G. Ayyıldız et al. / Hacettepe J. Biol. & Chem., 2024, 52 (2), 85-95

Research Article

Hacettepe Journal of Biology and Chemistry

journal homepage: www.hjbc.hacettepe.edu.tr

Reclassifying the Threat Categories of Two Rare Plant Species Endemic to Central Anatolia

İç Anadolu Bölgesine Endemik İki Nadir Bitki Türünün Tehdit Kategorilerinin Yeniden Sınıflandırılması

Gül Ayyıldız, Merve Yıldırım, Ali Murat Keser, Ahmet Emre Yaprak, Gül Nilhan Tuğ

Department of Biology, Faculty of Science, Ankara University, Ankara, Turkey.

ABSTRACT

Aethionema turcica and *Astragalus beypazaricus* are rare endemic plant species restricted to marly-gypsaceous soils from Ankara, Turkey. In a study in 2000, *Ae. turcica* and *A. beypazaricus* were classified under the "Least Concern" and "Critically Endangered" threat categories, respectively. This study aimed to reassess the global conservation status of these species according to the IUCN Red List Categories and Criteria by using the recent findings based on their population sizes, distribution areas, and the main threats. Field research was conducted between 2016 and 2018. Additionally, physical-chemical soil tests were run, and the climatic data were utilized to draw bioclimatic conclusions. In Ankara, there are two populations of *Ae. turcica,* with 359 mature individuals covering 12 km^2 AOO and 23.5 km^2 EOO areas. *A. beypazaricus* has only one fragmented population with a total of 5700 mature individuals in Beypazarı, and both AOO and EOO were discovered to be 4 km^2. Both species are on the verge of extinction due to habitat fragmentation and loss formed by intense anthropogenic activity. According to the findings, the IUCN threat categories for *Ae. turcica* and *A. beypazaricus* were suggested to be reclassified as CR based on the criteria B1ab(ii, iii) and B1ab(ii, iii)+2ab(ii, iii), respectively.

Key Words

Aethionema turcica H. Duman&Aytaç, *Astragalus beypazaricus* Podlech&Aytaç, Plant Conservation, IUCN.

ÖZ

Aethionema turcica ve *Astragalus beypazaricus*, Türkiye'de Ankara ilinden bilinen, marnlı jipsli topraklarla sınırlı iki nadir endemik bitki türüdür. 2000 yılında yapılan bir çalışmada, *Ae. turcica* ve *A. beypazaricus* sırasıyla "En Az Endişe Verici" ve "Çok Tehlikede" tehdit kategorileri altında sınıflandırılmıştır. Bu çalışmanın amacı, bu türlerin popülasyon büyüklükleri, yayılış alanları ve tehdit faktörleri bilgilerine dayanan son bulguları kullanarak, IUCN Kırmızı Liste Kategori ve Kriterlerine göre küresel koruma statülerini yeniden değerlendirmektir. Arazi çalışmaları 2016-2018 yılları arasında yapılmıştır. Ek olarak, fiziksel-kimyasal toprak testleri yapılmış ve biyoiklimsel sonuçlara varmak için iklim verileri kullanılmıştır. Ankara'da, *Ae. turcica*'nın toplam 359 bireyden oluşan ve 12 km^{2}lik AOO ile 23.5 km^{2}lik EOO alanlarını kapsayan iki popülasyonu vardır. *A. beypazaricus*, Beypazarı'nda toplam 5700 ergin birey ile tek ve parçalı bir popülasyona sahiptir, hem AOO hem de EOO alanları 4 km^2 olarak bulunmuştur. Yoğun antropojenik aktivitenin oluşturduğu habitat parçalanması ve habitat kaybı sonucu her iki tür de yok olma eşiğindedir. Elde edilen bulgulara göre, *Ae. turcica* ve *A. beypazaricus* için IUCN tehdit kategorilerinin sırasıyla B1ab(ii, iii) ve B1ab(ii, iii)+2ab(ii, iii) kriterlerine göre CR olarak yeniden sınıflandırılması önerilmiştir.

Anahtar Kelimeler

Aethionema turcica H. Duman&Aytaç, *Astragalus beypazaricus* Podlech&Aytaç, Bitki Koruma, IUCN.

Article History: Jan 28, 2023; Revised: Dec 9, 2023; Accepted: Dec 13, 2023; Available Online: Feb 8, 2024.

DOI: https://doi.org/10.15671/hjbc.1243954

Correspondence to: G. Ayyıldız, Department of Biology, Faculty of Science, Ankara University, Ankara, Turkey.

