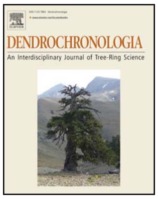
Dendrochronologia 49 (2018) 45–56

Contents lists available at ScienceDirect

Dendrochronologia

journal homepage: www.elsevier.com/locate/dendro



Tree-ring based December–February precipitation reconstruction in the southern Zagros Mountains, Iran

Mohsen Arsalani[a], Kambiz Pourtahamsi[b,*], Ghasem Azizi[a], Achim Bräuning[c], Hosein Mohammadi[a]

[a] *Department of Physical Geography, Faculty of Geography, University of Tehran, Iran*
[b] *Department of Wood and Paper Science and Technology, Faculty of Natural Resources, University of Tehran, Iran*
[c] *Institute of Geography, University of Erlangen-Nuremberg, Germany*

ARTICLE INFO

Keywords:
Dendroclimatology
Drought
Famine
Climate extremes
Tree-rings
Southern zagros
Climate reconstruction
Teleconnection patterns

ABSTRACT

We developed the first tree-ring width chronology from *Quercus brantii* Lindel for the period 1796–2015 in the southern Zagros Mountains, Iran, using standard dendrochronological procedures. Climate-growth relationships revealed that DecemberöFebruary precipitation has strong positive effects ($r = 0.66$; $P < 0.01$) on the species' growth while mean temperature during the growing season has strong negative effects. Spatial correlations with Palmer Drought Severity Index (PDSI) and gridded precipitation data revealed that the chronology contains regional climate signals and tree growth variations may represent precipitation fluctuations over large areas of the Middle East. The linear regression model accounts for 44% of the actual DecemberöFebruary precipitation variance. The reconstructed precipitation revealed that over the period 1850–2015 extreme dry years occurred in 1870-71, 1898, 1960 and 1963-64, and extreme wet years occurred in 1851, 1885, 1916 and 1921 in the southern Zagros region. The longest dry period lasted 16 years and occurred from 1958 to 1973. Two-year consecutive wet and dry events showed the highest frequencies and the average length of dry and wet events were 2.9 and 3.6 years over the reconstructed period. Correlations between the long-term reconstructed precipitation and the North Atlantic Oscillation (NAO), Southern Oscillation Index (SOI), and Pacific Decadal Oscillation (PDO) confirmed the effects of teleconnection patterns on precipitation in the southern Zagros region.

Introduction

Semi-arid regions and climate-sensitive ecosystems are more vulnerable to the effects of climate extremes. Severe droughts and flash floods are the most relevant extreme events which impose strong negative impacts on human settlements and local and regional ecosystems in semi-arid regions (Easterling et al., 2000). Iran is located in an arid to semi-arid climate zone and is therefore very vulnerable to climate extremes. Some of the mega-droughts and drought-related famines caused thousands of deaths in Iran during the 19th and 20th centuries (Kazemi, 2007; Okazaki, 1986; Ketabi, 2011; Giblar, 1976; Melville, 1988). Increasing temperatures and reduction in precipitation have been reported in many regions of Iran during the last decades (Tabari and Hosseinzadeh-Talaee, 2011a,b; Kousari et al., 2011; Delju et al., 2013; Gohari et al., 2013). These climate changes have aggravated water tensions and environmental problems in many regions in Iran. The southern Zagros Mountains are the main source for water supply for settlements in the surrounding arid regions, like e.g. the central Iranian desert. The highest peak of the Zagros Mountain range is Dena (4409 m a.s.l.) which is located in the southern Zagros and plays a vital role in the ecology and local climate condition of the region. Available instrumental climate data show significant changes in climate parameters of the region during the last decade. However, as in many other parts of Iran, long-term climate data are not available to investigate past climate fluctuations and to bring the current climate changes into a long-term perspective. This lack of long-term climate information is a main obstacle for climate modeling efforts and for environmental planning in the region.

