Distribution of the endemic species *Astragalus babatagi* Popov and growth characteristics of the plant in the Conditions of Tashkent (Uzbekistan)

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Research

Abstract

Background: Astragalus plants, due to their medicinal properties, are widely used in traditional medicine across various cultures. Endemic and rare species represent a particularly vulnerable category due to intensive and unsustainable harvesting of raw materials. Among them is *Astragalus babatagi* Popov, a member of the genus *Astragalus* in the family Fabaceae. Like other species of this genus, it is a rich source of biologically active compounds such as cycloartane glycosides and flavonoids. One of the ways to conserve this category of medicinal plants is through cultivation.

Methods: The objective of this study was to investigate the distribution of *Astragalus babatagi* in southern Uzbekistan, examine the plant's growth characteristics under Tashkent conditions, and analyze the elemental composition of its aerial and root parts. The habitat range of the endemic species *Astragalus babatagi* was studied, and a distribution map for *A. babatagi* was created based on materials from the Central Herbarium of Uzbekistan and expedition data using the Gisinfo.ru program.

Results: The potential for cultivating this plant in Tashkent conditions was demonstrated. It was found that sowing scarified seeds of *A. babatagi* yields viable plants with high growth parameters. The developmental phases of plants growing at an altitude of 1700 meters above sea level were identified under Tashkent conditions. The elemental composition of the aerial and root parts of wild and cultivated plants was studied. The results confirm that *A. babatagi* has significant adaptive potential, allowing it to successfully grow and develop in urban conditions in Tashkent.

Keywords: Astragalus babatagi, distribution range, cultivation, scarification, developmental phases, productivity, chemical elements

Background

The diversity and unique medicinal properties of species from the genus *Astragalus* have made them indispensable components of traditional medicine for many cultures, as evidenced by numerous ethnobotanical studies (Amiri *et al*. 2020).

Iran is particularly rich in biodiversity within this genus, and the most commonly used species for medicinl treatment include *A. brachycalyx* Fisch., *A. fasciculifolius* Boiss., *A. fischeri* Buhse, *A. globiflorus* Boiss., *A. gossypinus* Fisch., *A. gummifer* Labill., *A. hamosus* L., *A. mucronifolius* Boiss., *A. ovinus* Boiss., and *A. verus* Širj. (Mozaffarian 1998, Mozaffarian 2013). *Astragalus* species also have been used for centuries in traditional Chinese medicine (Tan & Vanitha 2004).

In the traditional medicine of southern Uzbekistan and other regions of Central Asia, the aerial part *A. sieversianus*, in the form of an infusion, are used for the treatment and prevention of nervous disorders, epilepsy, and venereal diseases, while its seeds are used to treat childhood fever (Tojjonov 2016). The local population uses a decoction of the aerial part of *A. babatagi*, collected during flowering, to prepare tea with sedative and hypotensive properties. Today, pharmaceutical preparations based on plants of the genus *Astragalus* are being actively studied and used in modern medicine (Zhao 2010).

Cycloartane glycosides have been identified in plants of the genus *Astragalus* (Svechnikova 1982). These compounds exhibit hypocholesterolemic, hypotensive, and cardiotonic activities, inhibit lipid oxidation, and possess sedative and anti-inflammatory properties (Khushbaktova 1994, Tsaruk 2008, Tsaruk 2010).

According to R.V. Kamelin, the genus was represented by 254 species in the territory of Uzbekistan (Kamelin 1981). Since 2014, the flora has been supplemented with new species of *Astragalus*, bringing the current total to 268 species, 34 of which are included in the Red Book of Uzbekistan (Tojibaev 2014, Khasanov 2019).

