DENDROCHRONOLOGICAL INVESTIGATIONS IN IRAN

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ABSTRACT

Dendrochronological research on *Juniperus polycarpos* growing in west and central Iran reveals that the radial growth in this species depends mainly on the amount of precipitation in the more arid regions. When the amount of rain is sufficient, i.e. above 450 mm, the prevailing summer temperature seems to become the limiting factor.

Favorable conditions which prevailed during the periods 1685-1695 and 1790-1800 resulted in better width growth, while less favorable conditions which prevailed during the years 1725-1735 and 1855-1865 resulted in narrow rings.

Des recherches dendrochronologiques portant sur *Juniperus polycarpos* croissant dans l'Iran occidental et central, démontrent que la croissance radiale de cette espéce dépend de la quantité de précipitations dans les régions les plus arides. Lorsque la pluviosité est sufficante (au-dessus de 450 mm), la température estivale semble devenir le facteur limitant.

Les conditions favorables qui prévalaient durant les périodes 1685-1695 et 1790-1800 ont provoqué une meilleure croissance en diamétre, tandis que les conditions moins favorables qui ont régné durant les années 1725 à 1735 et 1855 à 1865, correspondent à des cernes étroits.

Dendrochronologische Untersuchungen an dem Wacholder Juniperus polycarpos in West; und Central-Iran zeigen, daß das Dickenwachstum dieser Baumart in den trockneren Gebieten vor allem von den Niederschlägen abhängt. Wenn die Regenmenge dagegen ausreicht, d. h. mehr als 450 mm pro Jahr beträgt, wird die Sommertemperatur zum Minimufaktor.

Günstige Witterungsbedingungen in der Zeit von 1685 bis 1695 und von 1790 bis 1800 führten zu breiteren Jahrringen, während ungünstigere Bedingungen in den Jahren von 1725 bis 1735 und von 1855 bis 1865 enge Jahresringe zur Folge hatten.

INTRODUCTION

Dendrochronology is one of the best sources for past climate information and provides an accurate tool for the understanding of regional climatic systems. Reconstruction of long climatic records is of interest not only for climatologists and botanists, but may be of help also in predicting climatic changes in the future, a prediction which has become recently so important.

However, despite its considerable importance, only few dendrochronological analyses have been made in the Middle East. Mainly this is due to the scarcity of old trees and of specimens with distinct annual growth rings (cf. Fahn et al. 1963; Liphschitz and Waisel 1967, 1969:91; Felix 1968; Tamari 1976; Liphschitz et al. 1979; Waisel and Liphschitz 1968).

Juniperus polycarpos, however, is a coniferous species which seems to be suitable for dendrochronological analysis. *Juniperus* trees produce distinct growth rings and attain old age. *J. Polycarpos* is indicative for semiarid regions and trees appear in Turkey, southeast Arabia (Muscat), Iran, Caucasus, Baluchistan, Afganistan, northwest Himalaya, Transcaspia, and Turkestan (Townsend and Guest 1966 :91-92).

According to Dallimore and Jackson (1954), this species forms the link between the East Asiatic Chinese Juniper (*J. chinensis)* and the Western Grecian Juniper (*J. excelsa)* of the Mediterranean region. *J. polycarpos* seems to be closely related to the latter and was considered by some authors (Zohary 1963) to be synonymous.

The tree is one of the dominant species of the *Junipereto-Pistacietea* steppe forest dominated chiefly by *Juniperus polycarpos, Pistacia Khinjuk,* and *Pistacia atlantica.* In Iran, the stands of *Juniperus polycarpos* are limited mainly to southern slopes of the Elburz Mountains, but single stands occur also as far as the mountains (27° N latitude) near Bandar Abbas (Zohary 1963). Dendrochronological investigation in west and central Iran is of special interest since this area constitutes the most eastern district of the Middle East and Asia Minor and little information is available concerning past or present climate in this region (cf. Kinsley 1970).

Dendrochronological research on *Juniperus polycarpos* growing in the Elburz Mountains was therefore undertaken.

