IAWA Journal, Vol. 20 (3), 1999: 317–324

TREE-RING STUDIES IN THE EASTERN HIMALAYAN REGION: PROSPECTS AND PROBLEMS

by

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SUMMARY

Tree-ring samples of different conifer species in various ecological settings from subtropical to temperate regions of the Eastern Himalayan region have been evaluated for their potential for dendroclimatic reconstructions. Most of these tree species have cross-datable growth rings except *Taxus baccata* and *Tsuga dumosa* where series of micro-rings and lack of variation in these suppressed zones make cross-dating difficult. Tree-ring chronologies have been established from *Abies densa* and *Larix griffithiana*, the only deciduous conifer species in the Himalayas. Tree growth–climate relationships reveal that temperature is a determinant factor for the growth of trees at high elevations. *Abies densa* in the western part of Arunachal Pradesh shows a negative response to the July–September temperature whereas *Larix griffithiana* shows a positive response to the May temperature.

Key words: Eastern Himalayas, growth rings, dendroclimatology.

INTRODUCTION

A good number of studies have been made to unravel the climatic changes during the recent past in the Himalayan region, mostly in its western and central parts, using tree-ring data (Bhattacharyya et al. 1988, 1992; Bhattacharyya & Yadav 1990, 1992, 1996. 1999; Bilham et al. 1983; Borgaonkar et al. 1994, 1996, 1999; Hughes & Davies 1987; Hughes 1992; Pant & Borgaonkar 1984; Pant et al. 1995; Ramesh et al. 1985, 1986; Yadav & Bhattacharyya 1992; Yadav et al. 1997a, b, 1999). The present study is the first attempt to evaluate the dendroclimatic potential and problems in the Eastern Himalayan region which is under the influence of a monsoon climate and where both the instrumental as well as proxy climatic records are scant. Such studies will contribute to understand different aspects of climate changes in the entire Himalayan region and to analyse their linkages to other phenomena in a global context.

GENERAL CLIMATE OF THE AREA

The area is the most humid part in the Himalayas and is under the influence of pronounced monsoon rainfall. There is an average annual rainfall of 3,000 to 4,000 mm, more than 75% of which falls from June to September although the entire rainy season extends from April to October. Rainfall during winter, i.e., from November to

March, is from the North-East monsoon and is least, sometimes nil. January is the coldest month. The hottest time of the year is May and early June before the onset of the monsoon. The relative humidity is over 60% in July and over 80% in October (Rao 1981). Altogether, mesic climatic conditions are predominant.

SITE DESCRIPTION AND SAMPLE COLLECTION

In this first exploratory study tree-ring samples were collected from seven conifer species growing in diversified ecological sites in the Eastern Himalayan region covering Darjeeling, northern Sikkim and northwestern Arunachal Pradesh. The samples include *Abies densa, Juniperus indica, Larix griffithiana, Pinus roxburghii, P. wallichiana, Taxus baccata,* and *Tsuga dumosa.* The location of the sites and the nearest meteorological stations are shown in Figure 1.

Attempts have been made to collect samples from old trees growing under two contrasting situations: 1) trees restricted to steep slopes with thin soil cover or rocky habitat and easily recognised by their short stature, with heavy upper branches, stripped bark and pronounced crown die-back; 2) trees with large size and huge girth growing on good soil cover on gentle slopes. However, due to extensive deforestation such old trees are few in number. Many of such trees which escaped logging were found unsuitable for sampling since they have hollow trunks due to heartrot.

