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AGE AND RADIAL GROWTH ANALYSIS OF CONIFER TREE SPECIES FROM SHANGLA, PAKISTAN

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Abstract

Dendrochronological studies were conducted in 40 different sites in conifer dominated forests from Shangla District, Khyber Pakhtunkhwa Province, Pakistan. Wood samples in the form of cores were obtained by using Swedish increment borers including *Pinus wallichiana* A.B Jackson, *Abies pindrow* Royle, *Picea smithiana* (Wall) Boiss and *Cedrus deodara* (Roxb.) G.Donf. In order to determine their ages, growth rates based on annual ring-width characteristics. Diameter and age showed significant correlation ($P<0.001$) in *Pinus wallichiana*, *Picea smithiana* and *Cedrus deodara* except *Abies pindrow* which showed no relationship. Highest growth rate (1.1 ± 0.06 year/cm) was recorded in *Pinus wallichiana* while for *Abies pindrow* growth (5.4 ± 1.7 year/cm) was extremely slow. We concluded that age and growth rate greatly varies from tree to tree and site to site even in the same sized trees. It is also shown that largest tree in diameter is not necessarily the oldest. Present study confirmed previous finding that diameter is not a good indicator of age.

Key words: Dendrochronology, Age and growth rate, Shangla Forests, Conifers

Introduction

Dendrochronology (the tree ring studies) is a young and rapidly growing science started in 1986 in Pakistan while systematic studies started in 2005. It is frequently used in different fields, i.e. ecology, forestry, earthquake, glacial hydrology, climatology, archeology, population dynamics and many more other disciplines. Some scholars like Champion *et al.,* (1965); Khan, (1968) Sheikh, (1985) estimated age and growth rate of pine tree species from different forests of Pakistan. Their study was observational and mainly based on simple ring count of few cores, small sample size, ignoring modern techniques of dendrochronolgy. In present studies estimation of age and growth rate of pine trees are obtained by applying dendrochronological techniques. Some published data available for tree species in Pakistan. Ahmed (1984; 1988a,b; 1989), Ahmed *et al.,* (1990a, 1990b), Ahmed & Sarangzai (1991; 1992) applied modern dendrochronological techniques on alive trees to calculate age and growth rate from different locations of moist and dry temperate Himalayan ranges of Pakistan. In addition diameter, age and growth rate relationship also indicated the suitability of these species for advance dendrochronological investigations (Ahmed & Naqvi, 2005, Khan *et al.,* 2008). Ahmed *et al*., (2009) investigated 39 different sites of Swat, Dir, Chitral, Mansehra, Abbotabad, Northern areas and Azad Kashmir to estimate age and growth rates of six gymnospermic tree species. Khan (2011) investigated *Cedrus deodara* and *Pinus gerardiana* species from Chitral District using the same technique. Wahab (2011) estimated age and growth rates of tree species from District Dir. Siddiqui *et al*., (2013) sampled moist temperate areas of Himalayan and Hindukush regions of Pakistan to estimate age and growth rates of dominant conifers tree species, beside the above mentioned research, no one has presented this type of data from Shangla District of Khyber Pakhtunkhwa. Therefore this investigation is the first attempt to estimate age and radial growth of pine tree species of this area.

Materials and Methods

Forty different sites were sampled in four conifer dominated forests (*Pinus wallichiana, Abies pindrow, Cedrus deodara* and *Picea smithiana*) from Shangla district of Khyber Pakhtunkhwa, Pakistan. In order to estimate their age and radial growth rates, samples were obtained in the form of increment cores. A total of 200 wood samples were taken from healthy trees using Swedish increment borers following the methods described in Ahmed (2014). Trees stems less than 10 cm dbh were not sampled since trees than 50cm smaller were not considered matured trees (Wahab, 2011; Siddiqui, 2011 and Khan, 2011). Mostly one core per tree was obtained but in case of huge trees two cores from opposite side were taken. Cores were stored in plastic straw for safety and information of tree was recorded on them. All samples were then air dried and mounted on wood frames in the laboratory following standard dendrochronological methods of Stokes & Smiley (1968). After this step, all preserved cores were surfaced and polished by applying various grades of sand papers using electric sander machines. These tree-rings samples were studied one by one under stereo microscope. Reliability of cores was calculated and missing radius was estimated where the pith was missing following Ahmed (1984). Age and radial growth rate of each tree was determined by following methods of (Ahmed, 1984; Ahmed *et al.,* 2009). Correlation between age verses diameter and age verses growth rates were calculated by regression analysis method.