E-Mail: ayyildiz.gul@gmail.com

INTRODUCTION

All the organisms on Earth are being affected by the global changes that have occurred, particularly in the last few decades. Global change refers to planetary-scale changes affecting the earth system as a whole. Drivers of global change can be classified as natural and anthropogenic [1]. Anthropogenic drivers have human origins and are, but are not limited to, population growth and consumption, energy use, land use changes, pollution [2], agriculture and food production, forestry, industrial development, transport and international commerce, urbanization and recreational activities [3]. Agricultural development and expansion have already surpassed the area of surviving forest cover, encompassing 40% of the Earth's land surface. Thus, it accounts for most habitat loss and fragmentation that endangers terrestrial biodiversity [4]. Many landscapes exhibit natural habitat heterogeneity or mosaicking. Terrestrial species have had extensive evolutionary timelines to adjust to natural levels of patchiness and are thus unaffected. Human-modified landscapes have fragmented habitats at extraordinary rates compared to Earth's natural evolutionary history [5]. These rates far outstrip the majority of species' ability to adapt and survive in the face of rapidly diminishing appropriate habitats and rising habitat patchiness [6,7]. Edge habitat refers to the parts of a habitat patch that are impacted by external forces, whereas core habitat refers to the parts that are not influenced by the surrounding terrain [8,9]. The loss of habitat has a significant and constant detrimental impact on biodiversity, both directly and indirectly. Since it affects species abundance and distributions, genetic diversity, and species richness, disrupts species interactions, reduces trophic chain length, and diminishes dispersal ability and breeding success [10,11]. Small populations are more exposed to extinction due to stochastic demographic processes [12], and the loss of species is unavoidable when this happens on a regional basis [13].

The unique ecosystem and habitat diversity of Turkey has produced considerable species diversity. Eastern Anatolia and Southern Anatolia are among geographical regions, and Irano-Turanian (Ir-Tur) and Mediterranean regions among phytogeographical regions are rich in endemic plant species [14]. Although Turkey is home to many unique plants, some of which are endangered. The influence of global changes is much more severe on some species with exceptional habitat needs and restricted distribution areas. As stated in the current research, Turkey has 11707 wild plant taxa, 3649 (31.17%) of which are endemic [15]. Even though Central Anatolia is home to numerous rare, endemic, and vulnerable species, just two were chosen for this study: *Aethionema turcica* H. Duman & Aytaç and *Astragalus beypazaricus* Podlech & Aytaç [16].

Aethionema turcica H. Duman & Aytaç is a perennial dwarf shrub that distributes on marl-gypsaceous steppe between 730-1210 m altitudes as an Ir-Tur element in the Brassicaceae family (Figure 1). The species blooms from late April through late May. Only two populations of *Ae. turcica* were reported in Ankara from Ayaş, Aysantıbeli and Polatlı, Acıkır locations. H. Duman and Z. Aytaç [17] presented the species to the scientific community in 1991, and the discovery was based on a type specimen collected in 1990 from Acıkır area, 18 km west of Polatlı in Ankara B3

Figure 1. *Aethionema turcica* H. Duman & Aytaç.

Figure 2. *Astragalus beypazaricus* Podlech & Aytaç.

square. In the Red Data Book of Turkish Plants, the threat category for *Ae. turcica* was the Least Concern (LC) [18].

The perennial Fabaceae species *Astragalus beypazaricus* Podlech & Aytaç is a suffruticose, woody-based plant with flowering and fruiting seasons between May and July (Figure 2). It has just one population divided by a highway and is located in Beypazarı, Ankara, and distributes on marly-gypsaceous steppe between 610-680 m altitudes as an lr-Tur element [19,20]. D. Podlech and Z. Aytaç presented the species to the scientific community in 1998, and the discovery was based on the type specimen collected in 1997 from between Beypazarı and Nallıhan districts, 15.5 km west of Beypazarı, in Ankara A3 square. The threat category of *A. beypazaricus* was defined as Critically Endangered (CR) in the Red Data Book of Turkish Plants [18].

Both species are found in Ankara province and have specific soil characteristics that limit their range. Both taxa must be conserved since they are rare, endemic, and vulnerable species. Population sizes, distribution areas, and threat categories of these edaphic endemic species were thus reassessed according to IUCN Red List Categories and Criteria version 3.1 (second edition) [21] and the Guidelines version 14 [22]. Physical and chemical parameters such as pH, EC, gypsum, texture, and $CaCO_3$ were measured in soil samples, and bioclimatic interpretations were generated using the local climatic data.

MATERIALS and METHODS

On-site investigations and reassessment of IUCN Classification

The location of each species was verified through a comprehensive examination of literature and on-site visits to prominent herbaria (ANK, GAZI, HUB, OUFE). Suitable habitats in the vicinity of known distribution sites were searched for new locations during the field studies conducted throughout the vegetation phases between the years 2016 and 2018. Distribution areas were estimated via Google Earth to build a minimum convex polygon using GPS coordinates of locations. In order to determine population sizes, each mature individual (flowering or fruit-bearing) was counted individually for small populations. For larger populations, each mature individual within the distribution area was counted in 25 m^2 sampling zones at 10-meter intervals, based on the sampling area method. The average number of individuals per unit area was then calculated. Based on the acquired data, the re-evaluation of the threat category for each species was carried out in accordance with the IUCN Red List Categories and Criteria version 3.1 (second edition) [21]. This assessment considered factors such as area of occupancy (AOO), extent of occurrence

Table 1. Summary of certain criteria used to evaluate taxa belong in a threatened category (CR, EN, VU).

