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Bioclimatic characteristic of oak species *Quercus macranthera* subsp. *syspirensis* and *Quercus petraea* subsp. *pinnatiloba* in Turkey

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Abstract

This study was carried out to determine some bioclimatic characteristics such as humidity category (Q_2), winter variant (m), the length of the dry season (LDS) and the dry season water deficit (DSWD) of naturally growing two endemic oak taxa, *Quercus macranthera* subsp. *syspirensis* and *Q. petraea* subsp. *pinnatiloba*, living in Turkey. Our findings showed that bioclimatic tolerance range of *Q. macranthera* subsp. *syspirensis*' possess 7 different types of Mediterranean bioclimate while *Q. petraea* subsp. *pinnatiloba* had 8 of them. Although *Q. macranthera* subsp. syspirensis was ranging among the semiarid, freezing and very cold, *Q. petraea* subsp. pinnatiloba was among sub-humid, freezing and very cold ambient. It was briefly established that *Q. macranthera* subsp. syspirensis prefers semi-arid and very cold/freezing conditions and *Q. petraea* subsp. *pinnatiloba* prefers sub-humid and cold/very cold climatic conditions.

Key words

Quercus macranthera subsp. syspirensis, Quercus petraea subsp. pinnatiloba, Bioclimatic ambient/preference, Mediterranean bioclimate

Introduction

Naturally growing two oak species; *Quercus macranthera* subsp. *syspirensis* (C. Koch) Menitsky, called "Ispir mesesi" in Turkish and *Q. petraea* (Mattuschka) Liebl. subsp. *pinnatiloba* (C. Koch) Menitsky, called "Sapsiz mese" in Turkish, are both endemic for Turkey, and are classified at "LC" (least concern) groups regarding to IUCN risk categories (Ekim *et al.*, 2000; IUCN, 2001).

Q. macranthera subsp. *syspirensis* can grow up to 7 m height. This taxon occurs in mixed forest formation with *Quercus pubescens*, *Pinus nigra* subsp. *nigra* var. *caramanica*, *P. sylvestris* var. *hamata*, *Populus tremula*, *Juniperus communis* subsp. *nana* at between 1000-1900 m above sea level on dry slopes. In general, this taxon lives in northern part of Anatolia (Fig. 1), in provinces of Bolu, Zonguldak, Bartin, Karabuk, Kastamonu, Yozgat, Corum, Amasya, Sivas, Gumushane, Erzincan, Bayburt, Erzurum and Kars (Hedge and Yaltirik, 1982; Ozturk, 2010). These oak communities are located in Euro-Siberian phyto-geographical region of Turkey. They prefer to grow in slightly alkali, non-calcareous brown forest or non-calcareous brown soils.

Q. petraea subsp. *pinnatiloba* live on dry slopes at 1200-2200 m above sea level by forming communities with *Quercus libani*, *Q. infectoria* subsp. *boissieri*, *Q. cerris* var. *cerris*, *Cedrus libani*, *Abies cilicica* subsp. *cilicica*, *Pinus nigra* subsp. *nigra* var. *caramanica*. This taxon is found in south-east of Anatolia (Fig. 1) in general and extends in Hatay, Maras, Malatya, Elazig, Tunceli, Bingol, Mus, Bitlis, Van and Hakkari provinces (Hedge and Yaltirik, 1982). It is especially interesting point that this species located in Hatay province which has extreme climatic conditions than the others mentioned above. These oak communities are generally located in Irano-Turanian phyto-geographical region in Turkey. *Q. petraea* subsp. *pinnatiloba* prefers the high density of light and the soil with low pH to grow.

There are a few ecological studies on *Q. macranthera* subsp. *syspirensis* and *Q. petraea* subsp. *pinnatiloba* (Akman *et al.*, 1978,1979; Quezel and Bonin, 1980; Hedge and Yaltirik, 1982; Akman, 1995; Kaya, 1999; Makineci, 2005; Colak and Rotherham, 2007). However the studies on bioclimatic tolerance ranges including humidity category, winter variant, LDS, DSWD of oak species are very rare. In our knowledge, only the following studies were carried out on this issue but the now; Dufour-Dror and Ertas (2004), Kargioglu *et al.* (2009) and Serteser *et al.* (2009).

The climagrams were determined by a number of researchers in order to explain the bioclimatic tolerance ranges for other oak species such *Quercus pubescens, Q. cerris, Q. faginea, Q. ilex, Q. coccifera, Q. calliprinos, Q. suber, Q. ithaburensis, Q. vulcanica and Q. aucheri* were (Quezel, 1976,1980; Quezel and Barbero, 1985; Dufour-Dror and Ertas, 2004; Kargioglu *et al.*, 2009; Serteser *et al.*, 2009).