Among the endemic species of the genus in Uzbekistan is *Astragalus babatagi* Popov, which grows in the mountainous spurs of the Hissar Range in southern Central Asia, along the border of Uzbekistan and Tajikistan (Kamelin 1981, Vvedenskiy 1959). Like other species of the genus, *A. babatagi* is a source of cycloartane compounds. The plant contains β-sitosterin glucopyranoside, Cyclosiversioside A, Cyclosiversioside B, and Cyclosiversioside C (Isaev 1988). Previously, flavonoids such as rutin, quercitrin, hyperoside, quercetin, and kaempferol were isolated from this species (Yasinov 1986).

Changes in climatic conditions and increasing anthropogenic impacts have led to a sharp reduction in the natural resources of many valuable wild medicinal plants. Rapid and profound changes in vegetation are occurring, reducing the reserves and habitats of many species (Kelly 2008). It is predicted that the number of plants threatened with extinction, including endemic and rare species, will increase (Burlakova 2011, Işik 2011). These species are priority targets for conservation as carriers of a unique gene pool.

One of the most effective and long-term ways to preserve biodiversity is the cultivation of endemic and rare species under controlled conditions (Havens 2006, Kramer & Havens 2009). Cultivation of medicinal plants in culture allows for the preservation of natural reserves and is one of the ways to create a sustainable raw material base for the pharmaceutical industry. Successful cultivation of medicinal plants requires substantiating the feasibility of introducing valuable endemic and rare species. An effective approach to addressing this issue should be based on a deep understanding of the biological and ecological properties of such plants. In these studies, special attention should be paid to the latent and pre-generative periods of development, as they are the most indicative of a species' adaptation to new conditions. The insufficient theoretical development of approaches to the conservation of medicinal plant resources and the lack of experimental data in this area determined the relevance of this work. Objective: To study the distribution of *Astragalus babatagi* Popov in southern Uzbekistan, identify the plant's growth characteristics under the conditions of Tashkent, and analyze the elemental composition of its aerial and root parts.

Materials and Methods

The distribution map of *A. babatagi* was created based on materials from the Central Herbarium of Uzbekistan and expedition data using the Gisinfo.ru program (Fig. 1.

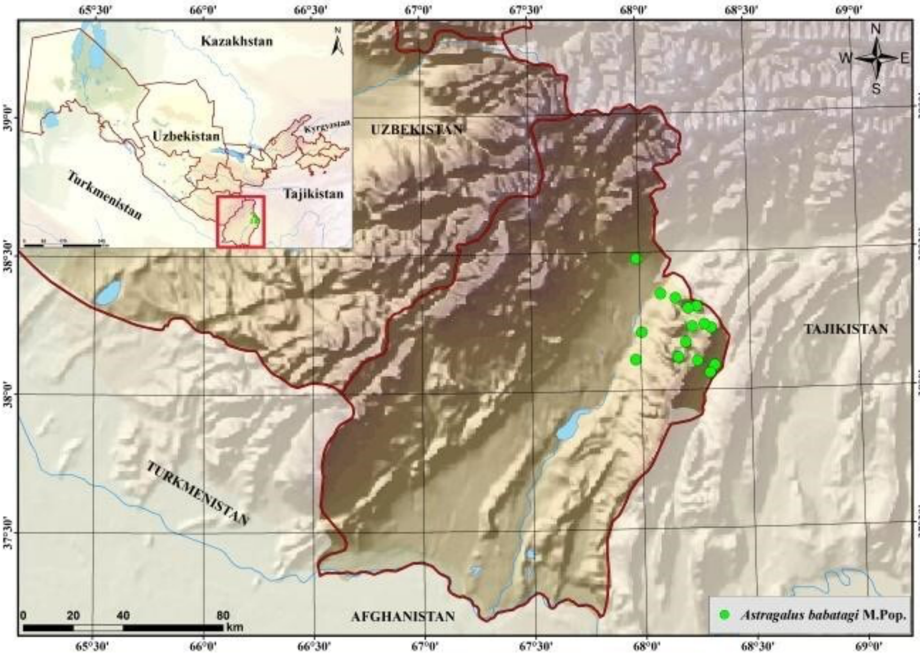

Figure 1. Distribution map of the *Astragalus. babatagi* plant. Location: Pamir Alai, Babatag Mountains