Threatened Categories	Extent of occurrence EOO (km^2)	Area of occupancy AOO (km^2)	Number of mature individuals	Number of locations
CR (Critically Endangered)	< < 100	< 10	< 250	1
EN (Endangered)	< 5.000	< 500	< 2.500	≤ 5
VU (Vulnerable)	< 20.000	< 2.000	< 10.000	≤ 10

Table 2. Some details on the meteorological observation stations in the study areas.

Station name	Observation duration	Station altitude	Covered locations	Covered species
Ayaş	15 years	910 m	A4 Ankara: 16 km east of Ayaş, Ankara-Ayaş route 50th km, Aysantıbeli, 1180-1210 m	*Aethionema turcica*
Polatlı	53 years	886 m	B3 Ankara: 18 km west of Polatlı, Acıkır mevkii, 730-770 m	*Aethionema turcica*
Beypazarı	58 years	682 m	A3 Ankara: 15.5th km of Beypazarı –Nallıhan route, 610-680 m	*Astragalus beypazaricus*

Table 3. Locality information of soil samples.

Species	Soil sample no	Localities
Aethionema turcica	1	A4 Ankara: 16 km east of Ayaş, Ankara-Ayaş route 50th km, Aysantıbeli, 1180-1210 m
	2	B3 Ankara: 18 km west of Polatlı, Acıkır mevkii, 730-770 m
Astragalus beypazaricus	3	A3 Ankara: 15.5th km of Beypazarı –Nallıhan route, on the left hand side, 610-660 m
	4	A3 Ankara: 15.5th km of Beypazarı –Nallıhan route, on the right hand side, 620-690 m

(EOO), number of mature individuals, number of locations, and the primary threats to each species (Table 1). AOO and EOO values were determined through the application of the IUCN mapping tool GeoCAT (Geospatial Conservation Assessment Tool) [23], in adherence to the guidelines outlined in version 14 of the "Guidelines for the Application of IUCN Red List Categories and Criteria" [22].

Bioclimatic Data Analysis

Climatic data, supplied by the General Directorate of Meteorology, were subsequently analyzed using the Emberger and Gaussen Methods [24-26] in a bioclimatic approach for all specified locations.

Soil Parameters Analysis

Soil samples were collected from three distinct elevations (high, middle, and low) within each species' distribution area (Table 3). Subsequently, the collected soil samples were dried and prepared for analysis as each weighing 2 kg. These samples were then sent to the BIOTAR soil analysis laboratory, where they underwent an examination of physical and chemical properties. The analysis, encompassed assessments of texture, pH levels, electrical conductivity (EC), salt content, as well as the presence of $CaCO_3$ and gypsum.

RESULTS

Aethionema turcica H. Duman & Aytaç

It is known from two populations (Figure 3), comprising a total of 359 mature individuals in Ayaş and Polatlı. The AOO was found to be 12 km^2, and the EOO was calculated as 23.5 km^2 (Figure 4). Alternatively, suitable habitats in the vicinity of known distribution sites were searched for new locations but no new distributions were observed for *Ae. turcica* in the surrounding areas. The expansion of agricultural areas, allotment gardening, terracing, and afforestation are the primary threats to this species. Based on these findings (Table 4), the IUCN threat category for the species was reclassified as Critically Endangered (CR) due to the EOO value and threats posed by extensive human activities on the species, as well as the likelihood of extinction in the near future [21].

Astragalus beypazaricus Podlech & Aytaç

A. beypazaricus has only one population known from Beypazarı in Ankara Province (Figure 5), and this population is fragmented by a highway [19,20]. Alternatively, suitable habitats in the vicinity of known distribution sites were searched for new locations during the field studies and some small-scaled distributions in the immediate vicinity of the location of *A. beypazaricus* were discovered and the mature individuals were counted by transection method. It was observed that

Figure 3. The location of two populations of *Ae. turcica* with a distance of ca.72 km (in a straight line).