Results and Discussion

Age of the minimum and maximum diameter tree, growth rate year/cm and mean growth rates from each site is shown in Table 1. The oldest tree (326 yrs) of *Pinus*

wallichiana with143 cm dbh was recorded from Matta Karin area at the elevation of 1720m with 4.56 years/cm growth rate. Whereas the 38 years old tree of 70 cm dbh was taken from Chakat area (stand no 24) with growth rate of 1.2 years/cm. Ahmed and Sarangzai (1992) found the radial growth of *Pinus wallichiana* as 2.5 years/cm from Murree hill. Ahmed *et al*., (2009) also reported highest growth rate 1.7 years/cm from Shaltalo Bala Dir District. They concluded that *Pinus wallichiana* is a fast growing tree. Similarly Siddiqui *et al*., (2013) recorded highest growth rate (1.1 year/cm) of *Pinus wallichiana* from Patriata-1, Murre hills and lowest growth rate (8.8 years/cm) from Shinu-2 Kaghan valley. Four hundred and twelve years old *Abies pindrow* tree with 114 cm dbh was sampled from Yakh Tangay 5, Acharo area and the tree of lowest age (117 years) having 81 cm dbh was taken from stand no 26 of Yakh Tangay 1 area showing 7.23 and 2.89 years/cm growth rates respectively. Ahmed and Sarangzai (1991) stated that *Abies pindrow* was a slow growing tree in moist temperate areas. Siddiqui *et al*., (2013) found narrow rings with 11.8 years/cm growth from Kuzah Gali-1 (Abbotabad) and wide rings with 1.4 years/cm growth from Malam Jabba-1, Swat valley from the same species. *Cedrus deodara* of 134 dbh tree attained 339 years was sampled from Nala area of Shangla district with 5.06 growth rate year/cm, while the low growing tree of 121 years old of 53 cm dbh tree with growth rate of 2.98 years/cm was obtained from Bund Dherai area. Siddiqui *et al*., (2013) recorded highest growth rate 1.4 year/cm from two forest of Naran and Kaghan valley, from same species. *Picea smithiana's* highest age (320 years) was recorded at Malam Jabba area from115 cm dbh tree with 5.57 years/cm growth rate whereas the lowest age was 82 years from 78cm dbh was recorded in Safaray Karral (stand 15) area with 2.1 growth rate year/cm. Wahab *et al*., (2008) recorded largest tree (154 cm dbh) of *Picea smithiana* with 140 rings and 7.1 year/cm growth rates. They did not found significant relationship between Dbh and age, which is totally different of current observation of *Picea smithiana* from Shangla District.

Ahmed (1988b) presented age of some planted tree species of Quetta and found significant relation between age and diameter. Ahmed *et al*. (1990b) estimated average age of 16 *Juniperus excelsa* trees (20 to 30cm dbh) was 160 years. Dendrochronological approach was used to estimate age and growth rate of various species from Himalayan range of Pakistan by Ahmed and Sarangzai (1991). Juniper trees of 21 cm dbh from Susnamana forest show age of 105 and 187, while trees of similar diameter from Ziarat ranged from 75 to 169 years. *Pinus wallichiana* with 20.5 Dbh attains age of 112 years from Zhob District, while same age is estimated from an individual of the same species having a dbh of 65 cm from Ayubia. Similarly *Abies pindrow* from Murree had 351 rings with diameter of only 11.3 cm (Ahmed, 1989) while 346 years old tree of 200 cm *Cedrus deodara* was recorded from Kalam valley. His relationship between diameter and age of *Pinus wallichiana*, *Pinus gerardiana, Juniperus excelsa* and *Abies pindrow* was highly significant. Growth rates of various tree species from Himalayan regions of Pakistan was presented by Ahmed and Sarangzai (1991). They recorded *Pinus gerardiana* from Zhob District with 6 to 24 years/cm growth rate, *Pinus wallichiana* from the same district grew 3 to 14 years/cm, *Abies pindrow* from Ayubia 3 to 20 years/cm, *Pinus roxburghii* from Swat 2 to 6 years/cm and *Cedrus deodara* from Kalam showed 2 to 10 years/cm growth rate. They also reported that growth rate decreases with increasing altitude and found negative significant relationship between these two variables. Ahmed *et al.,* (2009) presented age and growth rate data from 39 locations of various gymnospermic forests. A tree of *Picea smithiana* with 140 cm dbh was 281 years old, while *Cedrus deodara* with 180cm dbh was 533 years old from Ziarat (Drosh) District of Chitral. Except *Pinus roxburghii* all species, under investigation, show no relation between diameter and age, indicating that prediction of age from diameter is unreliable. They found no relation between elevation and growth rates. In their studies, *Pinus wallichiana* showed fast growth (1.7 years/cm) from District Dir, while *Abies pindrow* from Murree produced narrow (7.0 year/cm) rings. Average growth rate of 6 year/cm from *Picea smithiana* was recorded at Nalter Valley, while the growth rate of *Cedrus deodara* was 4.0 year/cm from Kalam.