The main aim of this study was to determine the bioclimatic tolerance range of both *Q. macranthera* subsp. *syspirensis* and *Q. petraea* subsp. *pinnatiloba* by using Emberger (Q_2, m), De Martonne (LDS) and Gaussen (DSWD) methods (Emberger, 1955, 1971a, b), and to compare their characteristics with other two endemic oaks (*Q. vulcanica* and *Q. aucheri*) of Turkey.

Table - 1: 16 Meteorological stations' data for *Quercus macranthera* subsp. *syspirensis* in Turkey

Station No.	Station name	Altitude (m)	Latitude (N)	Longitude (E)	Rainfall P (mm)	Temperature M (°C)	Temperature m (°C)	Humidity Q_2	LDS (months)	DSWD
1	Bolu	742	40.44	31.31	542	28	-3	61	0	*
2	Zonguldak	137	41.27	31.48	1236	25	3.5	200	0	*
3	Bartin	30	41.38	32.2	1024	28	0.4	129	0	*
4	Karabuk	400	41.12	32.38	510	32	-0.5	54	0	*
5	Kastamonu	800	41.22	33.47	482	29	-4	51	0	*
6	Yozgat	1298	39.49	34.48	600	26	-5.4	67	3	-331
7	Corum	776	40.33	34.57	446	29	-8	43	2	-224
8	Amasya	412	40.39	35.5	449	31	-1	49	3	-328
9	Sivas	1285	39.45	37.01	445	29	-7	44	3	-294
10	Zara	1348	39.54	37.45	533	28	-7.7	53	3	**
11	Gumushane	1219	40.28	39.28	465	29	-5.9	47	2	-259
12	Erzincan	1218	39.45	39.3	380	32	-6.5	35	3	-335
13	Bayburt	1584	40.15	40.14	446	27	-10.9	42	2	**
14	Ispir	1222	40.29	41	473	31	-7.1	44	3	**
15	Erzurum	1757	39.57	41.1	409	28	-15	34	1	**
16	Kars	1775	40.37	43.06	484	27	-15.6	41	0	*

* = Indicates that DSWD cannot be calculated due to "0" values of LDS. [P = mean annual precipitation, M = Mean maximum for the hottest month, m = Mean minimum for the coldest month, Q_2 = Emberger's pluviometric quotient ($2000.P\ M^{-2} - m^2$), LDS = Length of the dry season, DSWD = Dry season water deficit]

Table - 2: 13 Meteorological stations' data for *Quercus petraea* subsp. *pinnatiloba* in Turkey

Station No.	Station name	Altitude (m)	Latitude (N)	Longitude (E)	Rainfall P (mm)	Temperature M (°C)	Temperature m (°C)	Humidity Q_2	LDS (months)	DSWD
1	Hatay	100	36.12	36.1	1115	31	4.7	145.7	3	-374
2	Goksun	1344	38.01	36.3	618	29	-8.8	57.7	4	-421
3	Maras	572	37.36	37.56	729	36	1.4	72.2	4	-606
4	Malatya	898	38.21	38.21	382	34	-2.6	36.1	4	-568
5	Elazig	991	38.4	39.14	409	34	-3.6	37.7	4	-538
6	Tunceli	980	39.07	39.33	814	35	-5.3	70.1	4	-572
7	Bingol	1177	38.53	40.29	961	35	-5.8	81.9	4	-547
8	Solhan	1365	38.58	41.04	690	33	-8.5	58.3	3	-354
9	Mus	1284	38.44	41.29	783	33	-11.1	62.5	3	-383
10	Bitlis	1573	38.24	42.07	1254	31	-6.4	117.5	3	-356
11	Tatvan	1665	38.3	42.15	830	29	-6.3	82.7	3	-318
12	Van	1671	38.3	43.23	385	28	-7.2	38.6	4	-540
13	Hakkari	1728	37.35	43.44	765	31	-8	68.9	4	-508

P = mean annual precipitation, M = Mean maximum for the hottest month, m = Mean minimum for the coldest month, Q_2 = Emberger's pluviometric quotient ($2000.P\ M^{-2} - m^2$), LDS = Length of the dry season, DSWD = Dry season water deficit

