Tree-ring analysis of sub-fossil woods of Pinus wallichiana from Ziro valley, Arunachal Pradesh, North-East Himalaya

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Tree-ring Analysis of Sub-fossil Woods of *Pinus wallichiana* from Ziro Valley, Arunachal Pradesh, Northeast Himalaya

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Abstract: We report here a prospect of making a long tree-ring chronology from sub-fossil woods of *Pinus wallichiana* (PIWA) collected from Ziro valley, Arunachal Pradesh, Northeast Himalaya. Based on counting and measurement of ring-width from several sub-fossil wood pieces, and by cross dating, two floating tree-ring chronologies of PIWA covering time span of 331 and 83 years have been prepared. Two C-14 dates of 300 ± 130 BP (calibrated age: AD 1444-1676) and 1420 ± 110 BP (calibrated age: AD 530-720) derived from the inner most rings of two woods are utilized towards reconstruction of absolute chronology. These dates of sub-fossil woods one each as a component of long and short floating chronologies suggest that millennium year long tree-ring chronology can be proposed from this region.

Keywords: Sub-fossil wood, Floating chronology, Ziro valley, Arunachal Pradesh.

INTRODUCTION

Attempts are being made to understand the detailed climatic changes of India in the past millennium using various proxy records e.g. ice cores, lake sediments, glacier fluctuations, peat deposits etc. Even high resolution palaeoclimatic information for longer time scale from this region is scant. In recent years tree-ring data is emerging as an excellent proxy to retrieve high resolution past climatic changes from several geographical regions of India (Bhattacharyya et al. 1988; Bhattacharyya et al. 1992; Hughes, 1992; Bhattacharyya and Yadav, 1996; Borgaonkar et al. 1996; Chaudhary et al. 1999; Yadav et al. 1999; Bhattacharyya and Chaudhary, 2003; Bhattacharyya et al. 2006; Shah et al. 2007). It has been recorded that tree-ring based climatic reconstructions in India generally do not exceed beyond 400 years records except at some sites in the Northwest Himalaya. Thus, a long record of tree-ring data is needed to extend available climate reconstruction further back to determine climatic variability in sub-decadal, decadal and century scale. However, non availability of older living trees in most of the sites is hindering the preparation of long tree chronology. Such trees are logged off because of over exploitation of the forests to meet out the demands of increased pressure of civilization and urbanization. There are several global reports that the tree-ring data derived from sub-fossil woods are excellent source to develop long chronologies even beyond Holocene (Lara and Villalba, 1993; Grudd et al. 2002; Gunnarson and Linderholm, 2002; Helama et al. 2002; Naurzbaev et al. 2002; Leuschner et al. 2002; Spurk et al. 2002).

Northeast Himalaya is a promising region for high resolution paleoclimate studies using tree-ring as an evident source of proxy data (Bhattacharyya and Chaudhary, 2003; Buckley et al. 2005; Shah et al. 2009). However, the data so far accumulated are not enough for building long tree-ring chronology necessary for robust climatic reconstruction, especially to understand monsoon dynamics and its linkage to other climatic phenomena. In the present study we explore the possibilities of extension of existing tree-ring chronologies of this region by using tree-ring width records of sub-fossil woods of PIWA from the sediment deposited under swampy environment at Ziro valley, Arunachal Pradesh.

STUDY AREA AND LOCATION

Sub-fossil woods, buried in the peat or out washed slope deposits are common in river bed at several places of Ziro valley, Lower Subansiri district, Arunachal Pradesh, Northeast Himalaya (Fig.1). Samples were collected in the form of disc from 7 sub-fossil tree logs recorded from two sites of this area viz. Siro village (SIR) and Tarin (TAR) (Fig. 2) during the field expedition at this region, April, 2005.

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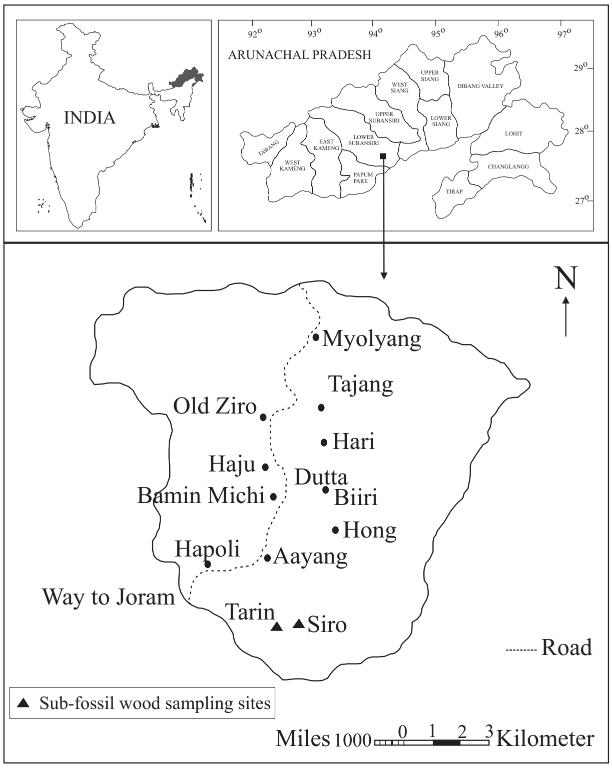

Fig.1. Sub-fossil wood sampling site.