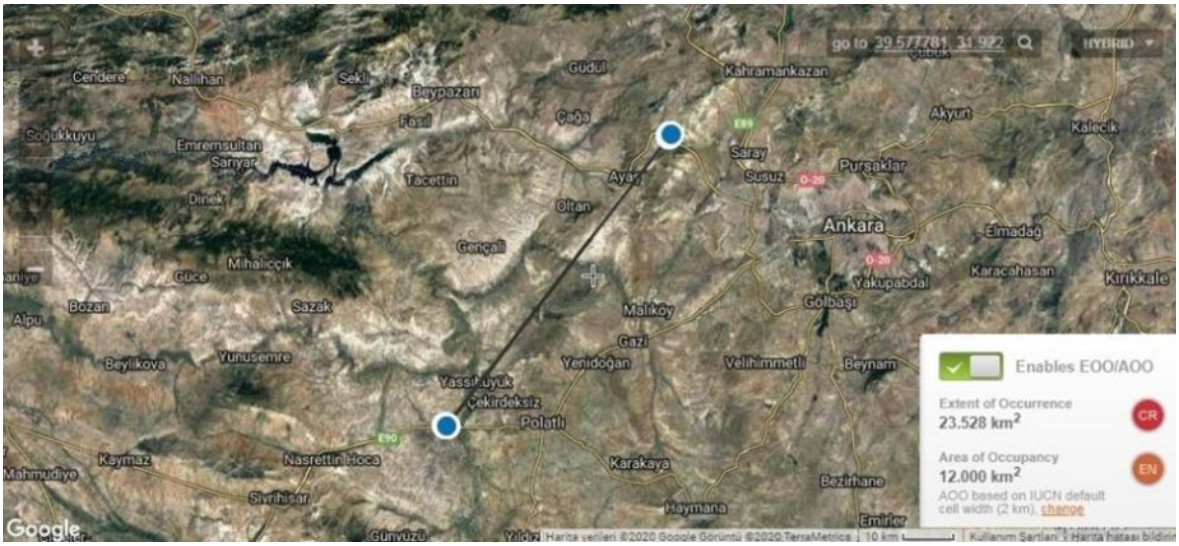

Figure 4. Area of occupancy and extent of occurrence of *Ae. turcica* (by GeoCAT).

Table 4. Field data of *Ae. turcica*

Locations	Extent of occurrence EOO (km²)	Area of occupancy AOO (km²)	Number of mature individuals	Area	Threat factors
A4 Ankara: 16 km east of Ayaş, Ankara-Ayaş route 50th km, Aysantıbeli, 1180 1210 m			193	2.15 ha	Expansion of agricultural areas, allotment gardening
B3 Ankara: 18 km west of Polatlı, Acıkır mevkii, 730-770 m			166	4.30 ha	Terracing and afforestation
Total	23.5	12	359	6.45 ha	

Figure 5. The location of *A. beypazaricus.*

Figure 6. Area of occupancy and extent of occurrence of *A. beypazaricus* (by GeoCAT).

the new sites as well as the current sites got stuck between the fields. Although the species is under protection, intensive clearing and expansion activities around the area pose a threat to the habitat of the species. It contains a total of 5700 mature individuals. The AOO was discovered to be 4 km^2 in size, whereas the EOO was discovered to be 0.4 km^2 (Figure 6). Because EOO is smaller than AOO, it should be adjusted to make it equal to AOO to maintain consistency with AOO's description as an area within EOO [22]. Thus, EOO value of *A. beypazaricus* can be assumed as 4 km^2. The main threats to this species are expanding agricultural areas, road construction, and the expansion of soda ash mining areas. Based on the findings, the IUCN threat category has been reclassified as CR [21] (Table 5).

Bioclimatic Data Analysis

The Emberger [25] approach was used to analyze bioclimatic data from the study areas (Table 6).

The rainfall regime is defined as Eastern Mediterranean type 2, where *Ae. turcica* is distributed in Ayaş (Aysantıbeli) and Polatlı (Acıkır). The rainy season is spring, while the driest season is summer under this regime type. The rainfall regime in Beypazarı, the location of *A. beypazaricus*, is categorized as Eastern Mediterranean type 1. The wet season is winter within this sort of regime, whereas the driest season is summer [26].

The Gaussen [24] method was used to construct ombrothermic diagrams of the research regions (Figure 7-9). The ombrothermic graphs give information about the dry seasons' duration for both distribution areas. According to these graphs, the dry season in Ayaş begins in June and lasts until the beginning of October. It begins in June and lasts until the middle of October in Polatlı. In Beypazarı, it starts in late May and lasts until the middle of October.

Table 5. Field data of *A. beypazaricus.*

Locations	Extent of occurrence EOO (km^2)	Area of occupancy AOO (km^2)	Number of mature individuals	Area	Threat factors
A3 Ankara: 15.5th km of Beypazarı –Nallıhan route, 610-690 m (both on right and left handside)	4	4	5700 birey	≈42 ha	Expansion of agricultural areas, road construction, Soda ash and Sodium Bicarbonate factory

Table 6. Bioclimatic analysis of the study areas.

