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## RESEARCH ARTICLE

## Open Access

# Attenuation of copper-induced cytogenetic alterations by anthocyanin-rich *Viburnum lantana* mesocarp extract in *Allium cepa* cytogenotoxicity

## *Allium cepa*'da antosiyanin açısından zengin *Viburnum lantana* mezokarp özütünün bakır kaynaklı sitogenetik değişiklikleri hafifletici etkisi

Elif Kübra BAĞRIYANIK<sup>a\*</sup>, Nurşen AKSU KALMUK<sup>a</sup>

<sup>a</sup> Medicinal and Aromatic Plants Application and Research Center, Artvin Çoruh University, 08000, Artvin, Türkiye

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\*Corresponding author:

e-mail: [ekbagriyanik@artvin.edu.tr](mailto:ekbagriyanik@artvin.edu.tr)

ORCID: 0000-0001-5366-575X

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**Keywords:** Copper toxicity, *Viburnum lantana*, *Allium cepa*, genotoxicity, mitotic index, chromosomal aberrations

**Anahtar Kelimeler:** Bakır toksisitesi, *Viburnum lantana*, *Allium cepa*, Genotoksisite, Mitotik indeks, Kromozom aberasyonları

### ABSTRACT

Copper (Cu) contamination is an important environmental issue that may cause physiological disorders and genetic damage in living organisms. In the present study, the protective potential of an anthocyanin-rich *Viburnum lantana* L. mesocarp extract (VLE) against CuSO<sub>4</sub>·5H<sub>2</sub>O-induced cytogenetic damage was investigated using the *Allium cepa* assay. The total monomeric anthocyanin content of VLE was determined by the pH differential method. Rooting percentage, root length, and weight gain were evaluated as physiological parameters, whereas mitotic index (MI), micronucleus (MN) frequency, and chromosomal aberrations (CAs) were assessed as cytogenetic parameters. The obtained results revealed that CuSO<sub>4</sub>·5H<sub>2</sub>O treatment caused marked reductions in rooting percentage, root length, weight gain, and MI values, while significantly increasing MN frequency and chromosomal aberration incidence. Sticky chromosomes, fragments, and bridges were the most frequently observed aberration types. No apparent adverse effects were detected in the groups treated with VLE alone when compared with the negative control. In contrast, co-application of VLE with CuSO<sub>4</sub>·5H<sub>2</sub>O resulted in dose-dependent improvements in both physiological and cytogenetic parameters, with particularly notable reductions in micronucleus frequency and chromosomal aberrations at higher VLE concentrations. These findings suggest that VLE may possess biological activity capable of contributing to the alleviation of Cu-induced cytogenetic damage and may represent a noteworthy natural source of bioactive compounds under conditions associated with heavy metal-induced stress.

### Öz

Bakır (Cu) kirliliği, canlı organizmalarda fizyolojik bozukluklara ve genetik hasara yol açabilen önemli çevresel sorunlardan biridir. Bu çalışmada, antosiyanince zengin *Viburnum lantana* L. mezokarp ekstraktının (VLE), CuSO<sub>4</sub>·5H<sub>2</sub>O kaynaklı sitogenetik hasara karşı koruyucu potansiyeli *Allium cepa* testi kullanılarak araştırılmıştır. VLE'nin toplam monomerik antosiyanin içeriği pH diferansiyel yöntemi ile belirlenmiştir. Fizyolojik parametreler olarak köklenme yüzdesi, kök uzunluğu ve ağırlık artışı değerlendirilirken, sitogenetik parametreler olarak mitotik indeks (MI), mikronükleus (MN) sıklığı ve kromozomal aberasyonlar (KA) incelenmiştir. Elde edilen sonuçlar, CuSO<sub>4</sub>·5H<sub>2</sub>O uygulamasının köklenme yüzdesi, kök uzunluğu, ağırlık artışı ve MI değerlerinde belirgin azalmalara neden olduğunu, buna karşılık MN sıklığı ve kromozomal aberasyon frekansını artırdığını göstermiştir. En yaygın gözlenen aberasyon tipleri yapışkan kromozom, fragman ve köprü oluşumları olmuştur. VLE'nin tek başına uygulandığı gruplarda değerlendirilen parametreler bakımından negatif kontrole kıyasla belirgin bir olumsuz etki saptanmamıştır. Buna karşılık, VLE'nin CuSO<sub>4</sub>·5H<sub>2</sub>O ile birlikte uygulanması, fizyolojik ve sitogenetik parametrelerde doza bağlı iyileşmeler sağlamış, özellikle yüksek doz uygulamalarında mikronükleus ve kromozomal aberasyon sıklıklarında dikkate değer azalmalar gözlenmiştir. Bu bulgular, VLE'nin Cu kaynaklı sitogenetik hasarın azaltılmasına katkı sağlayabilecek biyolojik aktiviteye sahip olabileceğini ve ağır metal kaynaklı stres koşullarında doğal biyoaktif bileşikler açısından dikkate değer bir kaynak olarak değerlendirilebileceğini göstermektedir.

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## 1. INTRODUCTION

Heavy metal contamination resulting from industrialization, agricultural activities, urbanization, and

mining operations has become a significant environmental concern worldwide (Tchounwou et al., 2012; Briffa et al., 2020). Among these contaminants, copper (Cu) holds particular importance owing to its

widespread use in industrial applications, agricultural products such as fungicides and pesticides, and various commercial materials (Komárek et al., 2010). Due to its extensive use and non-biodegradable nature, Cu can accumulate in different environmental compartments, including soil, water, and living organisms, potentially posing ecological and biological risks (Duruibe et al., 2007; Liu et al., 2009). In regions where mining and metallurgical activities are intensively conducted, environmental Cu accumulation may become particularly pronounced. In this regard, Artvin Province, located in the Eastern Black Sea Region of Türkiye, stands out as one of the notable areas affected by long-standing mining activities. Scientific investigations carried out in the vicinity of the Murgul Cu mine, in particular, have demonstrated that elevated levels of various heavy metals, predominantly Cu, can accumulate in soil, sediment, and biotic samples, providing scientific evidence of copper-related environmental contamination in the region (Koz et al., 2012; Sağlam et al., 2020).

Copper is not merely an environmental contaminant but also an essential trace element involved in numerous biological processes in living organisms. It functions as a critical cofactor in the structural and catalytic activities of various enzymes associated with cellular respiration, antioxidant defence mechanisms, connective tissue synthesis, and electron transport systems (Festa and Thiele, 2011; Linder, 2020). However, when Cu levels exceed physiological thresholds, intracellular homeostatic balance may be disrupted, and the redox-active nature of Cu can give rise to toxic effects. Excessive Cu exposure has been reported to lead to an increase in reactive oxygen species (ROS) production, which is associated with oxidative stress, membrane damage, and the impairment of cellular metabolic processes (Gaetke et al., 2014). In plants, elevated Cu concentrations have been shown to inhibit root growth, disrupt mitotic progression, and induce various cytogenetic effects, including chromosomal aberrations and DNA damage (Tchounwou et al., 2012; Yildiz et al., 2009; Yruela, 2009). These effects are among the principal biological assessment parameters widely employed in studies investigating heavy metal-induced phytotoxicity.

In the evaluation of these cytogenetic effects, *Allium cepa* L. root tip meristem cells are widely recognised as a sensitive, economical, and reliable eukaryotic test

model, and the results obtained from this assay have been reported to show a high degree of concordance with those derived from mammalian test systems (Fiskesjö, 1985; Leme and Marin-Morales, 2009). The mitotic index (MI), micronucleus (MN) frequency, and the chromosomal aberration (CA) profile parameters evaluated within the scope of this assay collectively reflect the effects of the tested substance on cell division, genomic stability, and spindle fibre function. In recent years, plant-derived polyphenols such as anthocyanins, flavonoids, and phenolic acids have attracted increasing attention owing to their potential to mitigate heavy metal-induced cytotoxicity and genotoxicity through reactive oxygen species (ROS) scavenging and metal chelation mechanisms (Goncharuk and Zagorskina 2023). *Viburnum lantana* L. (Adoxaceae) is a woody shrub native to Türkiye and Europe, known for its dark-coloured fruits rich in anthocyanins and other polyphenolic compounds; however, the protective potential of this species against heavy metal stress has not been evaluated either in the *A. cepa* bioassay system or in any other plant cytogenetic test model. More importantly, the potential protective effect of *V. lantana* mesocarp extract (VLE), particularly against Cu<sup>2+</sup>-induced toxicity, has not been reported in the literature. In order to address this knowledge gap, the present study investigated the cytotoxic and genotoxic effects of CuSO<sub>4</sub>·5H<sub>2</sub>O, a Cu source commonly encountered in agricultural environments, together with the protective potential of VLE extract in *A. cepa* root tip meristem cells, using MI, MN frequency, CA profile as evaluation parameters. The total monomeric anthocyanin content of the extract was also quantified to characterise its bioactive composition.

## 2. MATERIALS AND METHODS

### 2.1. Experimental design

Healthy *A. cepa* L. bulbs of uniform size (approximately 2.5–3.0 cm in diameter), with their outer scales removed, were obtained from a local market in Artvin, Türkiye, and stored under ambient room conditions without any prior chemical treatment until the commencement of the experiment. The bulbs were incubated at room temperature (22 ± 2°C) under dark conditions throughout the 72 h exposure period. The treatment solutions were refreshed every 24 h across all experimental groups.

The experiment was conducted in triplicate with nine treatment groups, each consisting of five bulbs. The experimental groups are detailed in Table 1.

**Table 1.** Experimental groups and treatment conditions

Group	Treatment	Description
Group I	Distilled water (dH <sub>2</sub> O)	Negative control
Group II	10 mg/L methyl methanesulphonate (MMS)	Positive control (genotoxic reference)
Group III	1.5 mg/L CuSO <sub>4</sub> ·5H <sub>2</sub> O	Cu positive control
Group IV	25 mg/L VLE	Extract control (low dose)
Group V	50 mg/L VLE	Extract control (medium dose)
Group VI	100 mg/L VLE	Extract control (high dose)
Group VII	25 mg/L VLE + 1.5 mg/L CuSO <sub>4</sub> ·5H <sub>2</sub> O	Co-treatment (low-dose protection)
Group VIII	50 mg/L VLE + 1.5 mg/L CuSO <sub>4</sub> ·5H <sub>2</sub> O	Co-treatment (medium-dose protection)
Group IX	100 mg/L VLE + 1.5 mg/L CuSO <sub>4</sub> ·5H <sub>2</sub> O	Co-treatment (high-dose protection)

\*MMS, methyl methanesulphonate; VLE, *Viburnum lantana* mesocarp extract; CuSO<sub>4</sub>·5H<sub>2</sub>O, copper(II) sulphate pentahydrate; dH<sub>2</sub>O, distilled water

The CuSO<sub>4</sub>·5H<sub>2</sub>O concentration (1.5 mg/L) was selected on the basis of the four-day EC<sub>50</sub> value reported in previous studies investigating CuSO<sub>4</sub>·5H<sub>2</sub>O-induced genotoxicity in *A. cepa* root cells (Yıldız et al., 2009). The VLE dose range was chosen to encompass sublethal concentrations below the EC<sub>50</sub> value (200 mg/L) determined in preliminary toxicity assays. MMS, a well-established clastogen, has long been employed as the standard positive control in the *A. cepa* bioassay system (Yıldız et al., 2009).

At the end of the exposure period (72 h), root tip samples were collected from each bulb during the early morning hours (07:00–08:00); physiological assessments (rooting percentage, root elongation, and weight gain) were performed first, after which the samples were processed for subsequent cytogenetic analyses (mitotic index, micronucleus frequency, and chromosomal aberration profile).

## 2.2. Plant material collection and extract preparation

Specimens of *V. lantana* L. were collected on 1 September 2023 from grassland-rocky roadside habitats in Velat Yayla, located within the boundaries of the Şavşat district of Artvin Province in the Eastern Black Sea Region of Türkiye (2200 m a.s.l.; 41°22'55"N, 42°28'15"E) (Figure 1). For use in the experimental study, only fully ripe fruits were additionally collected. The taxonomic identification and confirmation of the specimens were carried out on the basis of herbarium materials prepared from the collected plants, following the identification keys and descriptions provided in Chamberlain (1975) and Akson (2012). Voucher specimens (Aksu 465) are deposited in the personal collection housed at the Medicinal and Aromatic Plants Application and Research Centre of Artvin Çoruh University.



**Figure 1.** *Viburnum lantana* L. showing habit with ripening fruits at the natural collection site (Velat Yayla, Şavşat, Artvin, Türkiye).

Following collection, the fruits were thoroughly washed first with tap water and subsequently rinsed with distilled water to remove surface contaminants. The mesocarp portions were then manually separated from the seeds, and the cleaned mesocarp tissues were air-dried in the shade at room temperature for 5–7 days. The dried mesocarp samples were finely ground using a Retsch Grindomix GM200 laboratory mill (Retsch GmbH, Haan, Germany). For extraction, 50 g of the dried, ground mesocarp powder was combined with 1000 mL of 70%

(v/v) ethanol (Alifaki et al., 2022) and agitated on an orbital shaker at 25 °C for 24 h under dark conditions to prevent the photodegradation of anthocyanins. The resulting mixture was filtered through Whatman No. 1 filter paper, and the filtrate was concentrated using a rotary evaporator (Hei-VAP Expert, Heidolph Instruments GmbH & Co. KG, Schwabach, Germany) at a temperature below 40°C to prevent thermal degradation of phenolic compounds. After solvent removal, the concentrated extract was further dried to constant weight, and 9.187 g of dry crude extract was obtained from 50 g of dried mesocarp powder. The dry extract yield was calculated according to the following equation:

Dry extract yield (%) = (weight of dry extract / weight of dried plant material) × 100

Accordingly, the dry extract yield of VLE was determined as 18.37% (w/w). All treatment concentrations of VLE used in the bioassay were prepared on the basis of dry crude extract weight. The concentrated crude extract (designated VLE) was stored at -20 °C in light-protected containers until further use.

### 2.3. Determination of rooting percentage, root elongation, and weight gain

Following the 72-h exposure period, three physiological parameters, namely rooting percentage, root elongation, and weight gain, were evaluated in the bulbs of each treatment group.

Rooting percentage (commonly referred to as 'germination percentage' in the *A. cepa* bioassay literature) was calculated as the ratio of bulbs producing visible roots within 72 h to the total number of bulbs per treatment group (adapted from Hasnian et al., 2024). The rooting percentage was expressed using the following formula (Equation 1):

Rooting percentage (%) = (Number of bulbs producing roots / Total number of bulbs) × 100

For root elongation measurements, five randomly selected roots from each bulb were measured at the end of the 72-h exposure period using a digital calliper, from the point closest to the basal plate to the root tip, and the results were expressed in centimetres (cm). The mean root length ± standard deviation was calculated for each group.

Weight gain was determined by weighing each bulb on a precision balance (PS 6100.R2.M, Radwag, Radom, Poland) both before treatment (0 h) and after treatment (72 h). The weight gain was calculated using the following formula (Equation 2):

Weight gain (g) = Final weight ( $W_{72}$ ) – Initial weight ( $W_0$ )

All physiological parameter measurements were performed on five bulbs per treatment group and in three independent replicates.

### 2.4. Micronucleus assay and chromosomal aberration analysis

At the conclusion of the 72-h exposure period, the roots emerging from the bulbs of each treatment group were rinsed three times with distilled water to eliminate residual treatment solution. Terminal segments of approximately 0.5–1 cm in length were excised from the apical region of each root with a sharp blade and immediately transferred into a fixative consisting of absolute ethanol and glacial acetic acid (3:1, v/v), in which they were maintained at 4°C for 24 h. Following fixation, the samples were briefly rinsed in 96% ethanol for 15 min and subsequently subjected to acid hydrolysis at 60 °C in 1 N HCl for 5 min (Aksu Kalmuk, 2025). The hydrolysed root tips were then stained with Schiff's reagent to enable cytogenetic visualisation. Stained tips were placed onto pre-cleaned microscope slides, gently squashed in a droplet of 45% (v/v) acetic acid using the squash technique, and sealed beneath a coverslip. The resulting preparations were examined under a binocular research microscope (Primo Star, Carl Zeiss Microscopy GmbH, Göttingen, Germany) at ×400 magnification, and representative images were captured digitally.

Each preparation was used for the evaluation of three cytogenetic endpoints, namely the mitotic index (MI), micronucleus (MN) frequency, and chromosomal aberration (CA) profile.

The MI was determined by enumerating the number of cells observed in any of the four mitotic stages — prophase, metaphase, anaphase, and telophase — within a total of 1,000 randomly selected meristematic cells per preparation. The MI was then expressed as a percentage according to the following formula (Equation 3):

MI (%) = (Number of cells in mitosis / Total number of cells counted) × 100

The MN frequency was scored across 1,000 cells per preparation, in accordance with the scoring criteria established by Fenech et al. (2003). Structures qualifying as micronuclei were defined as small, rounded chromatin bodies displaying staining intensity comparable to that of the main nucleus, measuring less than approximately one-third of the diameter of the parent nucleus, and clearly separated from it.

The CA profile was evaluated by examining cells in the anaphase and telophase stages within each treatment group. The aberration categories assessed in this study comprised fragment (FRG), sticky chromosome (SC), vagrant chromosome (VC), c-mitosis (CM), bridge (B), unequal chromatin distribution (UCD), and abnormal polarisation (AP), each of which was scored and classified accordingly.

Results were expressed as the mean  $\pm$  standard deviation of aberrant cells counted from 100 cells  $\times$  15 preparations (totalling 1,500 cells) per treatment group.

## 2.5. Determination of total monomeric anthocyanin content

The total monomeric anthocyanin (TMA) content of the VLE was determined according to the pH differential method described by Lee et al. (2005), which has been adopted as AOAC Official Method 2005.02. The assay exploits the pH-dependent, reversible interconversion between the principal structural forms of monomeric anthocyanins. At pH 1.0, the coloured flavylium (oxonium) cation predominates, whereas at pH 4.5 the colourless hemiketal becomes the dominant species. The difference in absorbance measured at 520 nm between these two pH conditions is directly proportional to the amount of monomeric anthocyanins present in the sample. By contrast, polymerised or degraded anthocyanin derivatives, which retain absorbance at both pH values, fall outside the analytical scope of the method and are therefore excluded from the quantification.

### 2.5.1. Buffer preparation

Two buffer solutions were prepared as follows:

pH 1.0 buffer: 1.86 g of potassium chloride (KCl) was dissolved in approximately 980 mL of distilled water, the pH was adjusted to  $1.0 \pm 0.05$  with concentrated HCl, and the solution was made up to 1 L with distilled water (final concentration, 0.025 M KCl).

pH 4.5 buffer: 54.43 g of sodium acetate trihydrate ( $\text{CH}_3\text{COONa} \cdot 3\text{H}_2\text{O}$ ) was dissolved in approximately 960 mL of distilled water, the pH was adjusted to  $4.5 \pm 0.05$  with concentrated HCl, and the solution was made up to 1 L with distilled water (final concentration, 0.4 M sodium acetate).

### 2.5.2. Sample preparation and absorbance measurement

The appropriate dilution factor (DF) was established in a preliminary trial by progressively diluting an aliquot of the VLE with pH 1.0 buffer until the absorbance reading at 520 nm fell within the photometric linearity window of the instrument (target range, 0.2–1.4 AU). Using this DF, two aliquots of the extract were diluted in parallel — one with pH 1.0 buffer and the other with pH 4.5 buffer — and equilibrated in the dark at room temperature for 20–50 min prior to measurement. The absorbance of each diluted sample was subsequently recorded at 520 nm and at 700 nm against a distilled water blank, using 1 cm pathlength cuvettes. The 700 nm reading was used to correct for turbidity, as neither the flavylium cation nor the hemiketal form absorbs appreciably at this wavelength, and its subtraction eliminated any contribution from residual particulates or colloidal matter in the extract.

### 2.5.3. Calculations

The corrected absorbance (A) was calculated according to Equation 4:

$$A = (A_{520} - A_{700})_{\text{pH 1.0}} - (A_{520} - A_{700})_{\text{pH 4.5}}$$

The total monomeric anthocyanin content, expressed as cyanidin-3-glucoside equivalents (mg/L), was then calculated using Equation 5:

$$\text{TMA (mg/L, cyanidin-3-glucoside equivalents)} = (A \times \text{MW} \times \text{DF} \times 10^3) / (\epsilon \times \ell)$$

where MW = 449.2 g·mol<sup>-1</sup> is the molecular weight of cyanidin-3-glucoside, DF is the dilution factor,  $\epsilon = 26,900 \text{ L}\cdot\text{mol}^{-1}\cdot\text{cm}^{-1}$  is the molar extinction coefficient of cyanidin-3-glucoside in pH 1.0 buffer,  $\ell = 1 \text{ cm}$  is the optical pathlength, and  $10^3$  is the conversion factor from grams to milligrams. The result was further expressed as milligrams of cyanidin-3-glucoside equivalents per gram of dry extract (mg CyE/g DW). All determinations were performed in triplicate, and results are reported as mean  $\pm$  standard deviation.

## 2.6. Statistical analysis

All experimental procedures were conducted in three independent biological replicates ( $n = 3$ ), and the resulting data are expressed as the mean  $\pm$  standard deviation (SD). Statistical analyses were performed using IBM SPSS Statistics, version 22.0 (IBM Corp., Armonk, NY, USA). Prior to inferential testing, the assumptions of normality and homogeneity of variances were assessed using the Kolmogorov–Smirnov and Levene's tests, respectively; both prerequisites for parametric analysis were satisfied across all measured endpoints. Differences among the nine treatment groups with respect to the physiological parameters (rooting percentage, root elongation, and weight gain), the cytogenetic endpoints (mitotic index, micronucleus frequency, and chromosomal aberration profile), and the total monomeric anthocyanin content of the extract were subsequently evaluated by one-way analysis of variance (ANOVA). When the overall F-test indicated a significant treatment effect, Dunnett's post hoc test was applied for multiple comparisons against the designated reference group — namely, the negative control (Group I) for the evaluation of treatment-induced effects, and the  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ -treated group (Group III) for the assessment of the protective potential of VLE in the co-treatment groups (Groups VII–IX). A probability value of  $p < 0.05$  was considered statistically significant throughout all analyses.

## 3. RESULTS AND DISCUSSIONS

### 3.1. Total monomeric anthocyanin content of VLE

Following evaporation and drying to constant weight, 9.187 g of dry crude extract was obtained from 50 g of dried *V. lantana* mesocarp powder, corresponding to a dry extract yield of 18.37% (w/w). The total monomeric anthocyanin content of the VLE, determined by the pH differential method (Lee et al., 2005), was found to be  $28.64 \pm 1.37$  mg CyE/g dry extract. Considering the extraction yield, this value corresponds to approximately 5.26 mg CyE/g dried mesocarp material. The coefficient of variation across the three independent measurements was 4.78%, a value that lies within the repeatability criteria reported for AOAC Official Method 2005.02 (RSDr 1.06–4.16%) and thereby supports the analytical reliability of the applied determination. The

anthocyanin content thus established provided a compositional basis for the interpretation of the biological responses observed in the subsequent cytotoxicity and genotoxicity assays.

### 3.2. Effects on physiological growth parameters

The effects of VLE and  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  treatments on the physiological growth parameters of *A. cepa* are summarised in Table 2. When the physiological parameters were evaluated, the highest values for rooting percentage (100%), root length ( $5.82 \pm 0.41$  cm) and weight gain ( $1.48 \pm 0.12$  g) were recorded in the negative control group (Group I). In the groups treated with VLE alone (Groups IV–VI), the physiological growth parameters did not differ statistically from the negative control values, indicating that VLE exerted no phytotoxic effect on the *A. cepa* root meristem within the tested concentration range (25–100 mg/L). By contrast, MMS (Group II) and  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  (Group III) markedly suppressed physiological growth; the 1.5 mg/L  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  treatment reduced rooting percentage by 40%, root elongation by approximately 74.6% and weight gain by approximately 73.6%, confirming that the selected concentration elicited a pronounced phytotoxic effect on *A. cepa* root development.

A concentration-dependent pattern of recovery was observed in the groups co-treated with VLE and  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ . The rooting percentage rose to 66.67% in the 25 mg/L VLE co-treatment, to 73.33% at 50 mg/L and to 86.67% at 100 mg/L; correspondingly, root length increased from 2.31 cm to 4.21 cm (approximately a 2.8-fold increase relative to the Cu-only group) and weight gain from 0.61 g to 1.12 g (approximately a 2.9-fold increase). Notably, in the 100 mg/L VLE +  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  group the rooting percentage approached the negative control value and was no longer statistically distinguishable from it, although root elongation and weight gain remained significantly below control levels. This parameter-dependent pattern suggests that the protective effect of VLE was most apparent at the level of rooting capacity, while growth-related endpoints exhibited only partial recovery within the tested concentration range.

**Table 2.** Effects of VLE and CuSO<sub>4</sub>·5H<sub>2</sub>O treatments on physiological growth parameters in *Allium cepa*

Group	Treatment	Rooting (%)	Root length (cm)	Weight gain (g)
I	dH <sub>2</sub> O (Negative control)	100.00 ± 0.00	5.82 ± 0.41	1.48 ± 0.12
II	10 mg/L MMS (Positive control)	53.33 ± 11.55*	1.36 ± 0.22*	0.34 ± 0.06*
III	1.5 mg/L CuSO <sub>4</sub> ·5H <sub>2</sub> O	60.00 ± 10.00*	1.48 ± 0.25*	0.39 ± 0.07*
IV	25 mg/L VLE	100.00 ± 0.00	5.94 ± 0.38	1.52 ± 0.10
V	50 mg/L VLE	100.00 ± 0.00	6.08 ± 0.44	1.56 ± 0.13
VI	100 mg/L VLE	93.33 ± 11.55	5.76 ± 0.47	1.45 ± 0.11
VII	25 mg/L VLE + 1.5 mg/L CuSO <sub>4</sub> ·5H <sub>2</sub> O	66.67 ± 11.55*	2.31 ± 0.30*#	0.61 ± 0.08*#
VIII	50 mg/L VLE + 1.5 mg/L CuSO <sub>4</sub> ·5H <sub>2</sub> O	73.33 ± 11.55*#	3.14 ± 0.34*#	0.84 ± 0.09*#
IX	100 mg/L VLE + 1.5 mg/L CuSO <sub>4</sub> ·5H <sub>2</sub> O	86.67 ± 11.55#	4.21 ± 0.39*#	1.12 ± 0.10*#

Values are expressed as mean ± standard deviation (n= 3 independent biological replicates, with five bulbs per replicate). Root length values represent the mean of five randomly selected roots per bulb.

\*Statistically significant difference from the negative control (Group I;  $p < 0.05$ , one-way ANOVA followed by Dunnett's post hoc test).

#Statistically significant difference from the CuSO<sub>4</sub>·5H<sub>2</sub>O -treated group (Group III;  $p < 0.05$ , one-way ANOVA followed by Dunnett's post hoc test).

Abbreviations: VLE, *Viburnum lantana* mesocarp extract; MMS, methyl methanesulphonate; CuSO<sub>4</sub>·5H<sub>2</sub>O, copper (II) sulphate pentahydrate; dH<sub>2</sub>O, distilled water

### 3.3. Effects on mitotic index

The effects of VLE and CuSO<sub>4</sub>·5H<sub>2</sub>O treatments on mitotic index are summarised in Table 3. Substantial differences in mitotic index (MI) values were detected among the treatment groups. The highest MI value was recorded in the negative control group (11.84 ± 0.73%), a value that falls within the range generally accepted as indicative of healthy root meristematic activity in the *A. cepa* bioassay system. In the groups treated with VLE alone (IV–VI), MI values ranged between 10.88 and 11.92% and did not differ statistically from the negative control; this finding indicates that VLE exerted no antiproliferative or mitodepressive effect on *A. cepa* root meristem cells within the tested concentration range.

By contrast, the MMS (Group II) and CuSO<sub>4</sub>·5H<sub>2</sub>O (Group III) treatments markedly suppressed mitotic activity, with MI values declining to 3.12 ± 0.41% and 4.26 ± 0.52%, respectively, corresponding to approximate reductions of 73.6% and 64.0% relative to the negative control. The more pronounced mitotic suppression elicited by MMS compared with CuSO<sub>4</sub>·5H<sub>2</sub>O is

consistent with its established clastogenic profile and confirms the responsiveness of the bioassay system to genotoxic agents.

A concentration-dependent pattern of recovery was observed in the groups co-treated with VLE and CuSO<sub>4</sub>·5H<sub>2</sub>O. The MI rose to 6.02 ± 0.59% in the 25 mg/L VLE co-treatment, to 7.58 ± 0.64% at 50 mg/L and to 9.41 ± 0.71% at 100 mg/L, corresponding to approximately 1.41-, 1.78- and 2.21-fold increases over the Cu-only group, respectively. Notably, in the 100 mg/L VLE + CuSO<sub>4</sub>·5H<sub>2</sub>O group the MI value was no longer statistically distinguishable from the negative control, indicating that VLE supplementation at this concentration largely attenuated the CuSO<sub>4</sub>·5H<sub>2</sub>O -induced mitotic suppression at the statistical level. Nevertheless, since the MI value of 9.41% in Group IX corresponds to approximately 79.5% of the negative control, the recovery should be interpreted as substantial but biologically partial rather than complete.

**Table 3.** Effects of VLE and CuSO<sub>4</sub>·5H<sub>2</sub>O treatments on mitotic index (MI) in *Allium cepa* root meristem cells

Group	Treatment	Mitotic index (%)	% of NC
I	dH <sub>2</sub> O (Negative control)	11.84 ± 0.73	100.0
II	10 mg/L MMS (Positive control)	3.12 ± 0.41*	26.4
III	1.5 mg/L CuSO <sub>4</sub> ·5H <sub>2</sub> O	4.26 ± 0.52*	36.0
IV	25 mg/L VLE	11.37 ± 0.68	96.0
V	50 mg/L VLE	11.92 ± 0.81	100.7
VI	100 mg/L VLE	10.88 ± 0.77	91.9
VII	25 mg/L VLE + 1.5 mg/L CuSO <sub>4</sub> ·5H <sub>2</sub> O	6.02 ± 0.59*#	50.8
VIII	50 mg/L VLE + 1.5 mg/L CuSO <sub>4</sub> ·5H <sub>2</sub> O	7.58 ± 0.64*#	64.0
IX	100 mg/L VLE + 1.5 mg/L CuSO <sub>4</sub> ·5H <sub>2</sub> O	9.41 ± 0.71#	79.5

Values are expressed as mean ± standard deviation (n = 3 independent biological replicates). MI values represent the percentage of mitotic cells per 1,000 randomly selected meristematic cells per preparation.

\* Statistically significant difference from the negative control (Group I;  $p < 0.05$ , one-way ANOVA followed by Dunnett's post hoc test).

# Statistically significant difference from the CuSO<sub>4</sub>·5H<sub>2</sub>O-treated group (Group III;  $p < 0.05$ , one-way ANOVA followed by Dunnett's post hoc test).

% of NC: percentage of the negative control value. Abbreviations: VLE, *Viburnum lantana* mesocarp extract; MMS, methyl methanesulphonate; CuSO<sub>4</sub>·5H<sub>2</sub>O, copper (II) sulphate pentahydrate; dH<sub>2</sub>O, distilled water; NC, negative control

### 3.4. Effects on micronucleus frequency

Substantial differences in micronucleus (MN) frequency were detected among the treatment groups (Table 4). The lowest MN frequency was recorded in the negative control group (0.18 ± 0.05%), and in the groups treated with VLE alone (IV–VI), MN values ranged between 0.21 and 0.27% and did not differ statistically from the negative control. This finding indicates that VLE elicited no appreciable genotoxic effect on *A. cepa* root meristem cells within the tested concentration range (25–100 mg/L).

By contrast, the MMS (Group II) and CuSO<sub>4</sub>·5H<sub>2</sub>O (Group III) treatments markedly induced MN formation, with frequencies rising to 4.92 ± 0.41% and 3.84 ± 0.36%, respectively, corresponding to approximately 27.3- and 21.3-fold increases relative to the negative control. The higher MN induction elicited by MMS compared with CuSO<sub>4</sub>·5H<sub>2</sub>O is consistent with its well-established alkylating clastogen profile and confirms the responsiveness of the bioassay system to genotoxic agents. The pronounced rise in MN frequency observed in the CuSO<sub>4</sub>·5H<sub>2</sub>O-treated group indicates that exposure

to 1.5 mg/L CuSO<sub>4</sub>·5H<sub>2</sub>O generated a considerable genotoxic burden, eliciting clastogenic and/or aneugenic damage in the meristematic cells of *A. cepa*.

A concentration-dependent pattern of MN suppression was observed in the groups co-treated with VLE and CuSO<sub>4</sub>·5H<sub>2</sub>O. The MN frequency declined to 2.91 ± 0.28% in the 25 mg/L VLE co-treatment, to 1.96 ± 0.22% at 50 mg/L and to 1.08 ± 0.17% at 100 mg/L, corresponding to approximate reductions of 24.2%, 49.0% and 71.9% relative to the Cu-only group. Notably, in the 100 mg/L VLE + CuSO<sub>4</sub>·5H<sub>2</sub>O group, the MN frequency was no longer statistically distinguishable from the negative control; however, since the value of 1.08% corresponds to approximately six times the negative control level, this outcome should be interpreted as a substantial but not complete attenuation of the genotoxic burden at the statistical level, with a residual biological signal still detectable. Collectively, these findings indicate that VLE attenuated CuSO<sub>4</sub>·5H<sub>2</sub>O-induced micronucleus formation in a concentration-dependent manner within the tested concentration range.

**Table 4.** Effects of VLE and CuSO<sub>4</sub>·5H<sub>2</sub>O treatments on micronucleus (MN) frequency in *Allium cepa* root meristem cells

Group	Treatment	MN frequency (%)	% of NC
I	dH <sub>2</sub> O (Negative control)	0.18 ± 0.05	100.0
II	10 mg/L MMS (Positive control)	4.92 ± 0.41*	2733.3
III	1.5 mg/L CuSO <sub>4</sub> ·5H <sub>2</sub> O	3.84 ± 0.36*	2133.3
IV	25 mg/L VLE	0.21 ± 0.06	116.7
V	50 mg/L VLE	0.24 ± 0.07	133.3
VI	100 mg/L VLE	0.27 ± 0.08	150.0
VII	25 mg/L VLE + 1.5 mg/L CuSO <sub>4</sub> ·5H <sub>2</sub> O	2.91 ± 0.28*#	1616.7
VIII	50 mg/L VLE + 1.5 mg/L CuSO <sub>4</sub> ·5H <sub>2</sub> O	1.96 ± 0.22*#	1088.9
IX	100 mg/L VLE + 1.5 mg/L CuSO <sub>4</sub> ·5H <sub>2</sub> O	1.08 ± 0.17#	600.0

Values are expressed as mean ± standard deviation (n = 3 independent biological replicates). MN values represent the percentage of micronucleated cells per 1,000 randomly selected meristematic cells per preparation.

\* Statistically significant difference from the negative control (Group I;  $p < 0.05$ , one-way ANOVA followed by Dunnett's post hoc test).

# Statistically significant difference from the CuSO<sub>4</sub>·5H<sub>2</sub>O -treated group (Group III;  $p < 0.05$ , one-way ANOVA followed by Dunnett's post hoc test).

% of NC: percentage of the negative control value. Abbreviations: VLE, *Viburnum lantana* mesocarp extract; MMS, methyl methanesulphonate; CuSO<sub>4</sub>·5H<sub>2</sub>O, copper (II) sulphate pentahydrate; dH<sub>2</sub>O, distilled water; NC, negative control.

### 3.5. Effects on chromosomal aberrations

Substantial differences in the chromosomal aberration (CA) profile were detected among the treatment groups (Table 5). The total CA value in the negative control group was  $0.70 \pm 0.09$ , which falls within the range generally accepted as indicative of a low spontaneous aberration frequency in the *A. cepa* bioassay system. In the groups treated with VLE alone (IV–VI), total CA values ranged between 0.80 and 1.07 and did not differ statistically from the negative control; this finding indicates that VLE did not elicit any appreciable cytogenetic activity within the tested concentration range.

By contrast, the MMS (Group II) and CuSO<sub>4</sub>·5H<sub>2</sub>O (Group III) treatments produced marked increases across all aberration types; the total CA value rose to  $12.07 \pm 0.74$  and  $9.86 \pm 0.63$ , respectively, corresponding to approximately 17.2- and 14.1-fold increases relative to the negative control. The approximately 22% higher total aberration induction elicited by MMS compared with CuSO<sub>4</sub>·5H<sub>2</sub>O confirms the responsiveness of the bioassay system to cytogenetic damage. In the CuSO<sub>4</sub>·5H<sub>2</sub>O -treated cells, the most frequent aberration types were

ranked, in descending order, as sticky chromosome (SC;  $2.71 \pm 0.24$ ), bridge (B;  $1.73 \pm 0.16$ ), fragment (FRG;  $1.42 \pm 0.13$ ), vagrant chromosome (VC;  $1.16 \pm 0.12$ ), unequal chromatin distribution (UCD;  $1.04 \pm 0.10$ ), c-mitosis (CM;  $0.98 \pm 0.09$ ) and abnormal polarisation (AP;  $0.82 \pm 0.08$ ).

A concentration-dependent reduction pattern was observed across all aberration types in the groups co-treated with VLE and CuSO<sub>4</sub>·5H<sub>2</sub>O. The total CA value declined to  $7.50 \pm 0.51$  in the 25 mg/L VLE co-treatment, to  $5.34 \pm 0.42$  at 50 mg/L and to  $2.99 \pm 0.28$  at 100 mg/L, corresponding to approximate reductions of 24.0%, 45.8% and 69.7% relative to the Cu-only group. Examination of the type-specific protection profile at the highest dose (100 mg/L VLE + CuSO<sub>4</sub>·5H<sub>2</sub>O) revealed that the frequencies of fragment (-72.5%), vagrant chromosome (-70.7%), c-mitosis (-73.5%), bridge (-66.5%), UCD (-68.3%) and abnormal polarisation (-74.4%) were no longer statistically distinguishable from the negative control values. By contrast, although the sticky chromosome frequency was reduced by 67.5% in the 100 mg/L VLE co-treatment relative to the Cu-only group, it remained significantly elevated above the

negative control level. Collectively, these findings indicate that VLE attenuated the majority of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ -induced cytogenetic damage in a concentration-dependent manner within the tested concentration

range, although the protective effect was more limited against sticky chromosome formation compared with the other aberration types.

**Table 5.** Effects of VLE and  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  treatments on chromosomal aberration (CA) profile in *Allium cepa* root meristem cells

Group	FRG	SC	VC	CM	B	UCD	AP	Total CA
I dH <sub>2</sub> O	0.12 ± 0.04	0.18 ± 0.05	0.09 ± 0.03	0.05 ± 0.02	0.14 ± 0.04	0.07 ± 0.02	0.05 ± 0.02	0.70 ± 0.09
II 10 mg/L MMS	1.84 ± 0.16*	3.26 ± 0.28*	1.48 ± 0.14*	1.17 ± 0.11*	2.04 ± 0.19*	1.32 ± 0.13*	0.96 ± 0.10*	12.07 ± 0.74*
III 1.5 mg/L CuSO <sub>4</sub> ·5H <sub>2</sub> O	1.42 ± 0.13*	2.71 ± 0.24*	1.16 ± 0.12*	0.98 ± 0.09*	1.73 ± 0.16*	1.04 ± 0.10*	0.82 ± 0.08*	9.86 ± 0.63*
IV 25 mg/L VLE	0.16 ± 0.05	0.22 ± 0.06	0.11 ± 0.04	0.07 ± 0.03	0.18 ± 0.05	0.09 ± 0.03	0.07 ± 0.02	0.90 ± 0.11
V 50 mg/L VLE	0.14 ± 0.04	0.20 ± 0.05	0.10 ± 0.03	0.06 ± 0.02	0.16 ± 0.04	0.08 ± 0.02	0.06 ± 0.02	0.80 ± 0.10
VI 100 mg/L VLE	0.19 ± 0.05	0.26 ± 0.07	0.13 ± 0.04	0.09 ± 0.03	0.21 ± 0.05	0.11 ± 0.03	0.08 ± 0.03	1.07 ± 0.13
VII 25 mg/L VLE + Cu	1.08 ± 0.10*#	2.04 ± 0.19*#	0.88 ± 0.09*#	0.76 ± 0.08*#	1.29 ± 0.12*#	0.82 ± 0.08*#	0.63 ± 0.06*#	7.50 ± 0.51*#
VIII 50 mg/L VLE + Cu	0.76 ± 0.08*#	1.42 ± 0.15*#	0.63 ± 0.07*#	0.52 ± 0.06*#	0.96 ± 0.09*#	0.61 ± 0.06*#	0.44 ± 0.05*#	5.34 ± 0.42*#
IX 100 mg/L VLE + Cu	0.39 ± 0.06#	0.88 ± 0.10*#	0.34 ± 0.05#	0.26 ± 0.04#	0.58 ± 0.07#	0.33 ± 0.05#	0.21 ± 0.04#	2.99 ± 0.28#

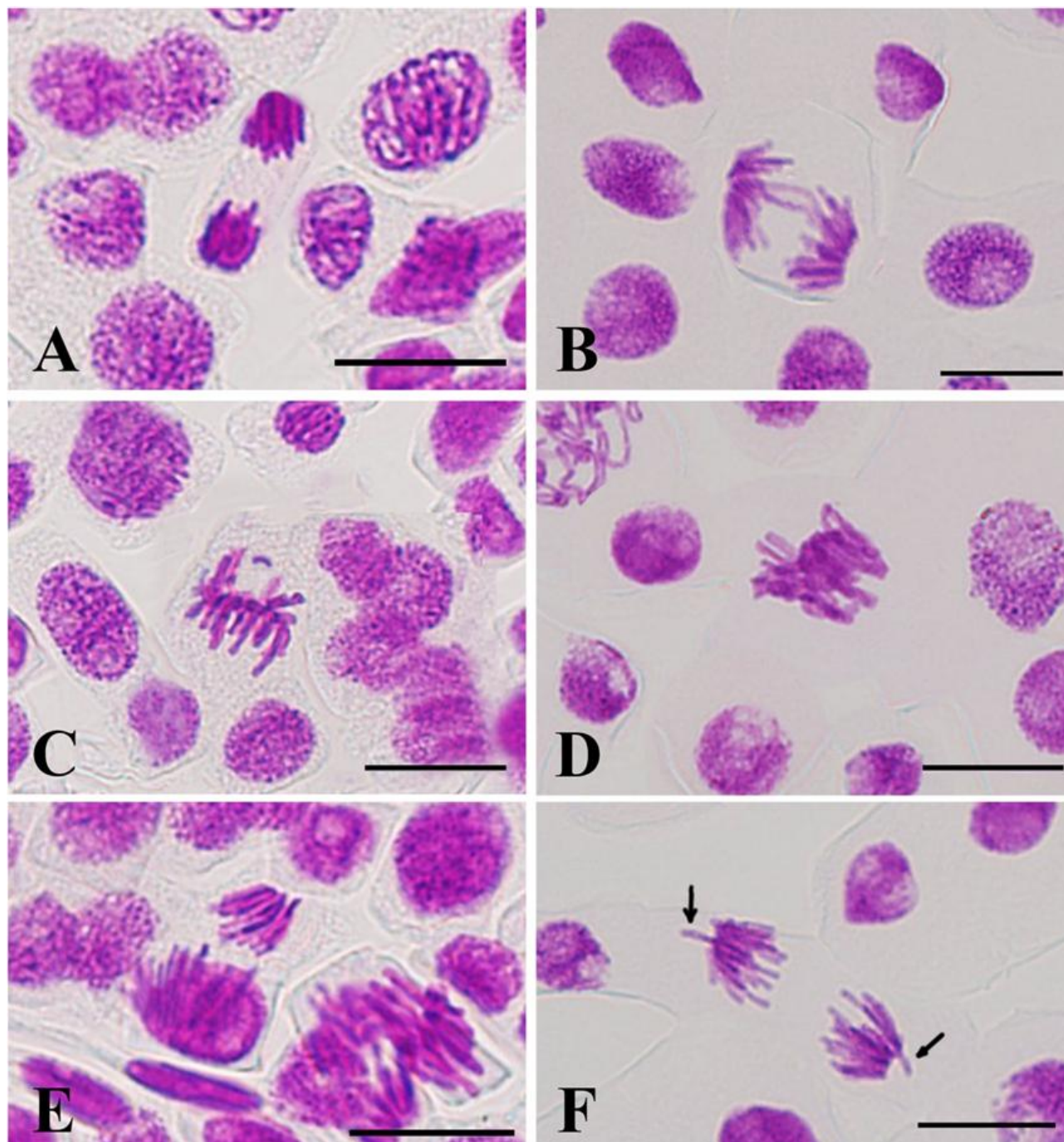
Values are expressed as mean number of aberrant cells (mean ± standard deviation, n = 3 independent biological replicates), based on the analysis of 100 cells × 15 preparations (a total of 1,500 cells per treatment group). "+ Cu" in Groups VII–IX denotes co-treatment with 1.5 mg/L  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ .

