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# AGE AND GROWTH RATES OF SOME GYMNOSPERMS OF PAKISTAN: A DENDROCHRONOLOGICAL APPROACH

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**Abstract**

Dendrochronological techniques were used in 49 different mature stands of 39 gymnosperms forests of Pakistan. Wood samples were obtained from 218 trees including *Pinus wallichiana* A.B. Jackson, *Pinus roxburghii* Sargent, *Picea smithiana* (Wall) Boiss., *Cedrus deodara* (Roxb.) G. Donf., *Abies pindrow* Royle and *Taxus wallichiana Zucc*., using Swedish Increment Borer to obtain age and growth rates of these trees. It showed that largest tree is not necessarily the oldest tree. Highest overall growth rate (2.65 ± 0.19 y/cm) was recorded in C*edrus deodara* from south facing slopes while slowest growth was observed in *Taxus wallichiana*, from East facing slope. Except in *Pinus roxburghii*, Dbh and age showed no significant relation. In addition no significant relation was found between elevation and growth rates. Statistics of some selected species and sites are also presented and it is suggested that growth rings of these species could be used in dendrochronological research.

## Introduction

Growth rate and age of trees are frequently used in silviculture, forestry, ecology and population dynamics studies. Despite the great importance of these estimates, there are a few published data available for Pakistani tree species (Swathi, 1953; Champion *et al*., 1965; Khan, 1968; Sheikh, 1985). These studies were mainly based on simple ring count, small cores, small sample size or just observational, without using any standard technique, hence great errors are associated with these estimates.

Dendrochronological techniques were used to estimate age and growth rates of some planted tree species of Quetta (Ahmed, 1988) with extrapolation for missing, false rings and the time required for tree to reach the height at which wood samples (cores) were taken for estimation. Using same methods Ahmed *et al*., (1990a, 1990b) and Ahmed *et al*., (1991) calculated age and growth rates of Juniper and Chilghoza pine trees from Balochistan. Ahmed & Sarangzai (1991, 1992) also provided age and growth rates of a different species from 19 different locations of moist and dry temperate Himalayan ranges of Pakistan.

In order to extend understanding of the diameter, age and growth rate relationship and check suitability of these species for dendrochronological investigations (Ahmed & Naqvi, 2005, Khan *et al*., 2008), we are presenting data of six gymnospermic species from 41 different mature forests of Pakistan.

## Materials and Methods

Swedish Increment Borer was used to obtain wood samples (cores) from living trees. Only healthy, sound and no sign of injury trees of different sizes were selected. At each

location 10 cores per species were obtained from breast height. Using GPS, locations, elevation and aspect of sampling sites were recorded. Degree of slopes were also obtained using standard slope meter. These wood samples were handled, air dried, stored, glued and polished followings the standard methods of Stokes & Smiley (1968). The cores were subject to visual cross-dating under a stereoscopic microscope to locate any missing and false (double) rings.

Many cores do not pass through the center or pith. In these cores reliability, missing radius and its years were calculated according to the method described by Ogden (1980) and Ahmed (1984). True age could be obtained just from the root collar, however it is not possible without cutting the tree. Therefore two sections were obtained from root collar on small samplings of each species at each location. The rings of these sampling were added to the age of each core. That is the approximate time (years) required for the tree to reach the height at which cores were taken. Missing years and number of years of samplings were added to the number of rings obtained from the wood samples to estimate the total age of the tree.

After the visual cross-matching under the microscope, rings of each core were measured to nearest 0.001 mm on computer-compatible measuring machine (Volmex) using program COFECHA (Holmes *et al*., 1986) to check quality of ring width characteristic and visual cross-dating. Linear Regression was used to obtain relation between Dbh/age and elevation/growth rates.