METHODOLOGY

For the present study, seven discs one each per log was sliced using saw. The surfaces of these discs were sanded with different grades of sand papers to prepare the wood for the microscopic analysis and chalk powder was used to enhance the clarity of each ring (Fig. 3). For identification of these wood discs, their anatomical features especially early wood, late wood and the nature of ring boundary were studied under stereo zoom microscope. For each disc, the radius without growth irregularities i.e. growth suppression or growth surges, wedging of rings were selected for the analysis. The rotten samples (radii), without clear demarcation of the individual rings were excluded from further analysis. Tree-rings along the radii had been counted from innermost to outermost ring and then Skeleton Plots were prepared for the purpose of cross dating (Stokes and Smiley, 1968). All these plots were compared to each other to find out common ring pattern and to identify existence of any missing and false ring. After checking and correcting any error due to existence of false and missing ring, ring-widths of each disc were measured under VELMEX measuring system attached to personal computer. These measurements and number of the location of ring had been rechecked using the computer program COFECHA (Holmes, 1983; Grissino-Mayer, 2001). This programme traces if there were any error due to cross dating, measurement and other ring width irregularities that may decrease the efficiency of ring-width time series for the tree-ring analysis. For making the chronology, the measured ring-width series were standardized with the double detrending technique – first a negative exponential curve or linear trend was fitted to each series, and then, each series was detrended second time by fitting a 30 years cubic smoothing spline.

RESULTS AND DISCUSSION

The anatomical features of the sub-fossil woods studied resemble closely to the wood of PIWA commonly growing in this region. The skeleton plots have been prepared from total 26 radii of sub-fossil woods of PIWA analyzed from this region. In which tree-rings of 22 radii from 6 discs (TARSFW-03, TARSFW-06, TARSFW-07, TARSFW-08, TRSFW-09 and TARSFW-11) collected from site Tarin are recorded to have good cross-date with each other. However, tree-rings of another 4 radii of only 1 disc (SIRSFW-06) collected from Siro village though have good cross dating within the same disc (Fig. 4) but do not cross match or show common tree-ring pattern with the samples collected from the other site, Tarin. Two floating chronologies, one each from two sites have been prepared. First one is a 331 year long chronology comprising highly correlated tree-ring data of 22 radii from 6 sub-fossil wood samples analyzed from site Tarin (Fig.5a), and other one of 83 years chronology from Siro village (Fig.5b), includes 4 radii of one sub-fossil wood sample. The chronology statistics of both the floating chronologies have been shown in Table 1. These two floating tree-ring chronologies do not have common growth pattern or cross matched with the well dated tree-ring chronology or master tree-ring chronology of PIWA (Fig.5c) made earlier from trees growing at 5 sites of Ziro valley and adjacent region (Shah et al. 2009). Non synchronous growth pattern recorded between master chronology and both the fossil floating chronologies of PIWA suggests that the latter are older than AD 1704. Their tree-rings could not be dated in terms of calendar years through cross dating since the

Table 1. Selected statistics of floating tree-ring chronologies of sub-fossil wood of *Pinus wallichiana* at Ziro valley

	Floating chronology 1	Floating chronology 2
Chronology length	331 years	83 years
No. of trees (No. of cores)	6 (23)	1 (4)
Mean sensitivity	0.180	0.144
Standard deviation	0.165	0.143
Serial correlation	0.131	0.230

Fig.2. Collection of sub-fossil woods from Ziro valley. [**A, C** and **D** are from site TAR; **B** and **E** are from site SIR]. Location of samples is indicated by arrow.