\* Statistically significant difference from the negative control (Group I; p < 0.05, one-way ANOVA followed by Dunnett's post hoc test).

# Statistically significant difference from the  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ -treated group (Group III; p < 0.05, one-way ANOVA followed by Dunnett's post hoc test).

Abbreviations for aberration types: FRG, fragment; SC, sticky chromosome; VC, vagrant chromosome; CM, c-mitosis; B, bridge; UCD, unequal chromatin distribution; AP, abnormal polarisation; CA, chromosomal aberration.

Abbreviations for treatments: VLE, *Viburnum lantana* mesocarp extract; MMS, methyl methanesulphonate;  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ , copper(II) sulphate pentahydrate; dH<sub>2</sub>O, distilled water.



**Figure 2.** Representative photomicrographs of the principal chromosomal aberrations observed in *Allium cepa* root meristem cells throughout the experiment. (A) Abnormal polarisation; (B) Bridge; (C) Fragment; (D) Sticky chromosome; (E) Unequal chromatin distribution; (F) Vagrant chromosome (arrows). Scale bars = 20 µm.

#### 4. DISCUSSION

The present study demonstrated that exposure to 1.5 mg/L  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  induced marked physiological and cytogenetic toxicity in *A. cepa* root meristem cells,

whereas these adverse effects were attenuated in a concentration-dependent manner in groups co-treated with VLE. The presence of a measurable and relatively high level of total monomeric anthocyanin content in the extract supports the phytochemical basis of the

observed protective effect, and the overall pattern of findings indicates that VLE exerts a multifaceted bioprotective profile against  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ -induced cellular damage.

When the physiological parameters were examined, 1.5 mg/L  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  exposure was found to reduce the rooting percentage by 40%, root length by approximately 74.6%, and weight gain by approximately 73.6%. This pattern of physiological suppression is consistent with the multifaceted toxicity mechanisms of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  in plant tissues. As a redox-active transition metal,  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  catalyses the generation of ROS through Fenton-like reactions, leading to membrane lipid peroxidation, protein carbonylation and DNA damage (Gaetke et al., 2014). In plant systems,  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  also inhibits mitotic activity in the root apical meristem, disrupts auxin signalling that mediates cell elongation, and restricts cell-wall plasticity (Yruela, 2009). The marked decrease observed in root elongation and biomass accumulation in the present study was interpreted as the morphological reflection of the combined action of these mechanisms. The quantitative reduction profile obtained here is consistent with the findings of Yildiz et al. (2009) and Geremias et al. (2010), who reported  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ -induced physiological suppression of comparable magnitude in *A. cepa* root meristem cells, and is also in agreement with Doğanlar and Atmaca (2011), who demonstrated that heavy-metal accumulation in plant tissues leads to physiological decline.

The lack of separation between the negative control and the groups treated with VLE alone over the 25–100 mg/L concentration range indicates that the extract did not exhibit phytotoxic activity within this dose range and supports the interpretation that the improvements observed in the co-treated groups reflect a genuine protective response. The concentration-dependent recovery pattern detected in groups co-treated with  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  and VLE is in agreement with the accumulating literature on the potential of anthocyanin-rich polyphenolic compounds to alleviate heavy-metal-induced phytotoxicity (Valentová et al., 2007). Anthocyanins act as both direct ROS scavengers and metal-interacting polyphenols through the C3/C5 hydroxyl substituents and the ortho-dihydroxy structures on the B-ring of the flavylum chromophore; this dual mechanism may reduce the pool of redox-active metal ions and, consequently, the intracellular oxidative

burden. The absence of statistically significant differences between the negative control and the groups treated with VLE alone over the 25–100 mg/L concentration range indicates that the extract did not exhibit phytotoxic activity within this dose range and supports the interpretation that the improvements observed in the co-treated groups reflect a genuine protective response. The concentration-dependent recovery pattern detected in the groups co-treated with  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  and VLE is consistent with the accumulating evidence that phenolic-rich plant extracts can alleviate heavy-metal-induced phytotoxicity by modulating oxidative stress-related damage (Goncharuk and Zagoskina, 2023). Anthocyanins act as both direct ROS scavengers and metal-interacting polyphenols through the C3/C5 hydroxyl substituents and the ortho-dihydroxy structures on the B-ring of the flavylum chromophore; this dual mechanism may reduce the pool of redox-active metal ions and, consequently, the intracellular oxidative burden (Sadowska-Bartosz and Bartosz, 2024). In this context, the pattern observed in the present study is also consistent with recent evidence from the *A. cepa* bioassay showing that phenolic-rich plant extracts can mitigate metal-induced toxicity in an endpoint-dependent manner. For instance, Kutluer (2025) reported that *Calendula officinalis* flower extract alleviated molybdenum-induced physiological, biochemical, and cytogenetic damage in *A. cepa*; however, although germination and genotoxic endpoints improved markedly, root elongation and weight gain showed only partial recovery relative to the control. A similar endpoint-dependent recovery hierarchy was observed in the present study, in which VLE co-treatment restored rooting capacity more strongly than root elongation and biomass accumulation. This pattern is biologically meaningful: rooting capacity, as a threshold-dependent endpoint, may be regained when the protective effect surpasses a critical cellular viability threshold, whereas growth-related parameters such as root elongation and weight gain require sustained metabolic flux, and the 72-h exposure period employed here may have been insufficient for the complete reversal of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ -induced subcellular damage. Accordingly, VLE appears to function primarily as a mitigative agent that enhances physiological resilience in specific parameters, rather than inducing complete recovery across all dimensions of root development.

The mitotic index (MI) results revealed that  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  exposure exerted a marked suppressive effect not only at the physiological level but also at the level of the cell cycle. The approximately 64% reduction in MI in the  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ -treated group indicates that cell division was severely inhibited. Such decreases in mitotic activity are generally attributed to the suppression of DNA synthesis, activation of cell-cycle checkpoints, or disruption of mitotic spindle microtubules (Leme and Marin-Morales, 2009). Indeed, Inceer and Beyazoğlu (2000) in *Vicia hirsuta* and Liu et al. (2009) in *Allium sativum* root tip cells reported that sticky chromosome was among the most frequently observed chromosomal anomalies following Cu exposure, indicating that  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  predominantly induces SC formation across different plant species; the 64% MI reduction obtained in the present study is in quantitative agreement with these literature values. The absence of any appreciable change in MI in the groups treated with VLE alone supports the interpretation that the extract does not possess antiproliferative or mitodepressive activity; conversely, the concentration-dependent 1.41-, 1.78- and 2.21-fold increases in MI relative to the Cu-only group observed in the co-treatment groups suggest that VLE attenuates  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  induced mitotic suppression via a dual mechanism — reduction of ROS-mediated DNA damage and chelation of free  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  ions, thereby protecting mitotic enzymatic targets. Nevertheless, the fact that MI in the 100 mg/L VLE group corresponded to only approximately 79.5% of the negative control level suggests that, although the protective effect was statistically substantial, a complete biological recovery cannot be claimed.

The micronucleus (MN) frequency and chromosomal aberration (CA) results clearly demonstrated that  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  exposure exerted a substantial genotoxic effect. Micronuclei originate from chromosomes or chromosome fragments that fail to be incorporated into the daughter nuclei during mitosis and are recognised among the reliable biomarkers of genomic instability (Fenech et al., 2003). In the present study, the approximately 21.3-fold increase in MN frequency induced by  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  exposure indicates the occurrence of substantial chromosomal damage in meristematic cells, which is in agreement with the position adopted by Silveira et al. (2017), who identified increased MN frequency as one of the principal indicators of chromosomal instability. The 24.2%, 49.0%

and 71.9% reductions in MN frequency observed in the VLE co-treatment groups relative to the Cu-only group suggest that the extract exhibits protective potential against clastogenic and/or aneugenic chromosomal damage.

Analysis of the chromosomal aberration profile revealed that  $\text{Cu}^{2+}$  exposure produced marked increases predominantly in sticky chromosome (SC), bridge (B), fragment (FRG) and c-mitosis (CM) types. Indeed, Inceer and Beyazoğlu (2000) likewise reported that the most frequently observed chromosomal anomaly in *Vicia hirsuta* root tip cells exposed to copper chloride was a sticky chromosome, and this independent observation indicates that  $\text{Cu}^{2+}$  predominantly induces SC formation in different plant species as well. SC formation is generally associated with covalent interactions between chromatin proteins and DNA and with disturbances in chromosome condensation, and is often regarded as an indicator of poorly reversible cytotoxic damage (Leme and Marin-Morales, 2009; Gupta et al., 2018). Fragment and bridge formations are typically associated with DNA double-strand breaks and faulty chromatid separation, whereas c-mitosis reflects disruption of the polymerisation–depolymerisation dynamics of mitotic spindle microtubules. It is an established finding that, owing to its redox-active nature,  $\text{Cu}^{2+}$  catalyses ROS generation through Fenton-like reactions and leads to DNA strand breaks (Theophanides and Anastassopoulou, 2002); this mechanism was considered the principal cause of the FRG and B predominance observed in the present study. The reductions of up to 69.7% in total CA value relative to the Cu-only group in the VLE co-treatment groups, together with the statistical parity reached with the negative control by the FRG, VC, CM, B, UCD and AP frequencies particularly in the 100 mg/L VLE group, demonstrate that the extract exhibits a protective effect across a broad mechanistic spectrum. This interpretation is consistent with recent evidence from the *A. cepa* bioassay showing that phenolic-rich plant extracts can attenuate metal-induced cytogenetic and genotoxic damage in a concentration-dependent manner. For instance, Kutluer (2025) reported that *Calendula officinalis* flower extract mitigated molybdenum-induced toxicity in *A. cepa* and provided dose-dependent protection against genotoxic endpoints, including fragment, bridge, and micronucleus frequencies.

Nevertheless, it is particularly noteworthy that, despite a 67.5% reduction relative to the Cu-only group, the sticky chromosome frequency in the 100 mg/L VLE co-treatment remained significantly elevated above the negative control level. This pattern may indicate a mechanistic limit to the protective scope of anthocyanins: it has previously been reported that  $\text{Cu}^{2+}$  can coordinate directly with the DNA phosphate backbone and interact with chromatin proteins (Theophanides and Anastassopoulou, 2002), and it is therefore suggested that SC formation may, at least in part, be associated with such direct metal–chromatin interaction modes. It can further be considered that the complete prevention of this type of chromatin-associated damage by ROS scavenging and metal chelation — the principal protective functions of polyphenols — may be relatively difficult. In this context, it can be interpreted that, while VLE exhibits marked protection against chromosomal aberration types regarded as predominantly oxidative in origin, it provides a more limited protective effect against aberration types such as sticky chromosome, whose mechanistic basis may be partly different. This endpoint-specific pattern is consistent with recent evidence indicating that phenolic-rich plant extracts may provide broad but not necessarily complete protection against metal-induced genotoxic damage in the *A. cepa* bioassay. For instance, Kutluer (2025) reported that *Calendula officinalis* flower extract mitigated molybdenum-induced toxicity in *A. cepa* and provided dose-dependent protection against genotoxic endpoints, including fragment, bridge, and micronucleus frequencies. Collectively, these findings indicate that antioxidant-rich plant extracts may offer a broad but mechanism-specific differentiated protective profile against heavy-metal-induced genotoxicity. The total monomeric anthocyanin content determined in the present study ( $28.64 \pm 1.37$  mg cyd-3-glu equiv/g dry extract) lies within the upper-middle range reported for the genus *Viburnum* and confirms that the extract possesses an anthocyanin-rich polyphenolic profile. This high anthocyanin content firmly supports the phytochemical basis of the strong protective effect observed in our study. Nevertheless, it should be taken into account that the biological activity of the extract cannot be attributed solely to monomeric anthocyanins; other phenolic compounds present in the mesocarp of *V. lantana* such as chlorogenic acid, quercetin glycosides, hydroxycinnamic acid derivatives and tannins are likely to contribute synergistically to the ROS-scavenging and

metal-chelation mechanisms. Sellappan et al. (2002) and Seeram (2008) reported that the total antioxidant capacity of anthocyanin-rich fruits correlates strongly not only with anthocyanin content but also with accompanying polyphenolic constituents, and the interpretation of the protective profile observed in the present study as a multicomponent polyphenolic activity is therefore more consistent within this framework.

## 5. CONCLUSION

The present study demonstrated that VLE, owing to its anthocyanin-rich polyphenolic profile, may serve as a potential bioprotective agent in attenuating, in a concentration-dependent manner, the physiological, cytotoxic, and genotoxic damage induced by 1.5 mg/L  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  in *A. cepa* root meristem cells. The protective effect did not exhibit a uniform profile across all endpoints; whereas marked recovery was observed for rooting capacity and for chromosomal aberration types considered to be predominantly oxidative in origin, relatively limited protection was obtained for aberration types such as sticky chromosome, whose mechanistic basis may be partly different. These findings indicate that anthocyanin-rich natural extracts can be considered among candidate matrices for the mitigation of heavy-metal-induced cellular stress. In this context, *V. lantana* represents a promising plant-derived material for further bioprospective evaluation at the interface of environmental toxicology and phytochemistry. Nevertheless, the scope of the present findings is, by the nature of the model system employed, confined to the level of an in vitro / short-term in vivo plant bioassay; therefore, any direct generalisation to field-scale protective strategies would be premature at this stage. To overcome this limitation, future studies should focus on (i) characterising the protective capacity of VLE across wider dose–response ranges and under long-term chronic exposure protocols, (ii) testing the generalisability of its efficacy to in vivo mammalian systems, (iii) identifying the individual polyphenolic constituents, such as chlorogenic acid, quercetin glycosides, hydroxycinnamic acid derivatives, and tannins, that contribute to the protective effect through HPLC-DAD and LC-MS/MS-based compound profiling combined with fractionation approaches, and (iv) elucidating, at the molecular level, the limits of protection against aberration types of mechanistically distinct nature, such as sticky chromosome. The mechanistic insights to be obtained along these lines

may provide the foundation for the rational design of plant-based protective approaches against heavy-metal-induced genotoxic stress.

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## RESEARCH ARTICLE

## Open Access

# Evaluation of artificial intelligence tools for the detection of herb–drug interactions

## Bitki-ilaç etkileşimlerinin tespitinde yapay zeka araçlarının değerlendirilmesi

Cengizhan CEYLAN<sup>a</sup>, Osman TUGAY<sup>b</sup>

<sup>a</sup> Department of Clinical Pharmacy, Faculty of Pharmacy, Selcuk University, 42130, Konya, Türkiye

<sup>b</sup> Department of Pharmaceutical Botany, Faculty of Pharmacy, Selcuk University, 42130, Konya, Türkiye

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\*Corresponding author:  
e-mail:

[cengizhan.ceylan@selcuk.edu.tr](mailto:cengizhan.ceylan@selcuk.edu.tr)

ORCID: 0000-0003-4164-9212

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**Keywords:** Herb-drug interaction, Artificial intelligence, ChatGPT, Gemini

**Anahtar Kelimeler:** Bitki-ilaç etkileşimi, Yapay zeka, ChatGPT, Gemini

### ABSTRACT

The use of medicinal plants has been increasing both globally and in Türkiye. Accurate identification of medicinal plants is essential for their safe use. Morphologically similar species may possess markedly different active constituents and toxicity profiles. his study aimed to assess the quality of responses generated by ChatGPT 5.5 and Gemini 3 regarding the identification of thirty medicinal plants commonly used in Türkiye and their potential herb–drug interactions. In the botanical evaluation, the mean score of ChatGPT 5.5 was  $4.50 \pm 0.78$  and that of Gemini was  $4.30 \pm 0.92$ . The median score was 5 for both systems. In the herb–drug interaction assessment, the mean scores were  $4.80 \pm 0.41$  and  $4.00 \pm 0.59$  for ChatGPT and Gemini 3. ChatGPT 5.5 showed superior performance in the assessment of herb–drug interactions and did not receive a score below 4 for any of the evaluated questions. ChatGPT 5.5 and Gemini 3 demonstrated promising capabilities in identifying medicinal plants commonly used in Türkiye. However, ChatGPT 5.5 provided more accurate and comprehensive information regarding herb–drug interactions.

### Öz

Tıbbi bitkilerin kullanımı hem dünya genelinde hem de Türkiye’de giderek artmaktadır. Tıbbi bitkilerin güvenli kullanımı için bunların doğru bir şekilde tanımlanması hayati önem taşımaktadır. Morfolojik olarak birbirine benzeyen türler, belirgin şekilde farklı aktif bileşenlere ve toksisite profillerine sahip olabilir. Bu çalışma, Türkiye’de yaygın olarak kullanılan otuz tıbbi bitkinin tanımlanması ve bunların potansiyel bitki-ilaç etkileşimleri konusunda ChatGPT 5.5 ve Gemini 3 tarafından üretilen yanıtların kalitesini değerlendirmeyi amaçlamıştır. Botanik değerlendirmede, ChatGPT 5.5’in ortalama puanı  $4,50 \pm 0,78$ , Gemini’nin ise  $4.30 \pm 0.92$  olarak belirlenmiştir. Her iki sistem için de medyan puan 5’tir. Bitki-ilaç etkileşimi değerlendirmesinde, ChatGPT ve Gemini 3 için ortalama puanlar sırasıyla  $4.80 \pm 0.41$  ve  $4.00 \pm 0.59$  olarak belirlendi. ChatGPT 5.5, bitki-ilaç etkileşimlerinin değerlendirilmesinde üstün performans gösterdi ve değerlendirilen soruların hiçbirinde 4’ün altında bir puan almadı. ChatGPT 5.5 ve Gemini 3, Türkiye’de yaygın olarak kullanılan şifalı bitkilerin tanımlanmasında umut verici yetenekler sergilemiştir. Bununla birlikte, ChatGPT 5.5, bitki-ilaç etkileşimleri konusunda daha doğru ve kapsamlı bilgiler sağlamıştır.

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## 1. INTRODUCTION

The use of medicinal plants has been increasing both globally and in Türkiye (Görgülü, 2020). A study conducted in the United States found that approximately 38% of individuals using herbal products also used prescription medications, while 42% used over-the-counter medications. The conditions most

commonly associated with herbal product use were stroke, cancer, and arthritis (Rashrash et al., 2017). In addition, herbal products are frequently used by special populations, including pregnant women. (Umar et al., 2021). In a study conducted in Türkiye, the prevalence of herbal product use among older adults was found to be 30%. Among those using herbal products, 64% were concurrently taking more than one prescription medication (Turkmenoglu et al., 2016).

Accurate identification of medicinal plants is essential for their safe use. Morphologically similar species may possess markedly different active constituents and toxicity profiles (Nithaniyal et al., 2017). Herbal products are often used because they are perceived to be safer than conventional medicines. However, some medicinal plants may interact with drugs and lead to adverse drug reactions. To prevent such events, various assessment tools and screening scales have been developed (Cnudde et al., 2024). In a study evaluating reports of herb–drug interactions, 53.6% of the interactions were classified as possible, 17% as probable, and 29% as suspected. Among the most frequently reported interactions were *Curcuma longa*–tacrolimus, *Echinacea purpurea*–etoposide, *Ginkgo biloba*–ibuprofen, *Camellia sinensis*–warfarin, and *Glycyrrhiza glabra*–thiazide interactions. (Alghamdi et al., 2023).

Large language models (LLMs), such as ChatGPT and Gemini, are artificial intelligence (AI) tools increasingly used by both patients and healthcare professionals to obtain health-related information. However, these tools may generate inaccurate responses by producing hallucinated information or fabricated references. Consequently, the number of studies evaluating the accuracy and reliability of these tools has been increasing (Hsu et al., 2023). In a study comparing the accuracy of information generated by ChatGPT and Gemini, two versions of ChatGPT produced information with an accuracy of 93.5%, whereas Gemini achieved an accuracy rate of 92.7% (Hsu et al., 2025).

Studies evaluating herb–drug interactions using artificial intelligence tools in the context of medicinal plant use remain limited. Therefore, this study aimed to assess the quality of responses generated by ChatGPT 5.5 and Gemini 3 regarding the identification of thirty medicinal plants commonly used in Türkiye and their potential herb–drug interactions.

## 2. MATERIALS AND METHODS

### 2.1. Type of research

This is a cross-sectional, descriptive, and comparative study aiming to evaluate the quality of the responses provided by ChatGPT 5.5 and Gemini 3 regarding the identification of commonly used medicinal plants in Türkiye and herb–drug interactions.

### 2.2. Selection of medicinal plants

Thirty medicinal plants were randomly selected from among the commonly used medicinal plants after reviewing Türkiye’de Bitkilerle Tedavi, a seminal reference work on medicinal plants in Türkiye authored by Baytop (Baytop, 1999). The plants are listed in Table 1. The Turkish names of the plants were obtained from the book Türkiye Bitkileri Listesi (Güner et al., 2012).

### 2.3. Data Collection and Analysis

Standard questions were prepared for each medicinal plant. The same question text was posed to both ChatGPT 5.5 and Gemini 3. The AI tools were asked to provide answers explaining the image of the medicinal plant, known or potential herb–drug interactions, the mechanism of interaction, the potential clinical outcome, and the risk level. The accuracy of the images of the medicinal plants was evaluated by a botanical expert, while the quality of the responses regarding herb–drug interactions was evaluated by a clinical pharmacist. In the evaluation, the botanical expert considered the following criteria: whether the image belonged to the specified plant, the appropriateness of the morphological characteristics, and whether there was any misidentification of the plant. The clinical pharmacist based the evaluation on current scientific literature, evidence-based clinical information, and herb–drug interaction databases.

### 2.4. Assessment and scoring system

Both the botanical expert and the clinical pharmacist used a 5-point Likert-type rating scale for their responses (1=poor quality to 5=excellent quality) (Carlà et al., 2024).

### 2.5. Statistical analysis

IBM SPSS (Statistical Package for the Social Sciences) version 22.0 was used to analyze the data. Continuous variables are expressed as mean  $\pm$  standard deviation or median (minimum–maximum), while categorical variables are expressed as counts and percentages. The Wilcoxon Signed-Rank test was used to compare the two different artificial intelligence tools. A *p*-value of <0.05 was considered statistically significant.

**Table 1.** Plant Name

Plant name / Turkish name
<i>Achillea millefolium</i> L. / Civanperçemi
<i>Althaea officinalis</i> L. / Delihatmi
<i>Artemisia absinthium</i> L. / Acı pelin
<i>Asplenium ceterach</i> L. / Dalakotu
<i>Capsella bursa-pastoris</i> (L.) Medik / Çobançantası
<i>Ceratonia siliqua</i> L. / Keçiboynuzu
<i>Chelidonium majus</i> L. / Kırlangıçotu
<i>Crataegus orientalis</i> Pall. ex M.Bieb / Alıç
<i>Ecballium elaterium</i> (L.) A.Rich. / Eşekhiyari
<i>Glycyrrhiza glabra</i> L. / Meyan
<i>Hypericum perforatum</i> L. / Kantaron
<i>Laurus nobilis</i> L. / Defne
<i>Lavandula angustifolia</i> Mill. / Lavanta
<i>Linum usitatissimum</i> L. / Otlak Keteni
<i>Malva sylvestris</i> L. / Ebegümeçi
<i>Matricaria chamomilla</i> L. / Almanpapatyası
<i>Origanum majorana</i> L. / Mercanköşk
<i>Paliurus spina-christi</i> P.Mill. / Karaçalı
<i>Papaver somniferum</i> L. / Haşhaş
<i>Peganum harmala</i> L. / Üzerlik
<i>Rosa canina</i> L. / Kuşbunur

<i>Rosmarinus officinalis</i> L. / Biberiye
<i>Salvia fruticosa</i> Mil. / Adaçayı
<i>Satureja cuneifolia</i> Ten. / Kayakekiği
<i>Sesamum indicum</i> L. / Susam
<i>Sideritis libanotica</i> Labill. / Gevreğen
<i>Thymus kotschyanus</i> Boiss. & Hohen. / Kekik
<i>Tilia tomentosa</i> Moench / Gümüşi ihlamur
<i>Urtica dioica</i> L. / Isırgan
<i>Vitex agnus-castus</i> L. / Hayıt

### 3. RESULTS

In the botanical evaluation, the mean score of ChatGPT 5.5 was  $4.50 \pm 0.78$  and that of Gemini 3 was  $4.30 \pm 0.92$ . The median score was 5 for both systems. In the herb–drug interaction assessment, the mean scores were  $4.80 \pm 0.41$  and  $4.00 \pm 0.59$  for ChatGPT 5.5 and Gemini 3, respectively. Details are presented in Table 2.

**Table 2.** Descriptive statistics

Assessment Criteria	Artificial Intelligence Tool	Mean $\pm$ SD	Median (Min–Max)
Botanical assessment	ChatGPT 5.5	$4.50 \pm 0.78$	5 (3–5)
Botanical assessment	Gemini 3	$4.30 \pm 0.92$	5 (2–5)
Herb–drug interaction assessment	ChatGPT 5.5	$4.80 \pm 0.41$	5 (4–5)
Herb–drug interaction assessment	Gemini 3	$4.00 \pm 0.59$	4 (3–5)

The comparison of ChatGPT 5.5 and Gemini 3 scores revealed no statistically significant difference in the botanical assessment ( $p = 0.141$ ). However, a statistically significant difference was observed in the herb–drug interaction assessment, with ChatGPT 5.5 receiving higher scores than Gemini 3 ( $p < 0.001$ ). Details are presented in Table 3.

**Table 3.** Comparison of ChatGPT 5.5 and Gemini 3

Assessment Criteria	Test	$p$
Botanical assessment	Wilcoxon Signed-Rank Test	0.141
Herb–drug interaction assessment	Wilcoxon Signed-Rank Test	<0.001

Score distributions for the botanical and herb–drug interaction assessments are shown in Table 3. In the botanical assessment, score 5 was assigned to 66.7% of ChatGPT 5.5 responses and 56.7% of Gemini 3 responses. In the herb–drug interaction assessment, 80.0% of ChatGPT 5.5 responses received a score of 5, whereas 66.7% of Gemini 3 responses received a score of 4. No herb–drug interaction responses generated by ChatGPT 5.5 received scores below 4. Details are presented in Table 4.

**Table 4.** Botanical and Herb-Drug Interaction Assessment

Point	Botanical Assessment ChatGPT 5.5 n (%)	Botanical Assessment Gemini 3 n (%)	Herb–Drug Interaction Assessment ChatGPT 5.5 n (%)	Herb–Drug Interaction Assessment Gemini 3 n (%)
1	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
2	0 (0.0)	1 (3.3)	0 (0.0)	0 (0.0)
3	5 (16.7)	6 (20.0)	0 (0.0)	5 (16.7)
4	5 (16.7)	6 (20.0)	6 (20.0)	20 (66.7)
5	20 (66.7)	17 (56.7)	24 (80.0)	5 (16.7)

#### 4. DISCUSSION

This study aimed to evaluate the identification of thirty medicinal plants commonly used in Türkiye and to assess the quality of the responses provided by ChatGPT 5.5 and Gemini 3 to questions regarding herb–drug interactions. Both ChatGPT 5.5 and Gemini 3 demonstrated comparable performance in the botanical evaluation, with no statistically significant difference observed between the two models. In contrast, ChatGPT 5.5 showed superior performance in the assessment of herb–drug interactions and did not receive a score below 4 for any of the evaluated questions. These findings suggest that both models can be used for botanical assessment; however, ChatGPT 5.5 appears to outperform Gemini 3 in the clinical evaluation of herb–drug interactions.

AI tools have been reported to achieve accuracy rates of up to 90% in the identification of commonly used plant species (Carranza-Rojas et al., 2017; Wäldchen & Mäder, 2018). Similarly, a study evaluating a machine learning–based plant identification system reported an accuracy rate of 85% (Amuthalingeswaran et al., 2019). In the present study, the use of widely recognized and commonly used medicinal plants may have contributed to the high scores achieved by the AI tools in plant identification.

ChatGPT 3.5 has been reported to perform successfully in the detection of drug–drug interactions (Aksoyalp & Erdoğan, 2024). Herb–drug interactions may result in serious clinical consequences, particularly in patients receiving multiple medications. This highlights the importance of routinely screening for potential herb–drug interactions (Puthiyedath & Pillai, 2025). In a study comparing different LLMs, ChatGPT was reported to achieve an accuracy rate of approximately 98% in predicting herb–drug interactions (Puthiyedath et al., 2025). The findings of our study are consistent with these results, as ChatGPT generated higher-quality responses than Gemini in the assessment of herb–drug interactions. Furthermore, a study conducted in Taiwan demonstrated that ChatGPT has the potential to be used for answering basic medication counseling questions (Hsu, 2023).

The use of commonly known medicinal plants, the time-dependent performance of the AI tools and the absence of a gold standard for comparison constitute the main limitations of this study.

In conclusion, both ChatGPT 5.5 and Gemini 3 demonstrated promising capabilities in identifying medicinal plants commonly used in Türkiye. However, ChatGPT 5.5 provided more accurate and comprehensive information regarding herb–drug interactions. Further studies involving larger sets of medicinal plants, multiple prompt variations, several independent evaluators, and direct comparisons with specialized herb–drug interaction databases are needed before these tools can be recommended for clinical practice or patient use.

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## RESEARCH ARTICLE

## Open Access

# Antiproliferative activity of silver nanoparticles synthesized from *Salvia aethiopsis*

## *Salvia aethiopsis*'den sentezlenen gümüş nanopartiküllerinin antiproliferatif aktivitesi

Esma Nur GEÇER<sup>a</sup>, İlyas YILDIZ<sup>a</sup>, Ramazan ERENLER<sup>\*a</sup>

<sup>a</sup> Department of Chemistry, Faculty of Arts and Sciences, Tokat Gaziosmanpaşa University, 60250, Tokat, Türkiye

### Article Info

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\*Corresponding author:

e-mail: [renenler@gmail.com](mailto:renenler@gmail.com)

ORCID: 0000-0002-6816-7443

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**Keywords:** Silver nanoparticles, *Salvia aethiopsis*, Antiproliferative Effect, Natural products

**Anahtar Kelimeler:** Gümüş nanopartikül, *Salvia aethiopsis*, Antiproliferatif etki, Doğal ürünler

### ABSTRACT

Nanotechnology has emerged as a rapidly developing field of science in recent years. It is used in fields such as agriculture, pharmaceuticals, electronics, and food. Plants exhibit broad-spectrum bioactivity due to their bioactive compound contents and are widely and effectively used in the pharmaceutical and food industries. In this study, the antiproliferative activity of the extract and silver nanoparticles (AgNPs) was evaluated using the human colorectal adenocarcinoma cell line (Caco-2), the human pancreatic adenocarcinoma cell line (Capan-1), and the mouse fibroblast cell line (L929) via MTT assay. In Caco-2 cell lines, cell viabilities were reported to be 27.5±0.7% and 36.8±1.7% after treatment with nanoparticles and the extract, respectively, at a 1.0 µg/mL concentration. In Capan-1 cell lines, the viabilities were determined to be 30.3±1.1% and 46.3±0.5% after treatment with AgNPs and the extract at 1.0 µg/mL, respectively.

### Öz

Nanoteknoloji, son yıllarda hızla gelişen bir bilim dalı olarak ortaya çıkmıştır. Tarım, ilaç, elektronik ve gıda gibi alanlarda kullanılmaktadır. Bitkiler, içerdikleri biyoaktif bileşikler sayesinde geniş spektrumlu biyoaktivite sergilemekte, ilaç ve gıda endüstrilerinde yaygın ve etkili bir şekilde kullanılmaktadır. Bu çalışmada, MTT testi yoluyla insan kolorektal adenokarsinom hücre hattı (Caco-2), insan pankreatik adenokarsinom hücre hattı (Capan-1) ve fare fibroblast hücre hattı (L929) kullanılarak ekstraktın ve gümüş nanopartiküllerinin (AgNPs) antiproliferatif aktivitesi incelendi. AgNPs yüksek antiproliferatif aktivite sergilediği belirlendi. Caco-2 hücre hatlarında, 1.0 µg/mL konsantrasyonda nanopartiküller ve özüt ile etkileşen hücrelerin, hücre canlılıklarının sırasıyla %27.5±0.7 ve %36.8±1.7 olduğu bildirilmiştir. Capan-1 hücre hatlarında ise, 1.0 µg/mL konsantrasyonda AgNP'ler ve ekstrakt ile etkileşen hücrelerin canlılık oranlarının sırasıyla %30.3±1.1 ve %46.3±0.5 olduğu belirlenmiştir.

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## 1. INTRODUCTION

Nanotechnology is advancing as a rapidly developing field of science with widespread applications (Geetha et al., 2013). Nanomaterials are extensively used in areas such as drug delivery, nanomedicine, food packaging, optics, electronics, renewable energy, wastewater treatment, and catalysis (Erenler et al., 2021). Among metal nanostructures, silver nanostructures have shown promising potential in many applications and have made significant contributions to the advancement of

nanotechnology (Genc, 2021). Silver has been commonly used by many nations throughout history, even in ancient times. Currently, antimicrobial AgNPs could potentially act as alternatives to existing antibiotics due to increasing bacterial resistance (Genc et al., 2021). Furthermore, the physicochemical properties of AgNPs can be tuned to prevent cellular toxicity, facilitating their biomedical applications (Dag, 2022).

Cancer is one of the leading causes of death worldwide and poses a major public health problem (Cragg et al., 2009). It is characterized by uncontrolled cell proliferation, invasion of surrounding tissues, and the potential to metastasize to distant organs (Fouche et al., 2008). Despite significant advances in diagnosis and treatment, many cancer types remain difficult to manage due to therapeutic resistance and disease recurrence (Seçme et al., 2024). The increasing global incidence of cancer highlights the urgent need for the development of more effective and safer therapeutic strategies (Lv et al., 2024). Natural products are gaining prominence in this field. Pure molecules obtained from plants and natural products containing bioactive compounds have been reported to be effective against some types of cancer (Lai et al., 2024). The use of plant-based materials and other biodegradable polymers, as well as the production of nanomaterials, is an active part of biotechnology (Erenler & Dag 2022). Biogenic metal nanoparticles can establish unique interactions with biomolecules both on the surface and within cells; this may offer a new approach to cancer treatment (Erenler et al., 2022).

Plants have been used for food and medicine for years (Kamah et al., 2025). After the discovery of bioactive molecules in plants, they became the focus of scientific studies (Djermane et al., 2025; Yaglioglu et al., 2022). Bioactive compounds isolated from plants and functionalized natural compounds have been used effectively for drug development (Bounaas et al., 2025; Eser et al., 2022). *Salvia* is an important genus in the Lamiaceae family, comprising nearly 900 species, and some *Salvia* species are cultivated worldwide for use in folk medicine and culinary applications (Koysu et al., 2018). *Salvia* species are a rich source of polyphenolic flavonoids and phenolic acids (Tung et al., 2017).

In this study, the antiproliferative activity of the extract and AgNPs was investigated using the Caco-2, Capan-1, and L929 cell lines.

## 2. MATERIALS AND METHODS

### 2.1. Plant materials

*Salvia aethiopsis* L. was cultivated at the Aromatic and Medicinal Plant Field of Tokat Gaziosmanpaşa University.

### 2.2. MTT assay

The L929, Caco-2, and Capan-1 cell lines were used to investigate antiproliferative effects. The cells ( $10 \times 10^3$  cells/mL) were plated and incubated for 24 hours. The prepared extract and nanoparticles were sterilized under UV light for 15 minutes. The samples (1, 0.5, 0.25, 0.125 µg/mL) were added to the cells, which were then incubated for 24 hours. Afterward, the medium in the wells was drained. MTT solution was added to the wells and incubated for 2.5 hours. After removing the MTT solution from the wells, isopropanol and the MTT solvent were added. An ELISA plate reader at 570 nm was used to calculate the viable cells (Erenler et al., 2023).

### 2.3. Statistical analysis

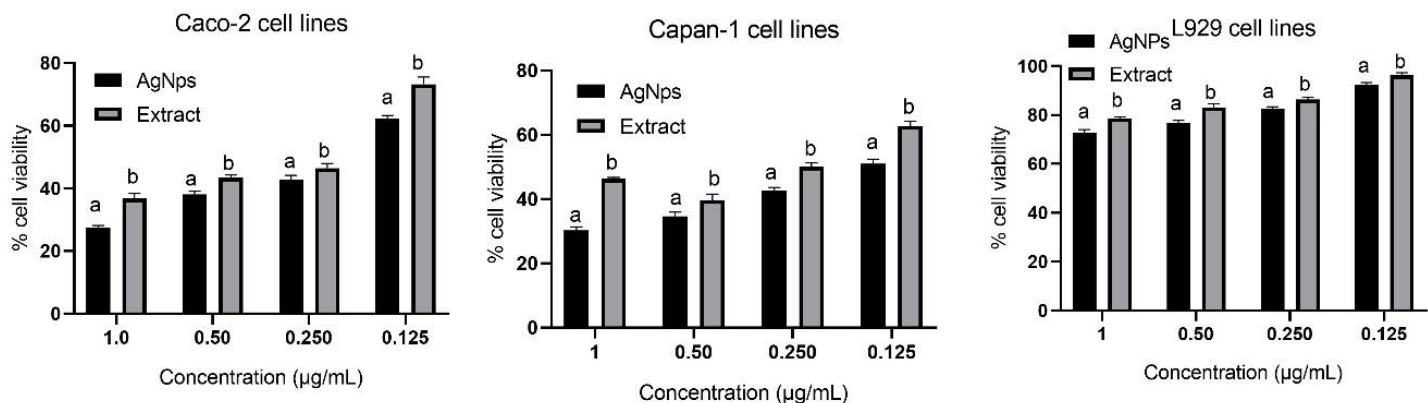
Statistical analysis was performed using GraphPad Prism 8.00. A one-way ANOVA with Tukey's multiple comparison test was used ( $P < 0.05$ ). The experiments were repeated in triplicate.

## 3. RESULTS AND DISCUSSIONS

Silver nanoparticles were synthesized using the leaves of *S. aethiopsis*. The spectra and values of AgNPs were presented in a reported study (Gecer, 2021). Antiproliferative activity of the extract and AgNPs was investigated using the Caco-2, Capan-1, and L929 cell lines (Figure 1). In Caco-2 cell lines, cell viabilities were  $27.5 \pm 0.7\%$  and  $36.8 \pm 1.7\%$  after treatment with nanoparticles and the extract, respectively, at a 1.0 µg/mL concentration. It was observed that cell viability increased as the concentration decreased. The viabilities of the Caco-2 cell were observed as  $42.8 \pm 1.4\%$  and  $46.5 \pm 1.5\%$  for the treatment of nanoparticles and extract, respectively, at 0.25 µg/mL. Moreover, viabilities were found to be  $62.4 \pm 0.9$  and  $73.3 \pm 2.3$  at 0.125 µg/mL for nanoparticles and the extract, respectively. In Capan-1 cell lines, the viabilities were determined to be  $30.3 \pm 1.1\%$  and  $46.3 \pm 0.5\%$  after treatment with AgNPs and the extract at 1.0 µg/mL, respectively. Moreover, viabilities were detected to be  $34.7 \pm 1.3\%$  and  $39.7 \pm 1.9\%$  for the treatment of AgNPs and extract at 0.5 µg/mL, respectively. At 0.25 µg/mL, these values were  $42.6 \pm 0.1\%$  and  $50.1 \pm 1.2\%$  for nanoparticles and extract, respectively. Concerning the L929 cell lines, the viabilities of L929 cell lines were determined to be  $72.6 \pm 1.4\%$  and  $78.6 \pm 0.7\%$  at 1.0 µg/mL for the AgNPs

and extract, respectively. The viabilities were found to be  $82.4 \pm 0.9\%$  and  $86.3 \pm 1.0$  at  $0.25 \mu\text{g/mL}$  after the treatment of nanoparticles and extract, respectively. Nanoparticles derived from plants were reported to exhibit significant antiproliferative activity. Silver nanoparticles were synthesized using *Erythrina suberosa*, and they exhibited cytotoxic effects against the A-431 osteosarcoma cell line (Mohanta et al., 2017).