The precipitation in the investigated area ranges between 250 and 550 mm with 237 mm annual amount in Tehran. Rains in north Iran are mostly distributed over nine months; during July to September the total amount is very small or negligible. The temperatures range between an absolute maximum of 42°C and mean maximum of 29.9°C in July and an absolute minimum of -20°C and mean minimum of 3.8°C in

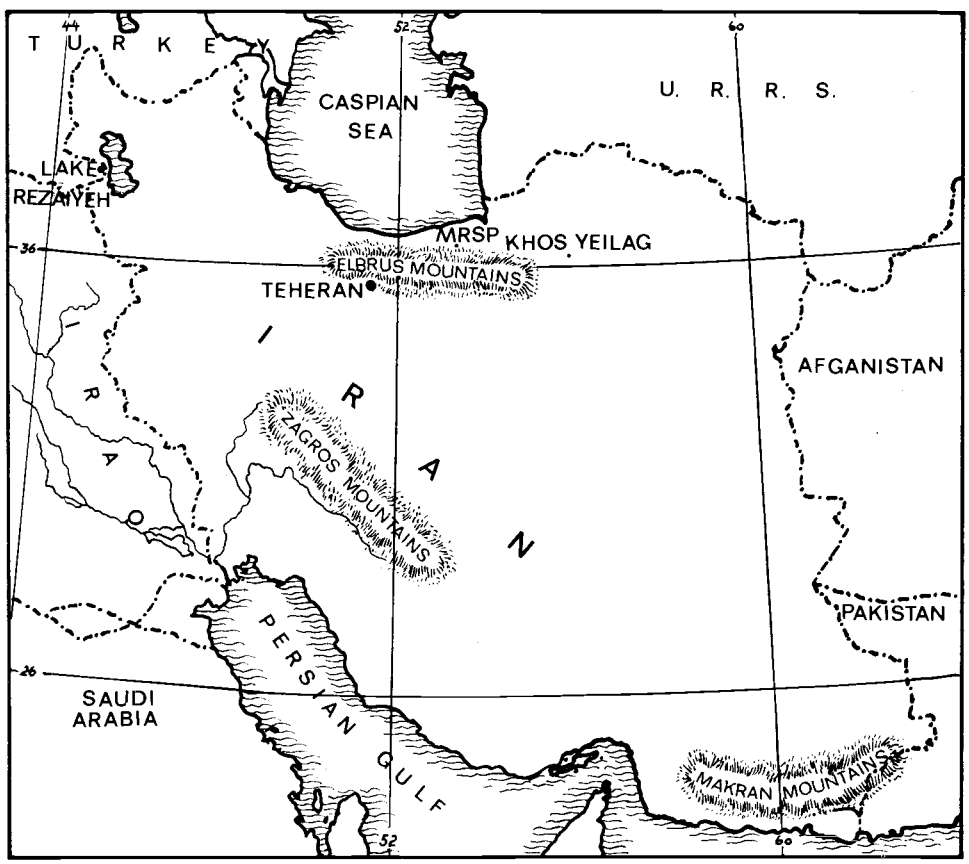

Figure 1. Map of Iran.

Table 1. Distribution according to ages. Correlation coefficients between individual trees and the master chronology of each of the three *J. polycarpos* populations.

Sampling site	Tree No.	Age	r	N	t
Khosh Yeilag	3	148	.525	148	7.445
	9**	254	.317	101	3.329
	10**	158	.308	158	4.042
	11	233	.402	232	6.660
	12	263	.447	263	8.066
	13	318	.624	298	13.735
	16	248	.432	248	7.503
	17	234	.449	234	7.657
	23	191	.462	191	7.167
	24	197	.554	197	9.300
	27	188	.344	188	4.996
	29	240	.344	235	5.593
	30	243	.393	239	6.579
	31	314	.409	314	7.920
	32*	150	.335	150	4.331
	41	261	.343	261	5.885
	42	261	.579	261	11.442
	43	295	.515	295	10.292
Mohamed Rizah	50	194	.567	192	9.494
Shah Park	51*	109	.748	109	11.657
	55	220	.385	220	6.162
	56*	304	.779	304	21.609
Lake Rezaiyeh	101	141	.502	141	6.836
	102	83	.493	83	5.101
	103*	138	.826	138	17.112
	104	104	.703	104	9.979
	105	84	.572	84	6.318

r = correlation coefficient
N = No. of years in correlation
t = Students "t" value
* - a core
** - Not included in the master

January, as recorded in Tehran (World Weather Records 1960; Iran Meteorological Records 1973).

MATERIALS AND METHODS

Twenty-three cross sections and four increment cores were collected in north Iran during the autumn of 1973. The samples were obtained from five stands: three of them at Khosh-Yeilag at approximately 10 km apart (55° 30'E, 36°45'N); one site at Mohamed Rizah Shah Park (=MRSP) (53°30' E, 37°15' N) and another site on one of the islands on Lake Rezaiyeh (45°15' E, 38°15' N) (Figure 1 and Table 1). Whenever possible, cross sections were taken for examination. Cores were collected only on sites where trees could not be felled.