Tree rings are useful paleoclimate proxies which provide valuable past climate information with annual and even intra-annual resolutions and help us to understand long-term climate fluctuations (e.g., Fritts, 1976). Tree-ring based precipitation reconstructions have been successfully accomplished in Turkey and provided multi-century climate data for the country which is located in NW Iran (D'Arrigo and Cullen,

---

[*] Corresponding author.
E-mail address: pourtahmasi@ut.ac.ir (K. Pourtahamsi).

https://doi.org/10.1016/j.dendro.2018.03.002
Received 13 December 2017; Received in revised form 6 March 2018; Accepted 7 March 2018

2001; Akkemik and Aras, 2005; Touchan et al., 2005a; Akkemik et al., 2005; Touchan et al., 2007; Akkemik et al., 2008; Köse et al., 2011; Touchan et al., 2003, Touchan et al., 2005b). In Iran, the first tree-ring chronologies were developed by Liphschitz et al. (1979). Recently, some dendrochronology studies have been accomplished to investigate the effects of climate variables on tree growth (Pourtahmasi et al., 2007, 2009, 2012; Najafi-Harsini, 2010; Karamzadeh et al., 2010). The first tree-ring based climate reconstruction in Iran was conducted by Arsalani (2012) in the central Zagros region. Also, the few available regional tree-ring based climate reconstructions provided valuable climate information in the central Zagros region in Iran (Azizi et al., 2013; Arsalani et al., 2014; Nadi et al., 2017), confirming that tree-rings of ring-porous oak species are promising climate indicators for inter-annual climate reconstructions. *Quercus brantii* Lindel is the dominant tree species in the Zagros region and the most xerophilous oak species in the region (El-Moslimany, 1986; Jazirehi and Ebrahimi-Rastaghi, 2003). This deciduous oak species reaches its bioclimatic limits in southern Zagros, making tree rings of the species very valuable for climate reconstructions. Previous studies have been focused in the central Zagros, while the oak trees in southern parts of the Zagros Mountain range experience more climate stress due to more arid climate conditions.

In this study, we develop the first tree-ring width chronology (1796–2015) from the southern Zagros Mountains and examine the climatic factors limiting radial growth of *Q. brantii* in the region. Based on climate-growth relationships, we reconstruct December–February precipitation (hereafter $P_{D\text{-}F}$) and extract dry/wet events of the region over the last 165 years (1850–2015).

Material and methods

Site description

The Deh-Braftab sampling site is located in Kohgiluyeh and Boyer-Ahmad province in the southern Zagros Mountains, Iran (30°46′N, 51°30′E), at an altitude of 1810 m a.s.l. (Fig. 1). The most dominant tree species in the mountainous area is *Q. brantii* intermixed with *Pistacia atlantica*. *Q. brantii* is a broad-leaved ring-porous species with remarkably wide wood rays (Fig. 2) which grows in the province at altitudes between 700 and 2700 m a.s.l. (Jazirehi and Ebrahimi-Rastaghi, 2003). The area of the sampling site is about 3000 ha and the tree stands are generally open with a crown coverage of ca 6–20% and 3–5 m high. Due to anthropogenic activities and climate changes, the natural oak forests are now partly degraded. The soil of the site is very shallow, rocky and calcareous. The mountainous area is an important source of water supply for local communities and settlements in the surrounding semi-arid regions (Fig. 1). The climate of the study site has Mediterranean character, with a wet and cool season from November to April and a dry and hot season from June to September (Fig. 3c), with transitional months in May and October. During the rainy months, the area is mostly affected by westerly disturbances, whereas during the summer it is dominated by the subtropical high-pressure belt. Mean annual precipitation is 801 mm, 95% of which falls during the wet season (November to May). Annual and seasonal precipitation of the region has declined during the period 1987–2016 (Fig. 3a and b). It should be emphasized that about 33% of the annual precipitation falls in autumn (October to December) and 58% of it falls in winter (January to March), indicating the main portion of the seasonal precipitation in total precipitation of the region.