In another study, AgNPs were synthesized from an aqueous extract of *Cornus officinalis* fruits, and these particles exhibited significant cytotoxicity against human prostate cancer (PC-3) and human liver cancer (HepG2) cell lines (He et al., 2017). AgNPs synthesized via *Piper longum* leaf revealed an excellent cytotoxic effect on HEP-2 cell lines (Justin Packia Jacob et al., 2012).



**Figure 1.** Antiproliferative activity of the extract and AgNPs. The different letters indicate the significant difference in the mean at the same concentration

#### 4. CONCLUSION

Silver nanoparticles and extract revealed considerable antiproliferative activity against the tested cell lines. Natural products have recently attracted considerable

attention for cancer treatment. So, the silver nanoparticles capped, stabilized, and reduced by the bioactive compounds could be a promising material for further studies.

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## RESEARCH ARTICLE

## Open Access

# Phenological dynamics and biometric characterization of introduced highbush blueberry (*Vaccinium corymbosum*) cultivars under the agroecological conditions of Adjara, Western Georgia

Acara, Batı Gürcistan'ın agroekolojik koşullarında introduksiyonla getirilen yüksek çalı maviyemişi (*Vaccinium corymbosum* L.) çeşitlerinin fenolojik dinamikleri ve biyometrik karakterizasyonu

Davit Zoidze<sup>a\*</sup>, Roza Lortkipanidze<sup>a</sup>, Nunu Chachkhiani-Anasashvili<sup>a</sup>

<sup>a</sup> Department of Agrarian Sciences Faculty of Agrarian Sciences, Akaki Tsereteli State University, 4600, Kutaisi, Georgia

### Article Info

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\*Corresponding author:

e-mail: [davitzoidze97@gmail.com](mailto:davitzoidze97@gmail.com)

ORCID: 0009-0008-9437-720X

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**Keywords:** Berry crop adaptation, Descriptive statistics, Fruit ripening, Genotype-environment response, Microzonal evaluation, Vegetative vigor

**Anahtar Kelimeler:** Üzümsü meyve adaptasyonu, Tanımlayıcı istatistik, Meyve olgunlaşması, Genotip-çevre etkileşimi, Mikrozonel değerlendirme, Vejetatif gelişim gücü

### ABSTRACT

Highbush blueberry (*Vaccinium corymbosum* L.) is becoming an increasingly important high-value berry crop in Western Georgia, particularly in Adjara, where humid subtropical conditions and expanding market opportunities support commercial production. Reliable introduction of new cultivars, however, requires locally validated information on phenological timing, ripening windows and vegetative performance. This study evaluated the phenological dynamics and biometric characteristics of three introduced cultivars, Legacy, Bluegold and Duke, in Kobuleti, Khelvachauri and Qeda municipalities during the 2024 growing season. Field records were systematized from the available primary dataset and processed by converting calendar dates into day-of-year values, calculating interval midpoints and preparing descriptive cultivar- and municipality-level summaries. Because the dataset contained one cultivar-by-location observation and no replicated plot-level measurements, inferential statistical testing was not applied. The results showed marked cultivar- and location-related differentiation.

### Öz

Yüksek çalı maviyemişi (*Vaccinium corymbosum* L.), özellikle nemli subtropikal koşulların ve gelişen pazar olanaklarının ticari üretimi desteklediği Batı Gürcistan'da, özellikle de Acara bölgesinde giderek önem kazanan yüksek değerli bir üzümü meyve türüdür. Ancak yeni çeşitlerin güvenilir biçimde bölgeye kazandırılması, fenolojik dönemler, olgunlaşma zamanları ve vejetatif gelişim özelliklerine ilişkin yerel koşullarda doğrulanmış bilgilere ihtiyaç duymaktadır. Bu çalışmada, 2024 yetiştirme sezonunda Kobuleti, Khelvachauri ve Qeda belediyelerinde yetiştirilen üç introduksiyon çeşidinin; Legacy, Bluegold ve Duke'un fenolojik dinamikleri ile biyometrik özellikleri değerlendirilmiştir. Mevcut birincil veri setinden elde edilen arazi kayıtları sistematize edilmiş; takvim tarihleri yılın günü değerlerine dönüştürülmüş, dönem aralıklarının orta noktaları hesaplanmış ve çeşit ile belediye düzeyinde tanımlayıcı özetler hazırlanmıştır. Veri setinin her çeşit-lokasyon kombinasyonu için yalnızca bir gözlem içermesi ve tekrarlı parsel ölçümlerinin bulunmaması nedeniyle çıkarımsal istatistiksel analiz uygulanmamıştır. Bulgular, çeşitler ve lokasyonlar arasında belirgin farklılıklar olduğunu göstermiştir.

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## 1. INTRODUCTION

Highbush blueberry (*V. corymbosum* L.) has developed from a regionally important fruit crop into a globally traded horticultural commodity with high economic value. Its expansion has been supported by increasing consumer demand for fresh berries, the recognition of blueberry fruit as a nutritionally valuable product, the growth of export-oriented production systems and the availability of cultivars that differ in chilling requirement, flowering period, ripening time and fruit-quality traits. Modern cultivar evaluation therefore increasingly integrates phenological and pomological indicators, because flowering and ripening schedules directly influence market timing, harvest logistics, frost exposure and fruit-quality stability.

In Georgia, blueberry production has gained particular importance in the western part of the country, where humid climatic conditions, naturally acidic soils in many production areas and access to Black Sea regional markets create favorable conditions for commercial cultivation. Earlier Georgian studies identified blueberry as a promising crop for national horticultural development and described its biological characteristics and cultivation requirements under local conditions. Subsequent investigations in Adjara and neighboring Guria emphasized cultivar-specific differences in growth, phenological development and adaptation potential (Jabnidze & Jabnidze, 2015; Jabnidze et al., 2017; Tsintsadze & Bobokashvili, 2023).

Phenology is one of the most informative indicators of cultivar adaptation because it reflects the interaction among genotype, environment and annual weather conditions. The timing of bud swelling, vegetative growth, flowering, fruit set, ripening, secondary shoot growth, flower-bud initiation and leaf senescence provides practical information on the suitability of a cultivar for a particular production environment. In blueberry, these relationships are especially important because early spring warming may accelerate budbreak and flowering, whereas late frosts, prolonged rainfall and unfavorable pollination conditions may negatively affect fruit set and yield. Flowering phenology is highly responsive to temperature and may be modeled using heat-accumulation approaches (Kirk & Isaacs, 2012). Under increasing climatic variability, chilling requirement, freeze tolerance, deacclimation dynamics and flowering and fruiting phenology have become critical determinants of production resilience (Lobos & Hancock, 2015; Chu, 2025).

International studies confirm substantial variation in blueberry phenology among cultivars and production environments. In Romania, cultivar identity and climatic year influenced the onset of vegetation, flowering and ripening, with phenological stages evaluated by BBCH and Julian-day approaches

(Cosmulescu et al., 2022). A multi-year evaluation of 32 cultivars in the Czech Republic further demonstrated the value of combining phenological and pomological traits for breeding and cultivation decisions (Pavliuk et al., 2025). More recently, the codification of highbush blueberry developmental stages according to the BBCH scale has provided a standardized framework for phenological monitoring and cross-regional comparison (Wichura et al., 2024). Within this context, evaluating introduced blueberry cultivars under the contrasting agroecological conditions of Kobuleti, Khelvachauri and Qeda are scientifically justified and practically relevant.

The aim of this study was to evaluate the phenological development and biometric performance of the introduced highbush blueberry cultivars Legacy, Bluegold and Duke under the agroecological conditions of Adjara, Western Georgia, and to assess their preliminary adaptation potential for commercial cultivation.

The specific objectives were to systematize the principal phenological stages of the selected cultivars during the 2024 growing season; to compare vegetation onset, flowering time, flowering duration and fruit-ripening periods among cultivars and municipalities; to evaluate bush height and annual shoot length as indicators of vegetative vigor; to convert reported calendar dates into day-of-year values and summarize the dataset descriptively; and to formulate preliminary recommendations for cultivar zoning, monitoring strategies and future replicated field trials in Adjara.

## 2. MATERIALS AND METHODS

### 2.1. Study area and plant material

The study was conducted during the 2024 growing season in three municipalities of Adjara, Western Georgia: Kobuleti, Khelvachauri and Qeda. These municipalities represent contrasting agroecological environments within the region and differ in altitude, thermal regime and degree of coastal climatic influence.

Kobuleti is located in the Black Sea coastal zone and is characterized by a humid subtropical climate, relatively mild winters and early spring warming, conditions that generally promote earlier phenological development. Khelvachauri represents an intermediate agroecological zone influenced by both coastal and inland climatic conditions. Qeda is situated in a more elevated inland area, where cooler temperatures and delayed spring warming generally result in later phenological development.

The plant material consisted of three introduced highbush blueberry (*V. corymbosum* L.) cultivars: Legacy, Bluegold and Duke. These cultivars are widely used in commercial blueberry production systems and differ in growth vigor, flowering phenology, ripening period and adaptation characteristics (Retamales & Hancock, 2018; Pavliuk et al., 2025). Their

contrasting phenological profiles make them suitable candidates for evaluating cultivar adaptation under the diverse environmental conditions of Adjara.

## 2.2. Phenological observations and data processing

Phenological observations were derived from the primary field dataset reported by Zoidze (2025). The available data included records of vegetation onset, flowering initiation, flowering termination, flowering duration, ripening onset and ripening termination for each cultivar-location combination.

The original monitoring program also included additional developmental stages, including bud swelling, fruit set, green fruit development, secondary vegetative growth, flower-bud initiation and leaf fall. Because quantitative information for these stages was not consistently available in tabulated form, only the phenological variables that could be processed consistently were included in the present descriptive analysis.

To enable comparison among cultivars and locations, reported calendar dates were converted into day-of-year (DOY) values. For date intervals presented as ranges, midpoint values were calculated and used only for descriptive visualization and summary statistics. These transformations supported the preparation of comparative phenological calendars and graphical representations of flowering and ripening dynamics.

Phenological stages were interpreted according to internationally accepted principles of blueberry phenological assessment. Future monitoring in Georgia should adopt the standardized BBCH scale proposed for highbush blueberry by Wichura et al. (2024), which would improve comparability among cultivars, locations, years and research programs.

## 2.3. Biometric measurements and statistical approach

Biometric characterization was based on two vegetative growth parameters: bush height and annual shoot length. These variables were selected as practical indicators of vegetative vigor and preliminary adaptation under local

growing conditions. Bush height was recorded as reported in the source dataset, while annual shoot length was presented as an observed range. For descriptive summaries and graphical visualization, midpoint values of the reported shoot-length ranges were calculated.

The interpretation of vegetative vigor was undertaken cautiously because plant growth can be influenced by factors beyond cultivar genetics, including pruning intensity, crop load, soil properties, nutrient availability, irrigation, plant age and local management practices (Jabnidze et al., 2017; Retamales & Hancock, 2018). Therefore, the biometric results should be treated as preliminary indicators of cultivar performance rather than definitive measures of genetic potential.

Because the available dataset consisted of one observation for each cultivar-by-location combination and did not include replicated plot-level measurements, inferential statistical testing was not conducted. The analysis was limited to descriptive statistics, including means, standard deviations and coefficients of variation where appropriate. The results are therefore interpreted as preliminary and hypothesis-generating.

## 3. RESULTS

### 3.1. Cultivar differences in flowering and ripening phenology

The phenological observations revealed clear differences among cultivars in vegetation onset, flowering initiation, flowering duration and fruit-ripening dynamics (Tables 1 and 2; Figures 1-3). Legacy consistently showed the earliest vegetation onset across all municipalities, beginning on 17 February in Kobuleti, 21 February in Khelvachauri and 29 February in Qeda. Bluegold and Duke generally initiated vegetative development later, particularly under the cooler conditions of Qeda.

**Table 1.** Phenological characteristics of three introduced highbush blueberry cultivars evaluated in Adjara during the 2024 growing season.

Municipality	Cultivar	Vegetation start	Flowering start	Flowering end	Flowering duration (days)	Ripening start	Ripening end
Kobuleti	Legacy	17.02	20-21.03	19-23.04	27-29	24-26.05	9-12.06
Kobuleti	Bluegold	1-2.03	3-5.04	5-7.05	28-29	9-11.06	25-27.06
Kobuleti	Duke	25-27.03	2-4.04	23-25.04	20-22	20-22.05	3-5.06
Khelvachauri	Legacy	21.02	23-25.03	25-27.04	27-28	29-30.05	15-17.06
Khelvachauri	Bluegold	5-7.03	8-9.04	10-11.05	26-27	13-15.06	29-30.06
Khelvachauri	Duke	28-30.03	5-7.04	27-28.04	20-21	23-25.05	5-7.06
Qeda	Legacy	29.02	2-4.04	3-5.05	26-28	7-9.06	20-22.06

Municipality	Cultivar	Vegetation start	Flowering start	Flowering end	Flowering duration (days)	Ripening start	Ripening end
Qeda	Bluegold	14-16.03	15-17.04	19-21.05	25-26	21-23.06	7-9.07
Qeda	Duke	3-6.04	11-13.04	2-5.05	22-24	2-4.06	11-14.06

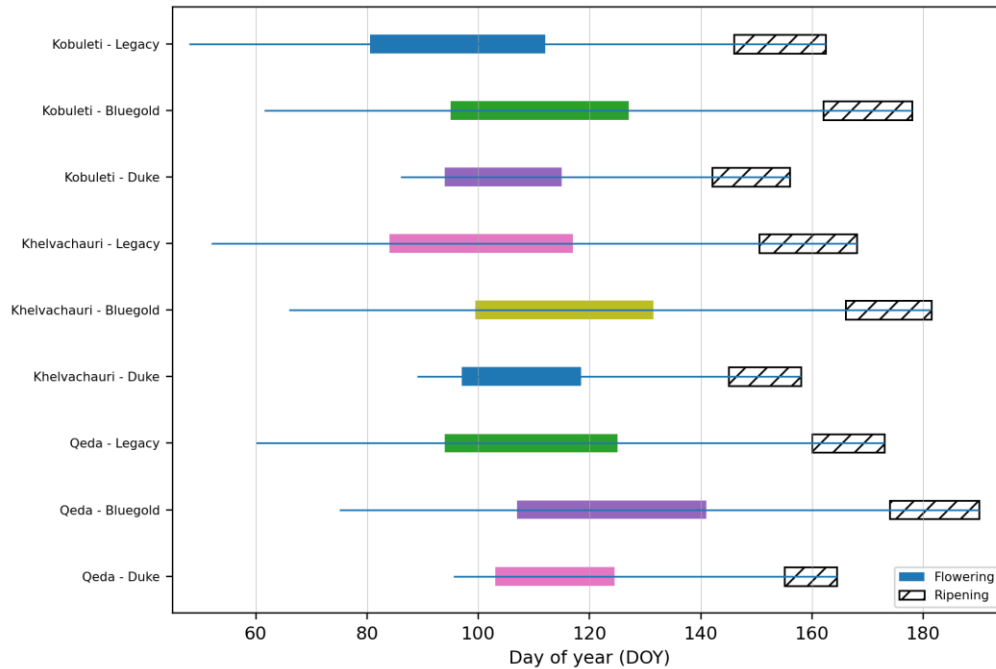
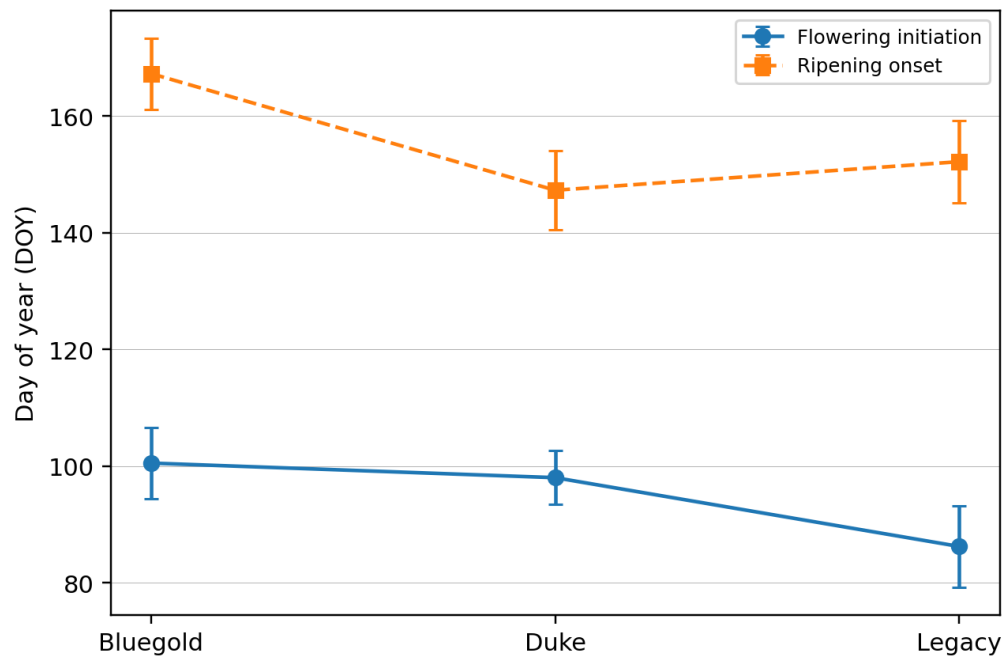
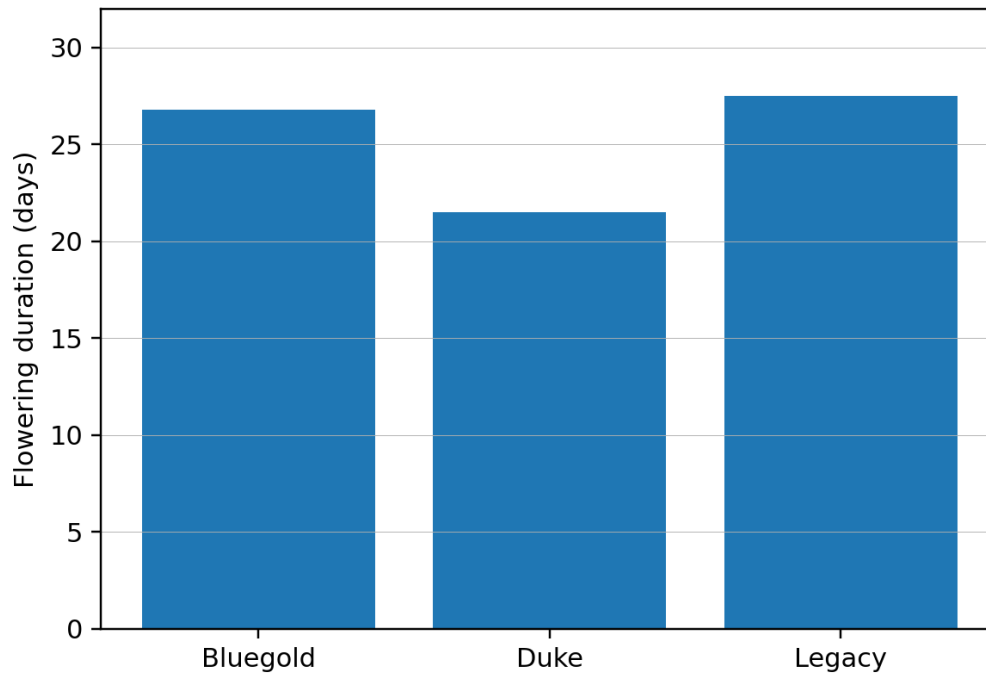


Figure 1. Phenological calendar showing vegetation onset, flowering period and ripening period of three highbush blueberry cultivars across the municipalities of Adjara



**Figure 2.** Mean flowering initiation and ripening onset of the evaluated cultivars expressed as day-of-year (DOY) values. Error bars represent descriptive standard deviations among municipalities



**Figure 3.** Mean flowering duration of highbush blueberry cultivars across the three municipalities of Adjara

Legacy also entered the flowering stage earlier than the other cultivars. Mean flowering initiation occurred on DOY 86.2 in Legacy, compared with DOY 98.0 in Duke and DOY 100.5 in Bluegold (Table 2). Flowering duration was relatively stable

across locations, averaging 27.5 days in Legacy, 26.8 days in Bluegold and 21.5 days in Duke.

**Table 2.** Cultivar-level descriptive statistics of selected phenological and biometric traits.

Cultivar	Mean vegetation start (DOY)	Mean flowering start (DOY)	SD flowering start (days)	Mean ripening start (DOY)	SD ripening start (days)	Mean flowering duration (days)	Mean bush height (m)	Mean annual shoot midpoint (cm)	CV annual shoot midpoint (%)
Bluegold	67.5	100.5	6.1	167.3	6.1	26.8	1.5	18.5	19.5
Duke	90.2	98.0	4.6	147.3	6.8	21.5	1.5	27.5	48.1
Legacy	53.3	86.2	7.0	152.2	7.1	27.5	2.0	60.5	19.3

Note: DOY = day of year; SD = standard deviation; CV = coefficient of variation. Values summarize location-to-location variation across the three municipalities and are descriptive only

Differences among cultivars were also evident in fruit-ripening dynamics. Duke showed the earliest mean ripening onset (DOY 147.3), followed by Legacy (DOY 152.2) and Bluegold (DOY 167.3). The latest ripening period was recorded in Bluegold,

particularly in Qeda, where fruit ripening extended into early July (Table 1). These cultivar-level averages indicate that Legacy combined early vegetative and reproductive development with prolonged flowering duration, whereas

Bluegold exhibited the latest phenological progression and Duke occupied an intermediate position for flowering initiation while showing the earliest average ripening onset.

### 3.2. Municipality-related variation in phenological timing

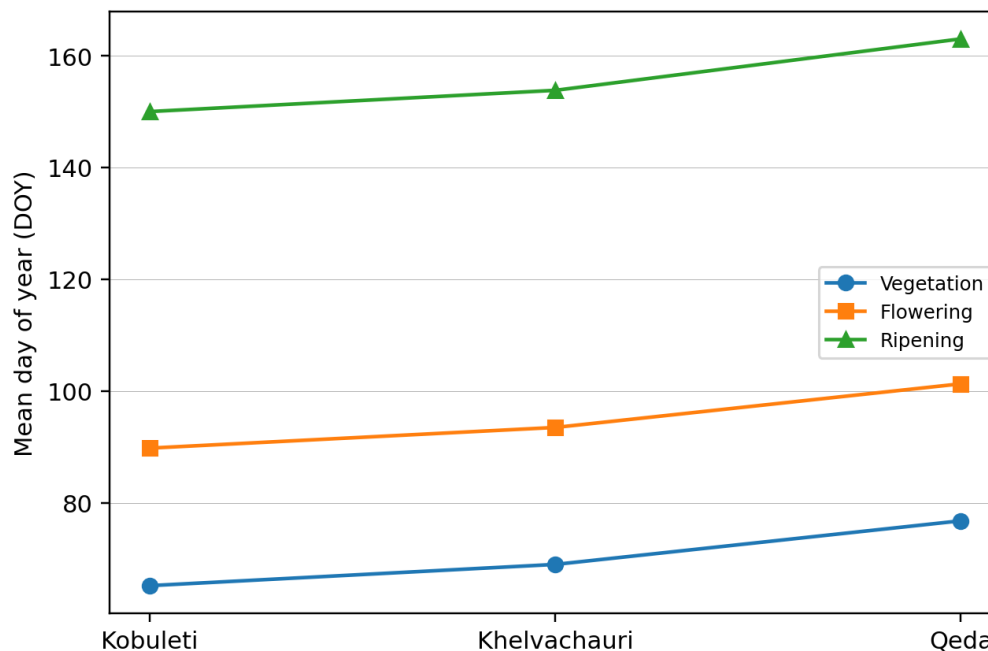
Location-related shifts in phenological development were observed among the three municipalities (Table 3; Figure 4).

Kobuleti exhibited the earliest mean vegetation onset (DOY 65.2), flowering initiation (DOY 89.8) and ripening onset (DOY 150.0). Khelvachauri displayed intermediate values for all phenological parameters, whereas Qeda consistently showed delayed development.

**Table 3.** Municipality-level descriptive statistics of phenological development and vegetative growth indicators.

Municipality	Mean vegetation start (DOY)	Mean flowering start (DOY)	Mean ripening start (DOY)	Mean ripening end (DOY)	Mean bush height (m)
Kobuleti	65.2	89.8	150.0	165.5	1.9
Khelvachauri	69.0	93.5	153.8	169.2	1.7
Qeda	76.8	101.3	163.0	175.8	1.5

Note: Values are means across the three cultivars within each municipality; descriptive summary only



**Figure 4.** Municipality-related variation in mean vegetation onset, flowering initiation and ripening onset

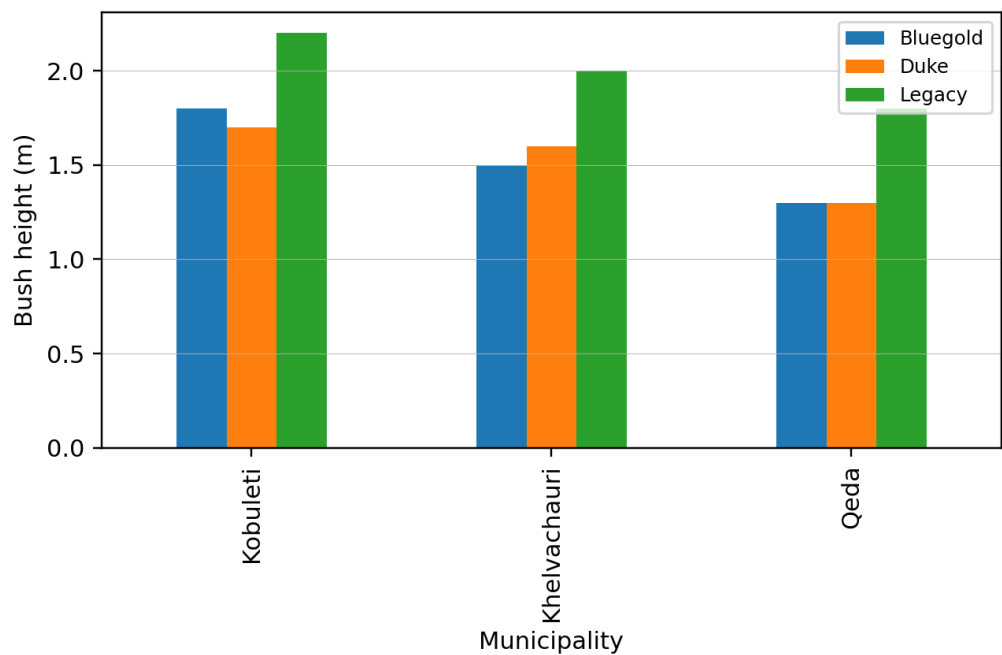
The magnitude of these differences was evident across all cultivars. For example, vegetation onset in Legacy occurred on 17 February in Kobuleti but on 29 February in Qeda. Similarly, the ripening period of Legacy shifted from late May-early June in Kobuleti to June in Qeda. Average ripening termination also differed among municipalities, occurring on DOY 165.5 in Kobuleti, DOY 169.2 in Khelvachauri and DOY 175.8 in Qeda (Table 3). These results demonstrate a progressive delay in phenological development from the coastal municipality of Kobuleti toward the more upland conditions of Qeda.

### 3.3. Biometric performance of cultivars

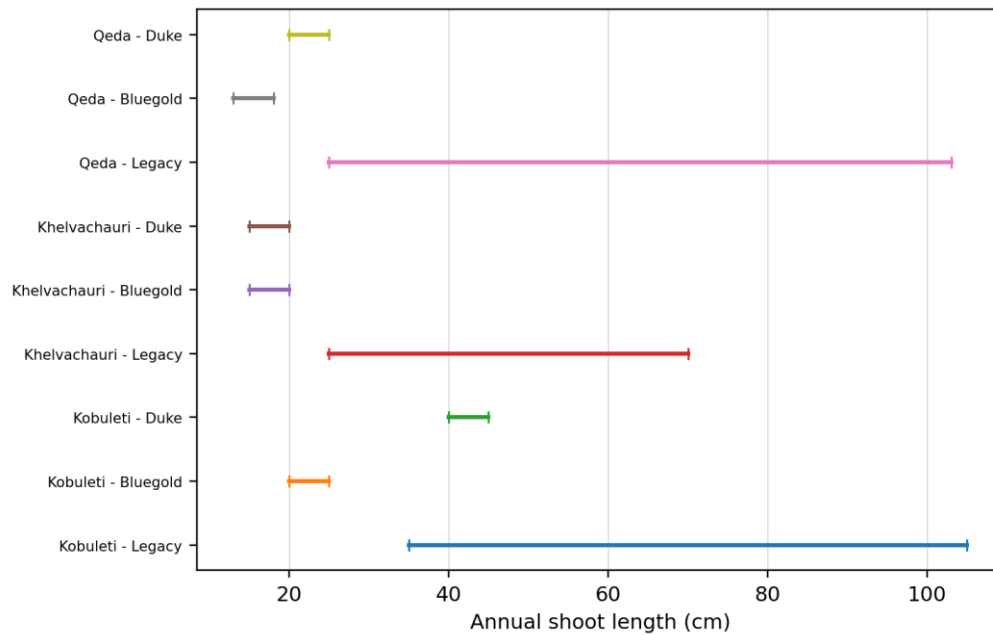
Biometric measurements revealed notable differences in vegetative growth among cultivars and locations (Tables 2 and 4; Figures 5 and 6). Legacy exhibited the greatest vegetative vigor across all municipalities. Bush height reached 2.2 m in Kobuleti, 2.0 m in Khelvachauri and 1.8 m in Qeda. The same cultivar also produced the longest annual shoots, with observed maximum values of 105 cm in Kobuleti and 103 cm in Qeda.

**Table 4.** Biometric characteristics of the evaluated blueberry cultivars across three municipalities of Adjara.

Municipality	Cultivar	Bush height (m)	Annual shoot length (cm)
Kobuleti	Legacy	2.2	35-105
Kobuleti	Bluegold	1.8	20-25
Kobuleti	Duke	1.7	40-45
Khelvachauri	Legacy	2.0	25-70
Khelvachauri	Bluegold	1.5	15-20
Khelvachauri	Duke	1.6	15-20
Qeda	Legacy	1.8	25-103
Qeda	Bluegold	1.3	13-18
Qeda	Duke	1.3	20-25



**Figure 5.** Bush height of the evaluated blueberry cultivars in Kobuleti, Khelvachauri and Qeda



**Figure 6.** Observed annual shoot-length ranges of the evaluated cultivars across municipalities

Bluegold displayed comparatively lower vegetative growth. Bush height ranged from 1.3 to 1.8 m across municipalities, while annual shoot length varied between 13 and 25 cm, with the lowest values recorded in Qeda. Duke showed intermediate biometric characteristics. Bush height ranged from 1.3 to 1.7 m, while annual shoot length varied between 15 and 45 cm. Compared with Legacy, Duke produced shorter annual shoots but maintained relatively consistent growth across municipalities.

Cultivar-level descriptive statistics confirmed these patterns (Table 2). Legacy achieved the highest mean bush height (2.0 m) and the greatest mean annual shoot midpoint value (60.5 cm), whereas Bluegold and Duke both averaged 1.5 m in bush height. Coefficients of variation for annual shoot midpoint values ranged from 19.3% in Legacy to 48.1% in Duke, indicating differences in growth consistency across locations.

The descriptive statistical analysis provided an integrated overview of cultivar- and municipality-level variation in phenological and biometric traits (Tables 2 and 3). Among cultivars, Legacy recorded the earliest mean vegetation onset and flowering initiation as well as the highest mean bush height. Duke exhibited the earliest mean ripening onset, while Bluegold recorded the latest mean ripening onset.

Variation among municipalities followed a consistent spatial pattern. Mean vegetation onset progressed from DOY 65.2 in Kobuleti to DOY 76.8 in Qeda. Mean flowering initiation increased from DOY 89.8 in Kobuleti to DOY 101.3 in Qeda, while mean ripening onset shifted from DOY 150.0 to DOY 163.0 over the same gradient. Overall, the descriptive statistics confirmed distinct cultivar-specific and location-related patterns in phenological development and vegetative growth under the agroecological conditions represented in this study.

### 3.4. Descriptive statistical summary

**Appendix Table A1.** Converted day-of-year and midpoint values used for descriptive visualization and statistical summaries.

Municipality	Cultivar	Vegetation start DOY	Flowering start DOY	Flowering end DOY	Ripening start DOY	Ripening end DOY	Flowering duration midpoint	Annual shoot midpoint (cm)
Kobuleti	Legacy	48.0	80.5	112.0	146.0	162.5	28.0	70.0
Kobuleti	Bluegold	61.5	95.0	127.0	162.0	178.0	28.5	22.5
Kobuleti	Duke	86.0	94.0	115.0	142.0	156.0	21.0	42.5

Municipality	Cultivar	Vegetation start DOY	Flowering start DOY	Flowering end DOY	Ripening start DOY	Ripening end DOY	Flowering duration midpoint	Annual shoot midpoint (cm)
Khelvachauri	Legacy	52.0	84.0	117.0	150.5	168.0	27.5	47.5
Khelvachauri	Bluegold	66.0	99.5	131.5	166.0	181.5	26.5	17.5
Khelvachauri	Duke	89.0	97.0	118.5	145.0	158.0	20.5	17.5
Qeda	Legacy	60.0	94.0	125.0	160.0	173.0	27.0	64.0
Qeda	Bluegold	75.0	107.0	141.0	174.0	190.0	25.5	15.5
Qeda	Duke	95.5	103.0	124.5	155.0	164.5	23.0	22.5

Note: DOY = day of year. Values were calculated from the midpoint of source date ranges. Midpoint values are descriptive only

#### 4. DISCUSSION

The present study demonstrated cultivar-specific and location-related differences in phenological development and vegetative growth among the introduced highbush blueberry cultivars Legacy, Bluegold and Duke under the agroecological conditions of Adjara. Although the dataset is limited to a single growing season and does not include replicated experimental observations, the observed patterns provide useful preliminary evidence regarding cultivar adaptation and production potential in Western Georgia.

Legacy consistently showed the earliest vegetation onset and flowering initiation across all municipalities. Early phenological development may be advantageous for growers targeting premium early-season markets, because fruit can be harvested before peak supply. However, early development may also increase vulnerability to late spring frost events and unfavorable pollination conditions. Similar relationships

between early flowering and environmental risk exposure have been reported in blueberry studies showing that flowering phenology is highly responsive to temperature accumulation and seasonal climatic variability (Kirk & Isaacs, 2012). Consequently, the early developmental pattern observed in Legacy should be interpreted as both an agronomic advantage and a management challenge, particularly under increasingly variable spring weather conditions.

Duke showed relatively later vegetation onset and flowering while maintaining the earliest average ripening onset among the evaluated cultivars. This combination is practically important because delayed flowering may reduce exposure to damaging spring weather while still allowing commercially attractive harvest timing. Previous research has emphasized the importance of integrating flowering phenology, chilling requirements, freeze tolerance and deacclimation dynamics when evaluating blueberry adaptation to changing climatic

conditions (Lobos & Hancock, 2015; Chu, 2025). The phenological profile observed in Duke therefore suggests a potentially favorable balance between production security and market timing.

Bluegold displayed the latest ripening pattern and comparatively weaker vegetative growth in the available observations. Although later ripening may reduce competitiveness in premium early-season markets, it can contribute to extending the harvest period and diversifying production schedules. This characteristic may be especially relevant for cooler production zones, where delayed phenological development can support a more continuous supply of fresh fruit. The extension of ripening into July in Qeda illustrates the importance of matching cultivar selection with local environmental conditions.

The municipality-level differences further emphasize the need for microzonal evaluation. Phenological development consistently occurred earliest in Kobuleti, was intermediate in Khelvachauri and was delayed in Qeda. These differences likely reflect variation in temperature regime, altitude and local climatic conditions. Similar genotype-by-environment interactions have been documented in blueberry production systems worldwide. For example, Cosmulescu et al. (2022) reported significant effects of cultivar identity and climatic year on blueberry phenology, while Pavliuk et al. (2025) demonstrated substantial variation in phenological and pomological traits across multiple environments and years. The present findings support the conclusion that cultivar recommendations for Adjara should be location-specific rather than based on generalized regional assumptions.

Biometric observations were generally consistent with the phenological findings. Legacy exhibited the greatest vegetative vigor, as reflected by bush height and annual shoot growth. Vigorous vegetative development may support future productivity through increased canopy formation and reproductive potential. However, excessive vegetative growth

can also influence canopy structure, light penetration and fruit-quality management unless balanced by appropriate pruning and crop-load regulation (Retamales & Hancock, 2018). Conversely, the weaker growth observed in Bluegold may reflect cultivar characteristics, environmental influences, management history or their interaction. Because the present study was not designed to isolate these effects experimentally, caution is required when interpreting biometric differences as direct indicators of genetic performance.

An important methodological implication concerns the standardization of phenological monitoring. The BBCH scale for highbush blueberry provides a comprehensive framework for describing vegetative growth, flowering, fruit development, ripening and harvest stages in a consistent manner (Wichura et al., 2024). Its adoption in Georgian blueberry research would improve comparability among studies, facilitate integration with international datasets and strengthen future phenological modeling. Such standardization is increasingly important as climate variability continues to influence crop development and production planning.

Recent research also highlights the broader significance of phenological traits in blueberry improvement. Babiker et al. (2025) reported associations between phenological variation and the stability of fruit-quality traits in cultivated tetraploid blueberry. This suggests that phenological adaptation should not be viewed solely as a determinant of flowering and harvest timing, but also as a factor potentially influencing long-term fruit quality and production stability. Future cultivar evaluation in Georgia should therefore integrate phenological, biometric, yield and fruit-quality assessments within a unified framework.

Several limitations must be acknowledged. The analysis was based on one growing season, lacked replicated plot-level measurements and did not include yield, fruit quality, soil characteristics, management practices or detailed meteorological variables. Consequently, the findings should be interpreted as preliminary and hypothesis-generating rather than definitive evidence of cultivar superiority. Multi-year replicated trials incorporating environmental, physiological and economic performance indicators are required to validate the patterns identified in this study and to support robust cultivar recommendations for commercial production.

## 5. CONCLUSIONS

The introduced highbush blueberry cultivars Legacy, Bluegold and Duke demonstrated distinct phenological and biometric responses under the agroecological conditions of Adjara, Western Georgia. The results revealed clear cultivar-specific and location-related variation in vegetation onset, flowering dynamics, ripening timing and vegetative growth.

Legacy exhibited the earliest phenological development and the greatest vegetative vigor, indicating strong preliminary adaptation potential for early-season production, particularly in coastal environments. Duke combined relatively later flowering with the earliest average ripening onset, suggesting a potentially advantageous balance between reduced exposure to spring weather risks and commercially favorable harvest timing. Bluegold displayed the latest ripening pattern and comparatively lower vegetative vigor, indicating potential value as a complementary cultivar for extending the harvest season, especially in cooler production zones.

Phenological development consistently occurred earlier in Kobuleti, was intermediate in Khelvachauri and was delayed in Qeda, highlighting the importance of location-specific cultivar evaluation. These findings demonstrate that cultivar recommendations for Adjara should consider local agroecological conditions rather than relying on uniform regional recommendations.

Although the available dataset was limited, the study provides a useful preliminary framework for cultivar zoning and adaptation assessment in Western Georgia. Future research should validate these findings through multi-year replicated trials integrating meteorological, phenological, biometric, yield, fruit-quality and pest-pressure data to support evidence-based recommendations for commercial blueberry production.

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## RESEARCH ARTICLE

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# Geophyte taxa naturally distributed in Artvin Province, Türkiye

## Artvin ilinde doğal yayılış gösteren geofit taksonları

Özgür EMİNAĞAOĞLU<sup>a,b</sup>, Haya AKYILDIRIM BEĞEN<sup>b</sup>, Bahar ASLAN<sup>b</sup>, Şevval SALIOĞLU<sup>a</sup>

<sup>a</sup> Artvin Coruh University, Faculty of Forestry, Department of Forest Engineering, Artvin, Türkiye

<sup>b</sup> Artvin Coruh University, Ali Nihat Gökyiğit Botanical Garden Application and Research Center, Artvin, Türkiye

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\*Corresponding author:

e-mail: [baharpalasoglu@artvin.edu.tr](mailto:baharpalasoglu@artvin.edu.tr)

ORCID: [0000-0002-7454-3943](https://orcid.org/0000-0002-7454-3943)

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**Anahtar Kelimeler:** Artvin, geofit, flora, fitocoğrafya, endemik bitkiler

**Keywords:** Artvin, geophytes, flora, phytogeography, endemic plants

### ÖZ

Artvin ili, Türkiye'nin kuzeydoğusunda yer almakta olup sahip olduğu geniş yükselti aralığı, farklı iklim tipleri ve zengin habitat çeşitliliği sayesinde ülkenin floristik açıdan en önemli bölgelerinden biridir. Bu çalışmada, Artvin ili ve ilçelerinde 1995 yılından 2026 yılı ilk yarısına kadar gerçekleştirilen floristik araştırmalar, herbaryum kayıtları ve ilgili literatür verileri değerlendirilerek doğal yayılış gösteren geofit taksonlarının belirlenmesi amaçlanmıştır. Çalışma kapsamında elde edilen veriler, Artvin Çoruh Üniversitesi Herbaryumu'nda (ARTH) bulunan örnekler ile desteklenmiştir. Araştırma sonucunda, çalışma alanında 26 familyaya ait 62 cins ve 205 geofit taksonu tespit edilmiştir. Belirlenen taksonlardan 22'sinin Türkiye için endemik olduğu belirlenmiş olup, endemizm oranı %10,48 olarak hesaplanmıştır. Buna karşılık, 183 taksonun endemik olmadığı belirlenmiş ve endemik olmayan taksonların oranı %89,27 olarak tespit edilmiştir. Bu taksonlardan 52'si Asgari Endişe (LC), 3'ü Tehdide Yakın (NT), 2'si Hassas (VU), 2'si Veri Yetersiz (DD) ve 1'i Uygulanamaz (NA) kategorisinde yer alırken, 123 takson için ise herhangi bir IUCN kategorisi belirtilmemiştir. Endemik taksonlardan 2'si Kritik Tehlikede (CR), 2'si Veri Yetersiz (DD) ve 1'i Asgari Endişe (LC) kategorisinde yer almaktadır. Takson sayısı bakımından en zengin familyalar Orchidaceae (48 takson, %22,86), Amaryllidaceae (41 takson, %19,52) ve Asparagaceae (25 takson, %11,90) olarak belirlenmiştir. Fitocoğrafik değerlendirme sonucunda taksonların 47'sinin (%22,38) İnan-Turan, 43'ünün (%20,48) Avrupa-Sibirya ve 10'unun (%4,76) Akdeniz fitocoğrafik bölgesi elementi olduğu belirlenmiştir. Ayrıca 105 taksonun (%50,00) geniş yayılışlı olduğu veya fitocoğrafik bölgesinin bilinmediği tespit edilmiştir.