Correlations

Linear regression equation and correlation coefficient between age / dbh, age /growth rate, and dbh / growth rate of pine trees were evaluated (Table 2). Based on overall data significant correlation ($P < 0.01$) was found between age and dbh in *Pinus wallichiana* and *Picea smithiana,* while *Picea smithiana* these variables were highly (0.001) correlated. Our results are matching with some other researchers like, Ahmed (1988a,b) who found significant correlation between age and diameter working in Quetta and elsewhere. Ahmed and Sarangzai (1991) observed significant correlation between age and dbh nearly in all sites of study area. In our study highly significant ($P< 0.001$) correlation was present in 3 species and in *Abies pindrow* no significant correlation was found, while Ahmed *et al*., (2009) found no significant correlation between dbh and age in four conifers trees, *Pinus wallichiana, Abies pindrow, Picea smithiana* and *Cedrus deodara.* Siddiqui (2011) observed significant relationship between age and dbh ($P< 0.001$) in *Pinus wallichiana* tree also found significant relationship between age and growth rates. In our study diameter and growth rates was not significantly related in three species except in *Picea smithiana*. Age and growth rates in all species were highly (0.001) significant in present study (Table 2). Siddiqui *et al.,* (2013) observed significant relation between age and dbh and age vs growth rate in *Pinus wallichiana* and *Cedrus deodara*.

Present study agreed with Ogden (1980); Ahmed (1984,1988a,b,1989,2009); Ahmed and Sarangzai (1991;1992); Ahmed *et al.,* (2010); Siddiqui *et al*., (2013), Wahab *et al*., (2008) and Hussain, (2013) that age and growth rates are greatly varied from tree to tree, site to site and even two closely situated same sized trees of the same species. Therefore, it is anticipated that significant correlation among above mentioned variables are only by chance since wide variance is associated it is not advisable to predict age or growth from the diameter in multi-aged or sized population.

Table1. Age and growth rates of different conifer tree species from 40 sites of Shangla district.