The width of the annual growth rings was measured on the smoothed surface of the cross sections. Measurements were made with a stereoscope and a micrometric ocular along three radii of each section, from the periphery towards the center. A curve was fitted to the data and the value of the ring widths were calculated as indices (Fritts

1963; Fritts et al. 1969). The indices are based on the relationship each year between the actual measurements and a value given to the very same year by the fitted curve.

After the indices of each of the trees were calculated, the growth curves of the trees were crossdated, and a master chronology was constructed. A master chronology represents the growth pattern of the entire population at one site.

The nearest meteorological station to all sampling sites that has available records for a long period of time (up to 66 years) is Tehran (Figure 1). Meteorological records were therefore obtained from this station.

Correlation coefficients between the master chronology and climatic variables such as precipitation (annual, monthly, and seasonal amounts) and temperatures (mean monthly minimum and maximum) were calculated.

RESULTS

The radial growth patterns of *Juniperus polycarpos* trees are presented in Figures 2-4.

Two populations of trees — one sampled at Khosh Yeilag and the other sampled at Mohamed Rizah Shah Park (=MRSP) showed a similar pattern of radial growth (Figures 2-3). A different pattern of growth was distinguished in trees which were sampled at Lake Rezaiyeh (Figure 4).

A period of wide ring production was seen in trees sampled at Khosh-Yeilag during the period 1670-1690 and 1790-1820. A period with narrow ring production occurred around the years 1690-1740 and 1835-1865.

A period of wide ring production occurred in trees sampled at MRSP during the years 1690-1725, 1795-1805 and 1945-1955. Narrow rings were formed at this site around the years 1725-1735 and 1865-1915.

A period of wide ring formation occurred in trees which were sampled at Lake Rezaiyeh around the years 1865-1885 and 1955-1970. Narrow rings were produced by these trees around 1850-1865 and 1930-1940.

Correlation between annual amount of precipitation and the growth indices of the four populations examined was insignificant.

For trees sampled at Khosh-Yeilag, a correlation coefficient of 0.307 was obtained for the correlation between the indices of the master chronology and the precipitation of March; correlation coefficients values ranging between -0.379 and -0.467 were obtained for correlations between the master indices and temperatures of June, July, August, and October (Table 2).

For trees sampled at MRSP a correlation coefficient of 0.615 was calculated between the master indices and a precipitation for September and a value of -0.505 was obtained when the temperature of June was correlated with the indices (Table 2).

Correlation coefficient values varying between 0.409 and 0.596 were obtained for trees sampled at Lake Rezaiyeh for the master indices and the temperatures of August, September, and October. No correlation was obtained with monthly precipitation (Table 2).

DISCUSSION

The data represented above suggest that the radial growth of *Juniperus polycarpos* trees depends mainly on the amount of precipitation in the more arid regions, i.e. in Khosh-Yeilag and MRSP districts, which receive about 150-200 mm of mean annual rainfall. When the amount of rains was sufficient, i.e. above 450 mm, the prevailing

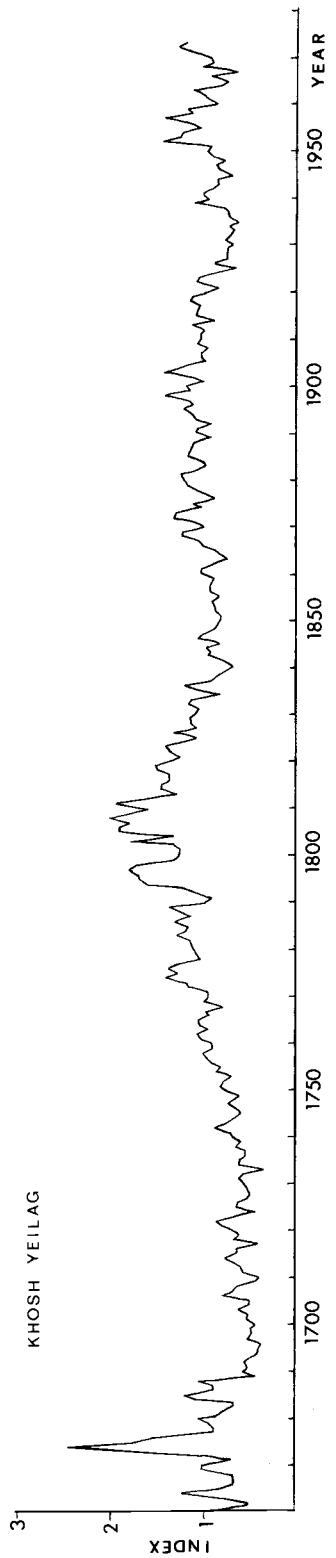

Figure 2. The master chronology for the Khosh Yeilag site.