### ABSTRACT

Artvin Province, located in northeastern Türkiye, is one of the most important floristic regions of the country due to its wide altitudinal range, diverse climatic conditions, and rich habitat diversity. In this study, naturally occurring geophyte taxa in Artvin Province and its districts were identified based on floristic surveys conducted between 1995 and the first half of 2026, together with herbarium records and relevant literature. The data obtained were further supported by specimens deposited in the Artvin Çoruh University Herbarium (ARTH). As a result of the study, a total of 205 geophyte taxa belonging to 62 genera and 26 families were identified within the study area. Of these, 22 taxa were determined to be endemic to Türkiye, corresponding to an endemism rate of 10.48%. In contrast, 183 taxa were found to be non-endemic, representing 89.27% of the total taxa. Among the non-endemic taxa, 52 were classified as Least Concern (LC), 3 as Near Threatened (NT), 2 as Vulnerable (VU), 2 as Data Deficient (DD), and 1 as Not Applicable (NA), while 123 taxa had not yet been assigned an IUCN conservation category. Among the endemic taxa, 2 were categorized as Critically Endangered (CR), 2 as Data Deficient (DD), and 1 as Least Concern (LC). In terms of taxonomic richness, the most species-rich families were Orchidaceae (48 taxa, 22.86%), Amaryllidaceae (41 taxa, 19.52%), and Asparagaceae (25 taxa, 11.90%). According to the phytogeographical evaluation, 47 taxa (22.93%) belonged to the Irano-Turanian phytogeographical region, 43 taxa (20.98%) to the Euro-Siberian phytogeographical region, and 10 taxa (4.88%) to the Mediterranean phytogeographical region. In addition, 105 taxa (51.22%) were determined to be either widely distributed or of unknown phytogeographical origin.

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## 1. GİRİŞ

Türkiye, Akdeniz, Avrupa-Sibirya ve İran-Turan fitocoğrafik bölgelerinin kesişiminde yer alması, farklı iklim tipleri, jeolojik yapısı ve topoğrafik özellikleri sayesinde dünyanın biyolojik çeşitlilik açısından öne çıkan ülkelerinden biridir (Çırpıcı, 1987; Güner ve ark., 2012). Yaklaşık 12.000 bitki taksonunu barındıran Türkiye florasında endemik takson sayısı 4.000'e yaklaşmakta olup, bu durum ülkeyi bitki çeşitliliği bakımından Avrupa'nın en zengin bölgelerinden biri haline getirmektedir (Güner ve ark., 2012).

Bu zengin floranın önemli bileşenlerinden birini geofitler oluşturmaktadır. Geofit terimi ilk kez Raunkiaer (1934) tarafından kullanılmış olup, yaşam döngülerinin elverişsiz dönemlerini soğan, yumru, rizom veya korm gibi toprak altı depo organları sayesinde geçiren çok yıllık bitkileri ifade etmektedir. Kriptofit olarak da adlandırılan bu bitkiler, dünya çiçekli bitki florasının yaklaşık %6,5–7'sini oluşturmaktadır (Ekim ve Koyuncu, 1992). Geofitler dünyanın hemen her bölgesinde yayılış göstermekle birlikte, çeşitliliklerinin önemli bir kısmı Akdeniz Havzası'nda yoğunlaşmaktadır (Ekim ve Koyuncu, 1992). Anadolu ise dünya ölçeğinde önemli geofit merkezlerinden biri olarak kabul edilmekte olup yaklaşık 100 tohumuz geofit, 1000–1200 dikotiledon geofit, 200–250 petaloid olmayan monokotiledon geofit ve yaklaşık 1000 petaloid monokotiledon geofit taksonuna ev sahipliği yapmaktadır (Demir ve Eker, 2015). Ayrıca Türkiye'deki geofit taksonlarının yaklaşık %35'inin endemik olması bu bitki grubunun biyolojik çeşitlilik ve koruma açısından önemini daha da artırmaktadır (Ekim ve ark., 1991; Sargin ve ark., 2013).

Geofitler yalnızca floristik açıdan değil, ekolojik ve ekonomik özellikleri bakımından da önemli bitki grupları arasında yer almaktadır. Toprak altı depo organlarında su ve besin maddelerini depolayabilmeleri sayesinde kuraklık, yangın ve benzeri çevresel stres koşullarına karşı yüksek dayanıklılık göstermektedirler (Baktır ve ark., 1997; Elinç, 1997). Yangın sonrasında vejetasyonda yeniden ortaya çıkan ilk bitkiler arasında yer almaları ve kurak dönemlerden sonra hızlı gelişim gösterebilmeleri bu özelliklerinin bir sonucudur. Bunun yanında geofitler, tarih boyunca insanlar tarafından gıda, tıp ve çeşitli endüstriyel alanlarda değerlendirilmiştir. Birçok geofit türü tıbbi ve aromatik özellikleri nedeniyle geleneksel

tedavilerde yaygın olarak kullanılmakta, günümüzde ise farmasötik ve kozmetik sektörleri için önemli doğal hammadde kaynakları oluşturmaktadır (Baytop, 1999; Tanker ve ark., 2007). Özellikle *Anemone*, *Crocus*, *Colchicum*, *Cyclamen*, *Fritillaria*, *Galanthus*, *Iris*, *Leucojum*, *Muscari*, *Ornithogalum*, *Orchis* ve *Scilla* cinslerine ait taksonlardan elde edilen çeşitli bileşikler modern tıpta kullanılmaktadır (Sargin ve ark., 2013). Örneğin galantamin alkaloidi *Galanthus* türlerinden, kolşisin ise *Colchicum* türlerinden elde edilmektedir (Akram ve ark., 2012). Ancak habitat tahribatı, aşırı otlatma, tarımsal faaliyetler, yangınlar, yol yapım çalışmaları ve kaçak bitki toplama faaliyetleri birçok geofit türü için önemli tehditler oluşturmaktadır (Ekim ve Koyuncu, 1992; Mammadov ve Sahranç, 2003).

Son yıllarda Türkiye'nin farklı bölgelerinde gerçekleştirilen floristik çalışmalar, geofitlerin taksonomik çeşitliliği, yayılışları ve koruma durumları hakkında önemli bilgiler sağlamıştır (Malyer, 1983; Mammadov ve Sahranç, 2003; Çelik ve ark., 2004; Eker ve ark., 2008; Çingay ve ark., 2012; Avcu ve ark., 2016; Demirelma ve Ertuğrul, 2016; Altundağ Çakır, 2017; Akbaş ve Varol, 2017; Yüce Babacan ve Eker, 2017; Değerli ve Varol, 2018). Bununla birlikte, Türkiye'nin biyolojik çeşitlilik bakımından en önemli merkezlerinden biri olan Artvin'de geofit taksonlarının tamamını kapsayan çalışmalar sınırlı sayıdadır.

Artvin, Kafkasya Biyoçeşitlilik Sıcak Noktası içerisinde yer alan ve Türkiye'nin biyolojik çeşitlilik bakımından en önemli illerinden biri olarak kabul edilen bir bölgedir (Eminağaoğlu, 2015). İl sınırları içerisinde Karçal Dağları, Çoruh Vadisi, Doğu Karadeniz Dağları ve Yalnızçam Dağları olmak üzere dört Önemli Bitki ve Doğa Alanı, Camili Biyosfer Rezervi, iki milli park, üç tabiatı koruma alanı ve beş tabiat parkı bulunmaktadır. Ayrıca Artvin, küresel ölçekte korunması öncelikli 200 ekobölgeden biri olan Kafkasya-Anadolu-Hirkan Ilıman Ormanları Ekobölgesi ile Kuzeydoğu Anadolu Bitki Çeşitliliği Merkezi sınırları içerisinde yer almaktadır (Eminağaoğlu, 2015).

Yaklaşık 4000 m'ye ulaşan yükselti farkı, Akdeniz, karasal ve okyanusal iklim tiplerinin birlikte etkili olması, zengin su kaynakları ile jeolojik ve jeomorfolojik çeşitlilik Artvin'de çok farklı habitatların oluşmasına olanak sağlamaktadır. Bu özellikler sonucunda il, 137 familya ve 761 cinse ait 2.727 doğal damarlı bitki taksonunu

barındırmakta olup Türkiye'nin damarlı bitki çeşitliliği bakımından en zengin ilidir. Bu taksonların 198'i endemik, 302'si ise nadir olmak üzere toplam 500 takson tehdit altında kabul edilmektedir (Eminağaoğlu, 2015). Ayrıca Türkiye'de tıbbi ve aromatik özellik taşıdığı belirlenen yaklaşık 1.400 bitki taksonununun 850'si (%60),

## 2. MATERYAL VE YÖNTEM

### 2.1. Araştırma Alanı

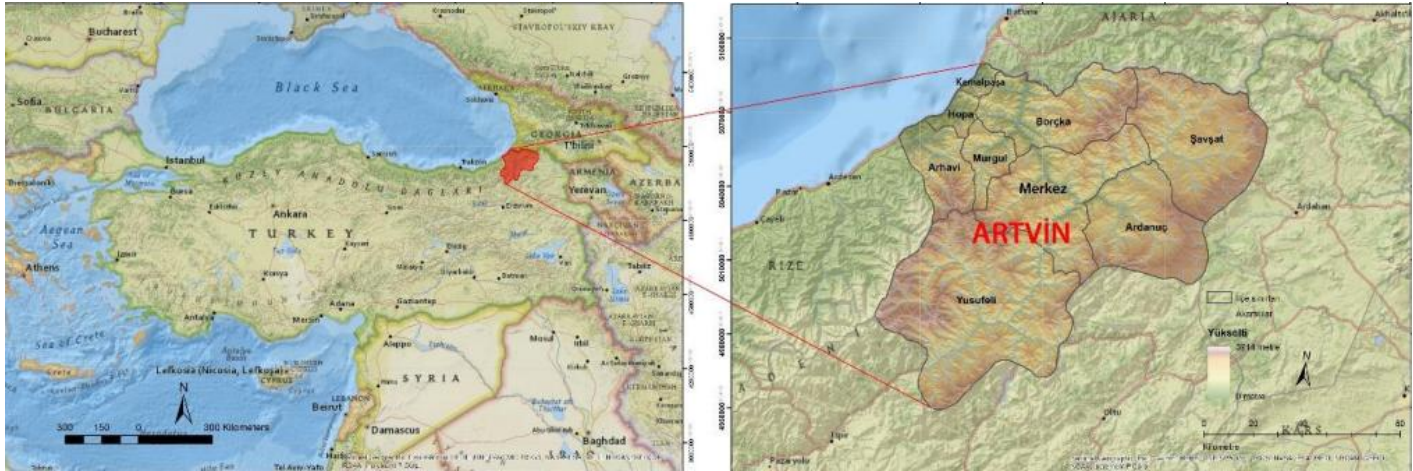
Araştırma alanını Türkiye'nin kuzeydoğusunda yer alan Artvin ili oluşturmaktadır. Artvin, yaklaşık 40°35'–41°32' kuzey enlemleri ile 41°07'–42°26' doğu boylamları arasında yer almakta olup Gürcistan ile sınır komşusudur (Şekil 1). İl, deniz seviyesinden başlayarak Kaçkar Dağları'nın en yüksek noktalarında 3937 m'ye ulaşan geniş bir yükselti aralığına sahiptir. Dağlık ve engebeli topoğrafyası, zengin su kaynakları ve farklı iklim tiplerinin etkisi altında bulunması nedeniyle çok çeşitli habitatları bünyesinde barındırmaktadır.

Fitocoğrafik açıdan Artvin, Holarktık Flora Alemi içerisinde Avrupa-Sibirya Fitocoğrafik Bölgesi'nin Kolşik (Colchic) alt bölgesinde yer almakta olup, Davis'in

ticarete konu olan yaklaşık 500 tıbbi-aromatik bitki türünün ise 350'si (%70) Artvin'de doğal yayılış göstermektedir (Özhatay ve ark., 2022; Eminağaoğlu ve Akyıldırım Beğen, 2023; Eminağaoğlu ve ark., 2022; Eminağaoğlu, 2023).

kareleme sistemine göre büyük ölçüde A8 ve A9 kareleri içerisinde bulunmaktadır (Davis ve ark. 1965; Zohary, 1973). İl sınırları içerisinde kıyı ekosistemleri, yapraklı ve iğne yapraklı ormanlar, subalpin ve alpin çayırlar, kayalık alanlar, sulak alanlar ve dere kenarı vejetasyonu gibi farklı ekosistemler yayılış göstermektedir.

Yaklaşık 7.436 km<sup>2</sup> yüzölçümüne sahip olan Artvin, sahip olduğu habitat çeşitliliği, yaklaşık 4000 m'ye ulaşan yükselti farkı ve Akdeniz, karasal ve okyanusal iklim tiplerinin birlikte etkisi altında bulunması nedeniyle Türkiye'nin floristik açıdan en zengin bölgelerinden biri olarak kabul edilmektedir (Eminağaoğlu, 2015).



Şekil 1. Araştırma alanının konumu (Artvin, Türkiye)

## 2.2. Geofit Taksonlarının Toplanması ve Teşhisi

Bu çalışmanın materyalini, 1995 yılından 2026 yılı ilk yarısına kadar Artvin ilinin farklı ilçelerinde gerçekleştirilen arazi çalışmaları sırasında toplanan geofit bitki örnekleri ile Artvin Çoruh Üniversitesi Herbariyumu'nda (ARTH) bulunan geofit örnekleri oluşturmaktadır. Arazi çalışmaları, geofit türlerin vejetatif ve generatif dönemleri dikkate alınarak farklı yükselti ve habitatlarda yürütülmüştür. Bu kapsamda ormanlık alanlar, açıklıklar, çayırlar, alpin ve subalpin alanlar, kayalık yamaçlar, sulak alanlar, dere kenarları ve yol kenarı habitatları ziyaret edilmiştir.

Arazi çalışmaları sırasında geofit taksonlara ait örnekler çiçekli ve/veya meyveli dönemlerinde toplanmış, lokalite bilgileri kaydedilmiş, koordinatları GPS yardımıyla belirlenmiş ve doğal ortamlarında fotoğraflanmıştır. Çalışma ayrıca ilgili floristik literatür ve herbariyum kayıtları ile desteklenmiştir (Eminağaoğlu ve Anşin, 2003, 2004, 2005; Eminağaoğlu ve ark., 2007; Eminağaoğlu, 2009, 2012, 2015; Güner ve ark., 2012; Eminağaoğlu ve Özcan, 2013; Eminağaoğlu ve ark., 2018a, 2018b; Camadan ve ark., 2023; Eminağaoğlu ve Akyıldırım Beğen, 2024).

Toplanan örnekler standart herbariyum tekniklerine uygun olarak preslenmiş ve kurutularak Artvin Çoruh Üniversitesi Herbariyumu'nda (ARTH) muhafaza altına alınmıştır. Bitki örneklerinin teşhisinde başta *Flora of Turkey and the East Aegean Islands* (Davis, 1965–1985; Davis ve ark., 1988; Güner ve ark., 2000) ve *Resimli Türkiye Florası* (Güner, ed., 2014–2022) olmak üzere temel flora kaynaklarından yararlanılmıştır. Ayrıca *Flora USSR* (Komarov, 1934–1964), *Flora Kavkaza* (Grossheim, 1939–1967), çeşitli bölgesel flora çalışmaları, resimli bitki atlasları (Özhatay ve ark., 2010; Eminağaoğlu ve Aksu, 2015) ve ARTH'ta bulunan karşılaştırma materyalleri

kullanılmıştır. Takson isimleri güncel nomenklatüre göre kontrol edilmiş ve değerlendirilmiştir.

Teşhisi tamamlanan tüm örnekler ARTH Herbariyumu'na kaydedilmiş olup, herbariyum verileri OTUBUR üzerinden çevrim içi olarak erişime açıktır. Bu nedenle, türlere ait ayrıntılı lokalite bilgileri bu çalışmada ayrıca sunulmamıştır.

## 2.3. Veri Analizi

Belirlenen geofit taksonları familya, cins ve tür düzeyinde değerlendirilmiştir. Taksonların fitocoğrafik bölge dağılımları, endemizm durumları ve tehdit kategorileri ilgili literatür kaynakları doğrultusunda belirlenmiştir. Ayrıca geofit taksonları sahip oldukları toprak altı depo organlarının özelliklerine göre soğanlı, yumrulu, rizomlu ve kormlu geofitler şeklinde sınıflandırılmıştır. Elde edilen veriler sayısal olarak değerlendirilmiş, familyalara, fitocoğrafik bölgelere ve depo organı tiplerine göre dağılımları hesaplanmış ve sonuçlar tablo ve grafikler halinde sunulmuştur.

## 3. BULGULAR

Araştırma kapsamında belirlenen geofit taksonları, güncel taksonomik sınıflandırmalar doğrultusunda değerlendirilmiş; familya, cins ve tür düzeyinde alfabetik sıraya göre düzenlenmiştir. Belirlenen taksonların 22'si endemik olup, endemizm oranı %10,48 olarak hesaplanmıştır. Endemik taksonlardan 2'si Kritik Tehlikede (CR), 2'si Veri Yetersiz (DD) ve 1'i Asgari Endişe (LC) kategorisinde yer alırken, 17 taksonun IUCN tehlike kategorisi henüz değerlendirilmemiştir (IUCN, 2025). Belirlenen geofit taksonlarına, endemizm durumlarına ve IUCN tehlike kategorilerine ilişkin ayrıntılı bilgiler Tablo 1'de sunulmuştur. Çalışma kapsamında belirlenen bazı endemik geofit taksonlarına ait örnekler ise Şekil 2'de sunulmuştur.

**Tablo 1.** Artvin ilinde doğal yayılış gösteren geofit taksonları

No.	Familya	Takson	Türkçe Adı	Geofit Tipi	Fitocoğrafik Bölge	IUCN	Herbariyum Kodu
1	Amaryllidaceae	<i>Allium affine</i> Ledeb.	Yabani soğan	Soğanlı	İran-Turan elementi	LC	ARTH 18260
2	Amaryllidaceae	<i>Allium albotunicatum</i> O.Schwarz	Ak soğan	Soğanlı	D. Akdeniz elementi	NA	ARTH 18261
3	Amaryllidaceae	<i>Allium artvinense</i> Miscz.	Acıkörmen	Soğanlı	İran-Turan elementi		ARTH 18262
4	Amaryllidaceae	* <i>Allium asperiflorum</i> Miscz.	Benekli soğan	Soğanlı	İran-Turan elementi		ARTH 12547
5	Amaryllidaceae	<i>Allium atroviolaceum</i> Boiss.	Lifli körmen	Soğanlı		DD	ARTH 18263
6	Amaryllidaceae	<i>Allium aucheri</i> Boiss.	Mavi soğan	Soğanlı	İran-Turan elementi		ARTH 12574
7	Amaryllidaceae	* <i>Allium balansae</i> Boiss.	Çakıl soğanı	Soğanlı	İran-Turan elementi		ARTH 12564
8	Amaryllidaceae	<i>Allium cardiostemon</i> Fisch. & C.A.Mey.	Yamaç körmeni	Soğanlı	İran-Turan elementi		ARTH 801
9	Amaryllidaceae	* <i>Allium czelghauricum</i> Bordz.	Gölesoğanı	Soğanlı	İran-Turan elementi	CR	ARTH 18265

10	Amaryllidaceae	<i>Allium decipiens</i> Fisch. ex Schult. & Schult.f.	Gelin soğanı	Soğanlı		LC	ARTH 18266
11	Amaryllidaceae	<i>Allium denudatum</i> F.Delaroche.	Kafkas soğanı	Soğanlı	İran-Turan elementi		ARTH 18267
12	Amaryllidaceae	<i>Allium dictyoprasum</i> C.A.Mey. ex Kunth	Top soğan	Soğanlı	İran-Turan elementi		ARTH 18268
13	Amaryllidaceae	* <i>Allium djimilense</i> Boiss. ex Regel	Cimil soğanı	Soğanlı	Karadeniz (dağ) elementi		ARTH 15427
14	Amaryllidaceae	<i>Allium flavum</i> subsp. <i>tauricum</i> var. <i>tauricum</i> (Besser ex Rchb.) Stearn	—	Soğanlı	Akdeniz elementi		ARTH 18269
15	Amaryllidaceae	<i>Allium fuscoviolaceum</i> Fomin	Karasırmo	Soğanlı	İran-Turan elementi		ARTH 18270
16	Amaryllidaceae	<i>Allium gramineum</i> K. Koch	Çayır soğanı	Soğanlı	İran-Turan elementi		ARTH 18271
17	Amaryllidaceae	<i>Allium hymenorrhizum</i> Ledeb.	Çim soğanı	Soğanlı			ARTH 18272
18	Amaryllidaceae	* <i>Allium kandemirii</i> İ.Genç & Özhatay	—	Soğanlı			ARTH 18273
19	Amaryllidaceae	* <i>Allium koenigianum</i> Grossh.	Dadaş soğanı	Soğanlı	Karadeniz elementi	DD	ARTH 18274
20	Amaryllidaceae	<i>Allium kunthianum</i> Vved.	Kuş körmeni	Soğanlı	İran-Turan elementi		ARTH 12554
21	Amaryllidaceae	* <i>Allium oltense</i> Grossh.	Oltu soğanı	Soğanlı	İran-Turan elementi		ARTH 16169
22	Amaryllidaceae	* <i>Allium olympicum</i> Boiss.	Uludağ soğanı	Soğanlı	Karadeniz elementi		ARTH 18275
23	Amaryllidaceae	<i>Allium oreophilum</i> C.A.Mey.	Sultan soğanı	Soğanlı	İran-Turan elementi		ARTH 18276
24	Amaryllidaceae	<i>Allium paniculatum</i> L.	Sürüsalkım	Soğanlı			ARTH 18277
25	Amaryllidaceae	<i>Allium ponticum</i> Misch. ex Grossh.	Hemşin körmeni	Soğanlı	Karadeniz elementi		ARTH 1277
26	Amaryllidaceae	<i>Allium pseudoflavum</i> Vved.	Küllü soğan	Soğanlı	İran-Turan elementi		ARTH 18278
27	Amaryllidaceae	<i>Allium pseudostrictum</i> Albov	—	Soğanlı			ARTH 18279
28	Amaryllidaceae	<i>Allium rollovii</i> Grossh.	Çoruh soğanı	Soğanlı	İran-Turan elementi		ARTH 18280
29	Amaryllidaceae	<i>Allium rotundum</i> L.	Deli pırasa	Soğanlı			ARTH 16362
30	Amaryllidaceae	<i>Allium rupestre</i> Steven	Taş körmeni	Soğanlı	Karadeniz elementi	DD	ARTH 18281
31	Amaryllidaceae	<i>Allium schoenoprasum</i> L.	Peynir sirmosu	Soğanlı		LC	ARTH 18282
32	Amaryllidaceae	<i>Allium sosnowskyanum</i> Misch., Grossh.	—	Soğanlı	Karadeniz elementi		ARTH 12550
33	Amaryllidaceae	<i>Allium sphaerocephalon</i> L. subsp. <i>sphaerocephalon</i>	—	Soğanlı	Avrupa-Sibirya elementi		ARTH 12557
34	Amaryllidaceae	<i>Allium szovitsii</i> Regel.	Yayla körmeni	Soğanlı	Karadeniz (dağ) elementi		ARTH 18283
35	Amaryllidaceae	<i>Allium vineale</i> L.	Sırmo	Soğanlı		LC	ARTH 18284
36	Amaryllidaceae	<i>Allium zebdanense</i> Boiss. & Noë	Çarşak sarmısağı	Soğanlı	İran-Turan elementi		ARTH 12548
37	Amaryllidaceae	<i>Galanthus alpinus</i> Sosn.	Dağ kardeleni	Soğanlı			ARTH 18285
38	Amaryllidaceae	<i>Galanthus krasnovii</i> A.P.Khokhr.	Kışçanı	Soğanlı			ARTH 13437
39	Amaryllidaceae	<i>Galanthus rizehensis</i> Stern	Rize kardeleni	Soğanlı	Karadeniz elementi		ARTH 13438
40	Amaryllidaceae	<i>Galanthus woronowii</i> Losinsk.	Akçabardak	Soğanlı			ARTH 1124
41	Apiaceae	<i>Bunium cylindricum</i> (Boiss. & Hohen.) Drude	Yuvaraksar	Yumrulu	İran-Turan elementi		ARTH 18286
42	Apiaceae	<i>Bunium microcarpum</i> subsp. <i>bourgaei</i> (Boiss.) Hedge & Lamond	Adol	Yumrulu	İran-Turan elementi		ARTH 18287
43	Apiaceae	<i>Bunium paucifolium</i> DC.	Koçkuzu	Yumrulu	İran-Turan elementi		ARTH 18288
44	Apiaceae	<i>Chaerophyllum bulbosum</i> L.	Handok	Yumrulu	Avrupa-Sibirya elementi		ARTH 18289
45	Araceae	* <i>Arum euxinum</i> R.R.Mill	—	Yumrulu			ARTH 18290
46	Araceae	<i>Arum italicum</i> Mill.	Domuz lahanası	Yumrulu			ARTH 18291
47	Araceae	<i>Arum maculatum</i> L.	Yılanekmeği	Yumrulu			ARTH 1873
48	Araceae	<i>Arum megobrebi</i> Lobin	Kabarcık	Yumrulu			ARTH 18292
49	Araceae	<i>Arum rupicola</i> Boiss.	Dağsorsalı	Yumrulu			ARTH 18293
50	Araceae	* <i>Eminium koenenianum</i> Lobin & P.C.Boyce	Yılanüzümü	Yumrulu	İran-Turan elementi		ARTH 14199
51	Asparagaceae	<i>Asparagus persicus</i> Baker	Mereço	Rizomlu	Avrupa-Sibirya elementi		ARTH 15986
52	Asparagaceae	<i>Bellevalia paradoxa</i> (Fisch. & C.A.Mey.) Boiss.	Aşpenceri	Soğanlı	İran-Turan elementi		ARTH 18294
53	Asparagaceae	<i>Bellevalia speciosa</i> Woronow ex Grossh.	Saplı sümbül	Soğanlı			ARTH 18295
54	Asparagaceae	<i>Muscari armeniacum</i> Leichtlin ex Baker	Gâvurbaşı	Soğanlı			ARTH 15974
55	Asparagaceae	* <i>Muscari artvinense</i> S.Demirci & E. Kaya	—	Soğanlı			ARTH 18296
56	Asparagaceae	<i>Muscari caucasicum</i> (Griseb.) Baker	Arap sümbülü	Soğanlı			ARTH 18297
57	Asparagaceae	<i>Muscari neglectum</i> Guss. ex Ten.	Arapüzümü	Soğanlı			ARTH 16530
58	Asparagaceae	<i>Muscari tenuiflorum</i> Tausch	Püsküllübaş	Soğanlı			ARTH 18298
59	Asparagaceae	<i>Ornithogalum montanum</i> Cirillo	Dağ akyıldızı	Soğanlı	D. Akdeniz Elementi		ARTH 16301
60	Asparagaceae	<i>Ornithogalum narbonense</i> L.	Akbaldır	Soğanlı	Akdeniz elementi		ARTH 16034
61	Asparagaceae	<i>Ornithogalum oligophyllum</i> E.D.Clarke	Kurtsoğanı	Soğanlı			ARTH 18299

62	Asparagaceae	<i>Ornithogalum orthophyllum</i> Ten.	Bayır yıldızı	Soğanlı		ARTH 18300
63	Asparagaceae	<i>Ornithogalum pyrenaicum</i> L.	Eşeksusamı	Soğanlı		ARTH 16003
64	Asparagaceae	<i>Ornithogalum sphaerocarpaceum</i> A.Kern.	Salkımsakarca	Soğanlı		ARTH 18301
65	Asparagaceae	<i>Polygonatum glaberrimum</i> K. Koch	Köse boğumluca	Rizomlu	Karadeniz elementi	ARTH 16471
66	Asparagaceae	<i>Polygonatum multiflorum</i> (L.) All.	Mührüsüleyman	Rizomlu		ARTH 13547
67	Asparagaceae	<i>Polygonatum orientale</i> Desf.	Boğumluca	Rizomlu	Karadeniz elementi	ARTH 18302
68	Asparagaceae	<i>Polygonatum verticillatum</i> (L.) All.	Bol boğum	Rizomlu	Avrupa-Sibirya elementi	
69	Asparagaceae	<i>Ruscus aculeatus</i> L.	Tavşanmemesi	Rizomlu		LC ARTH 7288
70	Asparagaceae	<i>Ruscus colchicus</i> Yeo	Zermek	Rizomlu	Karadeniz elementi	ARTH 18303
71	Asparagaceae	* <i>Scilla alinihatiana</i> Aslan & Yıldırım	Kaçkar sümbülü	Soğanlı		ARTH 18304
72	Asparagaceae	<i>Scilla monanthos</i> K.Koch	Sümbülcük	Soğanlı	Karadeniz elementi	ARTH 15060
73	Asparagaceae	<i>Scilla rosenii</i> K.Koch	Gülsümbülü	Soğanlı	İran-Turan elementi	ARTH 18305
74	Asparagaceae	<i>Scilla siberica</i> Haw.	Camişkiran	Soğanlı		ARTH 18306
75	Asparagaceae	<i>Scilla siberica subsp. armena</i> (Grossh.) Mordak	Camişkiran	Soğanlı	İran-Turan elementi	ARTH 16537
76	Asteraceae	<i>Helianthus tuberosus</i> L.	Yer elması	Yumrulu		LC ARTH 18307
77	Brassicaceae	<i>Cardamine bulbifera</i> (L.) Crantz	Dişlikök	Rizomlu	Avrupa-Sibirya elementi	ARTH 18308
78	Caprifoliaceae	<i>Valeriana tuberosa</i> L.	Top kediotu	Yumrulu		LC ARTH 18309
79	Colchicaceae	* <i>Colchicum leptanthum</i> K. Perss.	İtkesen	Kormlu	İran-Turan elementi	CR ARTH 18310
80	Colchicaceae	<i>Colchicum speciosum</i> Steven	Şepart	Kormlu	Avrupa-Sibirya elementi	ARTH 14914
81	Colchicaceae	<i>Colchicum szovitsii</i> Fisch. & C.A.Mey.	Katırçiğdem	Kormlu	İran-Turan elementi	ARTH 16378
82	Colchicaceae	<i>Colchicum trigynum</i> (Steven ex Adams) Stearn	Üç mahrut	Kormlu	İran-Turan elementi	ARTH 18311
83	Colchicaceae	<i>Colchicum umbrosum</i> Steven	Şaşortkovan	Kormlu	Karadeniz elementi	ARTH 18312
84	Cyperaceae	<i>Cyperus esculentus</i> L.	Abdülaziz	Yumrulu		LC ARTH 18313
85	Dioscoreaceae	<i>Dioscorea communis</i> (L.) Caddick & Wilkin.	Dolanbaç	Yumrulu		LC ARTH 15449
86	Fabaceae	<i>Lathyrus tuberosus</i> L.	Koşkoz	Yumrulu		LC ARTH 16422
87	Geraniaceae	<i>Geranium tuberosum</i> L.	Çakmuz	Yumrulu	İran-Turan elementi	ARTH 18314
88	Iridaceae	* <i>Crocus biflorus subsp. albocoronatus</i> Kernd.	Gökkız	Kormlu		ARTH 18315
89	Iridaceae	* <i>Crocus biflorus subsp. artvinensis</i> (Philippov) B.Mathew	Halkalı çiğdem	Kormlu	Avrupa-Sibirya elementi	ARTH 18316
90	Iridaceae	* <i>Crocus biflorus subsp. fibroannulatus</i> Kernd. & Pasche	Halkalı çiğdem	Kormlu		ARTH 18317
91	Iridaceae	<i>Crocus kotschyanus subsp. suworowianus</i> (K.Koch) B.Mathew	Yaylakestanesi	Kormlu		ARTH 4477
92	Iridaceae	<i>Crocus scharojanii</i> Rupr.	Yaylakovan	Kormlu		ARTH 14464
93	Iridaceae	<i>Crocus tauri</i> Maw	Halkalı çiğdem	Kormlu	İran-Turan elementi	ARTH 16523
94	Iridaceae	<i>Crocus vallicola</i> Herb.	Hozmancuk	Kormlu	Karadeniz elementi	ARTH 16736
95	Iridaceae	<i>Gladiolus atroviolaceus</i> Boiss.	Kıraçsüseni	Kormlu	İran-Turan elementi	ARTH 4478
96	Iridaceae	<i>Gladiolus kotschyanus</i> Boiss.	Çayır kılıçotu	Kormlu	İran-Turan elementi	ARTH 2077
97	Iridaceae	<i>Iris caucasica</i> Hoffm.	Kaf navruz	Rizomlu		ARTH 18318
98	Iridaceae	* <i>Iris caucasica subsp. nezahatiae</i> (Güner & H.Duman) Güner	Mavruzo	Rizomlu	İran-Turan elementi	ARTH 18319
99	Iridaceae	<i>Iris caucasica subsp. turcica</i> B.Mathew	Kaf navruz	Soğanlı	İran-Turan elementi	ARTH 18320
100	Iridaceae	* <i>Iris galatica</i> Siehe	Kaba navruz	Rizomlu	İran-Turan elementi	ARTH 18321
101	Iridaceae	<i>Iris pseudocaucaucasica</i> Grossh.	Van navruz	Soğanlı	İran-Turan elementi	ARTH 18322
102	Iridaceae	<i>Iris reticulata</i> M.Bieb.	Kara körpeze	Soğanlı		ARTH 18323
103	Iridaceae	<i>Iris sibirica</i> L.	Çayır süseni	Rizomlu	Avrupa-Sibirya elementi	NT ARTH 18324
104	Iridaceae	<i>Iris spuria subsp. musulmanica</i> (Fomin) Takht.	Yayla süseni	Rizomlu	İran-Turan elementi	ARTH 18320
105	Iridaceae	* <i>Iris taochia</i> Woronow ex Grossh.	Tortum süseni	Rizomlu	Karadeniz elementi	ARTH 15929
106	Lamiaceae	<i>Phlomis tuberosa</i> (L.) Moench.	—	Yumrulu		ARTH 18325
107	Liliaceae	<i>Fritillaria caucasica</i> Adam	Kaf lâlesi	Soğanlı	Hirkanya-Karadeniz (dağ) elementi	ARTH 16639
108	Liliaceae	<i>Fritillaria latifolia</i> Willd.	Yaylalâlesi	Soğanlı	Karadeniz (dağ) elementi	ARTH 4934
109	Liliaceae	<i>Fritillaria pinardii</i> Boiss.	Mahçuplâle	Soğanlı	İran-Turan elementi	ARTH 18326

110	Liliaceae	<i>Gagea bohemica</i> (Zauschn.) Schult. & Schult.f.	Sarıyıldız	Soğanlı		LC	ARTH 18327
111	Liliaceae	<i>Gagea chanae</i> Grossh.	Çan yıldızı	Soğanlı	İran-Turan elementi		ARTH 18328
112	Liliaceae	<i>Gagea glacialis</i> K.Koch	Buzyıldızı	Soğanlı	İran-Turan elementi		ARTH 18329
113	Liliaceae	<i>Gagea luteoides</i> Stapf	Altın yıldız	Soğanlı			ARTH 469
114	Liliaceae	<i>Gagea reticulata</i> (Pall.) Schult. & Schult.f.	Ağ yıldızı	Soğanlı	İran-Turan elementi		ARTH 4467
115	Liliaceae	<i>Gagea taurica</i> Steven	Bozkır yıldızı	Soğanlı	İran-Turan elementi		ARTH 2039
116	Liliaceae	* <i>Gagea tenuissima</i> Mischz.	İnce yıldız	Soğanlı	Karadeniz elementi	DD	ARTH 15898
117	Liliaceae	<i>Gagea villosa</i> (M.Bieb.) Sweet	Tüylü yıldız	Soğanlı			ARTH 18330
118	Liliaceae	<i>Lilium armenum</i> (Mischz. ex Grossh.) Manden.	—	Soğanlı			ARTH 18331
119	Liliaceae	<i>Lilium kesselringianum</i> Mischz.	Kaf zambağı	Soğanlı			ARTH 15670
120	Liliaceae	<i>Lilium monadelphum</i> M.Bieb.	Bey zambağı	Soğanlı			ARTH 18332
121	Liliaceae	* <i>Lilium ponticum</i> K.Koch.	Hemşin zambağı	Soğanlı			ARTH 18333
122	Liliaceae	<i>Lilium szovitsianum</i> Fisch. & Avé-Lall.	—	Soğanlı			ARTH 18334
123	Liliaceae	<i>Tulipa armena</i> Boiss.	Hoş lâle	Soğanlı			ARTH 16666
124	Liliaceae	<i>Tulipa julia</i> K.Koch	Yaban lâlesi	Soğanlı	İran-Turan elementi		ARTH 18335
125	Melanthiaceae	<i>Veratrum album</i> L.	Dokuztepelisi	Rizomlu	Avrupa-Sibirya elementi	LC	ARTH 18336
126	Melanthiaceae	<i>Paris incompleta</i> M.Bieb.	Tilkiüzümü	Rizomlu	Karadeniz elementi		ARTH 18337
127	Orchidaceae	<i>Anacamptis fragrans</i> (Pollini) R.M.Bateman	—	Yumrulu		LC	ARTH 16084
128	Orchidaceae	<i>Anacamptis palustris</i> (Jacq.) R.M.Bateman, Pridgeon & M.W.Chase.	—	Yumrulu		LC	ARTH 1159
129	Orchidaceae	<i>Anacamptis pyramidalis</i> (L.) Rich.	Sivrisalep	Yumrulu		LC	ARTH 1156
130	Orchidaceae	<i>Cephalanthera damasonium</i> (Mill.) Druce	Ormankuşçuğu	Rizomlu	Avrupa-Sibirya elementi	LC	ARTH 16228
131	Orchidaceae	<i>Cephalanthera kurdica</i> Bornm. ex Kraenzl.	Kurtkuşçuğu	Rizomlu	İran-Turan elementi		ARTH 18338
132	Orchidaceae	<i>Cephalanthera longifolia</i> (L.) Fritsch	Kuşsalebi	Rizomlu	Avrupa-Sibirya elementi	LC	ARTH 3766
133	Orchidaceae	<i>Cephalanthera rubra</i> (L.) Rich.	Çamçiçeği	Rizomlu		LC	ARTH 16221
134	Orchidaceae	<i>Coeloglossum viride</i> (L.) Hartman	Kurbağasalebi	Yumrulu		LC	ARTH 1155
135	Orchidaceae	<i>Corallorhiza trifida</i> Châtel.	Kurbağa salebi	Rizomlu	Avrupa-Sibirya elementi	LC	ARTH 18339
136	Orchidaceae	<i>Dactylorhiza euxina</i> (Nevski) Czerep.	Laz salebi	Yumrulu		NT	ARTH 18340
137	Orchidaceae	<i>Dactylorhiza iberica</i> (Bieb. ex Willd.) Soo	Kırım salebi	Yumrulu	D. Akdeniz elementi	VU	ARTH 18341
138	Orchidaceae	<i>Dactylorhiza incarnata</i> subsp. <i>cilicica</i> (Klinge) H.Sund.	Osmanlısalebi	Yumrulu			ARTH 18342
139	Orchidaceae	<i>Dactylorhiza osmanica</i> (Klinge) P.F.Hunt & Summerh.	Osmanlısalebi	Yumrulu			ARTH 16568
140	Orchidaceae	<i>Dactylorhiza romana</i> (Seb.) Soó	Elçik	Yumrulu		LC	ARTH 18343
141	Orchidaceae	<i>Dactylorhiza romana</i> subsp. <i>georgica</i> (Klinge) Soó ex Renz & Taubenheim	Çamkökü	Yumrulu			ARTH 11075
142	Orchidaceae	<i>Dactylorhiza saccifera</i> (Brongn.) Soó	Keselisalep	Yumrulu		LC	ARTH 16475
143	Orchidaceae	<i>Dactylorhiza umbrosa</i> (Karelin & Kirilow) Nevski	Gövdeli salep	Yumrulu			ARTH 16729
144	Orchidaceae	<i>Dactylorhiza urvilleana</i> (Steudel) Baumann & Künkele	Balkaymak	Yumrulu		LC	ARTH 16294
145	Orchidaceae	<i>Epipactis helleborine</i> (L.) Crantz	Bindallıçiçeği	Rizomlu		LC	ARTH 11090
146	Orchidaceae	<i>Epipactis microphylla</i> (Ehrh.) Swartz	Minikbindallı	Rizomlu	Avrupa-Sibirya elementi	NT	ARTH 3769
147	Orchidaceae	<i>Epipactis palustris</i> (L.) Crantz	Danakıranotu	Rizomlu	Avrupa-Sibirya elementi	LC	ARTH 18344
148	Orchidaceae	<i>Epipactis persica</i> (Soó) Hausskn. ex Nannf.	Acem danakıranı	Rizomlu			ARTH 1146
149	Orchidaceae	<i>Epipactis veratrifolia</i> Boiss. & Hohen.	İrazbindallı	Rizomlu	İran-Turan elementi	LC	ARTH 18345
150	Orchidaceae	<i>Epipogium aphyllum</i> Swartz	Cazı salebi	Rizomlu	Avrupa-Sibirya elementi	LC	ARTH 18346
151	Orchidaceae	<i>Goodyera repens</i> (L.) R. Br.	Yersalebi	Rizomlu	Avrupa-Sibirya elementi	LC	ARTH 3772
152	Orchidaceae	<i>Gymnadenia conopsea</i> (L.) R.Br.	Başaksalebi	Yumrulu	Avrupa-Sibirya elementi	LC	ARTH 16287