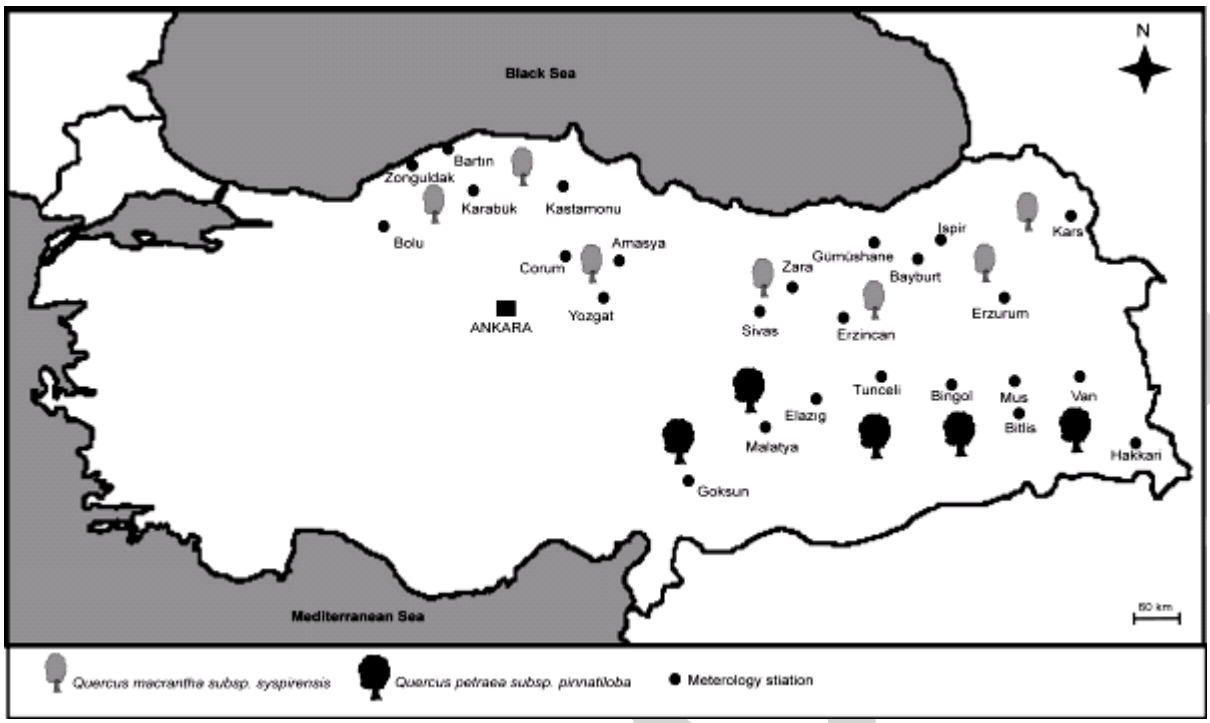

Fig. 1: Extent of occurrence of endemic "*Quercus macranthera* subsp. *syspirensis*" and "*Quercus petraea* subsp. *pinnatiloba*' in Turkey

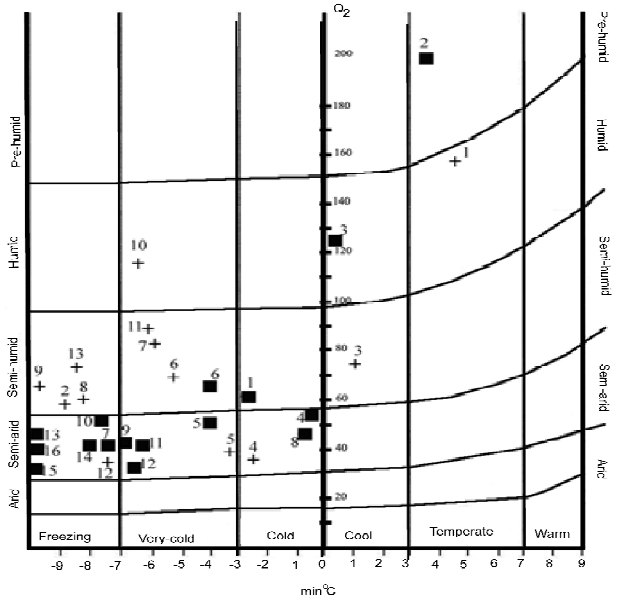

Fig. 2: Emberger's 'climagram' for *Quercus macranthera* subsp. *syspirensis* (■) and *Quercus petraea* subsp. *pinnatiloba* (+) (Akman, 1990)

Materials and Methods

Four variables were used to determine bioclimatic tolerance ranges of *Q. macranthera* subsp. *syspirensis* and *Q. petraea* subsp. *pinnatiloba* present in Turkey. Humidity category (Q_2) and winter variant (m) were determined by the methods of Emberger (1955, 1971a, b), while LDS by the method of Martonne (1948), and DSWD by Gaussen (1954) method. Q_2 and m values were calculated by using temperatures as described by Emberger, 1971a,b.

