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AN ECOLOGICAL STUDY OF ENDEMIC PLANT *POLYGONUM ISTANBULICUM* KESKIN AND ITS ENVIRONS

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Abstract

In this study, some ecological features of narrow endemic *Polygonum istanbulicum* Keskin, which was established as a new plant species in 2009, and its environs were examined. There are 41 known *Polygonum* taxa in Turkey and the genus is represented by 14 species in Istanbul. Plant and soil samples were collected from the place where the species merely lives in the world (Başıbüyük Forest, Maltepe District, Istanbul/Turkey). Plant and soil samples were collected by using standard methods and root, branch, leaf and soil mineral nutrients (Ca, Cu, K, Mg, Mn, N, P, Na, Zn), were measured. Additionally, soil texture, structure and other physical and chemical measurements such as pH, total protein and electrical conductivity (EC) were determined.

Introduction

Polygonaceae family, which has a cosmopolitan distribution especially in the northern temperate region (Heywood, 1978) is represented by approximately 48 genera and 1,200 species (Freeman & Reveal, 2005; Sanchez & Kron, 2008; Qaiser & Perveen, 2011). Among 60 species of the *Polygonum* L. distributed throughout the world, 41 of them are known to be from Turkey and the genus is represented by 14 species in Istanbul (Qaiser, 2001; Keskin, 2009; Yasmin *et al*., 2010a, b). The plants are mostly annual or perennial herbs or vines, shrubs and rarely trees. Distinguishing characters of the family are as follows; Leaves simple, alternate, rarely opposite or whorled, petiolate or subsessile, usually stipulate. Petioles expand at the base and fused with stipules forming a membraneous sheath around the stem called ochrea. Flowers are usually small, actinomorphic, bisexual or unisexual, plant either monoecious or dioecious. Inflorescence in spikes, fasicles or panicles, each branch or flower subtented by an ochrea like sheath (ochreola). Perianth 3-6-merous in 2-3 whorls, with segments united below, often enlarged in fruit. Stamens 6-9, rarely more, up to 16, filaments free or united at base, anthers 2-loculed, nectaries absent. Ovary superior, unilocular. Styles 2-3 or rarely 4, carpels as many as the styles. Fruit a trigonous, biconcave or biconvex achene or a small nut, usually falling with persistent perianth (Davis, 1967; Ronse & Akeroyd, 1988; Wilson, 1996).

Polygonum istanbulicum Keskin, which was established as a new plant species in 2009 is a narrow endemic plant for Istanbul-Turkey. The species is taken from a single site (Başıbüyük District-Maltepe/Istanbul) only in the Asian side of Istanbul, where it grows under a high anthropogenic pressure (Fig. 1). The population is not in good conditions and the number of individuals has been estimated to 200-300. Therefore it should be regarded as Critically Endangered (CR) (Keskin, 2009).

The purpose of this study was to learn more about the ecological properties of this narrow endemic by investigating its soil-plant interactions and mineral nutrition status.

Materials and Methods

Study area: Istanbul is located in the northwest part of Turkey (41^o 01.2' N, 28^o 58.2' E) and extends both on European (Thrace) and Asian (Anatolia) sides of the Bosphorus. The study area (Asian side) is located on the east side of Istanbul 40^o 48' and 41^o 16' in latitude and 29^o 04' and 29^o 58' in longitude (Altay *et al*., 2010; Yasar *et al*., 2010; Municipality, 2012). Its neighbors are the Black Sea in the north, Marmara Sea in the south, Kocaeli City in the east and Bosphorus in the west. According to Population-Based Registration System Database, Istanbul has 13,624,240 population in a land area of 5,343 km^2 (Anon., 2012; Municipality, 2012).

Topography, Soil and Geology: The main topographical structure of Istanbul is a low plateau, which has an elevation of approximately 100-200 m. The geological structure contains the Silurian, Devonian, Carboniferous and Tertiary ages originated formations. There are different kinds of rocks, which consist of granitic plutons, quartzes, grovacs, clayed schsists and radiolarites (Yaltirik *et al*., 1997; Yasar *et al*., 2010). Many different soil types are present in Istanbul. However, the brown forest soil covers the largest area. The noncalcareous brown soil is the second widespread and this type of soil is suitable for many plants (Yaltirik *et al*., 1997; Altay *et al*., 2010, Yasar *et al*., 2010). Geological age of the research area consists of a sedimentary sequence from Ordovician to Carboniferous, which reaches several thousand meters. In the research area, structural features of arkose and quartzite are seen (Tuysuz, 2003; Yasar *et al*., 2010).