153	Orchidaceae	<i>Himantoglossum robertianum</i> (Loisel.) P.Delforge	—	Yumrulu	LC	ARTH 18347
154	Orchidaceae	<i>Limodorum abortivum</i> (L.) Sw.	Saçuzatan	Rizomlu	LC	ARTH 4480
155	Orchidaceae	<i>Neotinea tridentata</i> (Scop.) R.M.Bateman, Pridgeon & M.W.Chase.	—	Yumrulu	LC	ARTH 18348
156	Orchidaceae	<i>Neottia cordata</i> (L.) Rich.	—	Rizomlu	LC	ARTH 18349
157	Orchidaceae	<i>Neottia nidus-avis</i> (L.) Rich.	Asalak salep	Rizomlu	Avrupa-Sibirya elementi	LC ARTH 1143
158	Orchidaceae	<i>Neottia ovata</i> (L.) Hartm.	—	Rizomlu	LC	ARTH 18350
159	Orchidaceae	<i>Ophrys apifera</i> Huds.	Arisalebi	Yumrulu	LC	ARTH 18351
160	Orchidaceae	<i>Ophrys holosericea</i> subsp. <i>holosericea</i>	—	Yumrulu	LC	ARTH 18352
161	Orchidaceae	<i>Ophrys sphegodes</i> subsp. <i>taurica</i> (Aggeenko) Soó ex Niketić & Djordjevic	Tavşan salebi	Yumrulu		ARTH 18353
162	Orchidaceae	<i>Ophrys tenthredinifera</i> Willd.	Böcek salebi	Yumrulu	Akdeniz elementi	LC ARTH 18354
163	Orchidaceae	<i>Orchis mascula</i> (L.) L.	Er salebi	Yumrulu	LC	ARTH 18355
164	Orchidaceae	<i>Orchis pallens</i> L.	Solgun salep	Yumrulu	Avrupa-Sibirya elementi	LC ARTH 15983
165	Orchidaceae	<i>Orchis palustris</i> Jacq.	Çayır salebi	Yumrulu	LC	ARTH 1159
166	Orchidaceae	<i>Orchis punctulata</i> Steven ex Lindley	Selef	Yumrulu	D. Akdeniz Elementi	VU ARTH 18356
167	Orchidaceae	<i>Orchis purpurea</i> Huds.	Hasancık	Yumrulu	LC	ARTH 4483
168	Orchidaceae	<i>Orchis simia</i> Lam.	Saleppüskülü	Yumrulu	Akdeniz elementi	LC ARTH 18357
169	Orchidaceae	<i>Platanthera bifolia</i> (L.) Rich.	Guguksalebi	Yumrulu	Avrupa-Sibirya elementi	LC ARTH 1153
170	Orchidaceae	<i>Platanthera chlorantha</i> (Cruster) Rchb.	Çarpık salep	Yumrulu	LC	ARTH 4481
171	Orchidaceae	<i>Spiranthes spiralis</i> (L.) Chevall	İncisalebi	Yumrulu	Akdeniz elementi	LC ARTH 18358
172	Orchidaceae	<i>Traunsteinera sphaerica</i> (M.Bieb.) Schltr.	Yayla salebi	Yumrulu	Hirkanya-Karadeniz (dağ) elementi	ARTH 18359
173	Oxalidaceae	<i>Oxalis acetosella</i> L.	Eksiyonca	Rizomlu		ARTH 13825
174	Oxalidaceae	<i>Oxalis articulata</i> Savigny	Pembe	Rizomlu		ARTH 5268
175	Oxalidaceae	<i>Oxalis corniculata</i> L.	Sarı eksiyonca	Rizomlu		ARTH 13147
176	Paeoniaceae	<i>Paeonia arietina</i> G.Anderson.	Şakayık	Yumrulu		ARTH 14554
177	Paeoniaceae	<i>Paeonia daurica</i> subsp. <i>macrophylla</i> (Albow) D.Y.Hong	Gagaç	Yumrulu		ARTH 18360
178	Paeoniaceae	<i>Paeonia daurica</i> subsp. <i>wittmanniana</i> (Hartwiss ex Lindl.) D.Y.Hong	Yörükgülü	Yumrulu		ARTH 18361
179	Paeoniaceae	<i>Paeonia mascula</i> (L.) Mill.	Aygülü	Yumrulu	LC	ARTH 12796
180	Papaveraceae	<i>Corydalis alpestris</i> C.A. Meyer.	Gök kazgagası	Yumrulu	Karadeniz elementi	ARTH 3148
181	Papaveraceae	<i>Corydalis angustifolia</i> (M.Bieb.) DC.	Koru tarlakuşu	Yumrulu		ARTH 13180
182	Papaveraceae	<i>Corydalis caucasica</i> DC.	Çalitarlakuşu	Yumrulu		ARTH 13189
183	Papaveraceae	<i>Corydalis conorrhiza</i> Ledeb.	Yayla kazgagası	Yumrulu	Karadeniz elementi	ARTH 14958
184	Papaveraceae	<i>Corydalis erdelii</i> Zucc.	Kazgagası	Yumrulu		ARTH 18362
185	Papaveraceae	<i>Corydalis oppositifolia</i> DC.	İpar kazgası	Yumrulu		ARTH 18363
186	Papaveraceae	<i>Corydalis persica</i> Cham. & Schtdl.	—	Yumrulu		ARTH 18364
187	Papaveraceae	<i>Corydalis rutifolia</i> (Sm.) DC.	—	Yumrulu		ARTH 13181
188	Papaveraceae	<i>Corydalis solida</i> (L.) Clairv.	Rumeli kazgagası	Yumrulu		ARTH 18365
189	Poaceae	<i>Hordeum bulbosum</i> L.	Boncuk arpa	Soğanlı	LC	ARTH 4515
190	Poaceae	<i>Poa bulbosa</i> L.	Yumrulu salkım	Soğanlı		ARTH 12752
191	Polygonaceae	<i>Rumex tuberosus</i> subsp. <i>horizontalis</i> (K.Koch) Rech.f.	Kömeturşusu	Yumrulu		ARTH 16092
192	Polygonaceae	<i>Rumex tuberosus</i> subsp. <i>tuberosus</i> L.	Kuzukıkırdağı	Yumrulu		ARTH 14916
193	Primulaceae	<i>Cyclamen coum</i> Mill.	Yersomunu	Yumrulu	LC	ARTH 18366
194	Primulaceae	<i>Cyclamen coum</i> subsp. <i>caucasicum</i> (K. Koch) O. Schwarz	Domuzağırşığı	Yumrulu		ARTH 18367
195	Primulaceae	* <i>Cyclamen parviflorum</i> Pobed.	Filiski	Yumrulu	LC	ARTH 18368
196	Ranunculaceae	<i>Ranunculus kochii</i> Ledeb.	Karççeği	Yumrulu		ARTH 14595
197	Ranunculaceae	<i>Ranunculus ficaria</i> L.	Arpacıkalebi	Yumrulu	LC	ARTH 18369
198	Solanaceae	<i>Atropa belladonna</i> L.	Güzelavratotu	Rizomlu	Avrupa-Sibirya elementi	ARTH 4291
200	Solanaceae	<i>Scopolia carniolica</i> Jacq.	Japon banotu	Rizomlu	LC	ARTH 18370
201	Xanthorrhoeaceae	<i>Asphodeline damascena</i> (Boiss.) Baker	Çekiçlik	Rizomlu	LC	ARTH 18371
202	Xanthorrhoeaceae	<i>Asphodeline lutea</i> (L.) Rchb.	Sarı çiriş	Rizomlu	Akdeniz elementi	ARTH 18372
202	Xanthorrhoeaceae	<i>Asphodeline prolifera</i> (M.Bieb.) Kunth.	Helük	Rizomlu	İran-Turan elementi	ARTH 18373

203	Xanthorrhoeaceae	<i>Asphodeline tenuior subsp. tenuiflora var. tenuiflora</i> (K.Koch) Tuzlacı	Tesbihcik	Rizomlu	İran-Turan elementi	ARTH 16177
204	Xanthorrhoeaceae	<i>Eremurus spectabilis</i> M.Bieb.	Çiriş	Rizomlu	İran-Turan elementi	ARTH 18374
205	Xanthorrhoeaceae	<i>Hemerocallis fulva var. fulva</i> (L.)	Güngüzeli	Rizomlu		ARTH 18375

\* Endemik taksonlar.

Bu çalışmada elde edilen bulgulara göre Artvin ilinde 26 familyaya ait 62 cins ve 205 geofit taksonu belirlenmiştir. Takson sayısı bakımından en zengin familyalar Orchidaceae (46 takson, %22,44), Amaryllidaceae (40

takson, %19,51) ve Asparagaceae (25 takson, %12,20) olarak tespit edilmiştir. Cins sayısı bakımından ise Orchidaceae (18 cins), Asparagaceae (7 cins) ve Liliaceae (4 cins) familyaları ilk sıralarda yer almaktadır (Tablo 2).

**Tablo 2.** Artvin ilinde belirlenen geofit taksonlarının familyalara göre cins ve takson sayıları

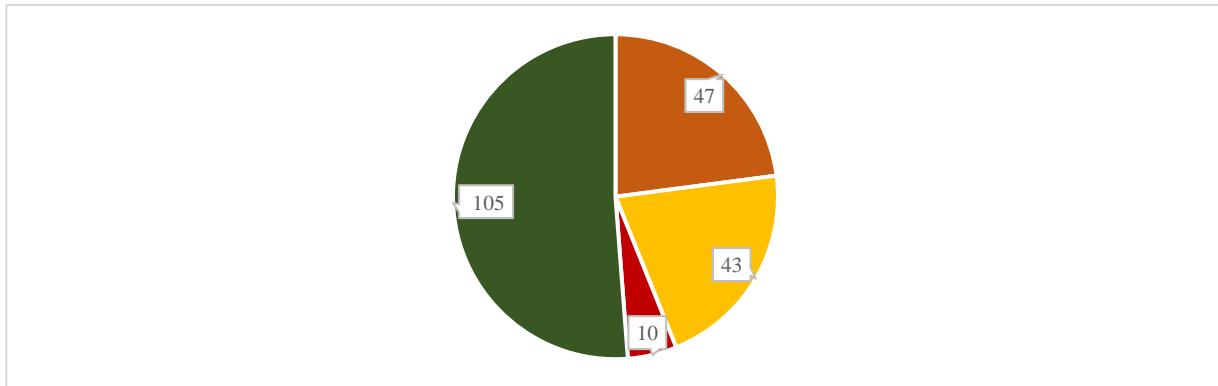
Familya	Cins Sayısı	Takson Sayısı	Oran (%)
Amaryllidaceae	2	40	19,52
Apiaceae	2	4	1,90
Araceae	2	6	2,86
Asparagaceae	7	25	11,90
Asteraceae	1	1	0,48
Brassicaceae	1	1	0,48
Caprifoliaceae	1	1	0,48
Colchicaceae	1	5	2,38
Cyperaceae	1	1	0,48
Dioscoreaceae	1	1	0,48
Fabaceae	1	1	0,48
Geraniaceae	1	1	0,48
Iridaceae	3	18	9,05
Lamiaceae	1	1	0,48
Liliaceae	4	18	8,57
Melanthiaceae	2	2	0,95
Orchidaceae	18	46	22,86
Oxalidaceae	1	3	1,43
Paeoniaceae	1	4	1,90
Papaveraceae	1	9	4,29
Poaceae	2	2	0,95
Polygonaceae	1	2	0,95
Primulaceae	1	3	1,90
Ranunculaceae	1	2	0,48
Solanaceae	2	2	0,95
Xanthorrhoeaceae	3	6	2,86
<b>Toplam</b>	<b>62</b>	<b>205</b>	<b>100,00</b>



Şekil 2. Artvin ilinde belirlenen bazı endemik geofit taksonları. (a) *Allium balansae*, (b) *Arum euxinum*, (c) *Lilium ponticum*, (d) *Cyclamen parviflorum*.

Fitocoğrafik bölge dağılımları incelendiğinde, taksonların 47'sinin (%22,93) İran-Turan, 43'ünün (%20,98) Avrupa-Sibirya ve 10'unun (%4,88) Akdeniz fitocoğrafik bölgesi elementi olduğu belirlenmiştir. Avrupa-Sibirya fitocoğrafik bölgesi içerisinde 21 takson Avrupa-Sibirya, 17 takson Karadeniz, 3 takson Karadeniz (dağ) ve 2

takson Hirkanya-Karadeniz (dağ) elementi olarak değerlendirilmiştir. Akdeniz fitocoğrafik bölgesi içerisinde ise 6 takson Akdeniz ve 4 takson Doğu Akdeniz elementi olarak belirlenmiştir. Ayrıca 105 taksonun (%51,22) geniş yayılışlı olduğu veya fitocoğrafik bölgesinin bilinmediği tespit edilmiştir. Ana fitocoğrafik bölgelere ait takson dağılımları Şekil 3'te verilmiştir.



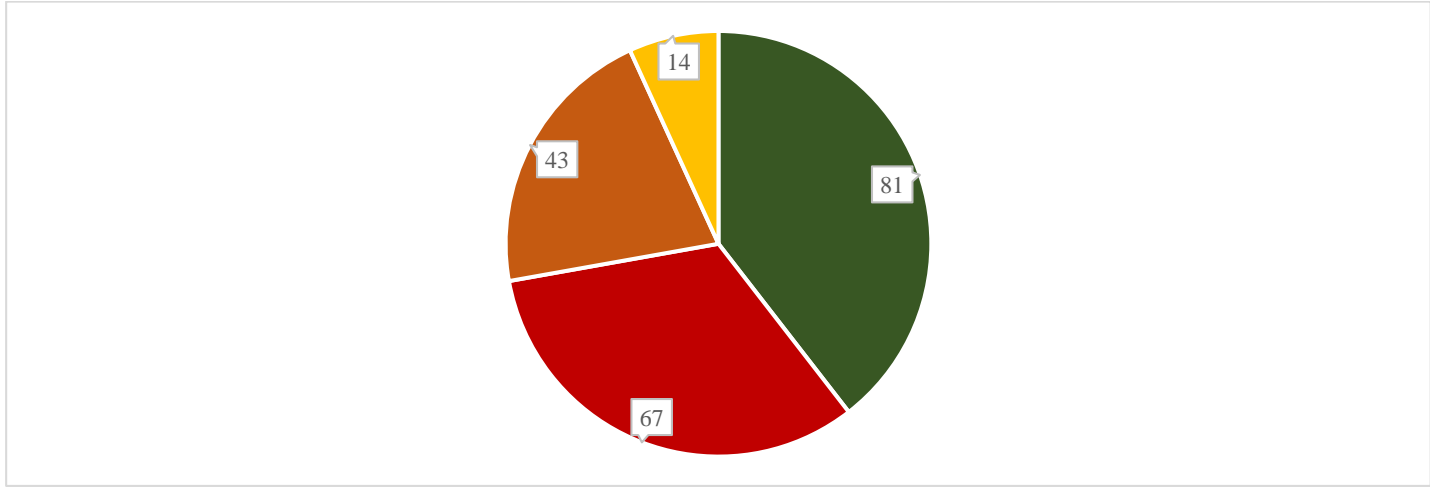
Şekil 3. Artvin ilinde belirlenen geofit taksonlarının fitocoğrafik bölgelere göre dağılımı (%)

Geofit taksonlarının sahip oldukları toprak altı depo organlarına göre dağılımları incelendiğinde, soğanlı geofitlerin 81 takson (%39,51) ile ilk sırada yer aldığı belirlenmiştir. Soğanlı geofitleri sırasıyla yumrulu

geofitler (67 takson, %32,68), rizomlu geofitler (43 takson, %20,98) ve kormlu geofitler (14 takson, %6,83) takip etmektedir (Tablo 4, Şekil 4).

**Tablo 4.** Artvin ilinde belirlenen geofit taksonlarının depo organlarına göre dağılımı

Geofit tipi	Takson sayısı	%
Soğanlı	81	39,52
Yumrulu	67	33,33
Rizomlu	43	20,48
Kormlu	14	6,67



**Şekil 4.** Artvin ilinde belirlenen geofit taksonlarının depo organlarına göre dağılımı (%)

#### 4. TARTIŞMA

Bu çalışmada Artvin ilinde doğal yayılış gösteren 26 familyaya ait 62 cins ve 205 geofit taksonu belirlenmiştir. Elde edilen sonuçlar, Artvin'in geofit çeşitliliği bakımından Türkiye'nin en zengin bölgelerinden biri olduğunu ortaya koymaktadır. Türkiye'nin farklı bölgelerinde gerçekleştirilen geofit araştırmalarıyla karşılaştırıldığında, Artvin'de belirlenen geofit taksonu sayısının oldukça yüksek olduğu görülmektedir (Tablo 4). Katran Dağı (Çanakkale) ve çevresinde 45 (Avcu ve ark., 2016) ve Hatay ilinde 67 (Kayıkçı ve ark., 2012) geofit taksonu belirlenmişken, bu çalışmada tespit edilen 205 takson Artvin'in geofit çeşitliliği açısından önemli floristik merkezlerden biri olduğunu göstermektedir. Bu durum, ilin geniş yükselti aralığına, farklı iklim tiplerine ve zengin habitat çeşitliliğine sahip olmasıyla açıklanabilir.

Familiya bazında yapılan değerlendirmelerde, Orchidaceae, Amaryllidaceae ve Asparagaceae familyalarının Artvin geofit florasının en zengin familyaları olduğu belirlenmiştir. Orchidaceae, 46 takson ile ilk sırada yer almakta olup, bu değer Alaşehir geofit florasında bildirilen 42 taksondan (Sargın ve ark., 2013) daha yüksektir. Benzer şekilde, Amaryllidaceae 40 takson ile temsil edilmekte olup, Muğla ilinde bildirilen 24 taksona (Varol, 2024) göre daha yüksek bir takson zenginliği göstermektedir.

Bu çalışmada belirlenen birçok geofit taksonunun Artvin'in farklı bölgelerinde gerçekleştirilen önceki floristik araştırmalarla da uyumlu olduğu görülmektedir. Nitekim Camili Biyosfer Rezervi'nde gerçekleştirilen bir çalışmada geofit karakterli türler arasında *Allium*, *Colchicum*, *Polygonatum*, *Dactylorhiza*, *Orchis*, *Galanthus*, *Cyclamen* ve *Lilium* cinslerine ait taksonların bulunduğu bildirilmiştir (Eraydın, 2010). Bu çalışmada da

söz konusu cinslere ait çok sayıda taksonun belirlenmiş olması, Artvin'in geofit florasının sürekliliğini ve zenginliğini ortaya koymaktadır.

Araştırmada belirlenen 22 endemik takson, Artvin'in endemik bitki çeşitliliği açısından da önemli bir merkez olduğunu göstermektedir. Özellikle Allium, Crocus, Iris ve Scilla cinslerine ait endemik taksonların varlığı bölgenin floristik özgünlüğünü yansıtmaktadır. Endemik taksonlardan Allium czelghauricum ve Colchicum leptanthum'un Kritik Tehlikede (CR) kategorisinde yer alması, bu türlerin korunmasına yönelik öncelikli tedbirlerin alınması gerektiğini göstermektedir. Ayrıca bazı endemik türlerin IUCN kategorilerinin henüz değerlendirilmemiş olması, bu türler üzerinde ayrıntılı popülasyon ve koruma biyolojisi çalışmalarının yapılmasının gerekliliğini ortaya koymaktadır.

Fitocoğrafik bölge dağılımları incelendiğinde İran-Turan elementlerinin ilk sırada yer aldığı görülmektedir.

Bununla birlikte Avrupa-Sibirya ve Karadeniz elementlerinin de önemli oranlarda temsil edilmesi, Artvin'in farklı fitocoğrafik bölgelerin kesişim alanında bulunduğunu göstermektedir. Özellikle Çoruh Vadisi boyunca görülen kurak ve sıcak mikroklimatik koşullar İran-Turan elementlerinin yayılışını desteklerken, Karadeniz kıyıları ve yüksek nemli orman ekosistemleri Avrupa-Sibirya ve Karadeniz elementlerinin bölgede yaygın olarak bulunmasına olanak sağlamaktadır.

Depo organlarına göre yapılan değerlendirmede soğanlı geofitlerin (%39,51) ilk sırada yer aldığı belirlenmiştir. Soğanlı geofitleri sırasıyla yumrulu (%32,68), rizomlu (%20,98) ve kormlu (%6,83) geofitler takip etmektedir. Benzer sonuçlar Türkiye'nin farklı bölgelerinde gerçekleştirilen geofit araştırmalarında da bildirilmiştir. Soğanlı geofitlerin yüksek oranda temsil edilmesi özellikle Allium, Muscari, Ornithogalum, Galanthus, Scilla ve Gagea cinslerine ait türlerin zenginliği ile ilişkilendirilebilir.

**Tablo 4.** Artvin ilinde belirlenen geofit taksonlarının Türkiye'nin farklı bölgelerinde gerçekleştirilen geofit çalışmaları ile karşılaştırılması.

Familiyalar	Artvin (Bu çalışma)	Artvin (Eraydın, 2010)	Trabzon (Erdoğan Genç ve ark., 2026)	Ordu-Giresun (Duman, 2010)	Gaziantep (Özusu ve İskender, 2009)	Çanakkale (Avcu ve ark., 2016)	Şanlıurfa (Eker ve ark., 2008)	Eskişehir (Çingay ve ark., 2012)	Hatay (Kayıkçı ve ark., 2012)	Denizli (Çelik ve ark., 2004)	Manisa (Sargın ve ark., 2013)	Muğla (Varol, 2024)
Amaryllidaceae	41	3	7	3	6	5	22	5	10	-	7	24
Araceae	6	1	2	1	2	1	5	-	-	2	3	2
Asparagaceae	25	-	16	-	10	10	22	8	6	7	14	21
Colchicaceae	5	2	-	-	2	1	5	5	2	2	4	8
Iridaceae	19	-	6	3	11	7	14	7	11	3	9	18
Liliaceae	18	-	7	13	3	6	11	6	5	5	12	15
Orchidaceae	48	8	31	19	3	11	4	4	11	6	7	42
Primulaceae	4	2	3	1	-	1	-	-	2	1	2	5
Ranunculaceae	2	-	-	3	1	2	6	3	3	2	2	-
Smilacaceae	-	-	-	-	-	-	-	-	-	-	-	-
Solanaceae	2	1	-	-	-	-	-	-	-	-	-	1
Xanthorrhoeaceae	6	-	-	-	2	1	4	-	-	-	1	1

## 5. SONUÇ VE ÖNERİLER

Artvin ilinde gerçekleştirilen bu çalışmada 26 familyaya ait 62 cins ve 205 geofit taksonu belirlenmiştir. Tespit edilen taksonların 22'si (%10,48) Türkiye için endemik olup, bunlardan *Allium czelghauricum* ve *Colchicum leptanthum* Kritik Tehlikede (CR), *Allium koenigianum* ve *Gagea tenuissima* Veri Yetersiz (DD), *Cyclamen parviflorum* ise Asgari Endişe (LC) kategorisinde yer almaktadır. Ayrıca belirlenen taksonların %50,95'inin geniş yayılışlı olması veya fitocoğrafik bölgesinin bilinmemesi, Artvin ilindeki geofit florasının fitocoğrafik bileşiminin önemli bir bölümünü geniş yayılışlı taksonların oluşturduğunu göstermektedir.

Takson sayısı bakımından Orchidaceae (46 takson), Amaryllidaceae (40 takson) ve Asparagaceae (25 takson) familyalarının öne çıkması, Artvin'in özellikle geofit çeşitliliği açısından önemli bir merkez olduğunu ortaya koymaktadır. Orchidaceae familyasına ait 48 taksonun belirlenmiş olması, Türkiye'nin farklı bölgelerinde gerçekleştirilen birçok çalışmadan daha yüksek bir çeşitliliğe işaret etmektedir. Benzer şekilde Amaryllidaceae familyasının 41 takson ile temsil edilmesi de bölgenin geofit zenginliğini desteklemektedir.

Artvin'de belirlenen yüksek geofit çeşitliliği ve endemik takson varlığı, ilin korunması gereken önemli floristik alanlardan biri olduğunu göstermektedir. Özellikle dar yayılışlı ve tehdit altındaki türlerin popülasyonlarının izlenmesi, yayılış alanlarının korunması ve gelecekte gerçekleştirilecek koruma biyolojisi çalışmalarına öncelik verilmesi gerekmektedir.

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## RESEARCH ARTICLE

## Open Access

### Bingöl Tuzlası gölü (Sivas) ve çevre flora

#### Flora of Bingöl saltworks (Sivas) and its surroundings

İsmet Erdoğan<sup>1</sup> , Hüseyin Aşkın Akpulat<sup>\*2</sup> 

<sup>1</sup>Ministry of National Education, Sivas, Türkiye

<sup>2</sup>Department of Biology, Faculty of Science and Literature, Cumhuriyet University, Sivas 58140, Türkiye

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\*Corresponding author:

e-mail: [aakpulat99@yahoo.com](mailto:aakpulat99@yahoo.com)

ORCID: 0000-0002-0505-3190

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**Anahtar Kelimeler:** Flora, Biyoçeşitlilik, Endemik Bitkiler, Fitocoğrafya, Sivas, Bingöl Tuzlası

**Keywords:** Flora, biodiversity, endemic plants, phytogeography, Sivas, Bingöl Tuzlası

#### ÖZ

Bu araştırma, Sivas Bingöl Tuzlası Gölü ve çevresinin florasını kapsamaktadır. Araştırma materyali, 11 ay süreyle toplanan bitki örneklerinden oluşmaktadır. Bu süre içinde toplanan 1127 örnekten, 425 takson tayin edilmiştir. 425 taksonun 52'si (%12,24) Türkiye için endemiktir. Araştırma bölgesinin florası 51 familya, 216 cins ve 425 takson oluşturmaktadır. Toplam taksonlardan 1'i Pteridophyta, 424'ü Spermatophyta bölümlerine aittir. Angiospermae alt bölümü 216 taksona sahiptir. Sırasıyla, Angiospermae alt bölümüne ait taksonların 385'i Dicotyledonea, 38'i Monocotyledonea sınıfında yer almaktadır. Taksonların bitki coğrafyası bölgelerine dağılım oranları şöyledir: İran-Turan elementleri 85 (%20), Avrupa-Sibirya elementleri 16 (%3,76), Akdeniz elementi 2 (%0,47), geniş yayılışlı ve yayılışlı bilinmeyenler 322 (%75,76). En büyük on familya ve takson sayıları şu şekildedir: Asteraceae (84), Fabaceae (52), Brassicaceae (43), Lamiaceae (35), Boraginaceae / Liliaceae (16), Apiaceae (14), Ranunculaceae / Poaceae (13), Caryophyllaceae (11), Caprifoliaceae / Papaveraceae / Amaranthaceae / Scrophulariaceae (9), Rosaceae (8) ve diğer familyalar (84). B6 karesi için yeni kayıt niteliğinde 15 endemik takson ile 24 halofit takson belirlenmiştir.

#### ABSTRACT

This research covers the flora of Sivas Bingöl Tuzlası Lake and its surroundings. The research material consists of plant samples collected over a period of 11 months. Of the 1127 samples collected during this period, 425 taxa were identified. Of these 425 taxa, 52 (12.24%) are endemic to Turkey. The flora of the research area consists of 51 families, 216 genera, and 425 taxa. Of the total taxa, 1 belongs to the Pteridophyta division and 424 to the Spermatophyta division. The Angiospermae subdivision has 216 taxa. Respectively, 385 of the taxa belonging to the Angiospermae subdivision are in the Dicotyledonea class, and 38 are in the Monocotyledonea class. The distribution rates of taxa in plant geography regions are as follows: Irano-Turanian elements 85 (20%), European-Siberian elements 16 (3.76%), Mediterranean elements 2 (0.47%), widely distributed and unknown distribution 322 (75.76%). The ten largest families and their taxa numbers are as follows: Asteraceae (84), Fabaceae (52), Brassicaceae (43), Lamiaceae (35), Boraginaceae / Liliaceae (16), Apiaceae (14), Ranunculaceae / Poaceae (13), Caryophyllaceae (11), Caprifoliaceae / Papaveraceae / Amaranthaceae / Scrophulariaceae (9), Rosaceae (8) and other families (84). For square B6, 15 endemic taxa and 24 halophyte taxa were identified as new records.

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## 1. GİRİŞ

Türkiye; Avrupa ve Asya kıtaları arasında köprü konumunda bulunması, farklı iklim tiplerine sahip olması ve Avrupa-Sibirya, Akdeniz ile İran-Turan fitocoğrafik bölgelerinin kesişim noktasında yer alması nedeniyle biyolojik çeşitlilik açısından dünyanın önemli ülkelerinden biridir. Bu özellikler, ülkenin yüksek bitki türü zenginliği ve endemizm oranına sahip olmasını sağlamış, Türkiye florasını botanik araştırmaları açısından önemli bir merkez hâline getirmiştir (Ekim, 1997).

Türkiye florasının sistematik olarak araştırılması 19. yüzyılda hız kazanmış, özellikle *Flora Orientalis* (Boissier, 1867–1884) ve daha sonra yayımlanan *Flora of Turkey and the East Aegean Islands* (Davis, 1965–1988) eserleri ülke florasının taksonomik temelini oluşturmuştur. Bu çalışmaların ardından Türkiye'nin farklı bölgelerinde çok sayıda floristik araştırma gerçekleştirilmiş ve yeni taksonların yanı sıra endemik türlerin dağılışı ile koruma durumlarına ilişkin önemli veriler elde edilmiştir.

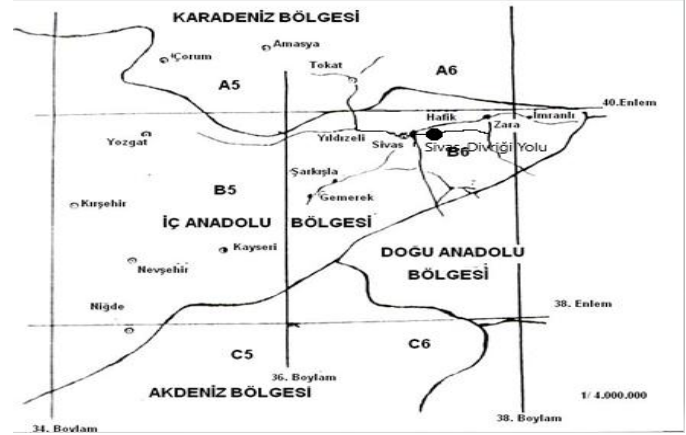
Araştırma alanını oluşturan Bingöl Köyü Tuzlası ve çevresi (Sivas), Davis'in kareleme sistemine göre B6 karesinde yer almakta olup, İç Anadolu Bölgesi'nin karakteristik step ve tuzcul habitatlarını barındırmaktadır. Bölge; tuzlu göl, tuzcul düzlükler, step ve tarım alanlarından oluşan heterojen habitat yapısıyla dikkati çekmektedir. Bununla birlikte, çalışma alanında bugüne kadar ayrıntılı bir floristik araştırma yapılmamıştır.

Bu çalışmanın amacı, Bingöl Köyü Tuzlası ve çevresinin vasküler bitki florasını ortaya koymak, floristik bileşimini değerlendirmek ve alanda yayılış gösteren endemik ile koruma önceliği bulunan taksonları belirleyerek Türkiye florası ve biyolojik çeşitliliğine katkı sağlamaktır.

Araştırma alanı, İç Anadolu Bölgesi'nde Sivas il merkezinin yaklaşık 10 km kuzeydoğusunda yer alan Bingöl Köyü Tuzlası ve çevresini kapsamaktadır. Alan, Davis'in kareleme sistemine göre B6 karesinde yer almakta olup, 39°43'48.86" K ve 37°07'54.57" D koordinatlarında bulunmaktadır (Şekil 1, 2). Çalışma alanı yaklaşık 16 km<sup>2</sup> büyüklüğünde olup deniz seviyesinden 1280–1350 m yükseltiye sahiptir. Araştırma alanı: tuzlu göl, tuzcul düzlükler, step ve tarım alanlarından oluşan heterojen habitat yapısına sahiptir. Arazinin batı kesimleri daha engebeli olup, düz alanlar ağırlıklı olarak tarımsal faaliyetler için kullanılmaktadır. Alan doğuda İnceyol, batıda İşhan, güneyde Tepeönü ve kuzeyde İnceağa köyleri ile çevrilidir (Şekil 3).

Davis (1971) tarafından tanımlanan Anadolu diyagonalı üzerinde yer alan araştırma alanı, farklı habitat tiplerini bir arada bulundurması nedeniyle floristik açıdan önemli bir çeşitlilik sergilemektedir. Çalışma sonucunda alanda belirlenen 141 endemik takson ve %17,5 endemizm oranı, bölgenin

endemik bitkiler bakımından önemli bir floristik zenginliğe sahip olduğunu ortaya koymaktadır (Şekil 4).



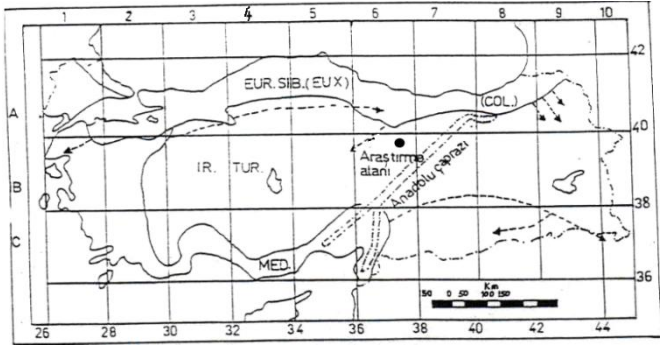
Şekil 1. Araştırma Alanının Coğrafi Konumu



Şekil 2. Araştırma Alanının Coğrafi Konumu



Şekil 3.



Şekil 4. Araştırma Alanının Konumu ve Anadolu Diyagonalı (Davis, 1971)

Araştırma alanının iklim özellikleri, Emberger (1954) tarafından geliştirilen ve Türkiye için Akman (1990) tarafından uyarlanan biyoklimatik sınıflandırma sistemine göre değerlendirilmiştir. Bu sınıflandırmaya göre çalışma alanının bulunduğu Sivas ili, Doğu Akdeniz 2. Tip yağış rejiminin etkisi altındadır (Akman, 1990)

Araştırma alanına ait sıcaklık verileri, Devlet Meteoroloji İşleri Genel Müdürlüğü'nden temin edilmiştir (MGM, 2024). Çalışmada, araştırmanın gerçekleştirildiği 2023–2024 yıllarına ait yıllık ortalama 10.8 °C, maksimum 24.9 °C ve minimum –1.7 °C sıcaklık değerleri ile karşılaştırma amacıyla 2000–2024 dönemine ait uzun yıllar sıcaklık ortalamaları kullanılmıştır.

Araştırma alanına ait yağış verileri, Meteoroloji Genel Müdürlüğü'nden (MGM, 2024) temin edilmiştir. Çalışmada, 2023–2024 yıllarına ait yıllık toplam 471,6 mm yağış değerleri ile karşılaştırma amacıyla 2000–2024 dönemine ait uzun yıllar ortalaması 384,3 mm olarak değerlendirilmiştir.

Araştırma alanına ait ortalama bağıl nem verileri, Meteoroloji Genel Müdürlüğü'nden (MGM, 2024) sağlanmıştır. Çalışmada, 2023–2024 yıllarına ait yıllık ortalama bağıl nem (%63,9) değerleri ile 2000–2024 dönemine ait uzun yıllar ortalaması (%64 mm) karşılaştırılmıştır.

## 2. MATERYAL VE METOD

Araştırma alanının florasını belirlemek amacıyla 2023–2024 yılları arasında Mart–Ekim ayları arasında, bitkilerin vejetasyon dönemleri dikkate alınarak 10–15 günlük aralıklarla toplam 32 arazi çalışması gerçekleştirilmiştir. Araştırma alanında vejetasyon nisan ayında başlamakta, eylül ayı başlarından itibaren ise bozkır karakteri belirginleşmektedir.

Arazi çalışmaları sırasında araştırma alanındaki sekiz farklı lokaliteden toplam 1162 bitki örneği toplanmıştır. Örneklerin teşhisinde gerekli olan kök, gövde, yaprak, çiçek ve meyve gibi

morfolojik karakterlerin korunmasına özen gösterilmiş, toplama noktalarının koordinatları ve yükseltileri Garmin GPSMAP 66s GPS cihazı kullanılarak kaydedilmiştir.

Bitki örnekleri standart herbarium tekniklerine uygun olarak preslenmiş ve kurutulmuştur. Taksonların teşhisinde başlıca *Flora of Turkey and the East Aegean Islands* (Davis ve ark., 1965–1988) ile *Flora of Turkey and the East Aegean Islands* Ek Cildi (Güner ve ark., 2000) kullanılmıştır. Gerekli durumlarda uzman görüşüne başvurulmuş ve bitki sistematigi, terminoloji ile yayılış bilgilerinin değerlendirilmesinde ilgili literatürden yararlanılmıştır (Stearn, 1973; Brummitt & Powell, 1992; Brunner ve Tanker, 1978; Donner, 1985, 1987; Altınayar, 1987, 1988; Tutel, 1993; Eminağaoğlu, 2015).

### Lokaliteler

Sivas-Karayün karayolu arasında yer alan Bingöl Köyü'ne ait Bingöl Tuzlası Gölü ve Çevresinde yapılan arazi çalışmalarında bitki toplanan lokaliteler:

1. B6 Sivas: Sivas-Karayün yolu, Bingöl Köyü girişi, yamaçlar (tarla kenarı)
2. B6 Sivas: Sivas-Karayün yolu, Bingöl Köyü, tuzla civarı
3. B6 Sivas: Sivas-Karayün yolu, Bingöl Köyü, Tatlı Kireç Fabrikası civarı
4. B6 Sivas: Sivas-Karayün yolu, Bingöl Köyü çıkışı, yamaçlar (tarla kenarı)
5. B6 Sivas: Karayün-Sivas yolu, Bingöl Köyü girişi, yamaçlar (tarla kenarı)
6. B6 Sivas: Karayün-Sivas yolu, Bingöl Köyü girişi, yamaçlar (tarla kenarı)
7. B6 Sivas: Karayün-Sivas yolu, Bingöl Köyü merkezi civarı
8. B6 Sivas: Karayün-Sivas yolu, Bingöl Köyü çıkışı, yamaçlar (tarla kenarı)

Taksonların adlandırılmasında *Flora of Turkey and the East Aegean Islands* esas alınmış; endemizm durumları, fitocoğrafik bölge elementleri ve tehlike kategorileri ilgili literatüre göre değerlendirilmiştir. Teşhis için yeterli karakter taşımayan örnekler değerlendirme dışında bırakılmıştır. Araştırma alanındaki tüm lokaliteler Davis'in kareleme sistemine göre B6 karesinde yer aldığından, lokaliteler "B6 Sivas" olarak ifade edilmiştir.

### 3. BULGULAR

#### Sistematik Liste

#### PTERIDOPHYTA

##### EQUISETACEAE

*Equisetum ramosissimum* Desf. 8; 1300-1320 m, 05.8.2023, Erdoğmuş 1929. Hem, P

#### SPERMATOPHYTA (PHANEROGAMAE)

#### GYMNOSPERMAE

##### PINACEAE

*Pinus nigra* J.F. Arn. subsp. *pallasiana* (Lamb.) Holmboe 1; 1280-1330 m, 13.10.2023, Erdoğmuş 2098, 1; 1280-1330 m, 13.10.2023, Erdoğmuş 2099. Avrupa-Sibirya elementi. Pha, P

#### ANGIOSPERMAE

#### DICOTYLEDONEAE / MAGNOLIOPSIDA

##### ACANTHACEAE

*Acanthus hirsutus* Boiss. 1; 1280-1330 m, 11.7.2023, Erdoğmuş 1650, 8; 1300-1320 m, 04.6.2023, Erdoğmuş 1418. Endemik, İran-Turan elementi. Hem, P, LC

##### AMARANTHACEAE

*Atriplex micrantha* Ledeb. 8; 1300-1320 m, 30.9.2023, Erdoğmuş 2070. A,

*Atriplex hortensis* L. 6; 1280-1330 m, 17.5.2024, Erdoğmuş 2151. A,

*Chenopodium album* L. subsp. *iranicum* 7; 1280-1320 m, 30.8.2023, Erdoğmuş 2004.

*Chenopodium berlandieri* Moq. 6; 1280-1330 m, 30.8.2023, Erdoğmuş 2013.

*Chenopodium vulgare* Gueldenst. ex. Ledeb. 8; 1300-1320 m, 30.9.2023, Erdoğmuş 2071.

*Noaea mucronata* (Forssk.) Asch. & Schweinf. 6; 1280-1330 m, 30.8.2023, Erdoğmuş 2006.

*Salicornia europaea* (Mass.) Lambinon & Vanderp. 2; 1280-1290 m, 15.9.2023, Erdoğmuş 2030, 2; 1280-1290 m, 13.10.2023, Erdoğmuş 2116, 2; 1280-1290 m, 11.10.2023, Erdoğmuş 2131. Hal.

*Salsola kali* L. 8; 1300-1320 m, 30.9.2023, Erdoğmuş 2065.

*Sueda vera* Forssk. ex J.F. Gmel. 7; 1280-1320 m, 05.8.2023, Erdoğmuş 1888.

#### APIACEAE

*Bifora radians* Bieb. 7; 1280-1320 m, 04.6.2023, Erdoğmuş 1455, 7; 1280-1320 m, 01.7.2023, Erdoğmuş 1621, 8; 1300-1320 m, 04.6.2023, Erdoğmuş 1402, 8; 1300-1320 m, 04.6.2023, Erdoğmuş 1404, 8; 1300-1320 m, 04.6.2023, Erdoğmuş 1429.