Site No	No of Cores	Sampling Dbh (cm)		Age range		Growth rate year / cm		Mean ± SE Growth rate year / cm	Mean ± SE Growth rate cm / year
		Min	Max	Min	Max	Min	Max		
A. *Pinus wallichiana*									
1	4	54	92	70	71	2.59	1.54	2.06 ± 0.52	0.52 ± 0.13
2	4	63.5	74	56	72	1.74	1.92	1.83 ± 0.09	0.55 ± 0.03
3	2	66	69.5	61	62	1.85	1.8	1.82 ± 0.02	0.55 ± 0.01
4	3	74	143	73	326	1.97	4.56	3.26 ± 1.29	0.365 ± 0.145
5	6	62	76	48	112	1.55	2.95	2.25 ± 0.7	0.495 ± 0.155
6	2	55	67	82	108	2.98	3.22	3.1 ± 0.12	0.325 ± 0.015
7	8	81	102	166	97	4.1	1.9	3 ± 1.1	0.385 ± 0.145
8	2	71	76	189	155	5.32	4.08	4.7 ± 0.62	0.22 ± 0.03
12	2	98	120	195	126	3.98	2.1	3.04 ± 0.94	0.365 ± 0.115
16	3	75	97	154	134	4.11	2.76	3.43 ± 0.67	0.3 ± 0.06
17	3	86	122	52	161	1.21	2.64	1.92 ± 0.71	0.605 ± 0.225
18	6	64	100	84	104	2.63	2.08	2.35 ± 0.27	0.43 ± 0.05
19	2	90	91	92	100	2.02	2.2	2.11 ± 0.09	0.475 ± 0.015
20	3	63	74	85	92	2.7	2.49	2.59 ± 0.10	0.385 ± 0.015
22	3	62.5	87	79	78	2.53	1.79	2.23 ± 0.22	0.45 ± 0.05
24	4	70	110	38	67	1.09	1.22	1.15 ± 0.06	0.87 ± 0.05
25	4	74	137	108	162	2.92	2.36	2.64 ± 0.28	0.38 ± 0.04
26	5	77	100	92	98	2.39	1.96	2.17 ± 0.21	0.465 ± 0.045
27	4	71	107	89	137	2.51	2.56	2.53 ± 0.02	0.395 ± 0.005
28	7	81	110	101	101	2.49	1.84	2.16 ± 0.32	0.47 ± 0.07
29	2	85	90	163	70	3.84	1.56	2.7 ± 1.14	0.45 ± 0.19
31	6	60	110	65	165	2.17	3	2.75 ± 0.18	0.37 ± 0.024
33	2	67.1	91	68	65	2.03	1.43	1.72 ± 0.30	0.59 ± 0.100
B. *Abies pindrow*									
11	2	118	142	262	223	4.44	3.14	3.79 ± 19.5	0.275 ± 0.04
12	5	86	125	187	158	4.35	2.53	3.44 ± 0.91	0.315 ± 0.085
13	6	78	127	186	190	4.77	2.99	3.88 ± 0.89	0.27 ± 0.06
23	3	85	91	290	119	6.82	2.62	4.72 ± 2.1	0.265 ± 0.115
26	4	81	95	117	157	2.89	3.31	3.1 ± 0.21	0.325 ± 0.025
27	2	88	91	153	140	3.48	3.08	3.28 ± 0.2	0.31 ± 0.02
30	2	104	114	194	412	3.73	7.23	5.48 ± 1.75	0.205 ± 0.065
32	11	75	104	152	362	4.05	6.96	4.81 ± 0.48	0.22 ± 0.01
39	24	69	104.2	213	250	6.17	4.8	4.86 ± 0.26	0.22 ± 0.01
C. *Picea smithiana*									
14	2	61	71	84	97	0.31	0.42	0.36 ± 0.05	2.77 ± 0.40
15	2	78	112	82	234	2.1	4.18	3.14 ± 1.03	0.35 ± 0.11
40	6	68	115	180	320	5.29	5.57	4.08 ± 0.50	0.26 ± 0.03
D. *Cedrus deodara*									
35	19	53.2	99.2	159	121	2.98	2.44	3.41 ± 0.22	0.31 ± 0.019
37	5	71.5	100.1	162	159	4.54	3.15	4.57 ± 0.42	0.22 ± 0.024
38	13	66	134	125	339	3.79	5.06	3.95 ± 0.25	0.26 ± 0.019

Table 2. Correlation between dbh vs age, dbh vs growth rate and age vs growth rate with linear regression equation of different pine tree species from study area.

Parameters	n	Regression equation	Correlation (r)	Significance Level
Pinus wallichiana				
Dbh / age	86	y = 1.436x – 15.37	r = 0.498	P < 0.01
Dbh / growth rate	86	y = 0.002x + 2.306	r = 0.0316	ns
Age / growth rate	86	y = 0.017x + 0.686	r = 0.868	P < 0.001
Abies pindrow				
Dbh / age	60	y = 1.938x+33.46	r = 0.367	ns
Dbh / growth rate	60	y = -0.005x + 5.132	r = 0.054	ns
Age / growth rate	60	y = 0.017x + 0.949	r = 0.896	P < 0.001
Cedrus deodara				
Dbh / age	37	y = 2.501x – 48.91	r = 0.753	P < 0.001
Dbh / growth rate	37	y = 0.01x + 2.944	r = 0.1816	ns
Age / growth rate	37	y = 0.012x + 1.803	r = 0.764	P < 0.001
Picea smithiana				
Dbh / age	10	y = 2.206x – 33.26	r = 0.635	P < 0.01
Dbh / growth rate	10	y = 0.013x + 1.353	r = 0.8330	P < 0.001
Age / growth rate	10	y = -0.001x + 0.489	r = 0.7943	P < 0.001

Note: dbh = diameter at breast height, ns = non-significant, n = number of core samples.