Stations, Study areas and species	P (mm)	M (°C)	M (°C)	Q	PE (mm)	S	Rainfall regime	Bioclimatic layers
Ayaş Aysantıbeli *Ae. turcica*	427.1	29.4	-2.9	46.19	58	1.97	Eastern Mediterranean Type 2	Semi-arid "upper", cold in winter, Mediterranean
Polatlı Acıkır *Ae. turcica*	364.2	30.6	-3.4	37.37	59	1.92	Eastern Mediterranean Type 2	Semi-arid "lower", very cold in winter, Mediterranean
Beypazarı *A. beypazaricus*	410.1	32.2	-1.8	41.85	58.2	1.8	Eastern Mediterranean Type 1	Semi-arid "lower", cold in winter, Mediterranean

P: Mean total annual rainfall (mm)
M: Mean max. temperature of the warmest month (°C)
m: Mean min. temperature of the coldest month (°C)
Q: Rainfall-temperature coefficient
PE: Summer rainfal total (mm)
S: Drought index

Soil Parameters Analysis

Soils differ primarily according to the physical, chemical, biological, and morphological qualities of the main source from which they are formed. Soils provide varying amounts of plant nutrients, organic matter, water, and air, resulting in diverse growing conditions for plants. For physical analysis, the texture parameter and for chemical analyses, pH, EC, salt, $CaCO_3$, and gypsum parameters were examined (Table 7).

DISCUSSION

According to the climatic evaluation results, all locations are influenced by a "semi-arid Mediterranean climate." Secondary steppe vegetation of anthropogenic origin is becoming prominent in various types of this climate. All the study areas represent anthropogenic-originated secondary steppe vegetation occasionally covered by

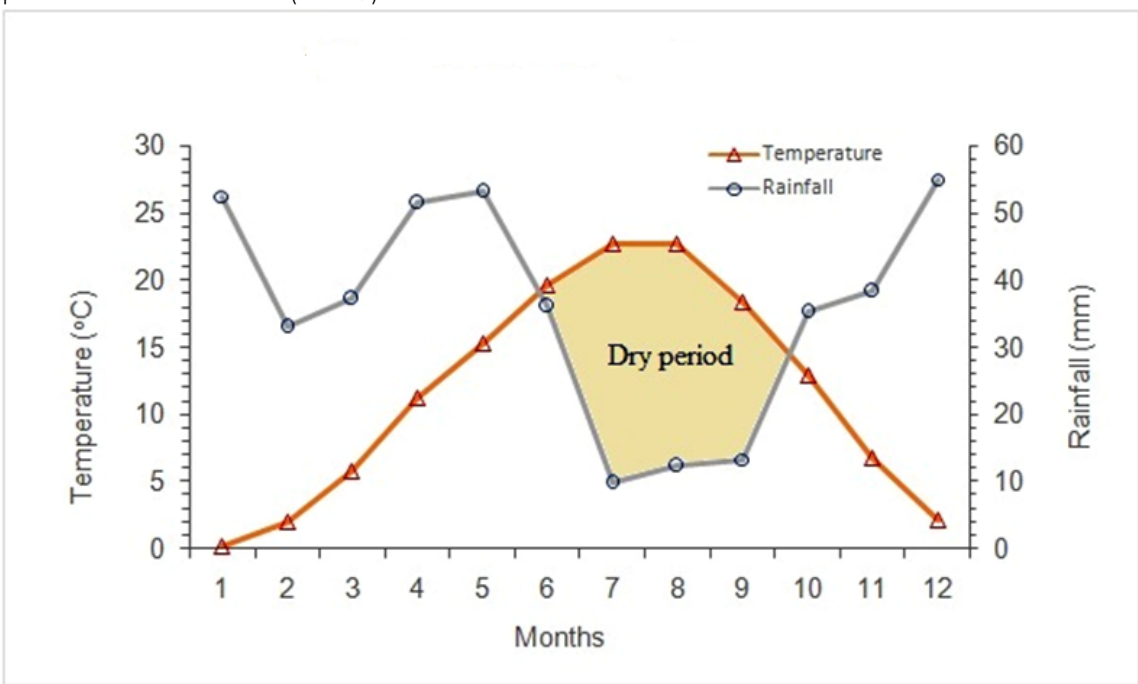

Figure 7. Ombrothermic diagram of Ayaş (Aysantıbeli) (*Ae.turcica*).