*Bupleurum croceum* Fenzl. 1; 1280-1330 m, 03.6.2023, Erdoğmuş 1314, 3; 1290-1330 m, 23.6.2023, Erdoğmuş 1474; 8; 1300-1320 m, 05.8.2023, Erdoğmuş 1915. İran-Turan elementi. Ter, A

*Bupleurum rotundifolium* L. 6; 1280-1330 m, 17.5.2024, Erdoğmuş 2154. A,

*Conium maculatum* L. 6; 1280-1330 m, 17.5.2024, Erdoğmuş 2152

*Echinophora tenuifolia* L. Subsp. *sibthorpiana* (Guss.) Tutin 6; 1280-1330 m, 30.8.2023, Erdoğmuş 2014, 6; 1280-1330 m, 30.9.2023, Erdoğmuş 2082. İran-Turan elementi.

*Eryngium bithynicum* Boiss. 2; 1280-1290 m, 11.7.2023, Erdoğmuş 2138. Endemik, İran-Turan elementi. Ter, A, LC

*Falcaria vulgaris* Bernh. 3; 1290-1330 m, 19.7.2023, Erdoğmuş 1794, 4; 1300-1330 m, 15.8.2023, Erdoğmuş 1936. Hem, B

*Lisaea heterocarpa* (DC.) Boiss. 8; 1300-1320 m, 01.7.2023, Erdoğmuş 1535, 8; 1300-1320 m, 01.7.2023, Erdoğmuş 1536. İran-Turan elementi.

*Lisaea papyracea* Boiss. 3; 1290-1330 m, 23.6.2023, Erdoğmuş 1483, 3; 1290-1330 m, 23.6.2023, Erdoğmuş 1480, 3; 1290-1330 m, 23.6.2023, Erdoğmuş 1481, 3; 1290-1330 m, 19.7.2023, Erdoğmuş 1802, 8; 1300-1320 m, 01.7.2023, Erdoğmuş 1564. İran-Turan elementi. Ter, A

*Pastinaca armena* Fisch. & Mey. subsp. *armena* 2; 1280-1290 m, 15.9.2023, Erdoğmuş 2031.

*Pastinaca sativa* L. subsp. *urens* (Req. ex Gordon) ^Celak. 1; 1280-1330 m, 11.7.2023, Erdoğmuş 1685, 2; 1280-1290 m, 11.7.2023, Erdoğmuş 1758, 7; 1280-1320 m, 05.8.2023, Erdoğmuş 1905.

*Peucedanum palimbioides* Boiss. 4; 1300-1330 m, 19.7.2023, Erdoğmuş 2139. Endemik, İran-Turan elementi. LC

*Pimpinella cappadocica* Boiss. & Bal. var. *cappadocia* 1; 1280-1330 m, 11.7.2023, Erdoğmuş 1693, 5; 1280-1330 m, 01.7.2023, Erdoğmuş 1614. Endemik, İran-Turan elementi. Hem, B, LC

*Turgenia latifolia* (L.) Hoffm. 3; 1290-1330 m, 19.7.2023, Erdoğmuş 1820, 8; 1300-1320 m, 01.7.2023, Erdoğmuş 1534. Ter, A

#### ARISTOLOCHIACEAE

*Aristolochia maurorum* L. 3; 1290-1330 m, 23.6.2023, Erdoğan 1491, 5; 1280-1330 m, 06.5.2023, Erdoğan 1098, 5; 1280-1330 m, 06.5.2023, Erdoğan 1100. İran-Turan elementi.

#### ASPARAGACEAE

*Asparagus officinalis* L. 2; 1280-1290 m, 23.6.2023, Erdoğan 1550.

*Prospera autumnale* (L.) Speta 8; 1300-1320 m, 05.8.2023, Erdoğan 1914. Akdeniz elementi, P, Geo,

#### ASPHODELACEAE

*Asphodelus fistulosus* L. 6; 1320-1330 m, 17.5.2024, Erdoğan 2155, 5; 1320-1330 m, 17.5.2024, Erdoğan 2156.

#### ASTERACEAE

*Achillea biebersteinii* Afan. 1; 1280-1330 m, 23.6.2023, Erdoğan 1499, 2; 1280-1290 m, 03.6.2023, Erdoğan 1327, 5; 1320-1330 m, 01.7.2023, Erdoğan 1602, 5; 1280-1330 m, 26.7.2023, Erdoğan 1845. İran-Turan elementi. Hem, P

*Achillea lycaonica* Boiss. & Heldr. 6; 1280-1330 m, 26.7.2023, Erdoğan 1825, 5; 1280-1330 m, 26.7.2023, Erdoğan 1846. Endemik, İran-Turan elementi. LC

*Achillea phrygia* Boiss. & Bal. 6; 1280-1330 m, 01.7.2023, Erdoğan 1608, 8; 1300-1320 m, 04.6.2023, Erdoğan 1407. Endemik, İran-Turan elementi.

*Achillea setacea* Waldst. & Kit. & Bal. 8; 1300-1320 m, 01.7.2023, Erdoğan 1575. Avrupa-Sibirya elementi. Elementi.

*Anthemis aciphylla* Boiss. var. *discoidea* Boiss. 1; 1280-1330 m, 05.5.2023, Erdoğan 1171, 1; 1280-1330 m, 05.5.2023, Erdoğan 1172, 2; 1280-1290 m, 05.5.2023, Erdoğan 1185. Endemik.

*Anthemis armenica* Freyn & Sint. 1; 1280-1330 m, 05.5.2023, Erdoğan 1173, 1; 1280-1330 m, 20.5.2023, Erdoğan 1239, 4; 1300-1330 m, 05.5.2023, Erdoğan 1203, 4; 1300-1330 m, 05.5.2023, Erdoğan 1206, 4; 1300-1330 m, 20.5.2023, Erdoğan 1290, 5; 1280-1330 m, 06.5.2023, Erdoğan 1106. Endemik, İran-Turan elementi. LC

*Anthemis arvensis* L. 7; 1280-1320 m, 30.9.2023, Erdoğan 2073.

*Anthemis cretica* L. subsp. *albida* (Boiss.) Grierson 1; 1280-1330 m, 23.4.2023, Erdoğan 1091, 1; 1280-1330 m, 23.4.2023, Erdoğan 1092, 1; 1280-1330 m, 11.7.2023, Erdoğan 1678, 1; 1280-1330 m, 11.7.2023, Erdoğan 1680, 1; 1280-1330 m, 11.7.2023, Erdoğan 1681, 2; 1280-1290 m, 08.4.2023, Erdoğan 1007, 2; 1280-1290 m, 23.6.2023, Erdoğan 1542, 5; 1320-1330 m, 23.4.2023, Erdoğan 1070, 5; 1280-1330 m, 04.6.2023, Erdoğan 1377, 5; 1280-1330 m,

04.6.2023, Erdoğan 1383, 5; 1280-1330 m, 04.6.2023, Erdoğan 1384. Hem, P, NT

*Anthemis tinctoria* (L.) K.Gay ex. Guss. var. *pallida* DC. 1; 1280-1330 m, 03.6.2023, Erdoğan 1322, 1; 1280-1330 m, 03.6.2023, Erdoğan 1323, 1; 1280-1330 m, 11.7.2023, Erdoğan 1698. Hem, P

*Anthemis tricornis* Eig 8; 1300-1320 m, 04.6.2023, Erdoğan 1409.

*Anthemis triumfettii* (L.) All. 1; 1280-1330 m, 23.6.2023, Erdoğan 1507; 1; 1280-1330 m, 23.6.2023, Erdoğan 1508.

*Artemisia araratica* Krasch 6; 1280-1330 m, 30.8.2023, Erdoğan 2005. İran-Turan elementi.

*Artemisia campestris* L. 7; 1280-1320 m, 05.8.2023, Erdoğan 1898.

*Carduus nutans* L. subsp. *leiophyllus* (Petr.) Staj. & Stef. 2; 1280-1290 m, 23.6.2023, Erdoğan 1548. Hem, P

*Carduus nutans* L. subsp. *nutans* sensu lato 3; 1290-1330 m, 03.6.2023, Erdoğan 1329. Hem, B

*Carduus pycnocephalus* L. subsp. *albidus* (Bieb.) Kazmi 1; 1280-1330 m, 11.7.2023, Erdoğan 1647.

*Carlina oligocephala* Boiss. & Kotschy subsp. *oligocephala* 1; 1280-1330 m, 15.8.2023, Erdoğan 1974. Endemik, Doğu Akdeniz elementi. Hem, P

*Centaurea benedicta* (L.) L. 6; 1280-1330 m, 04.6.2023, Erdoğan 1367.

*Centaurea iberica* Trev. ex. Sprengel 1; 1280-1330 m, 11.7.2023, Erdoğan 1648, 1; 1280-1330 m, 11.7.2023, Erdoğan 1649, 5; 1320-1330 m, 26.7.2023, Erdoğan 1878, 5; 1280-1330 m, 04.6.2023, Erdoğan 1368, 5; 1280-1330 m, 26.7.2023, Erdoğan 1855, 5; 1280-1330 m, 26.7.2023, Erdoğan 1856. Ter, A

*Centaurea kotchysii* (Boiss. & Heldr.) Hayek var. *decumbens* Wagenitz 1; 1280-1330 m, 11.7.2023, Erdoğan 1679. Endemik.

*Centaurea kotchysii* (Boiss. & Heldr.) Hayek var. *persica* (Boiss.) 1; 1280-1330 m, 11.7.2023, Erdoğan 1713, 1; 1280-1330 m, 11.7.2023, Erdoğan 1714, 8; 1300-1320 m, 01.7.2023, Erdoğan 1573, 8; 1300-1320 m, 05.8.2023, Erdoğan 1913.

*Centaurea pichleri* Boiss. subsp. *pichleri* 1; 1280-1330 m, 05.5.2023, Erdoğan 1154, 3; 1290-1330 m, 23.4.2023, Erdoğan 1073, 3; 1290-1330 m, 23.6.2023, Erdoğan 1477, 3; 1290-1330 m, 19.7.2023, Erdoğan 1799, 3; 1290-1330 m, 19.7.2023, Erdoğan 1821, 5; 1320-1330 m, 06.5.2023, Erdoğan 1111, 8; 1300-1320 m, 06.5.2023, Erdoğan 1131, 8; 1300-1320 m, 04.6.2023, Erdoğan 1413. Hem, P

***Centaurea polypodiifolia*** Boiss. var. ***szovitsiana*** (Boiss.) Wagen 1; 1280-1330 m, 11.7.2023, Erdoğan 1724. Hem, P

***Centaurea solstitialis*** L. subsp. ***solstitialis*** 1; 1280-1330 m, 11.7.2023, Erdoğan 1646, 4; 1300-1330 m, 15.9.2023, Erdoğan 2019, 5; 1280-1330 m, 26.7.2023, Erdoğan 1829, 5; 1280-1330 m, 26.7.2023, Erdoğan 1853.

***Centaurea solstitialis*** L. subsp. ***carneola*** Boiss. 4; 1300-1330 m, 15.9.2023, Erdoğan 2018, 7; 1280-1320 m, 30.8.2023, Erdoğan 2001, 7; 1280-1320 m, 30.9.2023, Erdoğan 2075, 7; 1280-1320 m, 30.9.2023, Erdoğan 2076. **Endemik.**

***Centaurea virgata*** Lam. (Grup A) 1; 1280-1330 m, 11.7.2023, Erdoğan 1690, 1; 1280-1330 m, 11.7.2023, Erdoğan 1691, 3; 1290-1330 m, 19.7.2023, Erdoğan 1809. İran-Turan elementi. Hem, P

***Cichorium intybus*** L. 1; 1280-1330 m, 23.6.2023, Erdoğan 1506, 4; 1300-1330 m, 19.7.2023, Erdoğan 1770, 5; 1280-1330 m, 01.7.2023, Erdoğan 1612, 5; 1280-1330 m, 26.7.2023, Erdoğan 1826, 5; 1280-1330 m, 26.7.2023, Erdoğan 1857, 5; 1280-1330 m, 26.7.2023, Erdoğan 1858, 7; 1280-1320 m, 05.8.2023, Erdoğan 1889, 8; 1300-1320 m, 01.7.2023, Erdoğan 1560. Hem, P

***Cirsium arvense*** (L.) Scop. subsp. ***vestitum*** (Wimm.& Grab.) Petr. 3; 1290-1330 m, 15.8.2023, Erdoğan 1943, 3; 1290-1330 m, 15.8.2023, Erdoğan 1944, 3; 1290-1330 m, 15.9.2023, Erdoğan 2024, 4; 1300-1330 m, 19.7.2023, Erdoğan 2136. Hem, P

***Cirsium ferox*** (L.) DC. 2; 1280-1290 m, 13.10.2023, Erdoğan 2120, 3; 1290-1330 m, 15.9.2023, Erdoğan 2027, 8; 1300-1320 m, 30.8.2023, Erdoğan 1996.

***Cirsium lappaceum*** (Bieb.) Fisch. subsp. ***anatolicum*** Petr. 1; 1280-1330 m, 15.9.2023, Erdoğan 2041, 2; 1280-1290 m, 15.8.2023, Erdoğan 1953. Hem, P, LC

***Cirsium vulgare*** (Savi) Ten. 2; 1280-1290 m, 15.8.2023, Erdoğan 1952, 2; 1280-1290 m, 13.10.2023, Erdoğan 2121.

***Condrilla juncea*** L. var. ***juncea*** 3; 1290-1330 m, 15.8.2023, Erdoğan 1945, 5; 1280-1330 m, 30.9.2023, Erdoğan 2080, 8; 1300-1320 m, 30.9.2023, Erdoğan 2062, 8; 1300-1320 m, 30.9.2023, Erdoğan 2064.

***Cota tinctoria*** (L.) J.Gay 3; 1290-1330 m, 23.6.2023, Erdoğan 1494, 3; 1290-1330 m, 23.6.2023, Erdoğan 1495.

***Crepis foetida*** L. subsp. ***rhoeadifolia*** (Bieb.) Cel. 1; 1280-1330 m, 11.7.2023, Erdoğan 1694, 1; 1280-1330 m, 15.9.2023, Erdoğan 2046, 1; 1280-1330 m, 15.9.2023, Erdoğan 2047, 2; 1280-1290 m, 15.8.2023, Erdoğan 1956, 2; 1280-1290 m, 15.8.2023, Erdoğan 1957, 2; 1280-1290 m, 15.9.2023, Erdoğan 2035, 5; 1320-1330 m, 30.8.2023, Erdoğan 1984, 5; 1280-1330 m, 26.7.2023, Erdoğan 1839, 5; 1280-1330 m, 28.10.2023, Erdoğan 2126, 8; 1300-1320 m, 05.8.2023, Erdoğan 1924. Ter, A

***Crepis macropus*** Boiss. & Heldr. 4; 1300-1330 m, 23.6.2023, Erdoğan 1457. **Endemik**, İran-Turan elementi.

***Crepis pulchra*** L. 4; 1300-1330 m, 19.7.2023, Erdoğan 1769.

***Crepis syriaca*** (Bornm.) Babcock & Nav. 1; 1280-1330 m, 23.6.2023, Erdoğan 1528, 5; 1320-1330 m, 01.7.2023, Erdoğan 1596.

***Echinops sphaerocephalus*** L. 6; 1280-1330 m, 30.8.2023, Erdoğan 2015.

***Galatella punctata*** (Waldst. & Kit.) Nees. 1; 1280-1330 m, 15.8.2023, Erdoğan 1964.

***Geropogon hybridus*** (L.) Sch. Bip. 6; 1320-1330 m, 17.5.2024, Erdoğan 2160. A,

***Helichrysum arenarium*** (L.) Moench subsp. ***aucheri*** (Boiss.) Davis & Kupic 6; 1320-1330 m, 30.8.2023, Erdoğan 1983. **Endemik**, İran-Turan elementi. Hem, P, LC

***Helichrysum armenium*** DC. subsp. ***armenium*** 1; 1280-1330 m, 15.8.2023, Erdoğan 1960, 2; 1280-1290 m, 15.8.2023, Erdoğan 1948. İran-Turan elementi. Hem, P

***Helichrysum orientale*** (L.) DC. 4; 1300-1330 m, 19.7.2023, Erdoğan 2135.

***Inula montana*** L. 1; 1280-1330 m, 11.7.2023, Erdoğan 1667, 1; 1280-1330 m, 11.7.2023, Erdoğan 1687.

***Lactuca serriola*** L. 1; 1280-1330 m, 15.8.2023, Erdoğan 1979.

***Leontodon crispus*** Vill. subsp. ***asper*** (Waldst. & Kit.) Rohl. var. ***asper*** 1; 1280-1330 m, 20.5.2023, Erdoğan 1250, 5; 1280-1330 m, 01.7.2023, Erdoğan 1613. Hem, P

***Leontodon laciniatus*** (Bertol.) Widder ex. Bornm. 6; 1320-1330 m, 01.7.2023, Erdoğan 1600.

***Onopordum acanthium*** L. 6; 1280-1330 m, 26.7.2023, Erdoğan 1827, 5; 1280-1330 m, 26.7.2023, Erdoğan 1830.

***Picris hieracioides*** L. 1; 1280-1330 m, 11.7.2023, Erdoğan 1657, 1; 1280-1330 m, 15.8.2023, Erdoğan 1977, 1; 1280-1330 m, 15.9.2023, Erdoğan 2038.

***Pilosella cymosa*** (L.) F.W. Schultea & Sch. Bip 1; 1280-1330 m, 11.7.2023, Erdoğan 1659.

***Picnomon acarna*** (L.) Cass. 8; 1300-1320 m, 30.8.2023, Erdoğan 1995. Akdeniz elementi. Ter, A

***Pulicaria dysenterica*** (L.) Bernh. 2; 1280-1290 m, 15.8.2023, Erdoğan 1958; 8; 1300-1320 m, 30.8.2023, Erdoğan 1986.

***Pulicaria vulgaris*** Gaertn. 1; 1280-1330 m, 15.8.2023, Erdoğan 1966, 1; 1280-1330 m, 15.9.2023, Erdoğan 2039, 2; 1280-1290 m, 15.9.2023, Erdoğan 2033, 4; 1300-1330 m, 15.8.2023, Erdoğan 1932, 4; 1300-1330 m, 15.9.2023,

Erdoğan 2017, 7; 1280-1320 m, 05.8.2023, Erdoğan 1892, 8; 1300-1320 m, 30.8.2023, Erdoğan 1994.

**Scorzonera cana** (C.A. Meyer) Hoffm. var. **jacquiniana** (W. Koch.) Chamberlain 1; 1280-1330 m, 23.6.2023, Erdoğan 1503, 1; 1280-1330 m, 23.6.2023, Erdoğan 1523, 1; 1280-1330 m, 15.9.2023, Erdoğan 2053, 2; 1280-1290 m, 23.6.2023, Erdoğan 1545, 7; 1280-1320 m, 04.6.2023, Erdoğan 1447.

**Scorzonera cinerea** Boiss. 7; 1280-1320 m, 04.6.2023, Erdoğan 1446. İran-Turan elementi.

**Scorzonera humilis** L. 4; 1300-1330 m, 20.5.2023, Erdoğan 1289, 5; 1280-1330 m, 21.5.2023, Erdoğan 1284.

**Scorzonera mirabilis** Lipschitz 6; 1320-1330 m, 01.7.2023, Erdoğan 1591, 5; 1320-1330 m, 26.7.2023, Erdoğan 1868, 5; 1320-1330 m, 26.7.2023, Erdoğan 1876, 5; 1320-1330 m, 26.7.2023, Erdoğan 1877. **Endemik**, İran-Turan elementi.

**Scorzonera mollis** Bieb. subsp. **szowitzii** (DC.) Chamb. 6; 1280-1330 m, 23.4.2023, Erdoğan 1061. İran-Turan elementi. Hem, P

**Scorzonera rigida** Aucher 1; 1280-1330 m, 15.8.2023, Erdoğan 1965, 1; 1280-1330 m, 15.8.2023, Erdoğan 1973, 3; 1290-1330 m, 19.7.2023, Erdoğan 1791, 3; 1290-1330 m, 19.7.2023, Erdoğan 1792, 4; 1300-1330 m, 19.7.2023, Erdoğan 1778. İran-Turan elementi.

**Senecio jacobaea** L. 1; 1280-1330 m, 11.7.2023, Erdoğan 1689.

**Senecio mollis** Willd. 4; 1300-1330 m, 19.7.2023, Erdoğan 1762, 5; 1320-1330 m, 26.7.2023, Erdoğan 1870, 8; 1300-1320 m, 05.8.2023, Erdoğan 1918. İran-Turan elementi.

**Senecio racemosus** (M. Bieb.) DC. 1; 1280-1330 m, 15.8.2023, Erdoğan 1968. İran-Turan elementi.

**Senecio vernalis** Waldst. & Kit. 1; 1280-1330 m, 20.5.2023, Erdoğan 1240, 1; 1280-1330 m, 20.5.2023, Erdoğan 1249, 2; 1280-1290 m, 05.5.2023, Erdoğan 1115, 2; 1280-1290 m, 05.5.2023, Erdoğan 1116, 2; 1280-1290 m, 05.5.2023, Erdoğan 1117, 2; 1280-1290 m, 05.5.2023, Erdoğan 1187, 3; 1290-1330 m, 03.6.2023, Erdoğan 1332, 5; 1320-1330 m, 21.5.2023, Erdoğan 1286, 5; 1320-1330 m, 28.10.2023, Erdoğan 2128. Ter, A

**Tanacetum argyrophyllum** (C.Koch) Tvel. var. **argyrophyllum** 4; 1300-1330 m, 05.5.2023, Erdoğan 1207. İran-Turan elementi.

**Tanacetum balsamita** L. 2; 1280-1290 m, 15.8.2023, Erdoğan 1959.

**Tanacetum eginense** (Hausskn. ex Bornm.) Grierson 1; 1280-1330 m, 11.7.2023, Erdoğan 1682, 2; 1280-1290 m, 11.7.2023, Erdoğan 1737. **Endemik**, İran-Turan elementi.

**Taraxacum bessarabicum** (Hornem) Hand.-Mazz. subsp. **bessarabicum** 2; 1280-1290 m, 15.9.2023, Erdoğan 2028, 2; 1280-1290 m, 13.10.2023, Erdoğan 2114, 3; 1290-1330 m, 15.8.2023, Erdoğan 1938, 3; 1290-1330 m, 13.10.2023, Erdoğan 2109, 7; 1280-1320 m, 30.9.2023, Erdoğan 2077.

**Taraxacum montanum** (C.A. Meyer) DC. 1; 1280-1330 m, 15.9.2023, Erdoğan 2051, 3; 1290-1330 m, 13.10.2023, Erdoğan 2106, 4; 1300-1330 m, 15.8.2023, Erdoğan 1937, 4; 1300-1330 m, 19.7.2023, Erdoğan 2137, 5; 1320-1330 m, 26.7.2023, Erdoğan 1879, 5; 1320-1330 m, 30.8.2023, Erdoğan 1982, 5; 1280-1330 m, 30.9.2023, Erdoğan 2079. İran-Turan elementi. Hem, P

**Taraxacum revertens** G. Hagl. 2; 1280-1290 m, 23.4.2023, Erdoğan 1083, 5; 1320-1330 m, 23.4.2023, Erdoğan 1063, 7; 1280-1320 m, 30.8.2023, Erdoğan 2002, 8; 1300-1320 m, 30.9.2023, Erdoğan 2067. **Endemik**, İran-Turan elementi. Hem, P, LC

**Tragopogon armeniaca** (Boiss. & Huet) Boiss. 7; 1280-1320 m, 04.6.2023, Erdoğan 1443.

**Tragopogon aureus** Boiss. 3; 1290-1330 m, 19.7.2023, Erdoğan 1812, 3; 1290-1330 m, 19.7.2023, Erdoğan 1822, 3; 1290-1330 m, 19.7.2023, Erdoğan 1823, 8; 1300-1320 m, 01.7.2023, Erdoğan 1565. **Endemik**. Hem, P, LC

**Tragopogon buphthalmoides** (DC.) Boiss. var. **buphthalmoides** 1; 1280-1330 m, 11.7.2023, Erdoğan 1711, 1; 1280-1330 m, 11.7.2023, Erdoğan 1721, 2; 1280-1290 m, 23.6.2023, Erdoğan 1549, 2; 1280-1290 m, 11.7.2023, Erdoğan 1739, 5; 1280-1330 m, 26.7.2023, Erdoğan 1852. İran-Turan elementi.

**Tragopogon coloratus** C.A.Meyer 3; 1290-1330 m, 19.7.2023, Erdoğan 1808, 4; 1300-1330 m, 19.7.2023, Erdoğan 1763, 8; 1300-1320 m, 01.7.2023, Erdoğan 1562. İran-Turan elementi.

**Tragopogon crocifolius** L. 6; 1280-1330 m, 17.5.2024, Erdoğan 2161, 5; 1280-1330 m, 17.5.2024, Erdoğan 2162. A,

**Tragopogon dubius** Scop. 1; 1280-1330 m, 23.6.2023, Erdoğan 1500, 5; 1280-1330 m, 04.6.2023, Erdoğan 1364, 8; 1300-1320 m, 01.7.2023, Erdoğan 1630, 5; 1280-1330 m, 17.5.2024, Erdoğan 2153, 5; 1280-1330 m, 17.5.2024, Erdoğan 2159. A,

**Tragopogon pratensis** L. subsp. **pratensis** 6; 1280-1330 m, 04.6.2023, Erdoğan 1389. Avrupa-Sibirya elementi.

**Tripleurospermum inodorum** (L.) Sch. Bip. 7; 1280-1320 m, 01.7.2023, Erdoğan 1625.

**Tussilago farfara** L. 2; 1280-1290 m, 11.7.2023, Erdoğan 1731, 8; 1300-1320 m, 08.4.2023, Erdoğan 1034. Avrupa-Sibirya elementi. Hem, P

*Urospermum picroides* (L.) F.W.Schmidt. 6; 1320-1330 m, 26.7.2023, Erdoğan 1861, 5; 1320-1330 m, 26.7.2023, Erdoğan 1862.

*Xanthium strumarium* L. subsp. *cavanillesii* (Schouw) D. Löve & P. Dansereau 2; 1280-1290 m, 15.8.2023, Erdoğan 1954, 8; 1300-1320 m, 30.9.2023, Erdoğan 2068.

*Xeranthemum annuum* L. 1; 1280-1330 m, 11.7.2023, Erdoğan 1708, 1; 1280-1330 m, 15.9.2023, Erdoğan 2054, 3; 1290-1330 m, 19.7.2023, Erdoğan 1806, 3; 1290-1330 m, 19.7.2023, Erdoğan 1813, 4; 1300-1330 m, 19.7.2023, Erdoğan 1766, 7; 1280-1320 m, 05.8.2023, Erdoğan 1890, 7; 1280-1320 m, 05.8.2023, Erdoğan 1896. Ter, A

*Xeranthemum cylindraceum* Sm. 3; 1290-1330 m, 20.5.2023, Erdoğan 1209, 4; 1300-1330 m, 23.6.2023, Erdoğan 1468, 4; 1300-1330 m, 23.6.2023, Erdoğan 1469.

*Xeranthemum inapertum* (L.) Mill. 1; 1280-1330 m, 15.8.2023, Erdoğan 1969.

*Xeranthemum virgatum* P.J.Bergius 1; 1280-1330 m, 11.7.2023, Erdoğan 1717, 5; 1320-1330 m, 01.7.2023, Erdoğan 1599, 5; 1280-1330 m, 26.7.2023, Erdoğan 1848, 5; 1280-1330 m, 26.7.2023, Erdoğan 1851.

#### BERBERIDACEAE

*Berberis crataegina* DC. 1; 1280-1330 m, 13.10.2023, Erdoğan 2090, 2; 1280-1290 m, 20.5.2023, Erdoğan 1300, 3; 1290-1330 m, 20.5.2023, Erdoğan 1216. İran-Turan elementi. Pha, P

*Berberis integerrima* Bunge. 2; 1280-1290 m, 20.5.2023, Erdoğan 1313.

*Leontice leontopetalum* subsp. *leontopetalum* 6; 1320-1330 m, 06.5.2023, Erdoğan 1109.

#### BORAGINACEAE

*Anchusa arvensis* (L.) Bieb. 3; 1290-1330 m, 23.4.2023, Erdoğan 1077, 3; 1290-1330 m, 23.4.2023, ERDOĞMUŞ 1080, 7; 1280-1320 m, 06.5.2023, Erdoğan 1140. Ter, A

*Anchusa azurea* Mill. var. *azurea* 8; 1300-1320 m, 04.6.2023, Erdoğan 1424, 8; 1300-1320 m, 04.6.2023, ERDOĞMUŞ 1425, 2; 1280-1290 m, 20.5.2023, Erdoğan 1308. Hem, P

*Anchusa leptophylla* Roemer & Schultes subsp. *leptophylla* 1; 1280-1330 m, 20.5.2023, Erdoğan 1231, 4; 1300-1330 m, 15.9.2023, Erdoğan 2020, 5; 1320-1330 m, 26.7.2023, Erdoğan 1872, 5; 1320-1330 m, 26.7.2023, Erdoğan 1873, 5; 1280-1330 m, 01.7.2023, Erdoğan 1610, 5; 1280-1330 m, 01.7.2023, Erdoğan 1617. Hem, P

*Anchusa officinalis* L. 7; 1280-1320 m, 21.5.2023, Erdoğan 1269.

*Anchusa strigosa* Labill. 7; 1280-1320 m, 30.9.2023, Erdoğan 2078.

*Anchusa stylosa* Bieb. 7; 1280-1320 m, 23.4.2023, Erdoğan 1049.

*Buglossoides arvensis* (L.) I.M. Johnst. 2; 1280-1290 m, 23.4.2023, Erdoğan 1086. Ter, A

*Cerithe minor* (L.) subsp. *auriculata* (Ten.) Domac 1; 1280-1330 m, 20.5.2023, Erdoğan 1254, 2; 1280-1290 m, 23.6.2023, Erdoğan 1533, 8; 1300-1320 m, 05.8.2023, Erdoğan 1925. Hem, B

*Echium angustifolium* Miller 6; 1320-1330 m, 28.10.2023, Erdoğan 2129.

*Echium sabulicola* Pomel 6; 1320-1330 m, 04.6.2023, Erdoğan 1354.

*Lappula barbata* (Bieb.) Gürke 6; 1320-1330 m, 04.6.2023, Erdoğan 1353. İran-Turan elementi. Hem, B

*Nonea optusifolia* (Willd.) D.C. 7; 1280-1320 m, 04.6.2023, Erdoğan 1450.

*Nonea pulla* (L.) DC. subsp. *cabrisquamata* A. Baytop 2; 1280-1290 m, 05.5.2023, Erdoğan 1181. İran-Turan elementi. Hem, P

*Nonea stenosolen* Boiss. & Ball. 1; 1280-1330 m, 20.5.2023, Erdoğan 1261, 2; 1280-1290 m, 23.4.2023, Erdoğan 1090. Endemik, İran-Turan elementi. Hem, P, LC

*Onosma tauricum* Pall. ex Willd. var. *tauricum* 2; 1280-1290 m, 20.5.2023, Erdoğan 1299, 2; 1280-1290 m, 20.5.2023, Erdoğan 1301, 2; 1280-1290 m, 20.5.2023, Erdoğan 1310. Hem, P

*Onosma thracicum* Velen 8; 1300-1320 m, 04.6.2023, Erdoğan 1408. Avrupa-Sibirya elementi.

#### BRASSICACEAE

*Aethionema arabicum* (L.) Andr. Ex DC. 1; 1280-1330 m, 05.5.2023, Erdoğan 1169. Ter, A

*Aethionema carneum* (Banks & Sol.) Fedtsch 6; 1280-1330 m, 04.6.2023, Erdoğan 1380, 5; 1280-1330 m, 04.6.2023, Erdoğan 1382. İran-Turan elementi.

*Alyssum szowitsianum* Fisch. & Mey. 2; 1280-1290 m, 11.7.2023, Erdoğan 1757.

*Alyssum alyssoides* (L.) L. 1; 1280-1330 m, 05.5.2023, Erdoğan 1168, 1; 1280-1330 m, 20.5.2023, Erdoğan 1243, 3; 1290-1330 m, 23.4.2023, Erdoğan 1079, 3; 1290-1330 m, 20.5.2023, Erdoğan 1222, 7; 1280-1320 m, 21.5.2023, Erdoğan 1270, 7; 1280-1320 m, 04.6.2023, Erdoğan 1437, 8; 1300-1320 m, 06.5.2023, Erdoğan 1126, 8; 1300-1320 m, 04.6.2023, Erdoğan 1397. Endemik, İran-Turan elementi. LC

*Alyssum argenteum* Schmalh. 1; 1280-1330 m, 05.5.2023, Erdoğan 1150, 1; 1280-1330 m, 05.5.2023, Erdoğan 1165, 2; 1280-1290 m, 20.5.2023, Erdoğan 1306.

*Alyssum desertorum* Stapf. var. *desertorum* 3; 1290-1330 m, 23.4.2023, Erdoğan 1074, 4; 1300-1330 m, 05.5.2023, Erdoğan 1197.

*Alyssum huetii* Boiss. 1; 1280-1330 m, 08.4.2023, Erdoğan 1005, 3; 1290-1330 m, 23.6.2023, Erdoğan 1475, 5; 1320-1330 m, 23.4.2023, Erdoğan 1069, 5; 1280-1330 m, 23.4.2023, Erdoğan 1057, 7; 1280-1320 m, 23.4.2023, Erdoğan 1050, 8; 1300-1320 m, 08.4.2023, Erdoğan 1031. **Endemik**, İran-Turan elementi.

*Alyssum montanum* L. 2; 1280-1290 m, 05.5.2023, Erdoğan 1178, 8; 1300-1320 m, 04.6.2023, Erdoğan 1400.

*Alyssum murale* Waldst. & Kit. var. *haradjianii* 7; 1280-1320 m, 23.4.2023, Erdoğan 1046.

*Alyssum xanthocarpum* Boiss. 2; 1280-1290 m, 23.6.2023, Erdoğan 1089.

*Brassica elongata* Ehrh. 2; 1280-1290 m, 23.6.2023, Erdoğan 1554, 3; 1290-1330 m, 23.4.2023, Erdoğan 1078. İran-Turan elementi. Hem, B

*Brassica napus* L. 1; 1280-1330 m, 11.7.2023, Erdoğan 1683, 1; 1280-1330 m, 11.7.2023, Erdoğan 1684.

*Camelina microcarpa* Andr. ex. DC. 4; 1300-1330 m, 05.5.2023, Erdoğan 1196, 7; 1280-1320 m, 06.5.2023, Erdoğan 1141.

*Capsella bursa-pastoris* (L.) Medik. 2; 1280-1290 m, 05.5.2023, Erdoğan 1183, 2; 1280-1290 m, 05.5.2023, Erdoğan 1184, 4; 1300-1330 m, 08.4.2023, Erdoğan 1017.

*Cardaria draba* (L.) Devs. subsp. *draba* 1; 1280-1330 m, 20.5.2023, Erdoğan 1230, 1; 1280-1330 m, 23.6.2023, Erdoğan 1527, 1; 1280-1330 m, 23.6.2023, Erdoğan 1531, 2; 1280-1290 m, 23.6.2023, Erdoğan 1085, 7; 1280-1320 m, 21.5.2023, Erdoğan 1275, 7; 1280-1320 m, 04.6.2023, Erdoğan 1436, 8; 1300-1320 m, 23.4.2023, Erdoğan 1054. Hem, P

*Chorispora iberica* (Bieb.) DC. 6; 1280-1330 m, 06.5.2023, Erdoğan 1105.

*Chorispora syriaca* Boiss. 7; 1280-1320 m, 06.5.2023, Erdoğan 1143. İran-Turan elementi.

*Chorispora tenella* (Pall.) DC. 3; 1290-1330 m, 05.5.2023, Erdoğan 1194, 4; 1300-1330 m, 23.6.2023, Erdoğan 1461, 2; 1280-1290 m, 14.4.2024, Erdoğan 2146, 2; 1280-1290 m, 14.4.2024, Erdoğan 2147. A,

*Chrysocamela noeana* (Boiss.) Boiss. 8; 1300-1320 m, 06.5.2023, Erdoğan 1124. **Endemik**, İran-Turan elementi. EN.

*Congringia orientalis* (L.) Andr. 3; 1290-1330 m, 05.5.2023, Erdoğan 1191.

*Congringia perfoliata* (C. A. Mey.) Busch. 8; 1300-1320 m, 06.5.2023, Erdoğan 1135. Ter, A

*Descurainia sophia* (L.) Webb.ex Pranti 8; 1300-1320 m, 23.4.2023, Erdoğan 1052, 1; 1280-1330 m, 20.5.2023, Erdoğan 1232, 1; 1280-1330 m, 20.5.2023, Erdoğan 1248, 5; 1280-1330 m, 04.6.2023, Erdoğan 1379.

*Eruca sativa* Mill. 7; 1280-1320 m, 23.4.2023, Erdoğan 1042, 7; 1280-1320 m, 23.4.2023, Erdoğan 1044, 7; 1280-1320 m, 23.4.2023, Erdoğan 1045.

*Erysimum alpestre* Kotschy ex. Boiss. 1; 1280-1330 m, 05.5.2023, Erdoğan 1149, 1; 1280-1330 m, 05.5.2023, Erdoğan 1167, 2; 1280-1290 m, 23.6.2023, Erdoğan 1081, 2; 1280-1290 m, 05.5.2023, Erdoğan 1177, 3; 1290-1330 m, 05.5.2023, Erdoğan 1189. **Endemik**, İran-Turan elementi. Hem, P

*Erysimum diffusum* Ehrh. 1; 1280-1330 m, 20.5.2023, Erdoğan 1251. Avrupa-Sibirya elementi.

*Erysimum repandum* L. 7; 1280-1320 m, 06.5.2023, Erdoğan 1147, 8; 1300-1320 m, 04.6.2023, Erdoğan 1419.

*Hesperis isatidea* (Boiss.) D.A. German & Al-Shehbaz 6; 1320-1330 m, 01.7.2023, Erdoğan 1595, 5; 1320-1330 m, 30.9.2023, Erdoğan 2084. **Endemik**.

*Isatis glauca* Auch. ex. Boiss. subsp. *glauca* 2; 1280-1290 m, 11.7.2023, Erdoğan 1748, 8; 1300-1320 m, 21.5.2023, Erdoğan 1262, 8; 1300-1320 m, 21.5.2023, Erdoğan 1263, 8; 1300-1320 m, 21.5.2023, Erdoğan 1264, 8; 1300-1320 m, 05.8.2023, Erdoğan 1928. İran-Turan elementi. Hem, P

*Isatis sivasica* Davis 8; 1300-1320 m, 01.7.2023, Erdoğan 1631. **Endemik**, İran-Turan elementi.

*Isatis tinctoria* L. subsp. *tinctoria* 6; 1280-1330 m, 21.5.2023, Erdoğan 1282.

*Iberis taurica* DC. 2; 1280-1290 m, 20.5.2023, Erdoğan 1297, 2; 1280-1290 m, 20.5.2023, Erdoğan 1298, 5; 1280-1330 m, 06.5.2023, Erdoğan 1107, 5; 1280-1330 m, 04.6.2023, Erdoğan 1385, 5; 1280-1330 m, 01.7.2023, Erdoğan 1615, 8; 1300-1320 m, 04.6.2023, Erdoğan 1433.

*Lepidium draba* L. 2; 1280-1290 m, 05.5.2023, Erdoğan 1119.

*Lepidium perfoliatum* L. 3; 1290-1330 m, 23.4.2023, Erdoğan 1076, 7; 1280-1320 m, 21.5.2023, Erdoğan 1273.

*Neslia apiculata* Fisch., Mey. & Ave-Lall. 1; 1280-1330 m, 05.5.2023, Erdoğan 1155, 1; 1280-1330 m, 05.5.2023, Erdoğan 1156, 3; 1290-1330 m, 05.5.2023, Erdoğan 1192, 4; 1300-1330 m, 23.6.2023, Erdoğan 1462, 7; 1280-1320 m, 06.5.2023, Erdoğan 1139, 7; 1280-1320 m, 06.5.2023, Erdoğan 1142, 8; 1300-1320 m, 23.4.2023, Erdoğan 1051.

*Nocca perfoliata* (L.) Al-Shehbaz 8; 1300-1320 m, 08.4.2023, Erdoğan 1038.

*Rapistrum rugosum* (L.) All. 8; 1300-1320 m, 04.6.2023, Erdoğan 1396.

*Rhamphospermum arvense* (L.) Andr. ex. Besser 4; 1300-1330 m, 08.4.2023, Erdoğan 1023, 8; 1300-1320 m, 08.4.2023, Erdoğan 1039. A,

*Sinapis arvensis* L. 2; 1280-1290 m, 23.6.2023, Erdoğan 1087, 2; 1280-1290 m, 05.5.2023, Erdoğan 1176, 5; 1320-1330 m, 23.4.2023, Erdoğan 1064, 5; 1320-1330 m, 23.4.2023, Erdoğan 1068, 8; 1300-1320 m, 23.4.2023, Erdoğan 1053, 8; 1300-1320 m, 06.5.2023, Erdoğan 1128.

*Sisymbrium loeselii* L. 8; 1300-1320 m, 01.7.2023, Erdoğan 1632.

*Tchihatchewia isatidea* Boiss. 2; 1280-1290 m, 13.10.2023, Erdoğan 2117; 5; 1320-1330 m, 17.5.2024, Erdoğan 2157. **Endemik**, B,

*Thlaspi perfoliata* L. 1; 1280-1330 m, 05.5.2023, Erdoğan 1151, 4; 1300-1330 m, 05.5.2023, Erdoğan 1200. Ter, A

*Thlaspi violascens* Boiss. 6; 1280-1330 m, 04.6.2023, Erdoğan 1375. **Endemik**.

*Turritis glabra* L. 3; 1290-1330 m, 20.5.2023, Erdoğan 1214, 3; 1290-1330 m, 20.5.2023, Erdoğan 1217, 8; 1300-1320 m, 21.5.2023, Erdoğan 1265.

