing and Analysing for Monthly Precipitation and Temperature Data in China. Meteorological Magazine (in Chinese) 20(10): 26-30.

Wigley et al., 1984. On the average value of correlated time series, with applications in dendroclimatology and hydrometeorology. Journal of Climate and Applied Meteorology 23: 203-213.

Zheng, D, 1996. The system of physico-geographical regions of the Qinghai-Xizang (Tibet) Plateau. Science in China (Series D), 39(4): 410-417.

Dendrochronological investigations of *Sabina przewalskii* in the northwest of China

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Introduction

In recent years, the expansion of tree-ring sample collection and the accumulation of long chronologies across different areas of the globe have enabled researchers to examine the spatiotemporal patterns of large-scale environmental changes (Mann, Bradley & Hughes, 1998; Briffa, 2000). In contrast, there are relatively few long tree-ring records available in the vast areas of the cold and arid regions of the northwestern China. The lack of data is a major impediment to our effort in increasing spatial resolution of the reconstruction of past environmental changes. Our field investigations in this region in the year 2001, as well as the previous studies (Kang et al., 2000), showed that there is a great potential for building millennium long ring-width chronologies from living *Sabina przewalskii* trees, and extending the chronologies to two-millennium long records with the aid of archaeological wood. In this paper, we report our preliminary studies of the tree-ring samples of this species, and address its dendrochronological potential in the northwest of China.

Geographic Distribution and Physical Settings

Sabina przewalskii is a conifer tree species in the family of *Cupressaceae*. In the northwest of China, it usually grows on the south-facing mountain slopes at the upper timberline above 2800 m in elevation. Other tree species of the *Sabina* genus in this region include *S. tibetica*, and *S. saltuaria* (Sun & Zheng, 1998). The highest location where *Sabina* trees were found is at 4700 m a.s.l. in the Angren area of southwestern Tibet (Fig. 1). The *Sabina* trees are mainly distributed in the cold and semiarid to arid sites in Tibet, southwestern Xinjiang, Qinghai and Gansu provinces (Fig. 1). In the Dulan region (35° 50′~ 36° 30′ N Lat., 97° 40′~ 98° 20′ E Long.) of Qinghai province where we collected tree-ring samples from *S. przewalskii* at the elevation between 3100 m-3800 m, the mean annual total precipitation is about 200 mm with most of the rainfall occurred in May to September, and the mean annual air temperature is 0.5° C with the coldest month (January) being -10.5° C and warmest month (July) being 14.9° C. The ground is frozen during December to early March of the following year. It usually grows as a single tree

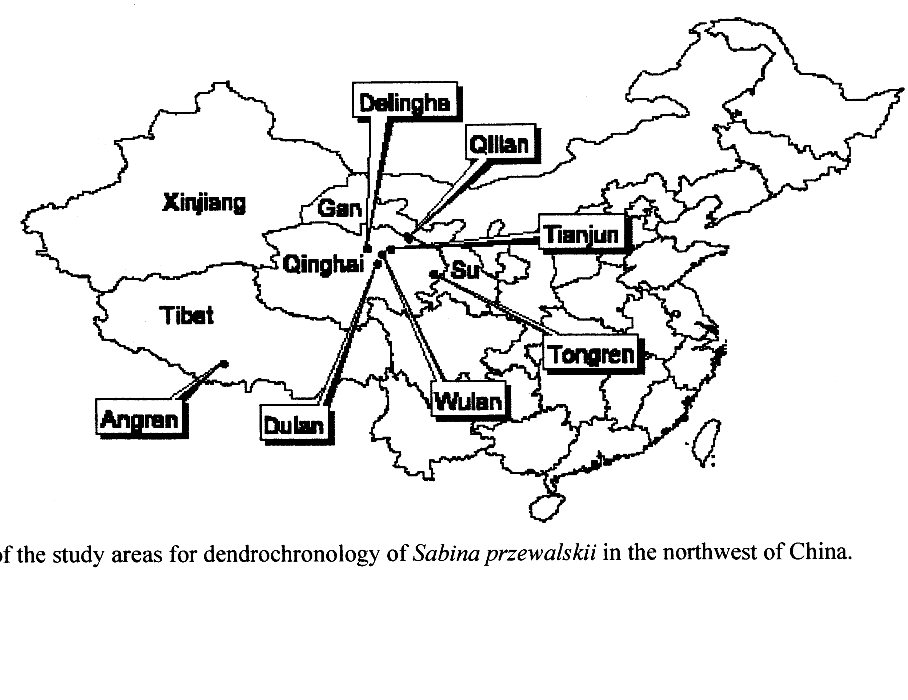

FIGURE 1. Map of the study areas for dendrochronology of *Sabina przewalskii* in the northwest of China.

species, but when it occasionally grows on the north-facing mountain slopes, it is often mixed with other tree species such as *Picea spp*.