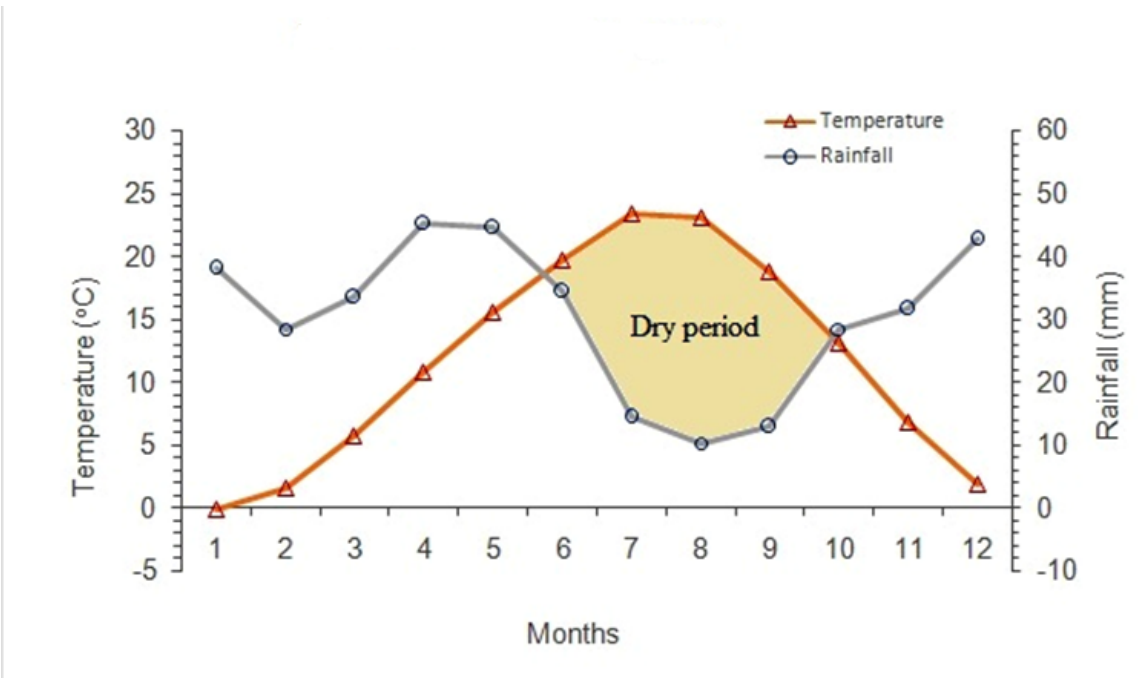

Figure 8. Ombrothermic diagram of Polatlı (*Ae.turcica).*

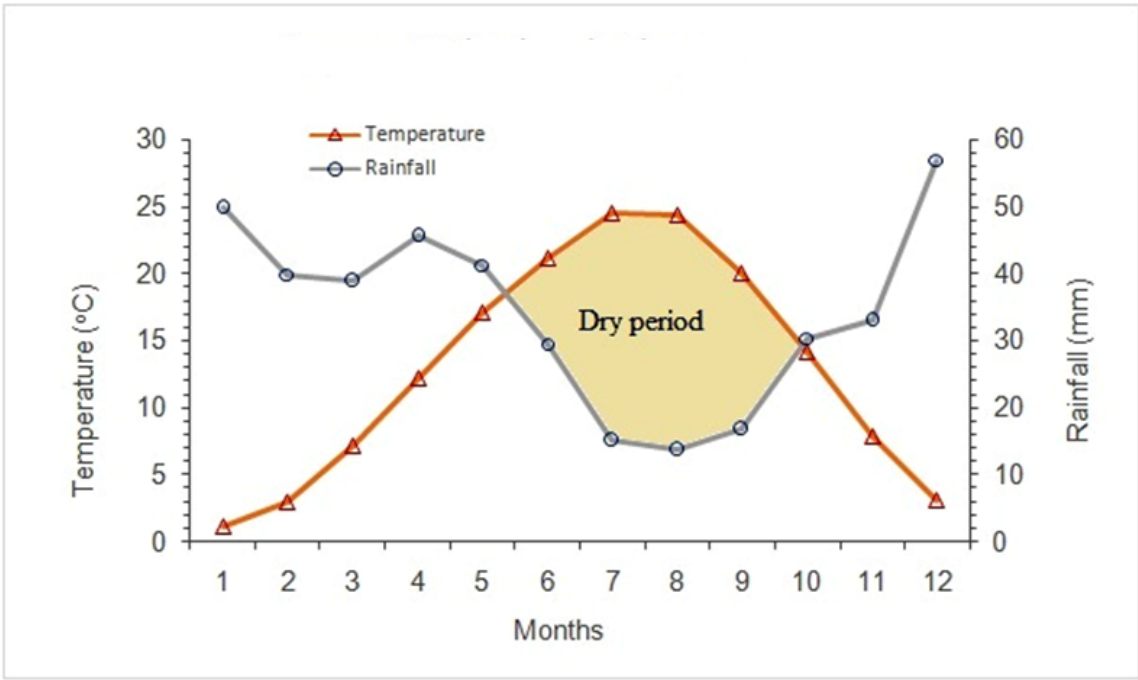

Figure 9. Ombrothermic diagram of Beypazarı *(A.beypazaricus).*

Table 7. Results of physical and chemical parameter analysis of soil samples.