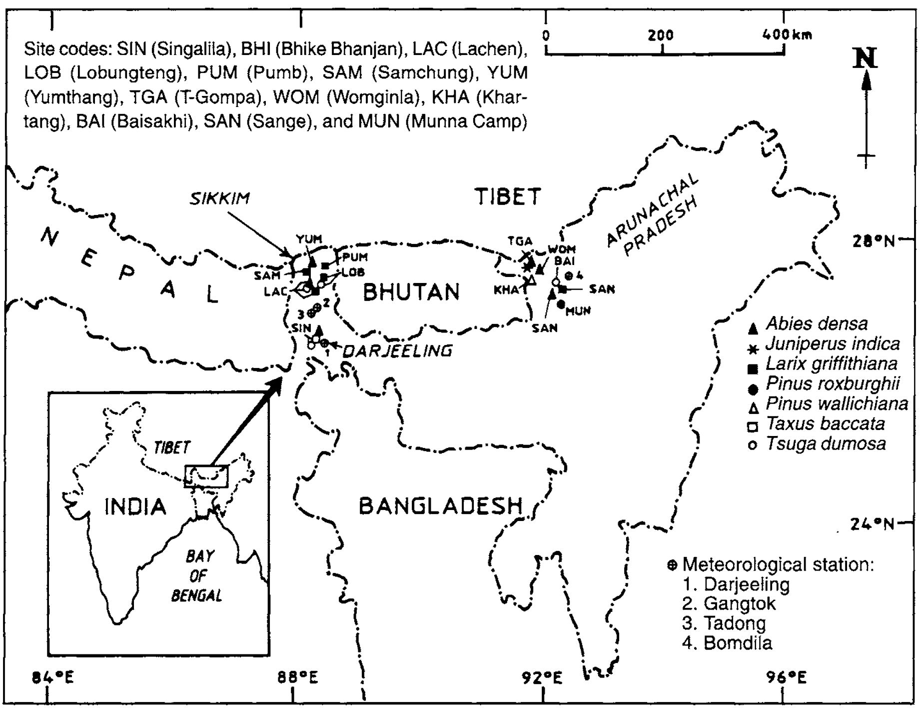

Fig. 1. Location of tree-ring sites and meteorological stations.

DATING OF SAMPLES

Samples were processed following standard procedures of tree-ring analysis (Fritts 1976). Ring structures were studied carefully before assigning calendar dates to each ring. In some samples of *Abies*, bands of traumatic cells resembling rings are present but they can be easily detected by cross-dating. In *Pinus roxburghii* there are many micro-rings in the later part of most of the cores that are sometimes represented by one-celled rings. Whether these rings are annual is yet to be checked. In *Tsuga* and *Taxus* there are long series of micro-rings at places within the whole tree-ring series which lack variation, thereby posing problems in dating these samples. As such, the problem of missing rings in conifers in this region is small except in *Taxus baccata.*

At many sites it has not been possible to collect trees of over 200 years old. There is evidence that this region has been disturbed heavily due to various human activities: logging, clearance for jhum cultivation [a kind of shifting cultivation], house building, road construction, resin extraction, lopping for firewood etc. during the recent past. Although it is difficult to get old trees in some of those areas, the possibility of getting older trees from undisturbed forests in remote areas cannot be ignored. Here, *Pinus* and *Larix* are mostly less than 200 years in age, whereas *Juniperus* and *Abies* range from 200–500 years.

CHRONOLOGY DEVELOPMENT

The rings of all these samples were measured to an accuracy of 0.01 mm. Cross-dating of the tree-ring series was checked with the COFECHA programme (Holmes 1983) before the chronologies were assembled. The age trend of these samples was removed by standardising the data using a negative exponential curve or a 40-year spline (Cook 1985) with a 50% frequency cut-off. Then, the standardised ring-width values from individual sites were averaged to form site chronologies for each taxon. The process of averaging reduced the amount of variability due to non-climatic factors and enhanced the climatic signal in the mean chronology. Five chronologies were developed of which three are of *Abies* (Fig. 2) and two of *Larix* (Fig. 3). The longest chronology of the present study is of *Abies densa* from Yumthang, North Sikkim, covering the time span from 1503 to 1994 AD, although replication of samples is poor before 1757 AD. Chronology development of other taxa is in process. Selected statistics of all the standard chronologies are given in Table 1.

Table 1. Selected statistics of standard chronologies.