Sampling, sample preparation and chronology development

Thirty increment core and disk samples from 18 *Q. brantii* trees were collected in Deh-Braftab. Core samples were taken from old living trees with no obvious damages from cutting of branches or other disturbance. The trees were cored with a 40 cm increment borer (Haglöf increment borer, Sweden) at breast height. Due to road construction at the site, some of the trees had already been cut down and we obtained 6 disks (12 measured radii) from dead trees using a chainsaw. Most parts of the inner wood of the old trees were rotten and hence the pith was not preserved. After sampling, core and disk samples were air-dried. The core samples were mounted on wooden holders for sample preparation in the laboratory. Before ring-width measurements, all the samples were sanded with progressively finer grades of sandpaper (120–1200). Air pressure and high-pressure water blast were used to remove the dust and tyloses from the sample surface and inside the vessels. After cleaning, the sample surface was rubbed with white chalk to increase the contrast and to make the growth ring boundaries more visible. Ring widths were measured with a LINTAB 6 measuring system (Rinntech, Heidelberg, Germany) at a precision of 0.01 mm using the software TSAP-Win (Rinn, 2003). First, a mean curve for each tree was developed by cross-dating and averaging of the two radii measured per tree. For crossdating the tree mean growth series visual inspection (Stokes and Smiley, 1968) and statistical tests (Fritts, 1976; Cook and Kairiukstis, 1990) were carried out using the software TSAP-Win (Rinn, 2003). Gleichläufigkeit (GLK) and *t*-test statistics were used for verifying the quality of the cross-dating. All radii were standardized to remove biological growth trends and possible effects of non-climatic signals from local disturbance and stand dynamics by using the ARSTAN program (Cook and Holmes, 1986). Detrending was performed by applying a cubic smoothing spline with a 67% frequency-response cutoff to each series which preserves 50% of the variance at a frequency equal to two-thirds of the length of each series. By applying this method and selecting the "standard" chronology provided by ARSTAN for further analyses, we preserved some low-frequency signals in the final chronology which may be associated with multidecadal climate variability. All individual detrended series were combined to a single chronology by computing the biweight robust mean to minimize the impacts of outliers (Cook and Kairiukstis, 1990). The reliability of the chronology was assessed by using Expressed Population Signal (EPS; Wigley et al., 1984) and inter-series correlation (Rbar). EPS ≥ 0.85 is the recommended threshold value which determines the robust parts of a chronology for climate reconstruction based on Rbar and sample size (Cook and Kairiukstis, 1990; Wigley et al., 1984). Both Rbar and EPS were computed for 50 year moving windows with 25 overlap. Other characteristics of the chronology were evaluated by computing first-order autocorrelation (AC1), standard deviation (SD), mean sensitivity (MS), and signal-to-noise ratio (SRN). AC1 evaluates the relationships between the current year's growth and the previous year's growth (Fritts, 1976), SD estimates the variability of measurements for the whole series, MS indicates the relative changes in ring-width variance between consecutive years, and SNR evaluates the signal strength of the chronology.

Climate data

Climate data of Yasuj meteorological station were obtained from Iran Meteorological Organization. The climate station is located about 25 km from the sampling site and provides the longest period of climate data in the province (1987–2015). Other climate stations in the surrounding area cover only very short periods (less than 10 years). Mean monthly temperatures from previous October to current September and monthly precipitation from previous October to current May as well as different seasonal windows of averaged climate data were used for chronology-climate relationships. In the study site, the recorded mean monthly precipitation from June to September was about one millimeter (Fig. 3c); therefore we did not use precipitation of the four months for calibration. Besides mean monthly temperature and precipitation, spatial correlation analyses between the standard site chronology and self-calibrated 0.5° × 0.5° gridded PDSI (CRU scPDSI 3.25, Van der Schrier et al., 2013) and 0.5° × 0.5° gridded precipitation (CRU TS4.01) time series were conducted using KNMI-Climate Explorer (https://climexp.knmi.nl/start.cgi) to identify local and regional