Species	Soil sample no	pH (saturated soil paste)	EC (dS/m)	Salt (%)	$CaCO_3$ (%)	Gypsum (%)	Texture
Aethionema turcica	1 (Ayaş)	Slightly alkaline 7.94	0.820	Non-saline 0.0357	Strongly calcareous 41.69	0.099	Clay loam
	2 (Polatlı)	Slightly alkaline 7.84	1.730	Non-saline 0.0676	Strongly calcareous 38.82	0.067	Clay loam
Astragalus beypazaricus	3 (Beypazarı- right handside)	Slightly alkaline 8.31	0.950	Non-saline 0.0435	Strongly calcareous 30.19	0.100	Clay
	4 (Beypazarı- left handside)	Slightly alkaline 8.09	0.920	Non-saline 0.0456	Strongly calcareous 23.72	0.092	Clay

tree or shrub forms. However, steppe vegetation devoid of trees predominates [26].

Both species favor soils that are "non-saline, slightly alkaline, and highly calcareous," according to the results of chemical analyses of soil samples. Although there are minor textural changes amongst the species, the clay content is the most prominent. They may all be classified as marly soil since it is primarily calcareous clayey. Furthermore, according to the literature [27], they cannot be categorized as gypsum soils because the gypsum substance is less than 2% in all samples. Nevertheless, all samples contain some gypsum, which is essential for the species. The results affirm that these soils are confined to marly-gypseous compositions.
Since all the study areas are represented by steppe vegetation with a "semi-arid Mediterranean climate" and marly-gypsaceous soils which are suitable for agricultural activities, the areas are under severe threat by massive expansion of agricultural areas.

The EOO (Extent of Occurrence), AOO (Area of Occupancy), the number of mature individuals (population size), and the number of locations were determined after the field research and analysis of the data acquired from it. Each species' IUCN Red List categories were re-evaluated, and the findings are presented in Table 8.

The threat category of *Ae. turcica* was LC in the Red Data Book of Turkish Plants [18], but it was reassessed as CR [B1ab(ii, iii)] based on new findings. Even though the majority of the findings (AOO, number of locations, and total mature individuals) indicate that the species

Table 8. Reclassification of the species' IUCN Red List Categories.

Species	Soil sample no	pH (saturated soil paste)	EC (dS/m)	Salt (%)	$CaCO_3$ (%)	Gypsum (%)
Aethionema turcica	23.5	12	359	2	LC (Least Concern)	CR
Astragalus beypazaricus	4	4	5700	1	CR	CR

belongs to the EN category, it is more appropriate to classify *Ae. turcica* into the CR category in terms of EOO value and risk of extinction in the near future due to intensive human activity threats [21]. Due to the number of locations, AOO, and EOO values, *A. beypazaricus* still has the same threat category as mentioned in the Turkish Plants Red Data Book; CR [B1ab(ii,iii) +2ab(ii, iii)]. The primary threats to this species are posed by road construction, as well as agricultural and mining activities.

Because our study was conducted between 2016-2018, the period wasn't long enough to evaluate the results based on CR Category Criterion A which the length of time frames must be at least three generations or ten years (whichever is longer), or for the Criterion C which must be at least one generation or three years (whichever is longer). In light of the findings, the most appropriate criterion for both species to meet the CR threat category was Criterion B which covers geographic range in the form of either EOO and/or AOO, number of locations and subpopulations, and the number of mature individuals [21].

During the field studies, the species have been taken under protection by the Republic of Turkey Ministry of Agriculture and Forestry Ninth Regional Directorate of Nature Protection and Natural Parks. For *A. beypazaricus*, both in-situ and ex-situ conservation treatments were realized. For *Ae. turcica*, in-situ conservation treatments were realized. Seeds of these taxa were also sent to gene banks to be preserved. Informative signboards were placed in the localities for both species and fenced in.

Acknowledgments - This research was supported by Ankara University Research Fund (Project no:18L0430010) and the Republic of Turkey Ministry of Agriculture and Forestry, Ninth Regional Directorate of Nature Protection and Natural Parks (Species Action Plan and Monitoring Project). Special thanks to Mecit Vural, Selçuk Tuğrul Körüklü, İsa Başköse, Batıkan Günal and Vildan Toprak for their significant contributions to this research.