Dendrochronological Characteristics

It has been realized in theory that trees growing in ecologically marginal areas tend to have a slow rate of annual stem growth and a high longevity (Schulman, 1954). Our field sampling of tree rings in Qinghai province in the year 2001 indicated that the radial growth of *S. przewalskii* is small and the age is long. For example, the mean ring-width of increment core samples in the Wulan area is 0.46 mm, and many samples have an age over 800 years. The height of old trees in all the sampling areas is only about 10-15 m. Trees are usually scatterly distributed in a stand, thus reducing the influence of competition among neighboring trees. The tree rings also show high variation on annual, decadal or centennial time-scales, suggesting that the radial growth of this species is sensitive to environmental changes. Comparison of the tree-ring chronologies in Wulan, Tianjun, and Qilian areas (Fig. 1) shows similar pattern in low-frequency variation, suggesting that the tree-rings of *S. przewalskii* contain information of large-scale climatic variability.

Current Research

The remarkable longevity and sensitivity of *Sabina* trees on sites of high elevation in the northwestern China have attracted the attention of Chinese and international dendrochronologiests. In recent years, there has been an expansion of tree-ring sample collection in this region and millennium-long tree-ring chronologies have been developed in the Qilian and Dulan areas (Kang et al., 2000, 2002).

We collected a total of 256 tree-ring samples in Tianjun, Wulan, Delingha, Dulan, and Tongren (Fig. 1) areas of Qinghai province in the year 2001. These samples were collected from (a) long-lived trees and ancient wood from tombs with the aim to extract long time-series of climatic information, (b) all the trees in a 20 m x 20 m plot with the aim to examine the ecological perspectives of the growth dynamics, and (c) trees growing on sites of different climatic regimes to compare the growth characteristics of the same species in response to climatic variables.

Here we address the significance of the tree-ring samples collected from ancient tombs which were built in the early Tang Dynasty about 1200 years before present. In combination with the living tree-ring samples, the ancient wood provides us with an opportunity to build a two-millennium long chronology for this ecologically marginal area. The long chronology will not only shed light on intercontinental comparisons of the past climatic changes including those in the Medieval Warm Period and Little Ice Age, but also help us better understand the role of climate in shaping local societies with a long history, a question of great interest with looming climate change.

Future Prospects

In the remote and high elevation areas of the northwestern China and Tibetan Plateau, there are little human activities that affect the growth of *Sabina* trees, consequently the tree-ring variation is largely a result of natural disturbance and climatic influences. The growth, distribution and forest disturbance regimes in this region may be more sensitive to global climatic change (Sun & Zheng, 1998). The longevity, sensitivity and growth on sites of high elevation (up to 4700 m a.s.l.) are unique characteristics for dendrochronological studies of *Sabina* trees in this vast region. We will have a field expedition further into the western Tibetan Plateau this year to collect tree-ring samples on the marginal sites of high elevation and cold and arid regions. We wish our preliminary study will generate a much broader interest and new projects that will add new tree-ring data to reconstruct large-scale synoptic climate variability, to facilitate continental comparisons, and to provide a potential tool for detecting current, and monitoring future climate change.

References

Briffa, K.R., 2000. Annual climate variability in the Holocene: interpreting the message of ancient trees. Quaternary Science Reviews, 19: 87-105.

Kang, X.C., Q.H. Zhang, L.J. Graumlich & P. Sheppard, 2000. Reconstruction of a 1835a past climate for Dulan, Qinghai province, using tree-ring. Journal of Glaciology and Geocryology, 22: 65-72.

Kang, X.C., G.D. Cheng, E.S. Kang & Q.H. Zhang, 2002. Runoff from mountain outlet in the Heihe region for the past one thousand years as reconstructed from tree-rings. Science in China (series D) (in press).

Mann, M.E., R.S. Bradley & M.K. Hughes, 1998. Global-scale temperature patterns and climate forcing over the past six centuries. Nature, 392: 779-787.

Schulman, E., 1954. Longevity under adversity in conifers. Science, 119: 396-399.

Sun, H. & D. Zheng (ed.), 1998. Formation, Evolution and Development of Qinghai-Xizang Plateau. Guangdong Science & Technology Press, China.