Site name	Site code	No. of radii / trees	Mean sens.	Stand. dev.	Auto-corr. ord. 1	S/N-ratio
T-Gompa	TGA	39 / 26	0.10	0.14	0.58	7.60
Yumthang	YUM	50 / 29	0.13	0.19	0.58	8.12
Singalila	SIN	25 / 17	0.15	0.24	0.63	2.27
Lachen	LAC	38 / 20	0.13	0.22	0.59	4.24
Sange	SAN	18 / 12	0.14	0.20	0.42	4.43

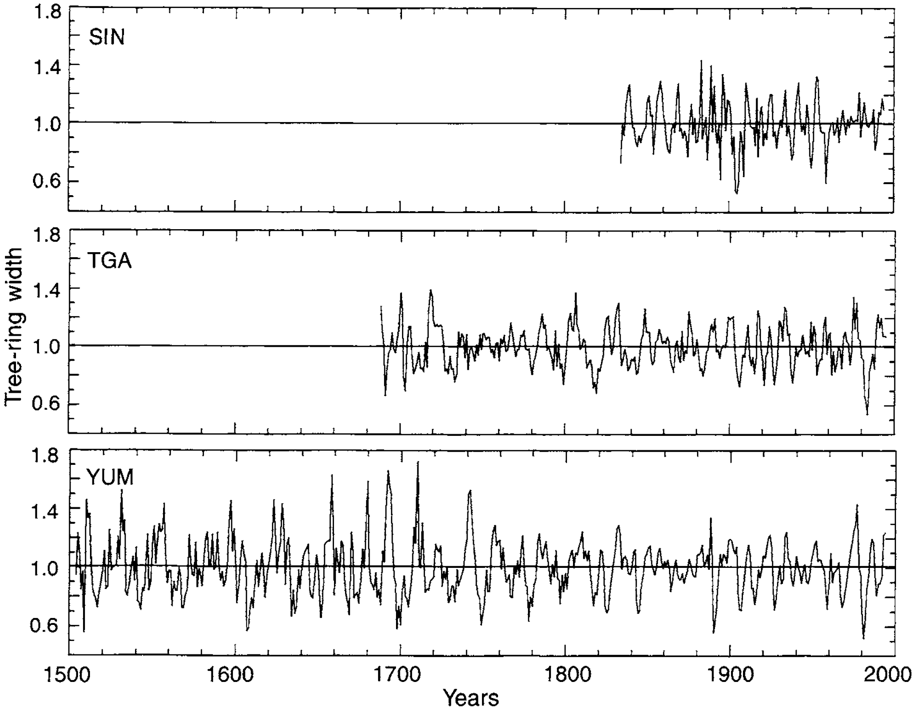

Fig. 2. *Abies densa* chronologies of Singalila (SIN), Darjeeling, T-Gompa (TGA), Arunachal Pradesh, and Yumthang (YUM), Sikkim.

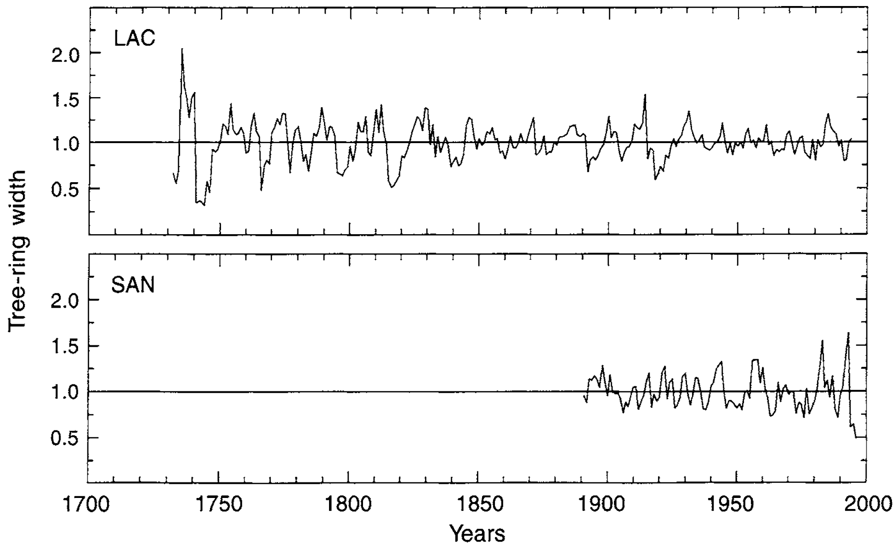

Fig. 3. *Larix griffithiana* chronologies of Lachen (LAC), Sikkim, and Sange (SAN), Arunachal Pradesh.

