Proc. Indian natn. Sci. Acad., B62, No. 3, pp. 233-238 (1996)

Biological Inferences from the Growth Climate Relationship in Teak from India

R R YADAV and A BHATTACHARYYA

Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007

(Received on 28 August 1995; after revision on 6 May 1996; Accepted on 10 June 1996)

Tree ring samples of teak (*Tectona grandis* L. f.) collected from dry deciduous forest in Korzi, Andhra Pradesh, were analysed to work out its dendroclimatic potential especially in the reconstruction of monsoon variability. Ring width chronology (1872-1987 AD) from nine radii of five trees was developed. The response function analysis carried out to understand tree growth climate relationship has shown strong direct relationship with precipitation. This feature shows that the teak chronologies could provide valuable data base to understand long term monsoon variability in India.

Key Words : **Teak, *Tectona grandis* L.f., Growth rings, Dendroclimatology, Precipitation reconstruction**

Introduction

Tropical forests in India are met in varied, non-seasonal to seasonal climate. The non-seasonal tropical forests are found in Western Ghats, southern and north eastern part of the country where high rainfall and temperature occur throughout the year with very little fluctuation. However, in many parts of the peninsular India, distinct seasonality in rainfall occurs. The phenological study of tropical trees growing even in non-seasonal climate indicate that many of the tropical taxa document definite seasonality of growth changes. Seasonal flushing, leaf fall, flowering and fruiting all indicate a rhythm that could be accompanied by radial growth cycles. In transition between the phases of cycles, there could be identifiable changes in anatomy of radial growth. Wood anatomical studies have indicated that around 25% of tropical tree species have growth rings (Chowdhary 1964), however, much attention has not been given on their datability.

Teak (*Tectona grandis*) is found to occur in natural forests in India, Burma, Thailand and Laos where monsoon is the common feature. The monsoon variability which has a direct impact on human society is one of the key phenomena for climatologists in the whole region. Tree rings, the high resolution proxy climate records, could contribute to a better understanding of monsoon, its phasing and teleconnections. Teak ring width chronologies from southeast Asian region have shown sensitivity to precipitation especially during the dry season (Berlage 1931, Jacoby 1989, Jacoby and D'Arrigo 1990, D'Arrigo et al. 1994, Murphy 1994, Pumijumong et al. 1995). Studies conducted in India though based on parochial sampling have also indicated their dendroclimatic potentiality (Pant and Borgaonkar 1983, Ramesh et al. 1989, Bhattacharyya et al. 1992). However, network of tree ring sequences from different ecological regions are required to be studied to have clear understanding of tree growth climate relationship. Development of climatically responsive teak chronologies will provide valuable data base for the reconstruction of precipitation.

Tree ring analysis of teak *(Tectona grandis* L.f.) from dry deciduous forest in Korzi, Andhra Pradesh has been reported in the present paper.

Phenology of Teak

Teak is a deciduous tree growing in moist to dry deciduous forests in India. In dry situations leaf fall occurs from November to January but in moist localities it starts from March or even later. The trees generally remain leafless throughout the dry season. Leaf fall has been found to be associated with cambial dormancy. New leaves appear from April to June. Flowers come up from June to August or September but may even appear earlier in wet conditions. Cambial reactivation and xylem differentiation have been found to begin with the onset of bud break (Rao & Dave 1981, Venugopal & Krishnamurty 1987). The cambial activity is at its peak during the time of flowering and fruiting.

Sampling and Dating of Growth Rings

The dry deciduous teak forest in Korzi, Andhra Pradesh (18° 26 ′ N- 79° 08′ E) was surveyed during the time of logging in November, 1987. Teak boles were often found much lobed due to heavy buttressing at the base. Therefore, attempts were made to collect the disc samples at breast height, where circuit uniformity was usually noted. Ten disc samples taken from this region were used for the present study. The cross sections were polished by using different grades of sand papers until the cellular details became distinct. Skeleton plot method (Stokes & Smiley 1968) was used to date the growth ring sequences. Nine radii of five trees could be dated successfully. It was not possible to date other trees because of the presence of bands of narrow rings in the outer portion of the stem. At such portions, only early wood vessels were noticeable and the portion of late wood was indistinct, making the identification of one ring from the other very difficult. Growth ring sequences of dated samples were measured to one hundredth of a millimetre by using the ring width measuring machine.