**Results and Discussions**

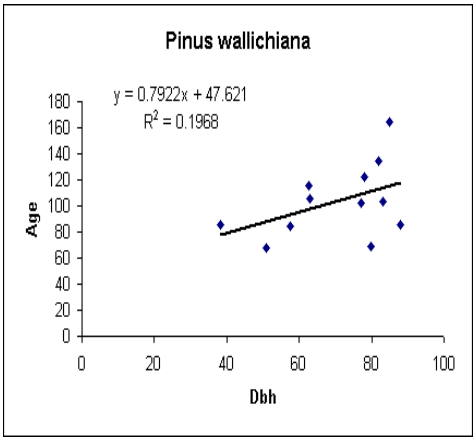
Location and details of study areas are given in Fig. 1 and Table 1 respectively. Age of largest tree, diameter of oldest tree and overall growth rate of the species from the particular site is shown in Table 2. The oldest tree (533y) *Cedrus deodara* with 180 cm Dbh was recorded from Ziarat (Drosh) District of Chitral. A 74 Dbh tree of *Cedrus deodara* was estimated 79 years old while from the same place another tree have 319 rings with smaller (74 cm) Dbh. Largest tree (148 cm Dbh) of *Picea smithiana* with 177 year was recorded from Nalter Valley, while oldest tree (347 years) with smaller size (91 cm Dbh) was recorded from the same Valley. Fast growing species *Pinus wallichiana* attained 164 cm Dbh in 85 years at Sundhan Gali of Azad Kashmir, while same species from same location takes 136 year to obtain the size of 112 cm Dbh. *Pinus roxburghii*, another fast growing gymnosperm showed similar behavior. Its 78 cm Dbh tree from Khatlan Bala, Lower Dir, attained an age of 41 years, while smaller size (62 cm Dbh) tree showed 113 years of age. An age of 108 years was calculated from a Abies pindrow tree of 137 cm Dbh, while the oldest tree (228 years) was considerably small sized tree (74 cm Dbh) from Ayubia, District Abbottabad. Age and Dbh data from some other forests and species are also available. Ahmed *et al*., (1991) reported age (112 years) of *Pinus wallichiana* from 20 to 65 cm Dbh trees from Takht-e-Sulaiman. Another tree from Murree Hill was 71 years old with 58 cm Dbh. A tree of *Pinus gerardiana* from Zhob District showed 288 ring with a Dbh of 80 cm, while from same location another tree of the same species reached the size of 65 cm Dbh in 411 years. Juniper trees of 21 cm Dbh from Susnamana forest (Ziarat) of Balochistan showed age of 105 and 187, while similar sized trees of Ziarat had age of 75 to 169. Table 2 postulated great variation in Dbh and age. Similar results were obtained by Ahmed & Sarangzai (1991) while working on some Himalayan tree species. Ahmed & Ogden (1987) also found the same with *Agathis australis* forests in New Zealand. This relationship is depicted with other species in most cases.

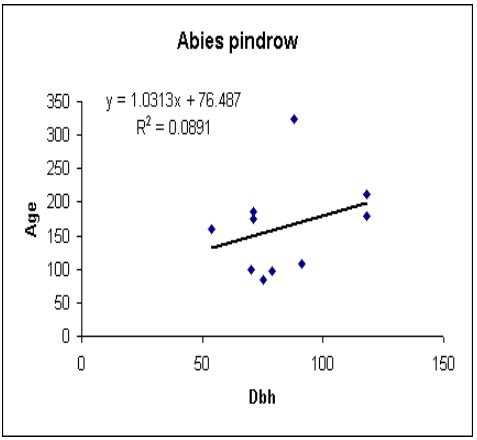

Fig. 1. Map of study area. For locations and sampled species, please refer to the Tables 1& 2.

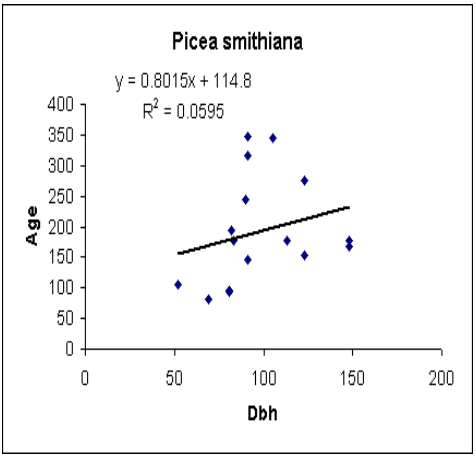
Tree age varies from site to site, species to species, within a species and even in similar sized trees of the same species in an area. Ahmed (1988) reported significant relation between diameter and age from planted tree species of Quetta. Ahmed & Ogden (1987) found significant, but wide variance between these two variable. Ahmed & Sarangzai (1991) also obtained significant correlation between diameter and age in nearly all investigated species and sites. However they also observed wide variance and concluded that at least in natural forest diameter is not a good indicator of age. Similarly in present study diameter is not significantly related with age (Fig. 2) except in *Pinus roxburghii* like Dbh and age, elevation and growth rates also do not show any significant relation.