time span of the extant or so far prepared master chronology of this tree of this region is 1704 to 2000 AD. To get a broad idea of the absolute age of these woods, inner most tree-rings of two discs have been dated through C-14 dating method at the Radio Carbon Laboratory, Birbal Sahni Institute of Palaeobotany, Lucknow. The calibrations of these C-14 dates to calendar years have been made using the standard practice (Stuiver et al. 1998). The C-14 date of TARSFW-08D is 300 ± 130yr BP. By calibration it is AD 1444-1676 (Fig. 5a). The date of SIRSFW-06A is 1420 ± 110yr.BP. The calibrated age of that sample is AD 530-720 (Fig. 5b). The sub-fossil sample, TARSFW-09 of longer floating chronology identifies at least a common period, AD 1704-1744 between extant and floating chronology by considering AD 1444 date of its innermost rings and presence of 300 rings in it. This common period may be variable due to uncertainties in assigning date by radio carbon dating method which ranges from AD 1444 to AD 1676. As mentioned earlier there is no cross matching amongst these floating chronologies and extant PIWA

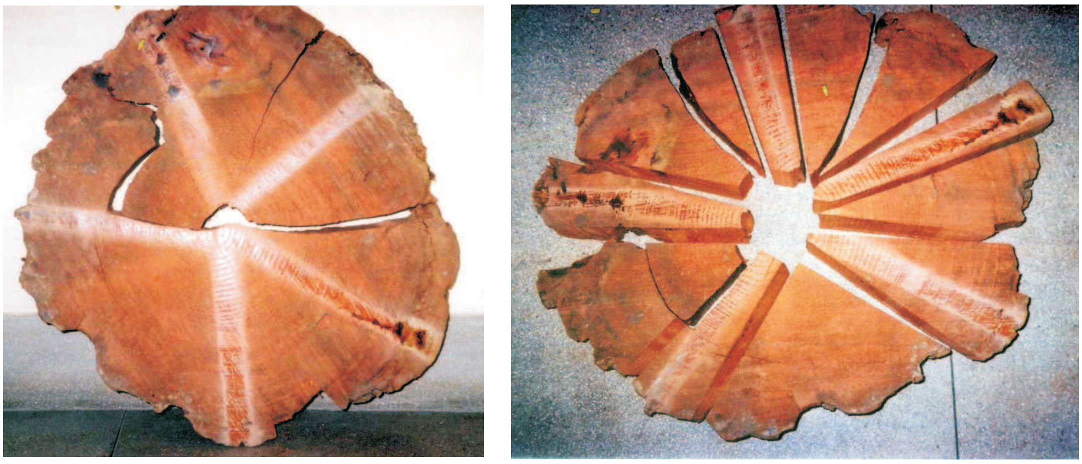

Fig.3. Processing of sub-fossil woods. Chalk powder is applied for enhancing the clarity of ring boundary.

chronology of this region. This may be either due to limitation of calibration of C-14 dates to calendar dates or inadequate number of samples covering this time span from both fossil and modern trees of this region. In this pilot attempt, it was not possible to make well dated tree-ring chronologies from sub-fossil PIWA of this region. For assigning exact calendar date to individual ring of these chronologies, more tree-ring samples need to be collected from both living and dead trees for cross dating. However, two C-14 dates of sub-fossil woods, around AD 1500 and AD 600 suggest that tree-ring data from this region could provide data base for making millennium year long tree-ring chronology (Fig.4). Earlier analysis on tree growth climate relationship of PIWA of this region suggests that the pre-monsoon precipitation (December–April) has important role in limiting the growth of this tree (Shah et al. 2009). Such long tree-ring records derived from sub-fossil woods of the Northeast Himalaya if dated precisely would be useful to analyze the long term pre-monsoon variability and its tele-connection with other climatic events viz. Monsoon Eurasian snow cover, El-Nino Southern Oscillation (ENSO) etc.