Analysis of Tree Ring Data

Rind width measurements of different radii were transformed into ring width indices by using programme ARSTAN (Cook 1985, Holmes et al. 1986). Two step detrending by using negative exponential followed by spline of 50% variance reduction at 128 years was used. The standard chronology (figure 1) extending from 1872-1987 AD was computed by averaging the individual series using biweight robust mean. The chronology statistics (table 1) such as high mean sensitivity (0.411) and low first order autocorrelation (0.291) indicate its suitability for climatic studies.

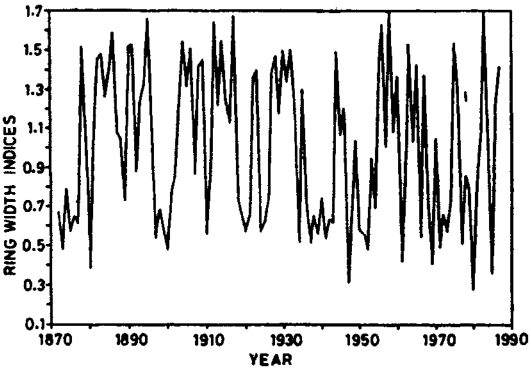

Figure 1 Standard chronology of teak (*Tectona grandis*) from Korzi, Andhra Pradesh

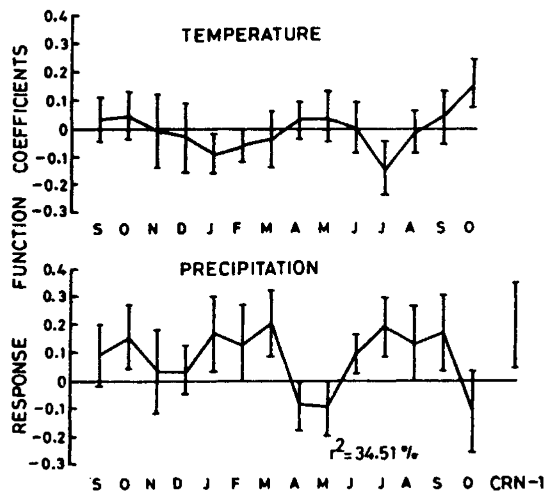

Figure 2 Response function of the standard chronology with 28 monthly climatic variables and one prior years growth

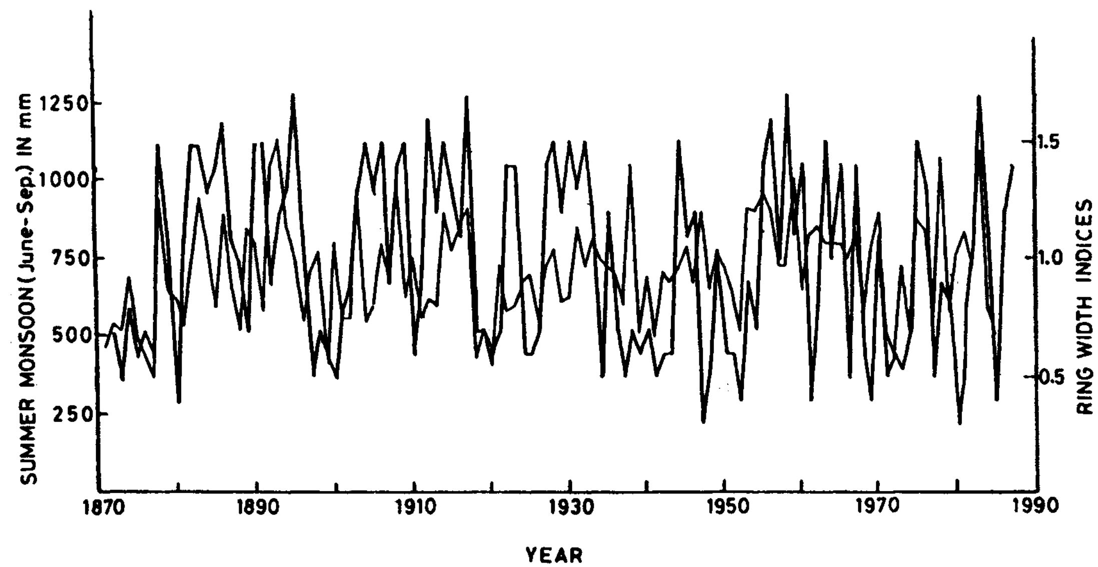

Figure 3 Standard chronology showing close relationship with summer precipitation

For climate growth relationship study, mean monthly temperature and precipitation data (1893-1987 AD) available from Hyderabad Airport Meteorological Station, which is about 100 km south of the sampling site, were used. Fourteen months' temperature and precipitation data from previous year's

Table 1 *Chronology statistics for 9 radii of 5 trees from 1872-1987 AD (116 years)*