#### CAPRIFOLIACEAE

*Cephalaria aristata* K. Koch. 8; 1300-1320 m, 30.8.2023, Erdoğan 1985.

*Cephalaria procera* Fisch. & Lall. 1; 1280-1330 m, 11.7.2023, Erdoğan 1703.

*Dipsacus laciniatus* L. 1; 1280-1330 m, 15.8.2023, Erdoğan 1975.

*Morina persica* L. 6; 1320-1330 m, 01.7.2023, Erdoğan 1581, 5; 1320-1330 m, 26.7.2023, Erdoğan 1875, 5; 1280-1330 m, 01.7.2023, Erdoğan 1616.

*Scabiosa atropurpurea* L. 1; 1280-1330 m, 23.6.2023, Erdoğan 1520, 1; 1280-1330 m, 23.6.2023, Erdoğan 1524.

*Scabiosa columbaria* L. 4; 1300-1330 m, 19.7.2023, Erdoğan 1786.

*Scabiosa pseudograminifolia* Hub. - Mor. 1; 1280-1330 m, 23.6.2023, Erdoğan 1526, 2; 1280-1290 m, 13.10.2023, Erdoğan 2112, 4; 1300-1330 m, 23.6.2023, Erdoğan 1459, 4; 1300-1330 m, 19.7.2023, Erdoğan 1765, 4; 1300-1330 m, 19.7.2023, Erdoğan 1781, 5; 1320-1330 m, 04.6.2023, Erdoğan 1343, 5; 1320-1330 m, 04.6.2023, Erdoğan 1346, 8; 1300-1320 m, 01.7.2023, Erdoğan 1629. **Endemik**, İran-Turan elementi.

*Scabiosa polykratis* Rech. Fil. 4; 1300-1330 m, 19.7.2023, Erdoğan 1771, 7; 1280-1320 m, 05.8.2023, Erdoğan 1895. **Endemik**.

*Symphoricarpus albus* (L.) S.F Bloke 3; 1290-1330 m, 13.10.2023, Erdoğan 2102.

#### CARYOPHYLLACEAE

*Cerastium dichotomum* subsp. *inflatum* (Link.) Cullen. 8; 1300-1320 m, 06.5.2023, Erdoğan 1132. Ter, A

*Dianthus orientalis* Adams 6; 1280-1330 m, 26.7.2023, Erdoğan 1837, 5; 1280-1330 m, 26.7.2023, Erdoğan 1841.

*Gypsophilla perfoliata* L. 2; 1280-1290 m, 23.6.2023, Erdoğan 1557, 3; 1290-1330 m, 19.7.2023, Erdoğan 1801. **Endemik**. İran-Turan elementi.

*Holostemum umbellatum* L. var. *umbellatum* 1; 1280-1330 m, 08.4.2023, Erdoğan 1004, 1; 1280-1330 m, 23.4.2023, Erdoğan 1096. Ter, A

*Holostemum marginatum* C.A. Meyer 4; 1300-1330 m, 05.5.2023, Erdoğan 1199, 4; 1300-1330 m, 05.5.2023, Erdoğan 1205, 5; 1280-1330 m, 06.5.2023, Erdoğan 1104, 8; 1300-1320 m, 06.5.2023, Erdoğan 1127, 8; 1300-1320 m, 06.5.2023, Erdoğan 1134, 8; 1300-1320 m, 04.6.2023, Erdoğan 1391, 8; 1300-1320 m, 04.6.2023, Erdoğan 1421.

*Holostemum umbellatum* L. Subsp. *umbellatum* 1; 1280-1330 m, 08.4.2023, Erdoğan 1001, 1; 1280-1330 m, 05.5.2023, Erdoğan 1153, 1; 1280-1330 m, 05.5.2023, Erdoğan 1174, 2; 1280-1290 m, 20.5.2023, Erdoğan 1291, 2; 1280-1290 m, 20.5.2023, Erdoğan 1302, 3; 1290-1330 m, 08.4.2023, Erdoğan 1013, 5; 1280-1330 m, 21.5.2023, Erdoğan 1283, 8; 1300-1320 m, 08.4.2023, Erdoğan 1040.

*Moehringia trinervia* (L.) Clairv. 6; 1320-1330 m, 01.7.2023, Erdoğan 1598, 7; 1280-1320 m, 05.8.2023, Erdoğan 1891.

*Sabulina verna* (L.) Rchb. 1; 1280-1330 m, 11.7.2023, Erdoğan 1727, 5; 1320-1330 m, 01.7.2023, Erdoğan 1582.

*Saponaria prostrata* Willd. subsp. *prostrata* 6; 1320-1330 m, 01.7.2023, Erdoğan 1590, 5; 1280-1330 m, 04.6.2023, Erdoğan 1361. **Endemik**, İran-Turan elementi. Hem, B, LC

*Silene italica* (L.) Pers. 2; 1280-1290 m, 20.5.2023, Erdoğan 1303, 8; 1300-1320 m, 04.6.2023, Erdoğan 1410, 8; 1300-1320 m, 04.6.2023, Erdoğan 1411. İran-Turan elementi. Hem, P

*Stellaria holostea* L. 6; 1280-1330 m, 17.5.2024, Erdoğan 2150. Avrupa-Sibirya elementi, A,

#### CISTACEAE

*Fumana procumbens* (Dunal) Gren. & Godr. 6; 1320-1330 m, 01.7.2023, Erdoğan 1587, 5; 1320-1330 m, 01.7.2023, Erdoğan 1588, 5; 1320-1330 m, 26.7.2023, Erdoğan 1864, 5; 1320-1330 m, 26.7.2023, Erdoğan 1871.

*Helianthemum canum* (L.) Baumg. (Grup D) 6; 1280-1330 m, 04.6.2023, Erdoğan 1388, 5; 1320-1330 m, 04.6.2023, Erdoğan 1359, 5; 1280-1330 m, 04.6.2023, Erdoğan 1360, 7; 1280-1320 m, 05.8.2023, Erdoğan 1897. Hem, P

#### CONVOLVULACEAE

*Convolvulus arvensis* L. 1; 1280-1330 m, 03.6.2023, Erdoğan 1318, 1; 1280-1330 m, 03.6.2023, Erdoğan 1319, 1; 1280-1330 m, 23.6.2023, Erdoğan 1517, 2; 1280-1290 m, 23.6.2023, Erdoğan 1539, 2; 1280-1290 m, 23.6.2023, Erdoğan 1541, 2; 1280-1290 m, 23.6.2023, Erdoğan 1544, 3; 1290-1330 m, 23.6.2023, Erdoğan 1492, 3; 1290-1330 m, 15.9.2023, Erdoğan 2023, 7; 1280-1320 m, 01.7.2023, Erdoğan 1624, 7; 1280-1320 m, 05.8.2023, Erdoğan 1899, 8; 1300-1320 m, 04.6.2023, Erdoğan 1417, 8; 1300-1320 m, 04.6.2023, Erdoğan 1420, 8; 1300-1320 m, 01.7.2023, Erdoğan 1633, 8; 1300-1320 m, 05.8.2023, Erdoğan 1908. Kozmopolit. Hem, P

*Convolvulus compactus* Boiss. 2; 1280-1290 m, 05.5.2023, Erdoğan 1122, 5; 1320-1330 m, 04.6.2023, Erdoğan 1352. İran-Turan elementi.

*Convolvulus galaticus* Rost. ex Choisy 3; 1290-1330 m, 23.6.2023, Erdoğan 1478, 3; 1290-1330 m, 23.6.2023, Erdoğan 1493, 7; 1280-1320 m, 01.7.2023, Erdoğan 1619, 7; 1280-1320 m, 01.7.2023, Erdoğan 1620, 7; 1280-1320 m, 05.8.2023, Erdoğan 1894, 7; 1280-1320 m, 05.8.2023, Erdoğan 1904, 8; 1300-1320 m, 30.9.2023, Erdoğan 2061.

**Endemik**, İran-Turan elementi. Hem, P, LC

*Convolvulus lineatus* L. 1; 1280-1330 m, 23.6.2023, Erdoğan 1501, 1; 1280-1330 m, 23.6.2023, Erdoğan 1530, 5; 1320-1330 m, 01.7.2023, Erdoğan 1585.

#### ELAEAGNACEAE

*Elaeagnus angustifolia* L. 2; 1280-1290 m, 13.10.2023, Erdoğan 2111, 2; 1280-1290 m, 13.10.2023, Erdoğan 2115, 3; 1290-1330 m, 13.10.2023, Erdoğan 2103.

#### EUPHORBIACEAE

*Euphorbia esula* L. subsp. *esula* 1; 1280-1330 m, 20.5.2023, Erdoğan 1258, 1; 1280-1330 m, 11.7.2023, Erdoğan 1722, 1; 1280-1330 m, 15.9.2023, Erdoğan 2049, 2; 1280-1290 m, 11.7.2023, Erdoğan 1730, 2; 1280-1290 m, 11.7.2023, Erdoğan 1740, 3; 1290-1330 m, 23.6.2023, Erdoğan 1497, 3; 1290-1330 m, 19.7.2023, Erdoğan 1810, 3; 1290-1330 m, 19.7.2023, Erdoğan 1811, 3; 1290-1330 m, 15.9.2023, Erdoğan 2022, 7; 1280-1320 m, 30.9.2023, Erdoğan 2074, 8; 1300-1320 m, 04.6.2023, Erdoğan 1422, 8; 1300-1320 m, 30.8.2023, Erdoğan 1988, 8; 1300-1320 m, 30.8.2023, Erdoğan 1993.

*Euphorbia falcata* L. subsp. *falcata* var. *falcata* 3; 1290-1330 m, 19.7.2023, Erdoğan 1815, 7; 1280-1320 m, 30.8.2023, Erdoğan 2000, 8; 1300-1320 m, 30.9.2023, Erdoğan 2066.

*Euphorbia lexigua* L. var. *exigua* L. 7; 1280-1320 m, 06.5.2023, Erdoğan 1146.

*Euphorbia macroclada* Boiss. 1; 1280-1330 m, 11.7.2023, Erdoğan 1723, 2; 1280-1290 m, 23.6.2023, Erdoğan 1553. İran-Turan elementi.

*Euphorbia nicaeensis* All. subsp. *glareosa* (Pallas ex Bieb.) var. *glareosa* 6; 1280-1330 m, 30.8.2023, Erdoğan 2007.

*Euphorbia virgata* Waldst. & Kit. 7; 1280-1320 m, 06.5.2023, Erdoğan 1138. Hem, P

#### FABACEAE

*Astragalus christianus* L. 1; 1280-1330 m, 20.5.2023, Erdoğan 1228, 1; 1280-1330 m, 20.5.2023, Erdoğan 1229, 1; 1280-1330 m, 15.9.2023, Erdoğan 2052, 3; 1290-1330 m, 15.8.2023, Erdoğan 1946, 3; 1290-1330 m, 15.8.2023, Erdoğan 1947. Cha, P, LC

*Astragalus hamosus* L. 1; 1280-1330 m, 11.7.2023, Erdoğan 1715, 1; 1280-1330 m, 11.7.2023, Erdoğan 1718.

*Astragalus hirticalyx* Boiss. ex Kotschy 6; 1280-1330 m, 01.7.2023, Erdoğan 1604, 5; 1280-1330 m, 26.7.2023, Erdoğan 1834, 5; 1280-1330 m, 30.8.2023, Erdoğan 2012. İran-Turan elementi. Cha, P

*Astragalus humillimus* Freyn & Sint. 6; 1320-1330 m, 04.6.2023, Erdoğan 1340. **Endemik**.

*Astragalus incertus* Ledeb 2; 1280-1290 m, 05.5.2023, Erdoğan 1180, 2; 1280-1290 m, 20.5.2023, Erdoğan 1309, 5; 1280-1330 m, 06.5.2023, Erdoğan 1103.

*Astragalus monspessulanus* L. 3; 1290-1330 m, 20.5.2023, Erdoğan 1218.

*Astragalus onobrychis* L. 1; 1280-1330 m, 03.6.2023, Erdoğan 1316, 1; 1280-1330 m, 23.6.2023, Erdoğan 1529, 3; 1290-1330 m, 03.6.2023, Erdoğan 1330.

*Coronilla orientalis* Mill. subsp. *orientalis* 1; 1280-1330 m, 11.7.2023, Erdoğan 1660, 3; 1290-1330 m, 03.6.2023, Erdoğan 1331. Hem, P

*Coronilla varia* L. subsp. *libanotica* Bornm. 2; 1280-1290 m, 11.7.2023, Erdoğan 1736. Hem, P

*Coronilla varia* L. subsp. *varia* 1; 1280-1330 m, 23.6.2023, Erdoğan 1502, 1; 1280-1330 m, 23.6.2023, Erdoğan 1521, 1; 1280-1330 m, 23.6.2023, Erdoğan 1522, 1; 1280-1330 m, 11.7.2023, Erdoğan 1688, 1; 1280-1330 m, 11.7.2023, Erdoğan 1710, 2; 1280-1290 m, 03.6.2023, Erdoğan 1326, 3; 1290-1330 m, 03.6.2023, Erdoğan 1328. Hem, P

*Dorycnium pentaphyllum* Scop. subsp. *anatolicum* (Boiss.) Gams. 1; 1280-1330 m, 11.7.2023, Erdoğan 1695, 1; 1280-1330 m, 23.6.2023, Erdoğan 1514. İran-Turan elementi. Hem, P

*Ebenus laguroides* Boiss. var. *laguroides* 6; 1320-1330 m, 26.7.2023, Erdoğan 1865. **Endemik**, İran-Turan elementi. Hem, P, LC

*Ebenus reesei* Hub.-Mor. 6; 1280-1330 m, 04.6.2023, Erdoğan 2134. **Endemik**.

*Genista aucheri* Boiss. 6; 1320-1330 m, 04.6.2023, Erdoğan 1349. **Endemik**, İran-Turan elementi.

*Glycyrrhiza glabra* L. var. *glabra* 1; 1280-1330 m, 15.8.2023, Erdoğan 1971, 1; 1280-1330 m, 15.9.2023, Erdoğan 2037.

*Glycyrrhiza glabra* L. var. *glandulifera* 1; 1280-1330 m, 11.7.2023, Erdoğan 1706, 1; 1280-1330 m, 11.7.2023, Erdoğan 1707.

*Hedysarum varium* Willd. 1; 1280-1330 m, 03.6.2023, Erdoğan 1320, 5; 1320-1330 m, 04.6.2023, Erdoğan 1339, 5; 1280-1330 m, 04.6.2023, Erdoğan 1366. İran-Turan elementi. Hem, P

*Lathyrus armenus* (Boiss. & Huet.) Sirj. 1; 1280-1330 m, 15.9.2023, Erdoğan 2045, 4; 1300-1330 m, 19.7.2023, Erdoğan 1780, 4; 1300-1330 m, 19.7.2023, Erdoğan 1782. **Endemik**, İran-Turan elementi. LC

*Lathyrus spathulatus* Cel. 1; 1280-1330 m, 15.9.2023, Erdoğan 2044, 3; 1290-1330 m, 15.9.2023, Erdoğan 2026, 8; 1300-1320 m, 30.8.2023, Erdoğan 1987.

*Lotus corniculatus* L. var. *corniculatus* 3; 1290-1330 m, 23.6.2023, Erdoğan 1485. Hem, P

*Lotus corniculatus* L. var. *tenuifolius* 2; 1280-1290 m, 15.9.2023, Erdoğan 2034, 3; 1290-1330 m, 19.7.2023, Erdoğan 1793, 8; 1300-1320 m, 30.9.2023, Erdoğan 2069. Hem, P

*Lotus macrotrichus* Boiss. 3; 1290-1330 m, 15.8.2023, Erdoğan 1939.

*Lotus maritimus* L. 7; 1280-1320 m, 04.6.2023, Erdoğan 1444.

*Lycium depressum* Stocks 6; 1280-1330 m, 26.7.2023, Erdoğan 1828.

*Medicago falcata* L. 1; 1280-1330 m, 23.6.2023, Erdoğan 1505, 1; 1280-1330 m, 23.6.2023, Erdoğan 1513, 1; 1280-1330 m, 11.7.2023, Erdoğan 1720, 5; 1280-1330 m, 04.6.2023, Erdoğan 1378, 7; 1280-1320 m, 30.8.2023, Erdoğan 1999, 8; 1300-1320 m, 01.7.2023, Erdoğan 1570, 8; 1300-1320 m, 01.7.2023, Erdoğan 1574. Hem, P

*Medicago sativa* L. subsp. *sativa* 2; 1280-1290 m, 23.6.2023, Erdoğan 1543, 4; 1300-1330 m, 15.8.2023, Erdoğan 1933,

5; 1320-1330 m, 28.10.2023, Erdoğan 2127, 5; 1280-1330 m, 28.10.2023, Erdoğan 2124.

*Medicago shepardii* Post ex Boiss. 1; 1280-1330 m, 05.5.2023, Erdoğan 1166, 2; 1280-1290 m, 05.5.2023, Erdoğan 1118. **Endemik**, İran-Turan elementi.

*Melilotus alba* Desr. 8; 1300-1320 m, 05.8.2023, Erdoğan 1930.

*Melilotus officinalis* (L.) Desr. 3; 1290-1330 m, 03.6.2023, Erdoğan 1333, 3; 1290-1330 m, 13.10.2023, Erdoğan 2105, 5; 1320-1330 m, 30.9.2023, Erdoğan 2087, 5; 1280-1330 m, 28.10.2023, Erdoğan 2123, 8; 1300-1320 m, 05.8.2023, Erdoğan 1917. Ter, A

*Onobrychis argyrea* Boiss. subsp. *angyrea* 6; 1320-1330 m, 01.7.2023, Erdoğan 1580, 5; 1320-1330 m, 01.7.2023, Erdoğan 1583, 5; 1320-1330 m, 26.7.2023, Erdoğan 1866, 5; 1320-1330 m, 26.7.2023, Erdoğan 1869. **Endemik**, İran-Turan elementi. LC

*Onobrychis hypargyrea* Boiss. 1; 1280-1330 m, 03.6.2023, Erdoğan 1321, 1; 1280-1330 m, 11.7.2023, Erdoğan 1663, 2; 1280-1290 m, 23.6.2023, Erdoğan 1534, 8; 1300-1320 m, 01.7.2023, Erdoğan 1569.

*Onobrychis oxyodonta* Boiss. 2; 1280-1290 m, 03.6.2023, Erdoğan 1325, 3; 1290-1330 m, 23.6.2023, Erdoğan 1488. Hem, P

*Onobrychis pisidica* Boiss. 1; 1280-1330 m, 23.6.2023, Erdoğan 1512.

*Onobrychis stenostachya* Freyn subsp. *krausei* 2; 1280-1290 m, 23.6.2023, Erdoğan 1540. **Endemik**, İran-Turan elementi.

*Ononis spinosa* (L.) subsp. *antiquorum*(L.) Briq. 1; 1280-1330 m, 15.9.2023, Erdoğan 2042. Hem, P

*Ononis spinosa* (L.) subsp. *leiosperma* (Boiss.) Sirj. 1; 1280-1330 m, 11.7.2023, Erdoğan 1702, 1; 1280-1330 m, 15.8.2023, Erdoğan 1978, 1; 1280-1330 m, 11.7.2023, Erdoğan 2130, 4; 1300-1330 m, 15.8.2023, Erdoğan 1935. Hem, P

*Polygala anatolica* Boiss. & Heldr. 2; 1280-1290 m, 20.5.2023, Erdoğan 1292, 2; 1280-1290 m, 20.5.2023, Erdoğan 1293, 2; 1280-1290 m, 20.5.2023, Erdoğan 1294.

*Sartoria hedysaroides* Boiss. & Heldr. 6; 1280-1330 m, 26.7.2023, Erdoğan 1838.

*Sophora alopecuroides* L. var. *alopecuroides* 8; 1300-1320 m, 30.9.2023, Erdoğan 2063.

*Trifolium hirtum* All. 1; 1280-1330 m, 20.5.2023, Erdoğan 1252.

*Trifolium hybridum* L. var. *hybridum* 7; 1280-1320 m, 04.6.2023, Erdoğan 1445, 7; 1280-1320 m, 04.6.2023, Erdoğan 1448.

*Vicia articulata* Hornem. 2; 1280-1290 m, 23.6.2023, Erdoğan 1559.

*Vicia cracca* L. subsp. *cracca* 8; 1300-1320 m, 04.6.2023, Erdoğan 1426. Avrupa-Sibirya elementi.

*Vicia cracca* L. subsp. *stenophylla* 2; 1280-1290 m, 11.7.2023, Erdoğan 1738. Avrupa-Sibirya elementi. Hem, P

*Vicia dadianorum* Somm. 6; 1280-1330 m, 28.10.2023, Erdoğan 2122.

*Vicia grandiflora* Scop. var. *grandiflora* 3; 1290-1330 m, 23.6.2023, Erdoğan 1482, 5; 1280-1330 m, 21.5.2023, Erdoğan 1277. İran-Turan elementi.

*Vicia hibrida* L. 7; 1280-1320 m, 04.6.2023, Erdoğan 1439.

*Vicia monantha* Retz. subsp. *monantha* 8; 1300-1320 m, 04.6.2023, Erdoğan 1430.

*Vicia narbonensis* L. subsp. *narbonensis* 3; 1290-1330 m, 23.6.2023, Erdoğan 1484, 3; 1290-1330 m, 19.7.2023, Erdoğan 1814, 4; 1300-1330 m, 05.5.2023, Erdoğan 1195, 5; 1320-1330 m, 06.5.2023, Erdoğan 1113, 8; 1300-1320 m, 04.6.2023, Erdoğan 1415, 8; 1300-1320 m, 04.6.2023, Erdoğan 1416, 8; 1300-1320 m, 01.7.2023, Erdoğan 1566. Ter,

*Vicia pannonica* Crantz var. *pannonica* 8; 1300-1320 m, 04.6.2023, Erdoğan 1423.

*Vicia sativa* L. subsp. *nigra* (L.) Ehrh. var. *nigra* 8; 1300-1320 m, 21.5.2023, Erdoğan 1266, 8; 1300-1320 m, 04.6.2023, Erdoğan 1427, 8; 1300-1320 m, 04.6.2023, Erdoğan 1428.

*Vicia villosa* Roth. subsp. *dasycarpa* 1; 1280-1330 m, 23.6.2023, Erdoğan 1532.

#### GENTIANACEAE

*Centaurium tenuiflorum* (Hoffmanns & Link) Fritsch 2; 1280-1290 m, 11.7.2023, Erdoğan 1728, 4; 1300-1330 m, 19.7.2023, Erdoğan 1785.

#### GERANIACEAE

*Erodium cicutarium* subsp. *cutarium* (L.) L'Her. Ex Aiton 1; 1280-1330 m, 05.5.2023, Erdoğan 1164, 1; 1280-1330 m, 20.5.2023, Erdoğan 1257, 2; 1280-1290 m, 08.4.2023, Erdoğan 1006, 4; 1300-1330 m, 08.4.2023, Erdoğan 1022, 8; 1300-1320 m, 23.4.2023, Erdoğan 1055, 7; 1280-1320 m, 05.8.2023, Erdoğan 1886.

*Geranium tuberosum* L. subsp. *tuberosum* 1; 1280-1330 m, 23.6.2023, Erdoğan 1097, 2; 1280-1290 m, 23.4.2023, Erdoğan 1084. Hem, P

#### GLOBULARIACEAE

*Glabularia orientalis* L. 1; 1280-1330 m, 23.4.2023, Erdoğan 1094, 1; 1280-1330 m, 05.5.2023, Erdoğan 1152, 2; 1280-1290 m, 23.4.2023, Erdoğan 1088, 5; 1320-1330 m, 23.4.2023, Erdoğan 1066, 5; 1320-1330 m, 23.4.2023, Erdoğan 1067. İran-Turan elementi.

#### HYPERICACEAE

*Hypericum lyidium* Boiss. 1; 1280-1330 m, 11.7.2023, Erdoğan 1672, 2; 1280-1290 m, 11.7.2023, Erdoğan 1755, 5; 1320-1330 m, 26.7.2023, Erdoğan 1874. İran-Turan elementi. Hem, P

*Hypericum retusum* Aucher ex Joub. & Spach. 1; 1280-1330 m, 03.6.2023, Erdoğan 1315, 1; 1280-1330 m, 11.7.2023, Erdoğan 1658. İran-Turan elementi. Hem, P

*Hypericum scabrum* L. 1; 1280-1330 m, 23.6.2023, Erdoğan 1519, 2; 1280-1290 m, 03.6.2023, Erdoğan 1324, 5; 1320-1330 m, 01.7.2023, Erdoğan 1577, 5; 1280-1330 m, 04.6.2023, Erdoğan 1381. İran-Turan elementi. Hem, P

#### LAMIACEAE

*Ajuga chamaepitys* (L.) subsp. *chia* var. *chia* 6; 1280-1330 m, 04.6.2023, Erdoğan 1362, 5; 1280-1330 m, 04.6.2023, Erdoğan 1365, 5; 1280-1330 m, 04.6.2023, Erdoğan 1371. Hem, P

*Ajuga chamaepitys* (L.) var. *ciliata* Briq. 4; 1300-1330 m, 05.5.2023, Erdoğan 1208, 5; 1320-1330 m, 01.7.2023, Erdoğan 1597, 8; 1300-1320 m, 05.8.2023, Erdoğan 1927. Hem, P

*Cyclotrichium stamineum* (Boiss. & Hohen) Manden & Scheng 4; 1300-1330 m, 23.6.2023, Erdoğan 1467. İran-Turan elementi.

*Lallemantia canescens* (L.) Fisch. & Mey. 3; 1290-1330 m, 19.7.2023, Erdoğan 1819, 5; 1280-1330 m, 04.6.2023, Erdoğan 1376. İran-Turan elementi.

*Lamium aleppicum* Boiss. & Housskn. 7; 1280-1320 m, 23.4.2023, Erdoğan 1047, 7; 1280-1320 m, 23.4.2023, Erdoğan 1048, 8; 1300-1320 m, 23.4.2023, Erdoğan 1056. İran-Turan elementi.

*Lamium amplexicaule* L. 2; 1280-1290 m, 20.5.2023, Erdoğan 1311, 3; 1290-1330 m, 05.5.2023, Erdoğan 1193, 3; 1290-1330 m, 23.6.2023, Erdoğan 1486, 4; 1300-1330 m, 05.5.2023, Erdoğan 1204, 5; 1280-1330 m, 21.5.2023, Erdoğan 1280, 8; 1300-1320 m, 08.4.2023, Erdoğan 1033, 8; 1300-1320 m, 06.5.2023, Erdoğan 1129, 8; 1300-1320 m, 21.5.2023, Erdoğan 1268, 8; 1300-1320 m, 04.6.2023, Erdoğan 1398, 8; 1300-1320 m, 04.6.2023, Erdoğan 1414. Avrupa-Sibirya elementi. Ter, A

**Marrubium parviflorum** Fisch. & Mey. subsp. **oligodon** (Boiss.) Seybold. 1; 1280-1330 m, 11.7.2023, Erdoğan 1692, 7; 1280-1320 m, 05.8.2023, Erdoğan 1906. **Endemik**.

**Marrubium vulgare** L. 6; 1280-1330 m, 04.6.2023, Erdoğan 1386, 5; 1280-1330 m, 26.7.2023, Erdoğan 1835. Avrupa-Asya elementi.

**Phlomis armeniaca** Willd. 6; 1320-1330 m, 01.7.2023, Erdoğan 1579, 8; 1300-1320 m, 01.7.2023, Erdoğan 1568. **Endemik**, İran-Turan elementi.

**Phlomis pungens** Willd. Subsp. **pungens** var. **pungens** (Willd.) Schmalh. 1; 1280-1330 m, 11.7.2023, Erdoğan 1674, 1; 1280-1330 m, 11.7.2023, Erdoğan 1675, 1; 1280-1330 m, 11.7.2023, Erdoğan 1725, 4; 1300-1330 m, 19.7.2023, Erdoğan 1775, 4; 1300-1330 m, 19.7.2023, Erdoğan 1779, 8; 1300-1320 m, 01.7.2023, Erdoğan 1572. Hem, P

**Salvia aethiopis** L. 3; 1290-1330 m, 19.7.2023, Erdoğan 1807. Hem, P

**Salvia atropatana** Burge. 6; 1320-1330 m, 04.6.2023, Erdoğan 1357, 5; 1320-1330 m, 04.6.2023, Erdoğan 1358. İran-Turan elementi.

**Salvia brachyantha** (Bordz.) Pobed. 1; 1280-1330 m, 23.6.2023, Erdoğan 1515, 1; 1280-1330 m, 15.8.2023, Erdoğan 1972,1; 1280-1330 m, 15.9.2023, Erdoğan 2040, 1; 1280-1330 m, 15.9.2023, Erdoğan 2050, 2; 1280-1290 m, 15.8.2023, Erdoğan 1955, 3; 1290-1330 m, 19.7.2023, Erdoğan 1800, 3; 1290-1330 m, 19.7.2023, Erdoğan 1803, 5; 1320-1330 m, 30.9.2023, Erdoğan 2086, 5; 1280-1330 m, 26.7.2023, Erdoğan 1847, 5; 1280-1330 m, 30.8.2023, Erdoğan 2008, 5; 1280-1330 m, 30.8.2023, Erdoğan 2011, 8; 1300-1320 m, 05.8.2023, Erdoğan 1923, 8; 1300-1320 m, 30.8.2023, Erdoğan 1990. İran-Turan elementi.

**Salvia cryptantha** Montbret & Aucher ex Bentham. 2; 1280-1290 m, 20.5.2023, Erdoğan 1304, 2; 1280-1290 m, 11.7.2023, Erdoğan 1753, 2; 1280-1290 m, 11.7.2023, Erdoğan 1754, 3; 1290-1330 m, 20.5.2023, Erdoğan 1224, 3; 1290-1330 m, 20.5.2023, Erdoğan 1225, 4; 1300-1330 m, 20.5.2023, Erdoğan 1288, 4; 1300-1330 m, 23.6.2023, Erdoğan 1463, 5; 1280-1330 m, 04.6.2023, Erdoğan 1387, 5; 1280-1330 m, 01.7.2023, Erdoğan 1611, 5; 1280-1330 m, 26.7.2023, Erdoğan 1832, 5; 1280-1330 m, 26.7.2023, Erdoğan 1833. **Endemik**, İran-Turan elementi. LC

**Salvia cyanescens** Boiss. & Bal. 6; 1320-1330 m, 26.7.2023, Erdoğan 1867. **Endemik**, İran-Turan elementi. Hem, P, LC

**Salvia fruticosa** Miller. 1; 1280-1330 m, 13.10.2023, Erdoğan 2094.

**Salvia hypargeia** Fisch & C.A. Mey. 6; 1320-1330 m, 01.7.2023, Erdoğan 1584, 5; 1320-1330 m, 01.7.2023, Erdoğan 1586. **Endemik**, İran-Turan elementi. LC

**Salvia multicaulis** Vahl. 1; 1280-1330 m, 20.5.2023, Erdoğan 1235, 1; 1280-1330 m, 20.5.2023, Erdoğan 1236, 1; 1280-1330 m, 20.5.2023, Erdoğan 1242, 5; 1320-1330 m, 21.5.2023, Erdoğan 1285. **Endemik**, İran-Turan elementi. Hem, P, LC

**Salvia russelli** Bentham. 1; 1280-1330 m, 23.6.2023, Erdoğan 1518, 1; 1280-1330 m, 11.7.2023, Erdoğan 1686, 4; 1300-1330 m, 19.7.2023, Erdoğan 1777. İran-Turan elementi.

**Salvia sclarea** L. 4; 1300-1330 m, 23.6.2023, Erdoğan 1464. Avrupa-Asya elementi. Hem, B

**Salvia staminea** Montbret & Aucher ex Bentham. 1; 1280-1330 m, 11.7.2023, Erdoğan 1669, 1; 1280-1330 m, 11.7.2023, Erdoğan 1670. İran-Turan elementi.

**Salvia suffruticosa** Montbret & Aucher ex Bentham 2; 1280-1290 m, 23.6.2023, Erdoğan 1536, 2; 1280-1290 m, 23.6.2023, Erdoğan 1555, 2; 1280-1290 m, 23.6.2023, Erdoğan 1556, 8; 1300-1320 m, 04.6.2023, Erdoğan 1403. İran-Turan elementi.

**Salvia syriaca** L. 3; 1290-1330 m, 23.6.2023, Erdoğan 1498, 8; 1300-1320 m, 04.6.2023, Erdoğan 1406. İran-Turan elementi. Hem, P

**Salvia verticillata** L. subsp. **amasiaca** (Frey & Bornm.) Bornm. 1; 1280-1330 m, 15.9.2023, Erdoğan 2048. İran-Turan elementi. Hem, P

**Salvia verticillata** L. subsp. **verticillata** Rech. 2; 1280-1290 m, 23.6.2023, Erdoğan 1551, 2; 1280-1290 m, 23.6.2023, Erdoğan 1552. Avrupa-Sibirya elementi.

**Salvia virgata** Jacq. 1; 1280-1330 m, 11.7.2023, Erdoğan 1705, 1; 1280-1330 m, 11.7.2023, Erdoğan 1712, 5; 1280-1330 m, 26.7.2023, Erdoğan 1842, 5; 1280-1330 m, 26.7.2023, Erdoğan 1843, 5; 1280-1330 m, 26.7.2023, Erdoğan 1844. İran-Turan elementi. Hem, P

**Scutellaria orientalis** (L.) subsp. **pinnatifida** Edmondson 1; 1280-1330 m, 20.5.2023, Erdoğan 1260, 3; 1290-1330 m, 20.5.2023, Erdoğan 1211.

**Sideritis libanotica** Labill. Subsp. **violascens** P. H. Davis. 1; 1280-1330 m, 23.6.2023, Erdoğan 1510, 1; 1280-1330 m, 23.6.2023, Erdoğan 1511. **Endemik**.

**Sideritis montana** L. subsp. **montana** L. 3; 1290-1330 m, 19.7.2023, Erdoğan 1817. Doğu Akdeniz elementi. Ter, A

**Stachys byzantina** C. Koch 1; 1280-1330 m, 11.7.2023, Erdoğan 1671, 1; 1280-1330 m, 11.7.2023, Erdoğan 1676. Avrupa-Sibirya elementi.

**Stachys cretica** L. subsp. **anatolica** Rech. Fil. 4; 1300-1330 m, 19.7.2023, Erdoğan 1773, 4; 1300-1330 m, 19.7.2023, Erdoğan 1774. **Endemik**, İran-Turan elementi. Hem, P, LC

*Stachys Iberica* Biep. subsp. *stenostachya* (Boiss.) Rech. 1; 1280-1330 m, 11.7.2023, Erdoğan 1656, 8; 1300-1320 m, 05.8.2023, Erdoğan 1919, 8; 1300-1320 m, 05.8.2023, Erdoğan 1920, 8; 1300-1320 m, 05.8.2023, Erdoğan 1921. İran-Turan elementi. Hem, P

*Teucrium chamaedrys* L. subsp. *chamaedrys* 1; 1280-1330 m, 15.8.2023, Erdoğan 1970, 1; 1280-1330 m, 15.8.2023, Erdoğan 1976, 2; 1280-1290 m, 11.7.2023, Erdoğan 1729. Avrupa-Sibirya elementi. Hem, P

*Teucrium polium* L. 6; 1280-1330 m, 26.7.2023, Erdoğan 1836, 5; 1280-1330 m, 26.7.2023, Erdoğan 1840, 5; 1280-1330 m, 26.7.2023, Erdoğan 1849. Hem, P

*Thymus pubescens* var. *pubescens* (Boiss. & Kotschy ex Celak.) Bornm. 1; 1280-1330 m, 11.7.2023, Erdoğan 1726, 5; 1280-1330 m, 01.7.2023, Erdoğan 1603, 5; 1280-1330 m, 01.7.2023, Erdoğan 1609. Hem, P

#### LINACEAE

*Linum flavum* L. subsp. *scabrinerve* (Davis) Davis 1; 1280-1330 m, 23.6.2023, Erdoğan 1504, 1; 1280-1330 m, 23.6.2023, Erdoğan 1525, 1; 1280-1330 m, 11.7.2023, Erdoğan 1673, 2; 1280-1290 m, 23.6.2023, Erdoğan 1546, 2; 1280-1290 m, 23.6.2023, Erdoğan 1547, 4; 1300-1330 m, 23.6.2023, Erdoğan 1466, 4; 1300-1330 m, 19.7.2023, Erdoğan 1760, 5; 1280-1330 m, 01.7.2023, Erdoğan 1607. **Endemik**, İran-Turan elementi. LC

*Linum obtusatum* (Boiss.) Stapf. 1; 1280-1330 m, 20.5.2023, Erdoğan 1233, 1; 1280-1330 m, 20.5.2023, Erdoğan 1234, 2; 1280-1290 m, 23.6.2023, Erdoğan 1558, 5; 1320-1330 m, 04.6.2023, Erdoğan 1342, 5; 1280-1330 m, 04.6.2023, Erdoğan 1370, 7; 1280-1320 m, 04.6.2023, Erdoğan 1434, 7; 1280-1320 m, 04.6.2023, Erdoğan 1435. **Endemik**, İran-Turan elementi.

*Linum tenuifolium* L. 6; 1320-1330 m, 01.7.2023, Erdoğan 1592. Hem, P

*Linum virgultorum* Boiss. & Heldr. 1; 1280-1330 m, 15.8.2023, Erdoğan 1961.

#### LORANTHACEAE

*Viscum album* L. subsp. *abietis* 1; 1280-1330 m, 13.10.2023, Erdoğan 2092, 2; 1280-1290 m, 15.9.2023, Erdoğan 2145. Par, P

#### MALVACEAE

*Alcea digitata* (Boiss.) Alef. 1; 1280-1330 m, 13.10.2023, Erdoğan 2096. İran-Turan elementi.

*Alcea pallida* Waldst. 1; 1280-1330 m, 11.7.2023, Erdoğan 1652, 3; 1290-1330 m, 19.7.2023, Erdoğan 1816.

#### PAPAVERACEAE

*Fumari vaillantii* Loisel. 4; 1300-1330 m, 20.5.2023, Erdoğan 1287.

*Glaucium corniculatum* (L.) Rud. subsp. *corniculatum* Boiss. & Huet. 7; 1280-1320 m, 05.8.2023, Erdoğan 1903, 8; 1300-1320 m, 01.7.2023, Erdoğan 1628. İran-Turan elementi. Hem, B

*Glaucium grandiflorum* Boiss. & Huet. var. *grandiflorum* 6; 1320-1330 m, 04.6.2023, Erdoğan 1337. İran-Turan elementi. Hem, P

*Papaver argemone* L. 1; 1280-1330 m, 20.5.2023, Erdoğan 1256, 8; 1300-1320 m, 04.6.2023, Erdoğan 1394.

*Papaver dubium* L. 8; 1300-1320 m, 01.7.2023, Erdoğan 1637.

*Papaver lacerium* Popov.2; 1280-1290 m, 15.9.2023, Erdoğan 2146.

*Papaver rhoeas* L. 6; 1320-1330 m, 01.7.2023, Erdoğan 1593. Ter, A

*Papaver syriacum* Boiss. & Blanche 6; 1320-1330 m, 04.6.2023, Erdoğan 1338.

*Roemeria refracta* DC. 1; 1280-1330 m, 03.6.2023, Erdoğan 1317.

#### PLANTAGINACEAE

*Linaria argentea* Chaix. 4; 1300-1330 m, 23.6.2023, Erdoğan 1460. Avrupa-Sibirya elementi. Hem, P

*Linaria genistifolia* (L.) Mill. subsp. *confertifolia* (Boiss.) Davis 6; 1320-1330 m, 30.8.2023, Erdoğan 1980, 5; 1320-1330 m, 30.8.2023, Erdoğan 1981, 8; 1300-1320 m, 30.8.2023, Erdoğan 1939. **Endemik**, İran-Turan elementi.

*Linaria genistifolia* (L.) Mill. subsp. *genistifolia* 1; 1280-1330 m, 15.9.2023, Erdoğan 2043, 3; 1290-1330 m, 15.9.2023, Erdoğan 2021, 3; 1290-1330 m, 15.9.2023, Erdoğan 2025, 4; 1300-1330 m, 19.7.2023, Erdoğan 1767, 5; 1280-1330 m, 30.9.2023, Erdoğan 2081, 8; 1300-1320 m, 05.8.2023, Erdoğan 1916. Avrupa-Sibirya elementi. Hem, P

*Plantago lagopus* L. 1; 1280-1330 m, 11.7.2023, Erdoğan 1697, 4; 1300-1330 m, 19.7.2023, Erdoğan 1764, 7; 1280-1320 m, 21.5.2023, Erdoğan 1272. Hem, P

*Plantago major* L. subsp. *intermedia* 2; 1280-1290 m, 15.9.2023, Erdoğan 2147, 7; 1280-1320 m, 30.8.2023, Erdoğan 2003. Hem, P

**Plantago lanceolata** L. 6; 1320-1330 m, 04.6.2023, Erdoğan 1350, 7; 1280-1320 m, 21.5.2023, Erdoğan 2132. Hem, P

#### PLUMBAGINACEAE

**Acantholimon venustum** Boiss. subsp. **venustum** 6; 1320-1330 m, 26.7.2023, Erdoğan 1860, 5; 1320-1330 m, 30.9.2023, Erdoğan 2088, 8; 1300-1320 m, 05.8.2023, Erdoğan 1909. İran-Turan elementi.

**Limonium bellidifolium** (Gouan.) Dumort. 8; 1300-1320 m, 30.8.2023, Erdoğan 1992. Avrupa-Sibirya elementi.

**Limonium narbanense** Mill. 8; 1300-1320 m, 30.8.2023, Erdoğan 1991, 2; 1280-1290 m, 15.9.2023, Erdoğan 2148, 3; 1290-1330 m, 15.8.2023, Erdoğan 1942, 2; 1280-1290 m, 11.7.2023, Erdoğan 1745, 3; 1290-1330 m, 19.7.2023, Erdoğan 1788.