Winter variant and humidity categories were shown and interpreted on a climagram (Fig. 2) (Akman, 1990; Daget *et al.*, 1988). The bioclimatic tolerance ranges in the expansion of *Q. macranthera* subsp. *syspirensis* and *Q. petraea* subsp. *pinnatiloba* were stated based on the meteorological data by using this climagram. The climagrams were determined by a number of researchers in order to explain the bioclimatic tolerance ranges for other oak species such as *Quercus pubescens*, *Q. cerris*, *Q. faginea*, *Q. ilex*, *Q. coccifera*, *Q. calliprinos*, *Q. suber*, *Q. ithaburensis*, *Q. vulcanica* and *Q. aucheri* were (Quezel, 1976, 1980; Quezel and Barbero, 1985; Dufour-Dror and Ertas, 2004; Kargioglu *et al.*, 2009; Serteser *et al.*, 2009).

The climatic data that have been used at this study were based on the records from almost 29 selected meteorological stations (Fig. 2, Table 1 and 2), which established around the study locations. The annual average rainfall of each station (P) refers to the period between 1975 and 2006 (31 yrs). The different average values of temperature, *i.e.* minimum of the coldest month (m), maximum of the hottest month (M) and the monthly mean temperature have been calculated for the period 1986-2006 (20 yrs). The basic climatic data have been provided by the Turkish Meteorological Center [TMC (DMI), 2006].

Results and Discussion

Humidity categories and winter variant description of *Q. macranthera* subsp. *syspirensis* were performed by using the data

from 16 meteorological stations. Q_2 values of these stations were between 34 (Erzurum) and 200 (Zonguldak), and m values varied between -15.6°C (Kars) and 3.5°C (Zonguldak). All the Q_2 and m values are shown in Table 1. The humidity categories and winter variant description of *Q. petraea* subsp. *pinnatiloba* were determined by using the data from 13 meteorological stations. Q_2 values of these stations were between 36.1 (Malatya) and 145.7 (Hatay), m values varied between -11.1°C (Mus) and 4.7°C (Hatay). Q_2 and m values are shown in Table 2. Additionally, LDS and DSWD values for both *Q. macranthera* subsp. *syspirensis* and *Q. petraea* subsp. *pinnatiloba* were also shown in Table 1 and 2.

Humidity categories and winter variants of *Q. macranthera* subsp. *syspirensis* were determined by using the data obtained from 16 meteorological stations. According to this determination, one station was located at a per-humid area, one at a humid, two stations were at a subhumid, and 12 stations were at a semi-arid area for *Q. macranthera* subsp. *syspirensis*. The six out of 16 belonged to freezing area, five of them belonged to very cold area, three of them belonged to cold, one of them belonged to cool, and one of them belonged to temperate area. When the arid was included at the data set we took the arid season in consideration, the dry season duration (LDS) of *Q. macranthera* subsp. *syspirensis* varied from 0 to 3 months, and DSWD values varied between 0 and -335.

For *Q. petraea* subsp. *pinnatiloba*, the humidity categories and winter variants were classified according to the data obtained from 13 meteorological stations. In this classification, two stations belonged to humid area, eight stations belonged at the sub-humid, and three stations belonged at the semi-arid area. Five out of 13 stations were in freezing area, five of them were at the very cold, one of them was at the cold, one of them was at the cool, and one of them was at the temperate. The LDS for *Q. petraea* subsp. *pinnatiloba* varied from 3 to 4 months, and the DSWD values were between -318 and -606 when we put the dry season in consideration.

Bioclimatic classification for another two endemic oak species, *Q. vulcanica* and *Q. aucheri* were recently reported (Kargioglu *et al*., 2009; Serteser *et al.*, 2009). Humidity categories and winter variant for *Q. vulcanica* were determined by using 12 meteorological stations' recorded data (Kargioglu *et al*., 2009). Humidity categories and winter variants for *Q. aucheri* were also determined by the data of 17 meteorological stations (Serteser *et al.*, 2009).