References

1. V. Muccione, M. Schaepman, Global Change -Terminology Brief Series, University Research Priority Programme on Global Change and Biodiversity, University of Zurich, 2014.
2. P.M. Vitousek, Beyond Global Warming: Ecology and Global Change.Ecology, 75(7). pp. 1861-1876, Washington, 1994.
3. W.Steffen, R.A.Sanderson, P.D.Tyson, J.Jäger, P.A. Matson, B. Moore III, F. Oldfield,K. Richardson, H.-J. Schellnhuber, B.L. Turner, R.J. Wasson, Global Change and the Earth System: A Planet under Pressure. Global Change - The IGBP Series, 2004.
4. D. Tilman, M. Clark, D.R. Williams, K. Kimmel, S. Polasky and C. Packer, Future threats to biodiversity and pathways to their prevention, Nature 546 (2017) 73–81.
5. D. Skole and C. Tucker, Tropical deforestation and habitat fragmentation in the Amazon: Satellite data from 1978 to 1988. Science 260(1993) 1905–1910.
6. S.L. Pimm, G.J.Russell, J.L.Gittleman, and T.M.Brooks, The future of biodiversity. Science 269 (1995) 347–350.
7. N. Myers and A.H. Knoll, The biotic crisis and the future of evolution, Proceedings of the National Academy of Sciences of the United States of America, 98 (2001) 5389–5392.
8. W.F. Laurence and E. Yensen, Predicting the impacts of edge effects in fragmented habitats, Biological Conservation 55 (1991) 77–92.
9. E.Z. Baskent, and G.A. Jordan, Characterizing spatial structure of forest landscapes, Canadian Journal of Forest Research 25 (1995) 1830–1849.
10. T.M. Donovan and C.H.Flather, Relationships amongst North American songbird trends, habitat fragmentation, and landscape occupancy, Ecological Applications 12 (2002) 364–374.
11. L.Fahrig, Effects of habitat fragmentation on biodiversity. Annual Review of Ecology, Evolution and Systematics 34(2003)487–515.
12. R. Lande, Risks of population extinction from demographic and environmental stochasticity and random catastrophes. American Naturalist, 142 (1993) 911–927.
13. I. Hanski, Metapopulation dynamics. Nature, 396 (1998) 41–49.
14. CBD, Convention on Biological Diversity, Turkey. https://www.cbd.int/countries/profile/?country=tr/, (Erişim yılı: 2021).
15. A.Güner, S. Aslan, T. Ekim, M. Vural and M. T. Babaç, Türkiye Bitkileri Listesi (Damarlı Bitkiler). Nezahat Gökyiğit Botanik

Bahçesi ve Flora Araştırmaları Derneği Yayını, 1290 pp. İstanbul, 2012.
16. A.Güner, H.Özhatay, T.Ekim and K.H.C. Başer (eds.), Flora of Turkey and the East Aegean Islands vol. 11 (Supplement II). Edinburgh University Press, pp. 33, 88, 173, 174, Edinburgh, 2000.
17. H.Duman, Z. Aytac, A new Aethionema from central Anatolia. Karaca Arbor. Mag. 1(2) (1991) 71-73, 1991.
18. T.Ekim, M.Koyuncu, M.Vural, H.Duman, Z.Aytaç, N.Adıgüzel, Türkiye Bitkileri Kırmızı Kitabı, 100. Yıl Üniversitesi ve Türkiye Tabiatını Koruma Derneği, Ankara, 2000.
19. D.Podlech, Z.Aytaç, Two new species of Astragalus L. sect. Dissitiflori DC. (Fabaceae) from Turkey, Sendtnera, 5 (1998) 265-268
20. Z.Aytaç, Türkiyenin Tehdit Altındaki Bitkileri: Beyparazı Gevenleri. Bağbahçe Dergisi, 26 (2009) 14-15.
21. W.Steffen, R.A.Sanderson, P.D.Tyson, J.Jäger, P.A. Matson, B. Moore III, F. Oldfield,K. Richardson, H.-J. Schellnhuber, B.L. Turner, R.J. Wasson, Global Change and the Earth System: A Planet under Pressure. Global Change - The IGBP Series, 2004.
22. IUCN Standards and Petitions Committee. Guidelines for Using the IUCN Red List Categories and Criteria. Version 15.1. Prepared by the Standards and Petitions Committee. 2022. https://www.iucnredlist.org/documents/RedListGuidelines.pdf.
23. GeoCAT, Geospatial Conservation Assessment Tool. https://geocat.iucnredlist.org/, (Erişim yılı: 2019).
24. H.Gaussen, L'étude des climats par les courbes ombrothermiques: application à la cartographie, L'Information Géographique, 20(5) (1956) 191-193.
25. L.Emberger, Recherches Sur La Zone Aride. Carte Bioclimatique De La Zone Méditerranéenne (s. XXI. Bölüm) in Paris: UNESCO-FAO, 1963.
26. Y.Akman, İklim ve Biyoiklim (Biyoiklim Metodları ve Türkiye İklimleri), Kariyer Matbaacılık, Ankara, 1999.
27. J.G. Alphen and F.Rios Romero, Gypsiferous soils: Notes On Their Characteristics and Management. International Institute for Land Reclamation and Improvement, pp 44, Wageningen, 1971.