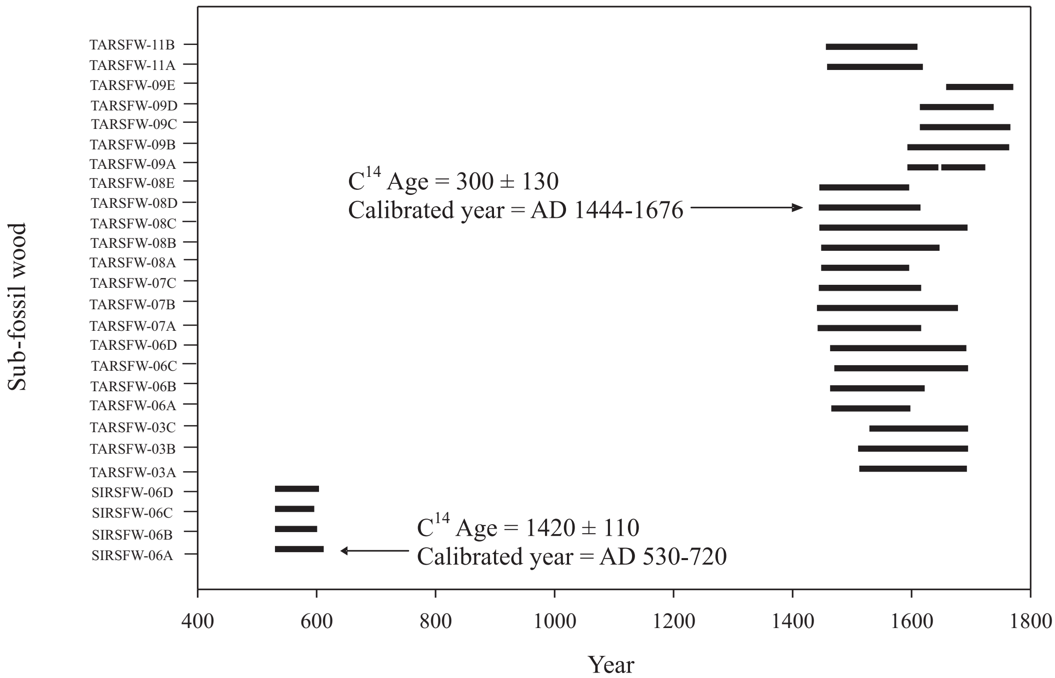

Fig.4. Time span of tree-ring record of sub-fossil woods and existing calendar dated tree-ring chronology of Ziro valley, Northeast Himalaya.

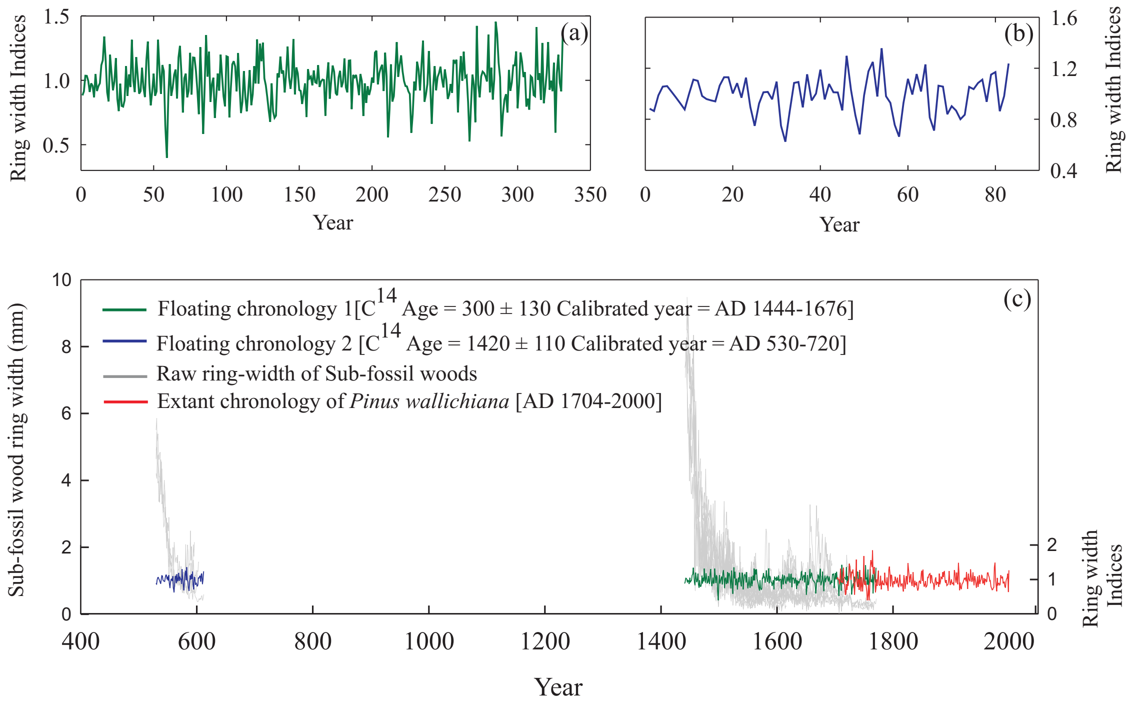

Fig.5. Ring-width index chronology of sub-fossil wood from northeast Himalaya. **(a)** 331 years **(b)** 83 years. **(c)** Raw ring widths and chronologies of sub-fossil wood along with the chronology of extant *Pinus wallichiana* growing in Ziro valley.

CONCLUSIONS

Two floating tree-ring chronologies constructed from sub-fossil stumps of PIWA collected from Ziro valley are 331 and 83 years which could not be dated due to lack of overlapping tree-ring sequence between extant and fossil tree analyzed from this region. Absolute dates of inner most rings of two fossil wood pieces are around AD 1500 and AD 600 hence indicate a possibility of making millennium year's long tree-ring chronology of Ziro valley.

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