Climate: The climate of research area is characterized as having either a humid subtropical climate, according to Köppen climate classification system, or a warm-summer Mediterranean climate, according to the updated Köppen-Geiger classification system (McKnight & Hess, 2000). In the research area, less precipitation and high temperature are usually observed in the summer. The annual mean temperature was measured as 15^{o}C in last three decades (Table 1).

Fig. 1. A-General habitat of *P. istanbulicum*, B-Young plants with white flowers, C-A young branch with white flowers, D- Two branches with fruits and red flowers.

Table 1. Climate data for Istanbul (Between 1970 - 2011).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average temperature (°C)	6.6	6.6	8.4	12.7	17.4	22.1	24.5	24.2	20.8	16.4	11.9	8.5	15.0
Average high (°C)	8.7	9.1	11.2	16.5	21.4	26.0	28.4	28.5	25.0	20.1	15.3	11.1.	18.8
Average low (°C)	2.9	2.8	3.9	7.7	12.0	16.0	18.5	18.7	15.5	12.0	8.5	5.3	10.5
Precipitation (mm)	98.4	80.2	69.9	45.8	36.1	34.0	38.8	47.8	61.4	96.9	110.7	123.9	843.9
Average precipitation days	17.7	15.3	13.6	10.3	7.8	5.3	3.6	4.0	6.1	10.3	12.9	16.9	123.8

*Prepared using the data of Anon., 2011a and Anon., 2011b.

Summer weather is moderately warm, with high temperatures in July and August averaging 28°C. Winter average temperature in January and February is about 4°C (Anon., 2011a). The total precipitation for Istanbul averages 843.9 mm per year and approximately 40% of the total precipitation falls in winter. The precipitation ratio in summer is higher than the typical Mediterranean stations. This characteristic is related with the Oceanic climate. The minimal rain falls in summer and its ratio is about 8%. Precipitation is less in spring (about 20-21%), while it increases in autumn (about 28-29%). Additionally, snow rarely falls in Istanbul. The rain regime is Winter-Autumn-Spring-Summer (W.A.Sp.Su). The relative humidity is between 73-77% in the city and these values decrease to 65-68% in summer despite the effect of the seas. The lower relative humidity, especially in the dry period, forms the xerophytic vegetation. Northeast originated wind is dominant in the city (Akman & Ketenoglu, 1987; Altay *et al*., 2010; Yasar *et al*., 2010; Anon., 2011a).

Samples collection and preparation: Plant and soil samples were collected from Maltepe, Başıbüyük District, Forest of Süreyyapaşa Hospital, 40° 56' 58.5" N, 29° 08' 20.9" E, 69 m a.s.l. (Keskin, 2009). Plant parts (root, branch and leaves) were isolated and oven-dried at 80 °C for 24 h, milled in micro-hammer cutter and fed through a 1.5-mm sieve. Samples were weighed as 0.5 g and transferred into Teflon vessels and then 8 ml 65 % HNO_3 was added. Soil samples (about 500 g) were collected from a depth of about 10 cm with a stainless steel shovel. They were air dried and passed through a 2-mm sieve. After that, they were weighed as 0.3 g and 9 ml 65% HNO_3, 3 ml 37 % HCl and 2 ml 48 % HF (Merck) were added. Samples were mineralized in microwave oven (Berghof-MWS2) as follows: in 145 °C for 5 min., in 165 °C for 5 min. and in 175 °C for 20 min. After cooling, they were filtered by Whattman filters, and made up to 50 ml with ultra-pure water in volumetric flasks and then stored in falcon tubes.

Analysis of samples: For this purpose, standard solutions were prepared by using multi element stock solutions-1000 ppm (Merck) and mineral element (Ca, Cu, Fe, K, Mn, Na and Zn) measurements were done by Inductively Coupled Plasma Optical Emission Spectroscopy (PerkinElmer-Optima 7000 DV). Electrical conductivity was determined according to Allison (1954). Soil pH was measured with an electronic pH-meter in a 1:2.5 soil/water suspension. The total N content was determined by the Kjeldahl method (Page *et al*., 1982), total phosphorus by the Bingham (1949) method and organic matters were measured according to Smith & Weldon, (1941). Additionally, total nitrogen and phosphorus of the plant samples were determined following the methods given by Bremner, (1965); Lott *et al*., (1956) & Kacar (1972).

Results and Discussion

The results of physical analysis of the soil samples collected from the limited distribution area of narrow endemic *P. istanbulicum* are presented in Table 2. According to the physical analysis results, the species grows on Clayey-loamy (CL) soils. The % concentration of $CaCO_3$ (5.4 %) shows that plant prefers medium levels of soil Ca. The organic matter concentration of the soil was found to be 2.597 % (middle rich). Electrical conductivity measured as 0.157 mmhos/cm shows the compatibility of Clayey-loamy texture. The pH was 6.66 (weakly acidic), while saturation was 57 %.