Table 2. Correlation matrix of all standard (S) and residual (R) chronologies.

Site	YUM.S	YUM.R	TGA.S	TGA.R	SIN.S	SIN.R	LAC.S	LAC.R	SAN.S
YUM.S									
YUM.R	0.688								
TGA.S	0.461	0.370							
TGA.R	0.348	0.480	0.779						
SIN.S	0.072	0.156	0.090	0.217					
SIN.R	0.091	0.224	0.090	0.269	0.796				
LAC.S	0.268	0.248	0.176	0.122	0.206	0.244			
LAC.R	0.212	0.264	0.169	0.157	0.208	0.270	0.904		
SAN.S	0.181	0.029	-0.008	-0.166	-0.053	-0.068	0.106	0.056	
SAN.R	0.059	-0.135	0.035	-0.180	-0.083	-0.135	0.054	0.038	0.765

Correlation analysis was done to see if there exists any correlation between different taxa and within the same taxa at different sites (Table 2). It has been noted that within the species, correlation is high. Thus in *Abies densa*, between YUM and TGA correlation is significantly high (0.48) taking into account that these two sites are more than 400 km apart from each other. However, inter-specific correlation is poor which may be due to different growth characteristics or different responses of different tree species to climate.

RESPONSE FUNCTION

Response functions were computed to analyse tree growth/climate relationships. The existence of few meteorological stations at higher elevations poses a problem in getting long enough instrumental records close to the tree sites. Many of these stations have been operational for the last 10–15 years only. In the present study records of the monthly mean temperature and the monthly sum of precipitation from three homogeneous meteorological stations, Darjeeling, Gangtok and Tadong, have been chosen although these stations are located far from the sampling sites (cf. Fig. 1). Later, data from all three stations were merged together to form a regionally averaged data set. Only Darjeeling has a comparatively long climatic record as compared to the other stations, spanning from 1848 to1978 (temperature) and 1867–1987 (precipitation). Since the climatic record of the Gangtok station starts only from 1966 AD and of Tadong from 1978 AD, data before 1966 are represented by the Darjeeling station alone.

The response function analysis was carried out for the TGA chronology (Fig. 4) with the regionally averaged meteorological record. Prior August to October and current July to September temperatures have an inverse relationship with tree growth while temperatures during current March and May are directly related to tree growth. An inverse relationship with the monthly precipitation of prior August and September

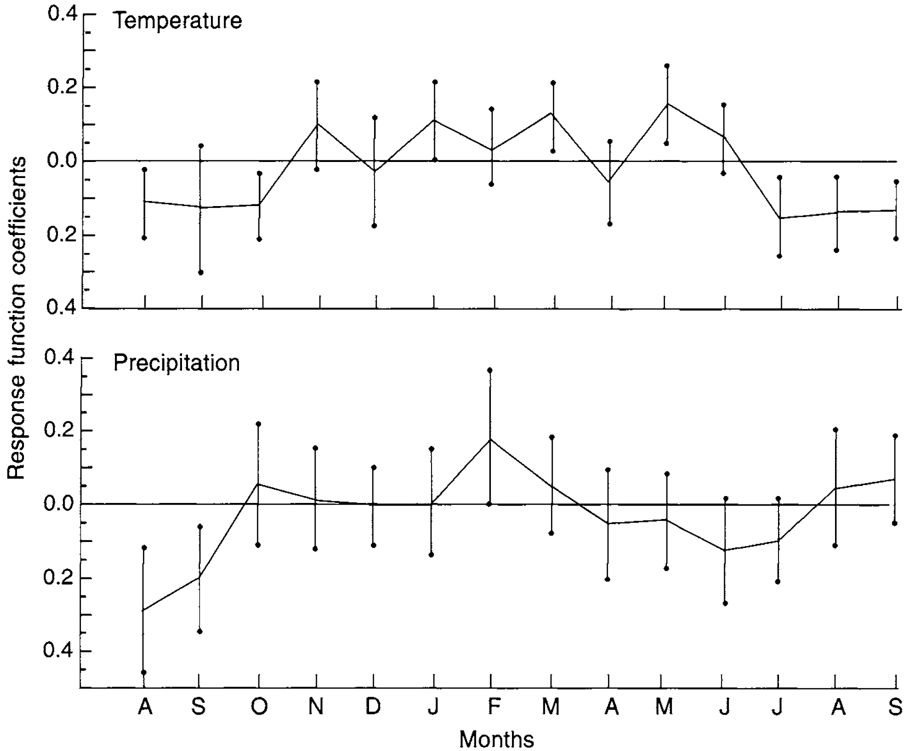

Fig. 4. Response function for *Abies densa* at T-Gompa, Tawang, Arunachal Pradesh.