References

Ahmed, M., 2014. *The Science of Tree Rings: Dendrochronology*. Qureshi Art Press, Nazimabad, Krachi. Pp. 302.

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

Ahmed, M., 1988a. Problems encountered in age estimation of forest tree species. *Pak. J. Bot.,* 20: 143-145.

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

Ahmed, M. 1989. Tree-ring chronologies of *Abies pindrow* (Royle) Spach, from Himalayan region of Pakistan. *Pak. J. Bot.,* 21(2): 347-354.

Ahmed, M., E.E. Nagi and E.L.M. Wang. 1990b. Present state of Juniper in Rodhmallazi forest of Baluchistan, Pakistan. *Pak. J. For.,* July, 227-236.

Ahmed, M., S.S. Shaukat, and A.A. Buzdar. 1990a Population structure and dynamics of *Juniperus excelsa* in Baluchistan, Pakistan. *J. Veg. Sci.,* 1: 271-276.

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

Ahmed, M., and A.M. Sarangzai. 1992. Dendrochronological potential of few tree species from Himalayan region of Pakistan, a preliminary investigation. *J. Pure and App. Sci.,* 11(2): 65-67.

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

Ahmed, M., M. Wahab, N. Khan, M.F. Siddiqui, M.U. Khan and S.T. Hussain. 2009. Age and growth rates of some gymnosperms in Pakistan. A dendrochronological approach. *Pak. J. Bot.,* 41(2): 849-860.

Ahmed, M., M. Wahab, N. Khan, J. Palmer, K. Nazim, M.U. Khan and M.F. Siddiqui. 2010. Some preliminary results of climatic studies based on two Pine tree species of Himalayan area of Pakistan. *Pak. J. Bot.,* 42(2): 731-738.

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

Hussain, A. 2013. *Phytosociology and Dendrochronological Study of Central Karakoram National Park, Northern Areas (Gilgit Baltistan), Pakistan*. Ph. D. Thesis. Department of Botany, Federal Urdu University, Gulshan-e-Iqbal, Karachi 75300.

Iqbal, J., M. Ahmed, A. Khan and M.F. Siddiqui. 2014. Vegetation description of pine forests of Shangla District of Khyber Pakhtoonkhuah, Pakistan. *FUUAST J. Biol.,* 4(1): 83-88.

Khan, A.H. 1968. Ecopathological observations in Trakhal Forest with special reference to damage by Fomes pini. Part I-Regeneration status of the Forest. *Pak. J. For.*, 18: 169-228.

Khan, N. 2011. *Vegetation Ecology and Dendrochronology of Chitral*. Ph.D Thesis, Department of Botany, Federal Urdu University, Gulshan-e-Iqbal, Karachi 75300.

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 J. Ecol.,* 3: 154-156.

Sheikh, M.I. 1985. Aforestation in *Juniper* forests of Baluchistan, Pakistan. *Forest Institute Peshawar*, pp.46.

Siddiqui, M.F., S.S. Shaukat, M. Ahmed, N. Khan and I. Ahmed. 2013. Age and growth rates of dominant conifers from moist temperate areas of Himalayan and Hindukush region of Pakistan. *Pak. J. Bot.,* 45(4): 1135-1147.

Siddiqui M.F. 2011. *Community structure and dynamics of coniferous forests of moist temperate areas of Himalayan and Hindukush ranges of Pakistan*. Ph. D. Thesis. Federal Urdu University of Arts, Science and Technology, Karachi.

Stokes, M.A and T.L.Smiley. 1968. *An Introduction to Tree ring Dating*. University of Chicago Press, Chicago, pp. 68.

Wahab, M., M. Ahmed and N. Khan. 2008. Phytosociology and dynamics of some pine forests of Afghanistan. *Pak. J. Bot.,* 40: 1071-1079.

Wahab, M. 2011. *Population Dynamics and Dendrochronological Potential of Pine Tree species from District Dir*. Ph. D. thesis. Department of Botany, Federal Urdu University, Gulshan-e-Iqbal, Karachi 75300.

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