Figure 3. The master chronology for the MRSP site.

Table 2. Correlation coefficients between climatic parameters and radial growth indices of the master chronology of the three populations sampled.

Sampling site	Climatic Parameter	r	t	N
Khosh Yeilag	precipitation - March	.307	2.495	59
	mean min. temp. June	-.454	2.040	18
	mean min. temp. July	-.389	1.690	18
	mean max. temp. July	-.467	2.113	18
	mean max. temp. August	-.379	1.637	18
	mean max. temp. August-October	-.395	1.664	18
Mohamed Rizah	precipitation - September	.615	5.894	59
Shah Park	mean min. temp. June	-.505	2.342	18
Lake Rezaiyeh	mean min. temp. August	.409	1.795	18
	mean min. temp. September	.446	1.931	18
	mean min. temp. August-October	.531	2.528	18
	mean max. temp. August	.534	2.161	18
	mean max. temp. September	.487	1.900	18
	mean min. temp. August-October	.596	2.876	18

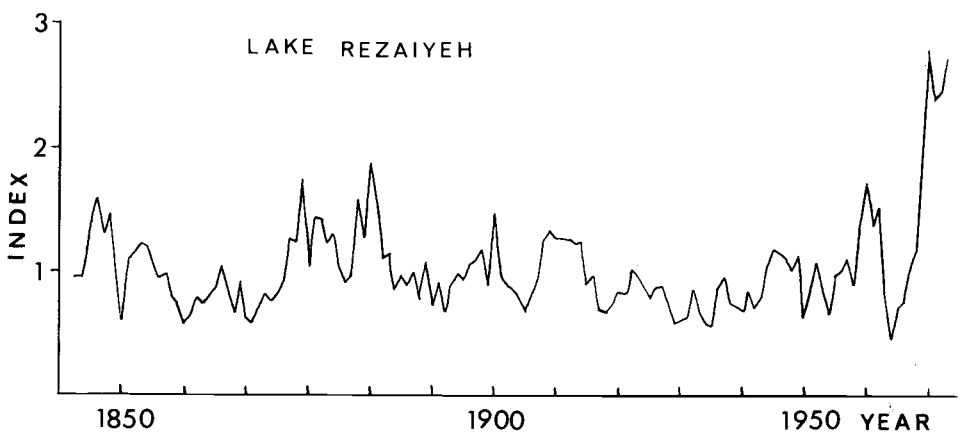

Figure 4. The master chronology for the Lake Rezaiyeh site.

temperature seems to become the limiting factor, especially during some months. Radial growth patterns of *J. polycarpos* trees from Lake Rezaiyeh — a cooler district, which receives above 450 mm of mean annual rainfall — seem to depend on summer temperature only. Wider rings were produced by those trees during years with relatively high summer temperature.

The growth patterns of *J. polycarpos* trees from Khosh-Yeilag and MRSP districts in the last 300 years suggest that during the period 1685-1695 and 1790-1800 temperate climate prevailed in the area, which enabled the production of wide rings, i.e. a more humid period with lower summer temperatures. During the years 1725-1735 and 1855-1865 less favorable conditions prevailed, which resulted in nar-

row ring production. These periods were rather more arid with relatively high summer temperatures. The second unfavorable period, i.e. 1855-1865, influenced also the trees which grew in the more humid district of Lake Resaiyeh, and probably conditions were more severe with less available water.

It is interesting to note that there is a clear similarity between the growth patterns of *Juniperus polycarpos* from Khosh-Yeilag (36°31′ N Lat.) and those of *Pinus nigra* of southwest Turkey (36°30′ N. Lat.) (cf. Liphschitz et al. 1979). A period of wide ring production occurred in southwest Turkey during the years 1670-1710 and 1800-1820. A drop in the growth curve due to narrow ring formation took place around the years 1720-1740 and 1830-1850.

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