and tree growth has been noticed. The negative relationship of current July to September temperature with the growth of *Abies* might be due to more cloudy days associated with rain which might have an inverse effect on photosynthesis.

The response function for SAN (Fig. 5) shows a positive relationship with prior November and current year's May to July temperatures whereas current January and April temperatures have a negative relationship with tree growth. Prior year's August and September, and current year's July precipitation have an inverse relationship whereas current year's January and February precipitation exhibit a direct relationship with tree growth.

CONCLUSION

It was observed earlier that trees growing under mesophytic conditions in this region may not be suitable for dendroclimatic analyses. However, in the present study several conifers growing in the Eastern Himalayan region have been found to have datable tree-ring series and these provide data to prepare climatically sensitive tree-ring chronologies. The problem of low signal-to-noise-ratios in most of the chronologies could possibly be solved in future by the addition of more samples and extensive collec-

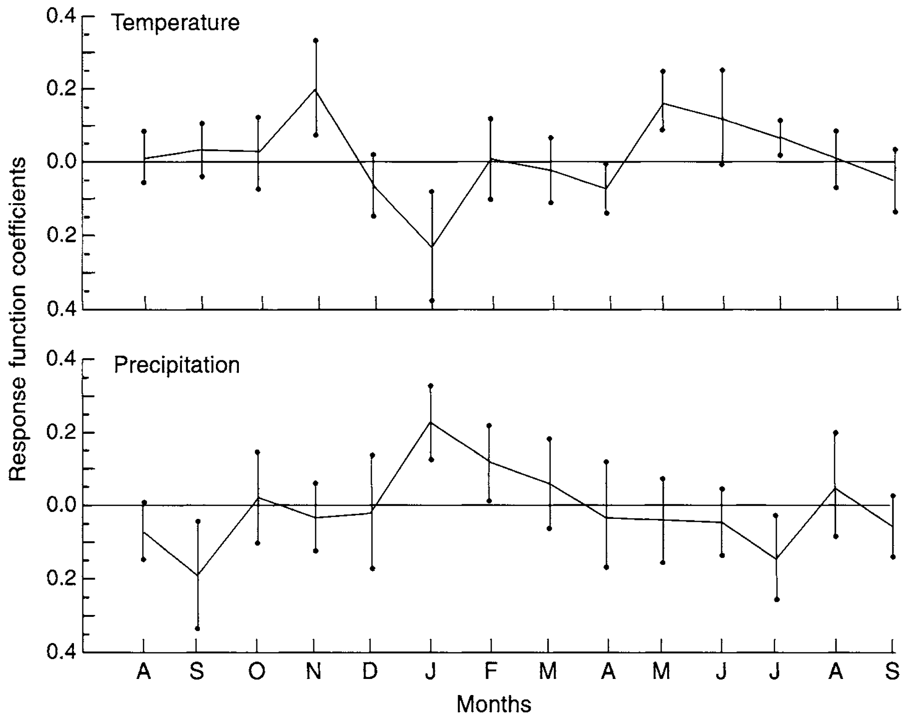

Fig. 5. Response function of *Larix griffithiana* at Sange, Arunachal Pradesh.

tions from undisturbed forest sites in remote areas. Moreover, lack of meteorological data near the sampling sites and sparse records in the Eastern Himalayan region poses problems in analysing tree growth-climate relationships. Multivariate regression analyses using multiple site chronologies and regional climatic data might be suited for the climatic reconstruction from this region.

ACKNOWLEDGEMENT

We are highly grateful to the officials of Darjeeling, Sikkim, and Arunachal Pradesh Forest Department for their kind help during the collection of samples.

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