#### POLYGONACEAE

**Polygonum aviculare** L. 7; 1280-1320 m, 05.8.2023, Erdoğan 1893.

**Polygonum bellardi** All. 8; 1300-1320 m, 01.7.2023, Erdoğan 1639. Ter, A

**Polygonum cognatum** Meissn. 2; 1280-1290 m, 23.6.2023, Erdoğan 1538, 7; 1280-1320 m, 06.5.2023, Erdoğan 1144. Hem, P

**Rumex gracilescens** Rech. 8; 1300-1320 m, 01.7.2023, Erdoğan 1641, 8; 1300-1320 m, 01.7.2023, Erdoğan 1642. Endemik.

#### PRIMULACEAE

**Androsace maxima** L. 1; 1280-1330 m, 05.5.2023, Erdoğan 1170, 4; 1300-1330 m, 05.5.2023, Erdoğan 1201, 6; 1280-1330 m, 23.4.2023, Erdoğan 1058. Ter, A

**Lysimachia foemina** (Mill.) U. Manns. & Anderb. 3; 1290-1330 m, 23.6.2023, Erdoğan 1496, 3; 1290-1330 m, 19.7.2023, Erdoğan 1789, 3; 1290-1330 m, 19.7.2023, Erdoğan 1818.

**Lysimachia linum-stellatum** L. 7; 1280-1320 m, 05.8.2023, Erdoğan 1902.

#### RANUNCULACEAE

**Adonis aestivalis** L. subsp. **aestivalis** 3; 1290-1330 m, 23.6.2023, Erdoğan 1489, 4; 1300-1330 m, 23.6.2023, Erdoğan 1470, 5; 1280-1330 m, 21.5.2023, Erdoğan 1278, 5; 1280-1330 m, 04.6.2023, ERDOĞMUŞ 1369, 7; 1280-1320 m, 04.6.2023, Erdoğan 1440, 7; 1280-1320 m, 04.6.2023,

Erdoğan 1451, 8; 1300-1320 m, 04.6.2023, Erdoğan 1390. Ter, A

**Adonis aestivalis** L. subsp. **parviflora** 1; 1280-1330 m, 05.5.2023, Erdoğan 1163, 1; 1280-1330 m, 20.5.2023, Erdoğan 1238, 1; 1280-1330 m, 20.5.2023, Erdoğan 1241, 1; 1280-1330 m, 20.5.2023, Erdoğan 1255, 2; 1280-1290 m, 05.5.2023, Erdoğan 1120, 7; 1280-1320 m, 04.6.2023, Erdoğan 1438.

**Adonis flammea** Jacq. 1; 1280-1330 m, 20.5.2023, Erdoğan 1227, 2; 1280-1290 m, 20.5.2023, Erdoğan 1305, 3; 1290-1330 m, 20.5.2023, Erdoğan 1219, 3; 1290-1330 m, 20.5.2023, Erdoğan 1220, 5; 1280-1330 m, 21.5.2023, Erdoğan 1279, 7; 1280-1320 m, 21.5.2023, Erdoğan 1276, 7; 1280-1320 m, 01.7.2023, Erdoğan 1622, 8; 1300-1320 m, 06.5.2023, Erdoğan 1125, 8; 1300-1320 m, 04.6.2023, Erdoğan 1399, 8; 1300-1320 m, 04.6.2023, Erdoğan 1412.

**Ceratocephala falcata** (L.) Pers. 4; 1300-1330 m, 08.4.2023, Erdoğan 1019. Ter, A

**Consolida glandulosum** (Boiss. & Huet.) Bornm 1; 1280-1330 m, 11.7.2023, Erdoğan 1654, 1; 1280-1330 m, 11.7.2023, Erdoğan 1655, 1; 1280-1330 m, 11.7.2023, Erdoğan 1696, 1; 1280-1330 m, 11.7.2023, Erdoğan 1704, 1; 1280-1330 m, 11.7.2023, Erdoğan 1716, 1; 1280-1330 m, 15.8.2023, Erdoğan 1962, 1; 1280-1330 m, 15.8.2023, Erdoğan 1967, 2; 1280-1290 m, 13.10.2023, Erdoğan 2110, 4; 1300-1330 m, 19.7.2023, Erdoğan 1761, 4; 1300-1330 m, 15.8.2023, Erdoğan 1934, 8; 1300-1320 m, 05.7.2023, Erdoğan 1926.

**Consolida orientalis** (Gay.) Schröd. 1; 1280-1330 m, 11.7.2023, Erdoğan 1516, 2; 1280-1290 m, 23.6.2023, Erdoğan 1535, 2; 1280-1290 m, 11.7.2023, Erdoğan 1752, 2; 1280-1290 m, 15.8.2023, Erdoğan 1949, 2; 1280-1290 m, 15.8.2023, Erdoğan 1950, 2; 1280-1290 m, 15.9.2023, Erdoğan 2032, 2; 1280-1290 m, 13.10.2023, Erdoğan 2119, 2; 1280-1290 m, 23.7.2023, Erdoğan 2133; 3; 1290-1330 m, 19.7.2023, Erdoğan 1795, 3; 1290-1330 m, 19.7.2023, Erdoğan 1798; 4; 1300-1330 m, 23.6.2023, Erdoğan 1472, 4; 1300-1330 m, 19.7.2023, Erdoğan 1776, 4; 1300-1330 m, 19.7.2023, Erdoğan 1784, 8; 1300-1320 m, 01.7.2023, Erdoğan 1561, 8; 1300-1320 m, 05.7.2023, Erdoğan 1912. Ter, A

**Consolida thirkenia** (Boiss.) Schröd. 1; 1280-1330 m, 15.8.2023, Erdoğan 1963. Endemik.

**Nigella arvensis** L. var. **caudata** 1; 1280-1330 m, 11.7.2023, Erdoğan 1719, 2; 1280-1290 m, 11.7.2023, Erdoğan 1750, 2; 1280-1290 m, 11.7.2023, Erdoğan 1751, 3; 1290-1330 m, 19.7.2023, Erdoğan 1796, 3; 1290-1330 m, 19.7.2023, Erdoğan 1797, 3; 1290-1330 m, 19.7.2023, Erdoğan 1798.

**Nigella segetalis** Bieb. 3; 1290-1330 m, 23.6.2023, Erdoğan 1476, 4; 1300-1330 m, 23.6.2023, Erdoğan 1465, 4; 1300-1330 m, 19.7.2023, Erdoğan 1768, 4; 1300-1330 m, 19.7.2023, Erdoğan 1772.

**Ranunculus arvensis** L. 1; 1280-1330 m, 20.5.2023, Erdoğan 1226, 3; 1290-1330 m, 20.5.2023, Erdoğan 1213, 4; 1300-1330 m, 08.4.2023, Erdoğan 1024, 7; 1280-1320 m, 04.6.2023, Erdoğan 1442, 8; 1300-1320 m, 06.5.2023, Erdoğan 1133; 8; 1300-1320 m, 04.6.2023, Erdoğan 1392, 8; 1300-1320 m, 04.6.2023, Erdoğan 1393, 8; 1300-1320 m, 01.7.2023, Erdoğan 1576, 8; 1300-1320 m, 01.7.2023, Erdoğan 1538, 8; 1300-1320 m, 01.7.2023, Erdoğan 1540. Ter, A

**Ranunculus cornutus** DC. 1; 1280-1330 m, 05.5.2023, Erdoğan 1159, 5; 1320-1330 m, 04.6.2023, Erdoğan 1341.

**Ranunculus dissectus** subsp. **rigidulus** (Boiss.) Davis 1; 1280-1330 m, 23.4.2023, Erdoğan 1093, 5; 1280-1330 m, 06.5.2023, Erdoğan 1099. **Endemik.**

**Ranunculus muricatus** L. 2; 1280-1290 m, 23.4.2023, Erdoğan 1082, 2; 1280-1290 m, 05.5.2023, Erdoğan 1121.

#### RESEDACEAE

**Reseda lutea** L. var. **lutea** 6; 1280-1330 m, 26.7.2023, Erdoğan 1850, 2; 1280-1290 m, 11.7.2023, Erdoğan 1749, 5; 1320-1330 m, 04.6.2023, Erdoğan 1348, 5; 1280-1330 m, 30.8.2023, Erdoğan 2010, 5; 1280-1330 m, 30.9.2023, Erdoğan 2083, 8; 1300-1320 m, 01.7.2023, Erdoğan 1563.

#### ROSACEAE

**Crataegus orientalis** Pall. ex Bieb. subsp. **Orientalis** 1; 1280-1330 m, 13.10.2023, Erdoğan 2089, 2; 1280-1290 m, 11.7.2023, Erdoğan 1743, 8; 1300-1320 m, 30.9.2023, Erdoğan 2056, 8; 1300-1320 m, 30.9.2023, Erdoğan 2057, 8; 1300-1320 m, 30.9.2023, Erdoğan 2058. Pha, P

**Crataegus szovitsii** Pojark. 1; 1280-1330 m, 13.10.2023, Erdoğan 2091, 1; 1280-1330 m, 13.10.2023, Erdoğan 2093, 1; 1280-1330 m, 13.10.2023, Erdoğan 2097.

**Potentilla argentea** L. 1; 1280-1330 m, 23.6.2023, Erdoğan 1509.

**Potentilla recta** L. (Grup B) 6; 1320-1330 m, 04.6.2023, Erdoğan 1335. Hem, P

**Pyrus elaeagnifolia** Pall. subsp. **elaegnifolia** 1; 1280-1330 m, 11.7.2023, Erdoğan 1644, 1; 1280-1330 m, 11.7.2023, Erdoğan 1645, 1; 1280-1330 m, 11.7.2023, Erdoğan 1699, 1; 1280-1330 m, 13.10.2023, Erdoğan 2100, 1; 1280-1330 m, 13.10.2023, Erdoğan 2101, 2; 1280-1290 m, 05.5.2023, Erdoğan 1186, 2; 1280-1290 m, 11.7.2023, Erdoğan 1744, 5; 1320-1330 m, 06.5.2023, Erdoğan 1108. Pha, P

**Rosa canina** L. 1; 1280-1330 m, 11.7.2023, Erdoğan 1643, 1; 1280-1330 m, 15.9.2023, Erdoğan 2055, 1; 1280-1330 m, 13.10.2023, Erdoğan 2095, 2; 1280-1290 m, 11.7.2023, Erdoğan 1747, 2; 1280-1290 m, 13.10.2023, Erdoğan 2118, 3; 1290-1330 m, 13.10.2023, Erdoğan 2107, 3; 1290-1330 m, 13.10.2023, Erdoğan 2108; 8; 1300-1320 m, 30.8.2023,

Erdoğan 1997, 8; 1300-1320 m, 30.9.2023, Erdoğan 2060. Pha, P

**Rosa foetida** Herrm. 6; 1320-1330 m, 17.5.2024, Erdoğan 2158. Pha, P,

**Sanguisorba minor** Scop. subsp. **minör** 6; 1320-1330 m, 01.7.2023, Erdoğan 1589, 8; 1300-1320 m, 04.6.2023, Erdoğan 1432. Hem, P

#### RUBIACEAE

**Asperula arvensis** L. 1; 1280-1330 m, 11.7.2023, Erdoğan 1662, 1; 1280-1330 m, 11.7.2023, Erdoğan 1665, 4; 1300-1330 m, 23.6.2023, Erdoğan 1473, 5; 1320-1330 m, 04.6.2023, Erdoğan 1356, 7; 1280-1320 m, 04.6.2023, Erdoğan 1441. Akdeniz elementi. Ter, A

**Cruciata laevipes** Opiz 4; 1300-1330 m, 23.4.2023, Erdoğan 1071.

**Cruciata taurica** (Pall. ex Willd.) Ehrend. 1; 1280-1330 m, 20.5.2023, Erdoğan 1244, 2; 1280-1290 m, 05.5.2023, Erdoğan 1182. İran-Turan elementi. Hem, P

**Galium tricornutum** Dandy. 3; 1290-1330 m, 05.5.2023, Erdoğan 1188, 4; 1300-1330 m, 05.5.2023, Erdoğan 1198, 5; 1280-1330 m, 06.5.2023, Erdoğan 1101, 5; 1280-1330 m, 06.5.2023, Erdoğan 1102, 7; 1280-1320 m, 04.6.2023, Erdoğan 1456, 7; 1280-1320 m, 01.7.2023, Erdoğan 1623, 8; 1300-1320 m, 04.6.2023, Erdoğan 1401. Akdeniz elementi.

**Galium trifidum** L. subsp. **trifidum** 2; 1280-1290 m, 11.7.2023, Erdoğan 1756.

**Galium verrucosum** Huds. 7; 1280-1320 m, 06.5.2023, Erdoğan 1145.

**Galium verum** L. subsp. **verum** 1; 1280-1330 m, 11.7.2023, Erdoğan 1661, 1; 1280-1330 m, 11.7.2023, Erdoğan 1709, 2; 1280-1290 m, 11.7.2023, Erdoğan 1732, 2; 1280-1290 m, 11.7.2023, Erdoğan 1746, 5; 1280-1330 m, 01.7.2023, Erdoğan 1606. Avrupa-Sibirya elementi. Hem, P

#### RUTACEAE

**Haplophyllum linifolium** (L.) G.Don. 2; 1280-1290 m, 20.5.2023, Erdoğan 1295.

#### SALICACEAE

**Populus alba** L. 6; 1320-1330 m, 30.9.2023, Erdoğan 2085.

**Populus canadensis** Moench. 8; 1300-1320 m, 05.8.2023, Erdoğan 1907.

**Salix alba** L. 3; 1290-1330 m, 13.10.2023, Erdoğan 2104, 7; 1280-1320 m, 23.7.2023, Erdoğan 1043. Avrupa-Sibirya elementi. Pha, P

#### SCROPHULARIACEAE

*Odontites aucheri* Boiss. 4; 1300-1330 m, 19.7.2023, Erdoğan 1783. İran-Turan elementi. Ter, A

*Pedicularis comosa* L. var. *acmodonta* (Boiss.) Boiss. 3; 1290-1330 m, 20.5.2023, Erdoğan 1221. Hem, P

*Scrophularia canina* L. 7; 1280-1320 m, 21.5.2023, Erdoğan 1271.

*Scrophularia lucida* L. 7; 1280-1320 m, 05.8.2023, Erdoğan 1900. Akdeniz elementi. Hem, P

*Verbascum cheiranthifolium* Boiss. var. *asperulum* (Boiss.) Murb. 4; 1300-1330 m, 19.7.2023, Erdoğan 1759, 8; 1300-1320 m, 05.8.2023, Erdoğan 1922. **Endemik.** LC

*Verbascum flavidum* (Boiss.) Freyn & Bornm. 6; 1280-1330 m, 26.7.2023, Erdoğan 1831. Avrupa-Sibirya elementi.

*Veronica multifida* L.1; 1280-1330 m, 05.5.2023, Erdoğan 1161, 1; 1280-1330 m, 25.5.2023, Erdoğan 1246, 2; 1280-1290 m, 05.5.2023, Erdoğan 1179, 7; 1280-1320 m, 04.6.2023, Erdoğan 1449, 8; 1300-1320 m, 06.5.2023, Erdoğan 1136, 8; 1300-1320 m, 04.6.2023, Erdoğan 1431. **Endemik,** İran-Turan elementi. Hem, P, LC

*Veronica polita* Fr. 2; 1280-1290 m, 31.3.2024, Erdoğan 2145. A,

*Veronica prostrata* L. 1; 1280-1330 m, 27.4.2024, Erdoğan 2149. A,

#### SOLANACEAE

*Hyoscyamus niger* L. 3; 1290-1330 m, 19.7.2023, Erdoğan 1805. Hem, B

*Hyoscyamus reticulatus* L. 1; 1280-1330 m, 20.5.2023, Erdoğan 1259. İran-Turan elementi.

*Lycium depressum* Stocks 6; 1280-1330 m, 26.7.2023, Erdoğan 1859.

*Lycium shawii* Roemer & Schultes 7; 1280-1320 m, 01.7.2023, Erdoğan 1618. İran-Turan elementi.

#### TAMARICACEAE

*Tamarix gracilis* Willd. 2; 1280-1290 m, 13.10.2023, Erdoğan 2113, 3; 1290-1330 m, 20.5.2023, Erdoğan 1210, 7; 1280-1320 m, 30.9.2023, Erdoğan 2072. Pha, P

#### THYMELAEACEAE

*Daphne oleoides* Schreber subsp. *oleoides* 1; 1280-1330 m, 11.7.2023, Erdoğan 1668. Pha, P

#### ULMACEAE

*Ulmus glabra* Hudson 1; 1280-1330 m, 11.7.2023, Erdoğan 1700, 1; 1280-1330 m, 11.7.2023, Erdoğan 1701. Avrupa-Sibirya elementi.

*Ulmus minor* Miller. subsp. *minör* 8; 1300-1320 m, 30.8.2023, Erdoğan 1998.

#### VIOLACEAE

*Viola arvensis* L. 3; 1290-1330 m, 23.4.2023, Erdoğan 1075.

*Viola kitaibeliana* Roem. & Schult. 3; 1290-1330 m, 05.5.2023, Erdoğan 1190, 4; 1300-1330 m, 05.5.2023, Erdoğan 1202, 8; 1300-1320 m, 08.4.2023, Erdoğan 1032.

#### XANTHORRHOEACEAE

*Asphodeline taurica* (Pall.) Endl. 1; 1280-1330 m, 11.7.2023, Erdoğan 1651, 2; 1280-1290 m, 20.5.2023, Erdoğan 1312, 5; 1280-1330 m, 04.6.2023, Erdoğan 1373.

#### MONOCOTYLEDONEAE

#### COLCHICACEAE

*Colchicum triphyllum* G. Kunze. 4; 1300-1330 m, 08.4.2023, Erdoğan 1021, 3; 1290-1330 m, 31.3.2024, Erdoğan 2140, 3; 1290-1330 m, 31.3.2024, Erdoğan 2140. Akdeniz elementi. Geo, P,

#### CYPERACEAE

*Carex nigra* (L.) Reichard. 3; 1290-1330 m, 23.4.2023, Erdoğan 1072.

#### IRIDACEAE

*Crocus cancellatus* Herb. 6; 1280-1330 m, 28.10.2023, Erdoğan 2125. Geo, P, LC

*Crocus chrysanthus* (Herb.) Herb. 3; 1290-1330 m, 08.4.2023, Erdoğan 1014, 3; 1290-1330 m, 08.4.2023, Erdoğan 1015, 4; 1300-1330 m, 08.4.2023, Erdoğan 1020, 8; 1300-1320 m, 08.4.2023, Erdoğan 1037. Geo, P, LC

*Crocus flavus* Weston. 3; 1290-1330 m, 08.4.2023, Erdoğan 1009, 8; 1300-1320 m, 08.4.2023, Erdoğan 1028. Geo, P

*Gladiolus atroviolaceus* Boiss. 1290-1330 m, 20.5.2023, Erdoğan 1215, 5; 1320-1330 m, 04.6.2023, Erdoğan 1355, 5; 1320-1330 m, 01.7.2023, Erdoğan 1594, 8; 1300-1320 m, 21.5.2023, Erdoğan 1267. İran-Turan elementi. Geo, P

*Iris galatica* W. Irving. 1; 1280-1330 m, 08.4.2023, Erdoğan 1002, 2; 1280-1290 m, 08.4.2023, Erdoğan 1008. **Endemik.** İran-Turan elementi. Geo, P

*Iris persica* L. 8; 1300-1320 m, 08.4.2023, Erdoğan 1029.  
**Endemik.** Iran-Turan elementi. Geo, P, LC

#### LILIACEAE/ AMARYLLIDACEAE

*Allium carinatum* L. 3; 1290-1330 m, 19.7.2023, Erdoğan 1787, 3; 1290-1330 m, 19.7.2023, Erdoğan 1824.

*Allium commutatum* Guss. 6; 1320-1330 m, 26.7.2023, Erdoğan 1863.

*Allium rotundum* L. 2; 1280-1290 m, 23.6.2023, Erdoğan 1537.

*Allium sativum* L. 1; 1280-1330 m, 20.5.2023, Erdoğan 1237; 6; 1280-1330 m, 23.4.2023, Erdoğan 1062.

*Bellevalia flexuosa* Boiss. 2; 1280-1290 m, 20.5.2023, Erdoğan 1296.

*Bellevalia speciosa* Woronow. Ex Grossh. 1; 1280-1330 m, 20.5.2023, Erdoğan 1245, 8; 1300-1320 m, 01.7.2023, Erdoğan 1571.

*Gagea villosa* (M. Bieb.) Sweet. var. *Villosa* 1; 1280-1330 m, 08.4.2023, Erdoğan 1003, 3; 1290-1330 m, 08.4.2023, Erdoğan 1012, 4; 1300-1330 m, 08.4.2023, Erdoğan 1016, 4; 1300-1330 m, 08.4.2023, Erdoğan 1018, 5; 1320-1330 m, 23.4.2023, Erdoğan 1065, 5; 1280-1330 m, 23.4.2023, Erdoğan 1059, 8; 1300-1320 m, 08.4.2023, Erdoğan 1027, 8; 1300-1320 m, 08.4.2023, Erdoğan 1030, 8; 1300-1320 m, 08.4.2023, Erdoğan 1036, 8; 1300-1320 m, 08.4.2023, Erdoğan 1041, 3; 1290-1330 m, 31.3.2024, Erdoğan 2142, 3; 1290-1330 m, 31.3.2024, Erdoğan 2144. Akdeniz elementi. Geo, P

*Gagea pratensis* (Pers.) Dumort. 3; 1290-1330 m, 31.3.2024, Erdoğan 2143. Akdeniz elementi. Geo, P

*Hyacinthella leucophaea* (K. Koch.) Schur. 3; 1290-1330 m, 08.4.2023, Erdoğan 1011, 5; 1280-1330 m, 23.4.2023, Erdoğan 1060

*Leopoldia comosa* (L.) Parl. 6; 1320-1330 m, 04.6.2023, Erdoğan 1351, 5; 1280-1330 m, 04.6.2023, Erdoğan 1374.

*Muscari botryoides* (L.) Mill. 3; 1290-1330 m, 08.4.2023, Erdoğan 1010, 4; 1300-1330 m, 08.4.2023, Erdoğan 1025, 8; 1300-1320 m, 08.4.2023, Erdoğan 1026. **Endemik.**

*Muscari comosum* (L.) Mill. 8; 1300-1320 m, 04.6.2023, Erdoğan 1395.

*Muscari neglectum* Guss. Ex Ten 1; 1280-1330 m, 20.5.2023, Erdoğan 1253, 2; 1280-1290 m, 05.5.2023, Erdoğan 1175, 5; 1320-1330 m, 04.6.2023, Erdoğan 1336, 8; 1300-1320 m, 08.4.2023, Erdoğan 1035.

*Ornithogalum narbonense* L. 8; 1300-1320 m, 04.6.2023, Erdoğan 1405. Akdeniz elementi.

*Ornithogalum orthophyllum* Ten. 1; 1280-1330 m, 05.5.2023, Erdoğan 1162, 3; 1290-1330 m, 20.5.2023, Erdoğan 1223.

#### ORCHIDACEAE

*Anacamptis laxiflora* (Lam.) R.M. Bate 7; 1280-1320 m, 04.6.2023, Erdoğan 1452, 7; 1280-1320 m, 04.6.2023, Erdoğan 1453, 7; 1280-1320 m, 04.6.2023, Erdoğan 1454. VU,

#### POACEAE

*Alopecurus pratensis* L. 6; 1280-1330 m, 21.5.2023, Erdoğan 1279.

*Arunda donax* L. 4; 1300-1330 m, 15.8.2023, Erdoğan 1931.

*Avena sterilis* L. 2; 1280-1290 m, 11.7.2023, Erdoğan 1734, 2; 1280-1290 m, 11.7.2023, Erdoğan 1735, 3; 1290-1330 m, 15.8.2023, Erdoğan 1940, 3; 1290-1330 m, 15.8.2023, Erdoğan 1941, 5; 1320-1330 m, 01.7.2023, Erdoğan 1601.

*Bromus tectorum* L. 7; 1280-1320 m, 21.5.2023, Erdoğan 1274.

*Dactylis glomenata* L. 6; 1320-1330 m, 01.7.2023, Erdoğan 1578.

*Festuca marginata* (Hack.) K. Richt. 2; 1280-1290 m, 14.4.2024, Erdoğan 148. Hal, P,

*Phragmites australis* (Cav.) Trin. ex Steud. 8; 1300-1320 m, 30.9.2023, Erdoğan 2059.

*Poa bulbosa* L. 1; 1280-1330 m, 05.5.2023, Erdoğan 1157, 1; 1280-1330 m, 20.5.2023, Erdoğan 1247. Hem, P

*Polypogon monspeliensis* (L.) Desf. 7; 1280-1320 m, 05.8.2023, Erdoğan 1901.

*Secale cereale* L. var. *Cereale* 8; 1300-1320 m, 01.7.2023, Erdoğan 1567.

*Sporobolus pungens* (Schreb.) Kunth. 2; 1280-1290 m, 15.9.2023, Erdoğan 2029.

*Stipa pennata* L. 1; 1280-1330 m, 11.7.2023, Erdoğan 1653, 1; 1280-1330 m, 11.7.2023, Erdoğan 1666, 5; 1280-1330 m, 01.7.2023, Erdoğan 1605, 7; 1280-1320 m, 01.7.2023, Erdoğan 1626, 7; 1280-1320 m, 01.7.2023, Erdoğan 1627.

*Triticum turgidum* L. 1; 1280-1330 m, 11.7.2023, Erdoğan 1664, 2; 1280-1290 m, 11.7.2023, Erdoğan 1733. Ter, A

#### 4. TARTIŞMA VE SONUÇLAR

Bu çalışmada Bingöl Tuzlası Gölü ve çevresinde 2023–2024 yıllarında gerçekleştirilen arazi çalışmaları sonucunda toplanan 1127 bitki örneğinin değerlendirilmesiyle 51 familyaya ait 216 cins ve 425 takson belirlenmiştir. Araştırma alanında belirlenen taksonların büyük çoğunluğunu kapalı tohumlu bitkiler oluşturmuştur. (Tablo 1).

**Tablo 1.** Araştırma Alanına Ait En Büyük On Familya ve İçerdikleri Cins ve Takson (Tür) Sayıları

FAMİLYA	CİNS SAYISI	TAKSON (TÜR) SAYISI	TOPLAM TAKSON(TÜR) SAYISINA ORANI (%)
1 Asteraceae	33	84	19,76
2 Fabaceae	19	52	12,23
3 Brassicaceae	25	43	10,11
4 Lamiaceae	12	35	8,23
Liliaceae	8	16	3,76
5 Boraginaceae	7	16	3,76
6 Apiaceae	11	14	3,29
Poaceae	13	13	3,05
7 Ranunculaceae	5	13	3,05
8 Caryophyllaceae	9	11	2,58
Amaranthaceae	6	9	2,11
Caprifoliceae	5	9	2,11
Papaveraceae	4	9	2,11
9 Scrophulariaceae	5	9	2,11
10 Rosaceae	5	8	1,88
Diğer 36 familya	49	84	19,76
<b>TOPLAM</b>	<b>216</b>	<b>425</b>	<b>100</b>

Araştırma alanımızdan saptanan ilk üç familya sıralaması **Asteraceae – Fabaceae – Brassicaceae** şeklindedir. İlk üç familya sırası bakımından, alanımıza yakın bazı araştırma sonuçları Berit Dağı Florası (Kahramanmaraş) (Yıldız, 1982), Sıcak Çermik-Yıldızeli Arası Florası (Sivas), Sivas-Sıcak Çermik Arası Florası (Sivas) (Akpulat, 1997), Sivas-Hafik Arası Florası (Sivas) (Dönmez, 2002) ile aynıdır.

Araştırma alanından saptanan taksonların bitki coğrafyası bölgelerine dağılımı bir tablo halinde aşağıda verilmiştir (Tablo 2).

**Tablo 2.** Araştırma Alanındaki Taksonların (Türlerin) Bitki Coğrafyası Bölgelerine Göre Dağılımı

BİTKİ COĞRAFYASI BÖLGESİ	TAKSON (TÜR) SAYISI	TOPLAM TAKSON (TÜR) SAYISINA ORANI (%)
İran-Turan	85	20,0
Avrupa-Sibirya	16	3,8
Akdeniz	2	0,5
Geniş Yayılışlı ve Yayılışlı Bilinmeyenler	322	75,8
<b>TOPLAM</b>	<b>425</b>	<b>100</b>

Tablo 2’de görüldüğü üzere, İran-Turan bitki coğrafyası elementleri %20, Avrupa-Sibirya bitki coğrafyası elementleri %3,8, Akdeniz bitki coğrafyası elementleri ise %0,5’e sahiptir. Bitki coğrafyası bölgesi bilinmeyenler 322 (%75,8). Araştırma alanımız İran-Turan bitki coğrafyası bölgesinde yer aldığından, İran-Turan bitki coğrafyası bölgesi elementlerin çoğunlukta olması doğaldır.

Araştırma alanından saptanan 52 endemik taksonun(türün) bitki coğrafyası bölgelerine dağılımı bir tablo halinde aşağıda verilmiştir (Tablo 3).

**Tablo 3.** Araştırma Alanındaki Endemik Taksonların (Türlerin) Bitki Coğrafyası Bölgelerine Dağılımı

BİTKİ COĞRAFYASI BÖLGESİ	TAKSON(TÜR) SAYISI	ENDEMİK TAKSON(TÜR) SAYISI	ORANI (%)
İran – Turan	85	33	7.8
Avrupa – Sibirya	16	0	0.0
Akdeniz	2	0	0.0
Geniş Yayılışlı ve Yayılışlı Bilinmeyenler	322	19	4.5
<b>TOPLAM</b>	<b>425</b>	<b>52</b>	<b>12.3</b>

Tablo 3 incelendiğinde araştırma alanında saptanan 425 taksonun sadece 52’sinin (%12,23) endemik olduğu görülmektedir. Bu 52 endemik taksonun 33’ünde İran-Turan elementi, Akdeniz elementi ve Avrupa-Sibirya elementleri bulunmamaktadır. Araştırma alanı İran-Turan bitki coğrafyası bölgesinde yer aldığı için, İran-Turan bitki coğrafyası bölgesi

endemiklerinin olması doğaldır. Türkiye florasında, bitki coğrafyası bölgeleri arasında en fazla endemik içeren coğrafi bölge, 1181 takson ile İran-Turan bitki coğrafyası bölgesidir. Bunu Akdeniz bitki coğrafyası bölgesi 946 taksonla, Avrupa-Sibirya bitki coğrafyası bölgesi de 256 taksonla izlemektedir (Davis, 1965-1988).

Çalışma alanında saptanan 52 endemik bitkinin 3'ü EN, 3'ü CR, 7'si VU, 4'ü NT ve 35'i LC tehlike sınıfında yer almaktadır. Ayrıca 1'i LC tehlike sınıfında yer alan endemik olmayan bir tür bulunmaktadır (Tablo 3).

**Tablo 3.** Araştırma Alanındaki Endemik Bitkilerin Tehlike Sınıflarına Göre Tür Sayıları ve Oranları

TEHLİKE SINIFLARI (KATEGORİ)	ENDEMİK TAKSON(TÜR) SAYISI	ENDEMİK OLMAYAN TAKSON(TÜR) SAYISI	ORANI (%)
EX (Tükenmiş)	-	-	0
EW (Doğada Tükenmiş)	-	-	0
CR (Çok Tehlikede)	3	-	5.8
EN (Tehlikede)	3	-	5.8
VU (Zarar Görebilir)	7	-	13.4
NT (Tehlike Altına Girebilir)	4	-	7.7
LC (Nadir ve Tehlike Altında Olmayan)	34	1	67.3
DD (Yetersiz Bilinen)	-	-	0
NE (Değerlendirilmeyen)	-	-	0
<b>TOPLAM ENDEMİK TÜR SAYISI</b>	<b>52</b>	<b>-</b>	<b>100</b>

Çalışma alanında saptanan 156 taksonun B6 karesi için; [Ekim \(1982\)](#), İncebel Dağları Florası; [İlarslan \(1982\)](#) Deveci Dağları Florası; [Çelik \(1985\)](#), Hınzır Dağları Florası; [Civelek \(1986\)](#), Taşlıdere Florası; [Bayram \(1988\)](#), Kızıliniş - Geyraz Arası Florası; [Civelek \(1989\)](#), Çamlıbel - Yıldız Dağları Florası; [Çelik & Yıldız \(1989\)](#), Tecer Dağları Florası; , Dönmez & Çelik (1999) Gövdeli Dağı Florası, Dönmez & Çelik (2002), Sivas - Hafik Arası Florası; [Akpulat \(2002\)](#), Sivas - Sıcak Çermik Arası Florası; [Doğan \(2007\)](#), Çeltek Dağı Florası; [Dağ \(2007\)](#), Sıcak Çermik-Yıldızlı Arası Florası adlı kaynaklar taranarak yeni kayıt olduğu saptanmıştır. B6 karesi için yeni kayıt durumunda olan bu bitkilerden, 15 tanesi endemiktir (Tablo 4).

**Tablo 4.** B6 Karesi İçin Yeni Kayıt Durumunda Olan Endemik Bitki Listesi

ENDEMİK BİTKİLER	
<i>Ebenus reesei</i> Hub.-Mor.	End. B6 yeni
<i>Anthemis aciphylla</i> Boiss. var. <i>discoidea</i> Boiss.	End. B6 yeni
<i>Centaurea kotchysi</i> (Boiss. & Heldr.) Hayek var. <i>decumbens</i> Wagenitz	End. B6 yeni
<i>Centaurea solstitialis</i> L. Subssp. <i>carneola</i> Boiss.	End. B6 yeni
<i>Thlaspi violascens</i> Boiss.	End. B6 yeni
<i>Scabiosas polykratis</i> Rech. Fil.	End. B6 yeni
<i>Rumex gracilescens</i> Rech.	End. B6 yeni
<i>Consolida thirkenia</i> (Boiss.) Schröd.	End. B6 yeni
<i>Ranunculus dissectus</i> subsp. <i>rigidulus</i> (Boiss.) Davis	End. B6 yeni
<i>Crepis macropus</i> Boiss. & Heldr.	End. Ir.-Tur. B6 yeni
<i>Helichrysum arenarium</i> (L.) Moench subsp. <i>aucheri</i> (Boiss.) Davis & Kupic	End. Ir.-Tur. B6 yeni
<i>Scorzonera mirabilis</i> Lipschitz	End. Ir.-Tur. B6 yeni
<i>Tanacetum eginense</i> (Hauskn. ex Bornm.) Grierson	End. Ir.-Tur. B6 yeni
<i>Alyssum huetii</i> Boiss.	End. Ir.-Tur. B6 yeni
<i>Medicago shepardii</i> Post ex Boiss.	End. Ir.-Tur. B6 yeni

B6 karesi için, çalışma alanında tuz çıkarılan havuzların ve tuzlu suya sahip gölün olmasından dolayı tuzcul olan bitki türleri de saptanmıştır. Bu türlerden 11 tanesinin B6 için yeni olduğu saptanmıştır (Tablo 5).

**Tablo 5.** Çalışma Alanında Saptanan Halofit (Tuzcul) Bitki Listesi

TAXON ADI	YAYILIŞI	B6 KARESİ
<i>Atriplex micrantha</i> Ledep.	İran-Turan elementi	yeni
<i>Chenopodium berlandieri</i> Moq.	Yayıllı bilinmiyor	var
<i>Chenopodium album</i> L. subsp. <i>iranicum</i>	Geniş yayıllı	yeni
<i>Chenopodium vulgare</i> Gueldenst. ex. Ledep	Yayıllı bilinmiyor	var
<i>Noaea mucronata</i> (Forssk.) Asch. & Schweinf.	Yayıllı bilinmiyor	var
<i>Salicornia europaea</i> (Mass.) Lambinon & Vanderp	Yayıllı bilinmiyor	yeni
<i>Suaeda vera</i> Forssk. Ex J.F. Gmel	İran-Turan elementi	yeni
<i>Salsola kali</i> L.	Geniş yayıllı	var
<i>Artemisia araratica</i> Krasch	İran-Turan elementi	yeni
<i>Artemisia campestris</i> L.	Geniş yayıllı	var
<i>Inula montana</i> L.	Avrupa-Sibirya elementi	var
<i>Pulicaria vulgaris</i> Gaertn.	Avrupa-Sibirya elementi	var
<i>Scorzonera cana</i> (C.A. Mey.) Hoffm. var. <i>jacquiniana</i> (W. Koch.) Cham.	Geniş yayıllı	yeni
<i>Taraxacum bessarabicum</i> (Horn.) Hand.-Mazz. subsp. <i>bessarabicum</i>	Geniş yayıllı	var
<i>Lepidium perfoliatum</i> L.	Geniş yayıllı	var
<i>Lotus maritimus</i> L.	Geniş yayıllı	yeni
<i>Prospero autumnale</i> (L.) Speta	Geniş yayıllı	var
<i>Plantago lagopus</i> L.	Geniş yayıllı	yeni
<i>Plantago major</i> L. subsp. <i>intermedia</i>	Geniş yayıllı	yeni
<i>Plantago lanceolata</i> L.	Geniş yayıllı	var
<i>Limonum bellidifolium</i> (Gouan.) Dumort.	Avrupa-Sibirya elementi	yeni
<i>Limonum narbanense</i> Mill.	Akdeniz elementi	var
<i>Acantholimonum venustum</i> Boiss. subsp. <i>venustum</i>	İran-Turan elementi	var
<i>Tamarix gracilis</i> Willd.	Geniş yayıllı	yeni

## 5. ÖNERİLER

Sonuç olarak, bu çalışma ile daha önce ayrıntılı floristik yönden araştırılmamış olan Bingöl Tuzlası Gölü ve çevresinin vasküler bitki florası ortaya konulmuştur. Araştırma sonucunda bazı taksonların bilinen yayılış alanları genişletilmiş, fitocoğrafik bölgesi belirsiz olan bazı taksonların yayılışları yeniden

değerlendirilmiştir. Ayrıca, B6 karesi için yeni kayıt niteliğinde 15 endemik takson ile 24 halofit takson belirlenmiştir. Elde edilen bulgular, araştırma alanının floristik çeşitliliğini ortaya koymasının yanı sıra Türkiye florasına, bitki coğrafyasına ve tuzcul habitatların floristik özelliklerinin anlaşılmasına katkı sağlamaktadır. Bunun yanında, çalışma sonuçlarının bölgede gerçekleştirilecek floristik, taksonomik, ekolojik, fitokimyasal, tıbbi ve tarımsal araştırmalar için temel veri kaynağı oluşturması beklenmektedir.

## Teşekkürler

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## EK ŞEKİLLER



Ek Şekil 1. *Salicornia europaea* (Mass.) Lambion & Vanderp



Ek Şekil 2. *Tamarix gracilis* Willd.



Ek Şekil 3. *Suaeda vera* Forssk. ex J.F. Gmel



Ek Şekil 4. *Plantago lanceolata* L.



Ek Şekil 7. *Limonum narbanense* Mill.



Ek Şekil 5. *Plantago major* L. subsp. *intermedia*



Ek Şekil 8. *Atriplex micrantha* Ledeb.



Ek Şekil 6. *Plantago lagopus* L.



Ek Şekil 9. *Artemisia campestris* L.



Ek Şekil 10. *Noaea mucronata* (Forssk.) Asch. & Schweinf.

Artvin ilinde doğal yayılış gösteren geofit taksonları.



Ek Şekil 11. *Chenopodium berlandieri* Moq.



Ek Şekil 15. *Chenopodium vulgare* Gueldenst. ex Ledeb.



Ek Şekil 12. *Limonum bellidifolium* (Gouan.) Dumort.



Ek Şekil 16. *Acantholimonum venustum* Boiss. subsp. *venustum*



Ek Şekil 13. *Artemisia araratica* Krasch



Ek Şekil 14. *Chenopodium album* L. subsp. *iranicum*



Ek Şekil 17. *Salsola kali* L.



## CORRIGENDUM/DÜZELTME MAKALESİ

## Open Access

# Utility of partial 26S rDNA sequences in DNA-based identification of endemic plants

Endemik Bitkilerin Filogenetik Tanımlaması için Kısmi 26S rDNA Dizilerinin Kullanımının Değerlendirilmesi

Asiye ULUĞ<sup>a</sup>, Fevzi ÖZGÖKÇE<sup>b</sup>, Gül Esmâ AKDOĞAN KARADAĞ<sup>c</sup>, Funda ÖZDEMİR DEĞİRMENCI<sup>d</sup>

<sup>a</sup> Department of Biology, Faculty of Science and Literature, Kafkas University, 36100, Kars, Türkiye

<sup>b</sup> Department of Molecular Biology and Genetics, Faculty of Science, Van Yüzüncü Yıl University, 65080, Van, Türkiye

<sup>c</sup> Department of Molecular Biology and Genetics, Faculty of Science and Literature, Kafkas University, 36100, Kars, Türkiye

<sup>d</sup> Department of Crop Science, Faculty of Agriculture, Ahi Evran University, 40100, Kırşehir, Türkiye

### Article Info

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\*Corresponding author:

e-mail: [duru36@gmail.com](mailto:duru36@gmail.com)

ORCID: 0000-0001-5524-8431

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This is an Open Access article under the CC BY NC ND license (<http://creativecommons.org/licenses/by/4.0/>).

A correction request has been submitted by the authors for the above-mentioned article published in our journal's 2025, Volume 8, Issue 1. The omissions that were inadvertently overlooked have been revised, and it has been deemed appropriate to make the correction as follows.

### Text Correction

The following correction has been made on page 4:

As a result, exact matches through BLAST searches could not be established. Accession codes for sequences obtained from the 26S rDNA region were taken and deposited in the GenBank database (NCBI, 2024) (Table 2). The preliminary observations on *Lathyrus karsianus* and *Astragalus globosus* were previously reported (Uluğ et al., 2023). The present study expands upon that work through the inclusion of additional samples and more comprehensive analyses.

### The following reference has been added to the References section.

Uluğ A., Akdoğan G.E., Özdemir Değirmenci F. (2023). Phylogenetic Identification of Endemic *Lathyrus karsianus* and *Astragalus globosus* from Kars Province. *Journal of Biological Sciences and Health*, 1(1): 1–6. <https://jobish.com.tr/index.php/j/article/view/12>

### Ethical Statement

We have no conflicts of interest to disclose. The study was conducted in accordance with ethical values.

### Supporting Institution

Kafkas University  
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