Table 2. Physical analysis results of the soil samples of *P. istanbulicum* habitats.

Soil	
Texture	Clayey-loamy (CL)
$CaCO_3$ (%)	5.4
Organic matter (%)	2.597
pH	6.66
EC (mmhos/cm)	0.157
Saturation (%)	57

Chemical analysis of the *P. istanbulicum* soils showed that % N content is 0.21±0.01 (Table 3). In general, % N contents of mineral soils are between 0.02 % and 0.5 %, while the average value is 0.15% (Kacar & Katkat, 2010). Our results show that N amounts are within normal ranges, although higher than average. Average P values were measured as 20.2±4.2 mg/kg and this result shows that soil P is low in the area (Bingham, 1949). K amount was 0.265±0.007 g/kg. Normally, % K amounts in soil are between 0.5 % and 2.5 %, which are equal to 5 and 25 g/kg, while the average value is 1.5% (15 g/kg) (Kacar & Katkat, 2010). Therefore, it can be concluded that *P. istanbulicum* prefers soils deficient in K. Average Ca amount of the soil samples were measured as 1.733±0.030 g/kg which shows Ca deficiency in the study area (Kacar & Katkat, 2010). Soil Na measured as 103.453±2.38 mg/kg is within normal limits (Kacar & Katkat, 2010). Cu, Mn and Zn are the micronutrients that are essential for plant growth but required in much smaller amounts than those of the primary nutrients such as N, P, S and K (Hansch & Mendel, 2009). In this study, soil Cu was measured as 6.511±0.177 mg/kg, while Mn 182.66±5.86 mg/kg and Zn 21.123±0.388 mg/kg respectively. All these values are within normal limits (Kacar & Katkat, 2010).

Table 3. Chemical analysis of the plant parts (leaf, branch and root) of *P. istanbulicum* and soil samples.

	Leaf	Branch	Root	Soil
Protein (%)	7.31 ± 0.35	7.38 ± 0.23	7.73 ± 0.62	-
N (%)	1.17 ± 0.06	1.18 ± 0.04	1.24 ± 0.10	0.21 ± 0.01
P (mg/kg)	956.153 ± 75.7	521.440 ± 39.4	1317.493 ± 207	20.2 ± 4.2
K (g/kg)	4.979 ± 0.07	2.418 ± 0.06	2.246 ± 0.03	0.265 ± 0.007
Ca (g/kg)	3.574 ± 0.30	2.662 ± 0.10	3.530 ± 0.10	1.733 ± 0.030
Cu (mg/kg)	6.65 ± 0.21	7.40 ± 0.24	8.46 ± 2.73	6.511 ± 0.177
Mn (mg/kg)	37.52 ± 2.88	16.24 ± 0.78	39.67 ± 1.43	182.66 ± 5.86
Na (mg/kg)	359.66 ± 21	217.27 ± 7.14	324.00 ± 24	103.453 ± 2.38
Zn (mg/kg)	18.20 ± 2.75	17.91 ± 2.56	19.79 ± 0.92	21.123 ± 0.388

In this study, chemical analyses of some plant parts (leaf, branch and root) were done. Although there are not many studies on plant mineral nutrient contents of Polygonaceae family members, the average mineral element values were compared to two congeners of *P. istanbulicum*, which are *Polygonum bistorta* L. and *Polygonum cognatum* Meissn. Average % N amount in leaves of *P. istanbulicum* was found as 1.17±0.06, while 1.18±0.04 in branches and 1.24±0.10 in roots. It is a well-known fact that N content in plants generally varies between 0.2 and 6% (Ozdemir & Ozturk, 1996). According to our values, % N levels of *P. istanbulicum* in all plant parts are lower than normal limits. Average P values of *P. istanbulicum* were measured as; 956.153±75.7 mg/kg in leaves, 521.440±39.4 mg/kg in branches and 1317.493±207 mg/kg in roots. According to the Johnson & Ulrich (1959), our P levels in all plant parts are within normal limits, although the soil P values are lower. This situation shows P uptake and accumulation abilities of *P. istanbulicum*. Our P values in aboveground parts of *P. istanbulicum* are close to the P values of its two congeners, *P. bistorta* (390.6 mg/kg) and *P. cognatum* Meissn. (490.8 mg/kg) (Turan *et al*., 2003).