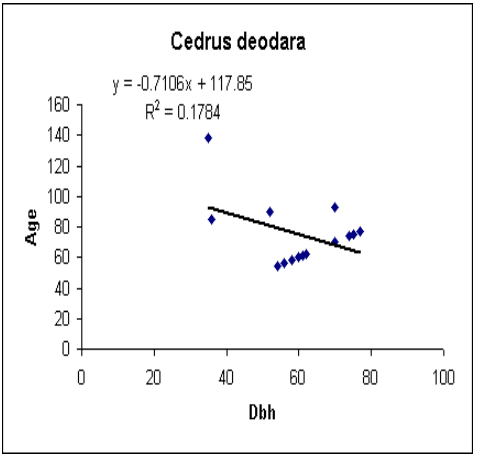
Overall growth rates (Table 2) are based on all cores of individual species of a particular site. Like age, growth rate also varies greatly from species to species. Similar sized tree of a same species from similar site may grow on different rate. *Pinus wallichiana* showed higest growth rate (1.7 years/cm) from Shalthalo Bala, (District Dir) while *Abies pindrow* from Lalazar (Murree) produced most narrow (7.1 years/cm) rings.

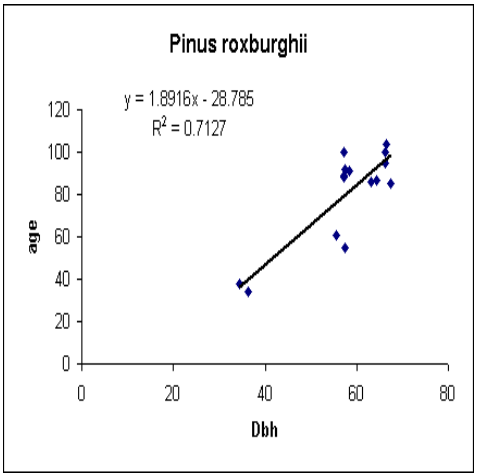
Aspect plays an important role to determine plant growth (Fritts 1976; Ahmed, 1984). To understand this relationship, growth rates of each individual tree species are pooled into different aspects (Table 3). *Cedrus deodara*, *Pinus wallichiana* and *Picea smithiana* grow faster on south facing slope while *Abies pindrow* and *Pinus ruxburghii* grow faster on North facing slopes. However slowest growth of *Picea smithiana* and *Abies pindrow* were recorded from east facing slope. This Table also indicates overall growth rate of various aspects and overall growth rates of individual species, regardless of their sites or locations. Except *Picea smithiana* where south facing slope is significantly different from ($p<0.05$) other slopes, no significant relation was observed between aspect and growth rates with other species. Overall growth rate of species shows that *Pinus wallichiana* is fastest growing (2.96±0.19) tree while *Taxus wallichiana* and *Abies pindrow* are slow growing tree respectively. Like age, diameter, aspect and growth rates do not show significant relation, this may be due to the poor sample size in some aspects.



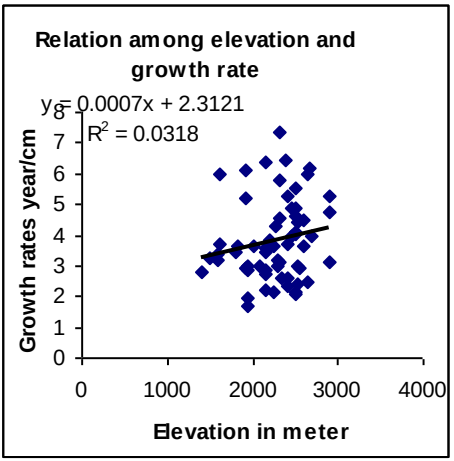




Fig. 2. Relation between diameter and age, using different species. Except *Pinus roxburghii* (significant $p<0.001$), no significant relation was found. Relation between elevation and growth rate year / cm was also not significant.