Chronology type	Standard	Resid (AR 1)	ARSTAN
Mean	1.0000	1.0000	.9950
Median	1.0239	.9461	.9607
Mean sensitivity	.4112	.3898	.3549
Standard deviation	.4022	.3612	.4211
Skewness	.0984	.4423	.5206
Kurtosis	−1.2460	−.4624	−.2558
Autocorrelation order 1	.2910	.1629	.5275
order 2	−.0009	−.1006	−.1306
order 3	.0674	.0960	.1022
Variance due to autoregression	8.2%		30.7%
Error variance	.037450		.036497
Ratio of error variance of chronologies ARSTAN/STNDRD) Common interval 1985 to 1987 (103 years) 4 trees 7 radii			.9745

	Detrended series	Residuals (white noise)
Mean correlations :		
Among all radii	.235	.232
Between trees (Y variance)	.156	.158
Within trees	.711	.675
Signal-to-noise ratio	.739	.751
Agreement with population chron	.425	.429
Variance in first eigenvector	37.71%	38.59%
Chron common interval mean	1.009	.985
Chron common interval std dev	.403	.338

September to current October and one prior year's growth were used for response function analysis (figure 2). Total climatic variance noted in the chronology was 34.51%.

Response function analysis shows that temperature of current year's January, February and July has significantly negative, whereas October has positive impact on teak growth. The tree is physiologically dormant during January and February. Above average temperature during these months could accelerate the metabolic activity thus exhausting the food reserve leading to poor growth during the ensuing growing period. July temperature seems to play indirect role on tree growth. Hot July could lead to water deficiency by enhancing the evapotranspiration, thereby causing negative impact on tree growth.

Response function with precipitation records that the moisture supply plays very important role for teak growth in the study area where moisture is extremely deficient. The precipitation of previous year's October and current January, March and June to September show positive effect on teak growth. Current year's April, May and October precipitation are negatively related with tree growth. Phenological studies of teak show that in dry areas it flushes from April to June. The wetter conditions stimulate the flushing which is also associated with radial growth of the tree. Therefore, the negative influence of April and May precipitation is difficult to explain at the moment. More replication of samples is desired to verify the present finding. It is further recorded through the response function that the tree growth is much favoured by summer precipitation. Tree ring chronology plotted along with the summer precipitation (figure 3) shows that the tree growth very closely follows the pattern of summer precipitaton. Similar to the present finding, Pumijumong et al. (1995) also noted that teak growth in northern Thailand is much favoured by rainfall during the wet season. However, Pant and Borgaonkar (1983) found that October precipitation, prior to the growth period plays important role on teak growth in moist deciduous forests in Thane region.

Previous year's ring width has been found to be positively related with the current year's growth. This shows that the food reserves of the previous year trigger the ensuing year's tree growth.

Conclusion

The present study though based on very limited number of samples from a dry deciduous forest has indicated the potentiality of teak chronology for dendroclimatic studies from the Indian subcontinent. The ring width chronology is found to be responsive to precipitation. The teak chronologies developed from moisture stressed sites could be very useful for precipitation reconstruction. In India, where monsoon failures are very common, long-term climatic reconstructions from tree ring chronologies would help in understanding the monsoon behaviour. Therefore, an emphasis needs to be given to build long teak chronologies from moisture stressed sites.

Teak has been found to have considerable promise in chronological terms too. Recently Yadav and Bhattacharyya (mss) prepared 800 year long chronology from one teak disc sample stored in Wood Museum, Bangalore. There is also a good chance of getting teak trees reaching upto 600 years in age from India (Krishnamurthy 1983). But due to the high demand for its timber for construction purposes, natural forest trees are being logged intensively, resulting in the permanent loss of a valuable natural archive of climate. An integrated approach is needed to salvage the rapidly vanishing resource, which could provide high resolution palaeoclimatic information for several centuries.

Due to the resistance of teak to termites and other insects, there is also a good scope of getting valuable tree ring material from old building. Several centuries old teak wood from the old city of Vijayanagar (Hampi) in South Deccan has been reported to be in very good condition (Gamble 1902). Some wood blocks of teak collected from the ancient city of Ujjain have been stored in the Forest Research Institute, Dehra Dun. These woods are expected to be very old. Such few records of the availability of old tree ring materials show the possibility of extending the tree ring chronology prepared from living trees to a few more centuries. The longer chronologies would be of significant use in the understanding of climate dynamics.

Acknowledgements

Authors express their sincere thanks to the authorities of the Forest Department, Andhra Pradesh for help in collection of samples for this work.

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