Plant average K values were found as 4.979±0.07 g/kg in leaves, 2.418±0.06 g/kg in branches and 2.246±0.03 g/kg in roots. Kacar, (1972) reported that K values in plants vary between 2 and 110 g/kg, hence our results are within normal limits although closer to the lower limits. This could be the reflection of soil K deficiency in its habitat. Additionally, average K levels of aboveground parts of *P. bistorta* and *P. cognatum* are within normal limits, although higher than our values (Turan *et al*., 2003). Average Ca amounts were measured as 3.574±0.30 g/kg in leaves, 2.662±0.10 g/kg in branches and 2.246±0.03 g/kg in roots. According to Chapman (1967), Ca content is adequate when above 9.3 g/kg. In our samples, the mean Ca contents are below the adequate level. Thus, we conclude that either *P. istanbulicum* shows a deficiency in calcium intake or this could be the result of lower soil Ca. Like our values, average Ca amounts of aboveground parts of *P. bistorta* and *P. cognatum* were found lower than adequate, although higher than our values (Turan *et al*., 2003). Na concentrations in *P. istanbulicum* were measured as follows; 359.66±21 mg/kg (leaf) 217.27±7.14 mg/kg (branch) and 324.00±24 mg/kg (root). In plants, Na concentration varies between 100-100,000 mg/kg (Kacar & Katkat, 2010). Thus, it can be concluded that Na concentrations of *P. istanbulicum* are within the normal values. However, the measured concentrations are higher than *P. bistorta* (72.2 mg/kg) and *P. cognatum* (38.18 mg/kg).

In this study, Cu was measured 6.65±0.21 mg/kg in leaves, 7.40±0.24 mg/kg in branches and 8.46±2.73 mg/kg in roots. Literature indicates that Cu concentration in plants varies between 1 and 20 mg/kg (Hansch & Mendel, 2009). Between or over 20-100, mg/kg are accepted as toxic levels (Kabata-Pendias & Pendias, 2001). According to the literature, our values are within normal limits. In a similar study, Cu concentrations were measured as 0.11 mg/kg in *P. bistorta* and 11.17 mg/kg in *P. cognatum* shows the different Cu accumulation abilities of Polygonaceae family members.

Manganese concentrations of leaf, branch and root samples of *P. istanbulicum* are; 37.52±2.88 mg/kg 16.24±0.78 mg/kg 39.67±1.43 mg/kg respectively. Hansch & Mendel, (2009) reported that Mn values in plants vary between 10-100 mg/kg. Toxic values are in range of 300-500 mg/kg (Kabata-Pendias & Pendias, 2001). Hence our results are within the normal limits. However, Mn values of *P. bistorta* (1.3 mg/kg) and *P. cognatum* (2.4 mg/kg) are much lower than *P. istanbulicum*. Zinc amounts of the selected plant parts are 18.20±2.75 mg/kg in leaves, 17.91±2.56 mg/kg in branches and 19.79±0.92 mg/kg in roots. According to the literature, the normal limits of Zn vary between 15 and 50 mg/kg (Hansch & Mendel, 2009), and in range of 100 and 400 mg/kg are accepted as toxic (Kabata-Pendias & Pendias, 2001). Our values are within normal limits, but closer to the lower values. However, they are much higher than those of *P. bistorta* (7.6 mg/kg) and *P. cognatum* (3.1 mg/kg).

As it can be seen in the results above, narrow endemic *P. istanbulicum* shows different mineral element uptake and accumulation status and prefers different types of soil properties than its two congeners *P. bistorta* and *P. cognatum*. *P. istanbulicum* merely grows in Maltepe, Başıbüyük District, Forest of Süreyyapaşa Hospital (Open *Pinus* forest) in the world. It is mainly associated with *Allium guttatum* Steven subsp. *guttatum*, *Allium peroninianum* Azn., *Asparagus aphyllus* L., *Cistus creticus* L., *Cistus salviifolius* L., *Colchicum chalcedonicum* Azn. subsp. *chalcedonicum*, *Cynodon dactylon* L., *Isoetes duriei* Bory, *Isoetes hystrix* Bory var. *hystrix*, *Scilla autumnalis* L., *Tragus racemosus* (L.) All. and *Veronica persica* Poiret (Keskin, 2009). There is not any other *Polygonum* species living in its habitat, which could also support that *P. istanbulicum* is a narrow endemic plant and prefers different ecological properties.

In conclusion, *P. istanbulicum* prefers weakly acidic clayey-loamy soils, which contain medium levels of $CaCO_3$ and middle rich organic matters. Although, Cu, N, Na, Mn and Zn levels in soil are within normal range, the P levels are found to be low and Ca and K are deficient. The results for plant mineral nutrients are within normal ranges for Cu, Mn, Na, P and Zn while, K is in normal ranges but closer to lower limits and low values were measured for Ca and K.

In the light of all the obtained data, *P. istanbulicum* differentiates from its congeners and other plant species in terms of habitat, mineral uptake and transport characteristics and its choice of different soil texture. Hopefully this study will enlighten future studies related with endemics, narrow endemics and newly found species.

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