Ahmed & Sarangzai (1992 also reported *Abies pindrow* as a slow growing tree in moist temperate areas while dry temperate area *Pinus gerardiana* characterized as an extremely slow growing (16 year/cm) tree. Table 3 also postulated a few statistics describing the ring width characteristics of some gymnospermic species. It is shown that broad rings are produced by *Cedrus deodara* while other 3 tree species show similar ring-width. It contrast to our previous statement that *Pinus wallichiana* produced wide rings. This should borne in mind that during the measurement we only include sensitive cores, avoiding extraordinary complacent word samples. Auto correlation shows the amount of non-climatic or climatic effects carried out to the next year's growth rings. Higher the value, higher the effect. This data is not filtered or standardized at this stage. Mean sensitivity indicate the year to year variability of the ring-width. Highest value is recorded from *Picea smithiana* while lowest is recorded from fast growing moist temperate species *Pinus wallichiana.* It is indicated that these tree species from some of these sites have cross-matchable annual ring-width sequence, which could be used for dendrochronological investigation. A dated *Abies pindrow* chronology from Ayubia (Ahmed, 1989) and *Picea smithiana* from Nalter (Ahmed & Naqvi, 2005) gave additional support to the opinion.

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### References

Ahmed, M. 1984. Ecological and Dendrochronological studies on Agathis Australis (D.Don) Lindl. (Kauri). Ph.D thesis, University of Auckland, New Zealand.

Ahmed, M. 1988. Population structure of some planted tree species in Quetta. *J. Pure and Applied Science*, 7:25-29.

Ahmed. M. 1989. Tree-Ring chronologies of Abies pindrow (Royle) Spach from Himalayan Regions of Pakistan. *Pak. J. Bot*., 21(2): 118-127.

Ahmed, M. and A.M. Sarangzai. 1991. Dendrochronological approach to estimate age and growth rates of various species of Himalayan Region of Pakistan. *Pak. J. Bot*., 23(1): 78-89.

Ahmed, M. and A.M. Sarangzai. 1992. Dendrochronological potential of a few tree species from Himalayan Region of Pakistan. *J. Pure and Applied Sciences*. 11(2): 65-67.

Ahmed, M., E. Naqi and E.L.M. Wang. 1990a. Present state of Juniper in Rodhmallazi Forest of Baluchistan, Pakistan. *Pakistan Journal of Foresty*. July: 227-236.

Ahmed, M. and J. Ogden. 1987. Population Dynamics of the emergent conifer Agathis australis (D.Don) Lindl. (Kauri) in New Zealand. Population structure and tree growth rates in mature forests. *New Zealand Journal of Botany*, 25: 217-229.

Ahmed, M., M. Ashfaq, M. Amjad and M. Saeed. 1991. Vegetation structure and dynamics of Pinus gerardiana forests in Baluchistan, Pakistan. *J. Vegetation Science*, 2: 199-124.

Ahmed, M. and S.H. Naqvi. 2005. Tree-Ring. chronologies of Picea smithiana (Wall) Boiss., and its quantitative vegetational deseription from Himalayan Range of Pakistan. *Pak. J. Bot*., 37(3): 697-707.

Ahmed, M., S.S. Shaukat and A.H. Buzdar. 1990b. Population structure and dynamics of Juniper excelsa in Baluchistan, Pakistan. *J. Vegetation Science*, 1: 271-276.

Champion, H., G.S.K. Seth and G.M. Khattak. 1965. Forest Types of Pakistan. Pak. Forest Institute, Peshawar.

Fritts, H.C. 1976. Tree Ring and Climate. Oxford Printing Press. 576 pp.

Holmes, R.L., R.K. Adams and H.C. Fritts. 1986. Quality control of cross dating and measuring, a user manual for program COFECHA. In tree ring chronologies of Western North America: California, Eastern Oregen and Northern Great Basin. Chronology series 6: 41-49.

Khan, A.H. 1968. Ecopathological observation in Trarkhal Forest. Part. 1 Regeneration status of the forest. *Pak. J. Foresty*, 18: 169-228.

Khan, N., M. Ahmed and M. Wahab. 2008. Dendrochronological potential of *Picea smithiana* (Wall) Boiss., from Afghanistan. *Pak. J. Bot*., 40(3): 1063-1070.

Ogden, J. 1980. Dendrochronology and dendroecology, an introduction. *New Zealand Journal of Ecology*, 3: 154-156.

Sheikh, I.S. 1985. Afforestation in Juniper forests of Balochistan. Pak. Forest Institute, Peshawar.

Stockes, M.A and T.L. Smiley. 1968. An Introduction to Tree-Ring Dating. Uni. Chicago Press, Chicago, 68pp.

Swati, A.S. 1953. Note on the Junipers forest of Balochistan. Unpublished Report of Balochistan Forest Department.

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