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

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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 km² AOO and 23.5 km² EOO areas. A. beypazaricus has only one fragmented population with a total of 5700 mature individuals in Beypazari, and both AOO and EOO were discovered to be 4 km². 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.

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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 beyzazaricus 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
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 Ir-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 Nallihan 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 CaCO₃ 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 m² 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
The Extent of occurrence (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, 25, 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 CaCO₃ and gypsum.

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

<table>
<thead>
<tr>
<th>Threatened Categories</th>
<th>Extent of occurrence EOO (km²)</th>
<th>Area of occupancy AOO (km²)</th>
<th>Number of mature individuals</th>
<th>Number of locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR (Critically Endangered)</td>
<td>&lt;100</td>
<td>&lt;10</td>
<td>&lt;250</td>
<td>1</td>
</tr>
<tr>
<td>EN (Endangered)</td>
<td>&lt;5,000</td>
<td>&lt;500</td>
<td>&lt;2,500</td>
<td>≤5</td>
</tr>
<tr>
<td>VU (Vulnerable)</td>
<td>&lt;20,000</td>
<td>&lt;2,000</td>
<td>&lt;10,000</td>
<td>≤10</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Station name</th>
<th>Observation duration</th>
<th>Station altitude</th>
<th>Covered locations</th>
<th>Covered species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ayaş</td>
<td>15 years</td>
<td>910 m</td>
<td>A4 Ankara: 16 km east of Ayaş, Ankara-Ayaş route 50th km, Aysantibeli, 1180-1210 m</td>
<td>Aethionema turcica</td>
</tr>
<tr>
<td>Polatlı</td>
<td>53 years</td>
<td>886 m</td>
<td>B3 Ankara: 18 km west of Polatlı, Acıkır mevkii, 730-770 m</td>
<td>Aethionema turcica</td>
</tr>
<tr>
<td>Beypazarı</td>
<td>58 years</td>
<td>682 m</td>
<td>A3 Ankara: 15.5th km of Beypazarı –Nallihan route, 610-680 m</td>
<td>Astragalus beypazaricus</td>
</tr>
</tbody>
</table>

**Table 3. Locality information of soil samples.**

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

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**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*

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

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

Figure 6. Area of occupancy and extent of occurrence of *A. beyazarius* (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).

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

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

**Table 6.** Bioclimatic analysis of the study areas.

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

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 rainfall 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, CaCO₃, 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.

Figure 7. Ombrothermic diagram of Ayaş (Aysantibeli) (Ae.turcica).

Figure 8. Ombrothermic diagram of Polatlı (Ae.turcico).
All the study areas represent anthropogenic-originated secondary steppe vegetation occasionally covered by 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 “semiarid Mediterranean climate” and marly-gypseous 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 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.

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**References**

1. V. Muccione, M. Schaepman, Global Change -Terminology Brief Series, University Research Priority Programme on Global Change and Biodiversity, University of Zurich, 2014.

<table>
<thead>
<tr>
<th>Species</th>
<th>Soil sample no</th>
<th>pH (saturated soil paste)</th>
<th>EC (dS/m)</th>
<th>Salt (%)</th>
<th>CaCO₃ (%)</th>
<th>Gypsum (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aethionema turcica</td>
<td>23.5</td>
<td>12</td>
<td>359</td>
<td>2</td>
<td>LC (Least Concern)</td>
<td>CR</td>
</tr>
<tr>
<td>Astragalus beypazaricus</td>
<td>4</td>
<td>4</td>
<td>5700</td>
<td>1</td>
<td>CR</td>
<td>CR</td>
</tr>
</tbody>
</table>

**Table 8. Reclassification of the species’ IUCN Red List Categories.**