Average annual temperature values of the presence area of *Q. macranthera* subsp. *syspirensis* varied between 6 and 9°C and annual temperature demand of this taxon is lower than that of *Q. vulcanica*, *Q. aucheri* and *Q. petraea* subsp. *pinnatiloba*. On the other hand, the average annual rainfall was observed to be between 600-800 mm. Under these climatic conditions, its bioclimatic tolerance range were observed to be varied and were characterized as semiarid-freezing, semiarid-very cold, semiarid-cold, subhumid-very cold, subhumid-cold, humid-cool and perhumid-temperate. Therefore, *Q. macranthera* subsp. *syspirensis* does clearly possess 7 different Mediterranean climate types (Fig. 2). It means that *Q. macranthera* subsp. *syspirensis*'s bioclimatic suitability could be characterized as highly heterogeneous form. Its bioclimatic classification could be stated as semi-arid and freezing / very cold area. All these findings suggest that *Q. macranthera* subsp. *syspirensis* prefers semi-arid and very cold conditions to successfully grow.

Q. petraea subsp. *pinnatiloba*'s humidity request is in the second rank among the four endemic oak species by following *Q. aucheri*. This taxon, grows at the moist climatic regions of Anatolia, is very sensitive to extreme temperature changes. The average annual temperatures of the region which it spreads out were between 8 and 10°C. The average annual rainfalls of the regions are between 800-1100 mm. *Q. petraea* subsp. *pinnatiloba*'s bioclimatic tolerance ranges include 8 types of Mediterranean bioclimate (Fig. 2) which are semiarid-freezing, semiarid-very cold, semiarid-cold, subhumid-freezing, subhumid-very cold and subhumid-cool, respectively. However, when we considered its growing conditions, these plants live in it the bioclimatic class described by Emberger, the region could be characterized as sub-humid and freezing / very cold. Conclusively, we could establish that its favorite conditions to grow are sub-humid ambient.

Kargioglu *et al.* (2009) reported that *Q. vulcanica* had 6 different Mediterranean bioclimatic tolerance ranges as well as *Q. petraea* subsp. *pinnatiloba*. On the other hand, *Q. vulcanica* is also present in arid-very cold, semiarid-very cold, semiarid-cold, subhumid-cold, humid-very cold and humid-cold tolerance ranges by differing itself from other oak taxa. High presence of moss and Euro-Siberian elements in its living areas, Sultan Daglari, Karadag and Kovada-Gokbelenkoy, of *Q. vulcanica* indicates that a moist demanding preference is needed. Kargioglu *et al.* (2009) reported these data in detail.

The precipitation and temperature needs of *Q. aucheri* precipitation and temperature demand is the highest greater when compared with other three endemic oak taxa. As reported by Serteser *et al.* (2009), its optimal annual temperature average was 17-18°C and annual precipitation demand was 600-1200 mm. It includes 4 types of Mediterranean bioclimate, subhumid-temperate, subhumid-warm, humid-temperate and humid-warm. All these findings suggest to us that *Q. aucheri* prefers humid conditions to survive and spread its population (Serteser *et al.*, 2009).

The annual rainfall demands for *Q. ithaburensis* subsp. *macrolepis*, living in Turkey and *Q. ithaburensis* supsp. *ithaburensis*, living in Israel, are as follow: 387-1127 and 452-662 mm, respectively. On the other hand, *Q. ithaburensis* subsp. m*acrolepis* includes 10 types of mediterranean bioclimate, verycold-semiarid, cold-semiarid, cold-subhumid, cool-semiarid, cool-subhumid, cool-humid, temperate-subhumid, temperate-humid, hot-subhumid and hot-humid. *Q. ithaburensis* subsp. *ithaburensis* includes 4 types of mediterranean bioclimate temperate - semiarid, temperate-subhumid, hot-semiarid and hot-subhumid (Dufour-Dror and Ertas, 2004).

When we compared the bioclimatic tolerance ranges of these two oak species with the others, the following results were obtained - the highest level for humidity category (O_2) was 200 for *Q. macranthera* subsp. *syspirensis* and the lowest level was 27.9 for *Q. vulcanica.*

Winter variant (m)'s highest level (9.5°C) belonged to Q. aucheri and the lowest level (-15.6°C) to *Q. macranthera* subsp. *syspirensis*.

This study established the bioclimatic features of two Turkey's endemic oaks, *Q. macranthera* subsp. *syspirensis* and *Q. petraea* subsp. *pinnatiloba.* The other two endemic oak species, *Q. vulcanica* and *Q. aucheri*, of Turkey are under the unfavorable conditions as well as these two taxa studied in the present paper. In this situation, both state and NGOs should develop some strategies (could be a national park, or natural park or conservation area *etc.*) to protect these symbol oaks of Anatolia and we should bequeath these richness to the next generation at least as they are.

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