1. Kyndyk-Kutan (west of Pesha-Mazar): Badlands on the western slope at an altitude of 810 meters above sea level. Located in the UzSSR, Surkhandarya region, Babatag ridge, on the right bank of the Faizava River, on steep red slopes of the "Kzylcha." *Collection No. 3839, May 5, 1953, E.E. Korotkov.*
2. Gypsum-bearing clay outcrops near the village of Nawat, Babatag Mountains: *Collection No. 726, July 28, 1936, S. Lepeshkin, A. Mukhamedzhanov.*
3. Tugay along the river, Surkhandarya: Thickets of giant cereals (bulrush and reed grass), located near Denau city. *Collection No. 249, June 26, 1936.*
4. Gypsum, crimson sandstone, and clay outcrops in the Kafirnigan River valley near the Kanchi salt mines, Babatag Mountains: *Collection No. 937, August 9, 1936, S. Lepeshkin, A. Mukhamedzhanov.*
5. Herbarium of the Bukhara Expedition of 1914, Babatag Mountains: Near the village of Kel-Bulak, close to the city of Denau. *Collection No. Гх403, June 29, 1914, M.G. Popov.*
6. Surkhandarya region, 1.5 km southwest of 1023 meters above sea level: Sandy soil. *Collection by A. Kayumov, May 22, 1966.*
7. Surkhandarya region, 1-2 km north of the Tagan mountains or 2-3 km from the village of Bardymkuli:Altitude of 1109.2 meters above sea level. Sandy soil. *Collection by A. Kayumov, May 31, 1966.*
8. Surkhandarya region, two kilometers north of the village of Shargun: Altitude of 1800 meters above sea level. Sandy loamy soil. *Collection by A. Kayumov, May 1966.*
9. Surkhandarya region, 1.5-2 km west of the village of Kuruk-Say: Eastern slope of the Batan Mountains. Altitude of 1040 meters above sea level. Sandy soil. *Collection by A. Kayumov, May 26, 1966.*
10. Pamir Alai, Babatag, Adyr: *Collection No. 213, 214, 221, May 18, 1941, Lopott and Pinkhasov.*

For cultivation trials, *A. babatagi* seeds were collected in early June 2019 from the Surkhandarya region, specifically from the midsection of Mount Babatag, a mountain range in southern Central Asia (near the village of Zarkamar) at an altitude of 1,700 m above sea level, within the pistachio formation.

Chemical scarification was conducted by treating seeds with concentrated sulfuric acid for 20 minutes, followed by thorough rinsing with running water.

The plants were cultivated at the experimental plot of the S.Yu. Yunusov Institute of the Chemistry of Plant Substances, Academy of Sciences of Uzbekistan.

Seed germination rates were determined using Method 19 (Nikolaeva 1985). Phenological observations were conducted following standard methodology.

The vegetation duration of *A. babatagi* was determined based on phenological observations. The timing of phenological phases and ontogeny periods was determined visually. The onset of each phase was defined as its occurrence in approximately 10% of specimens, and full onset as its occurrence in 75% of specimens.

Quantitative analysis of the elemental composition of plant material was conducted using optical emission spectrometry with inductively coupled argon plasma (Nikolaeva 2019).

Results

The distribution of the species was studied. Based on materials from the Central Herbarium of Uzbekistan and expedition data collected in the Surkhandarya region from 2020 to 2022, a distribution map was created (Fig. 1). *Astragalus babatagi* is distributed mainly in the Surkhandarya region of Uzbekistan, on the slopes of the northern low hills of Mount Babatag in gypsum-bearing variegated formations (Fig. 1). It is found in the middle part of Mount Babatag, near villages such as Zarkamar and Chagam, as well as in the Kyndyk-Kutan tract and other locations. It occurs rarely or so sparsely, in isolated specimens, that it does not form plant groupings, making harvesting entirely unfeasible (Fig. 2).

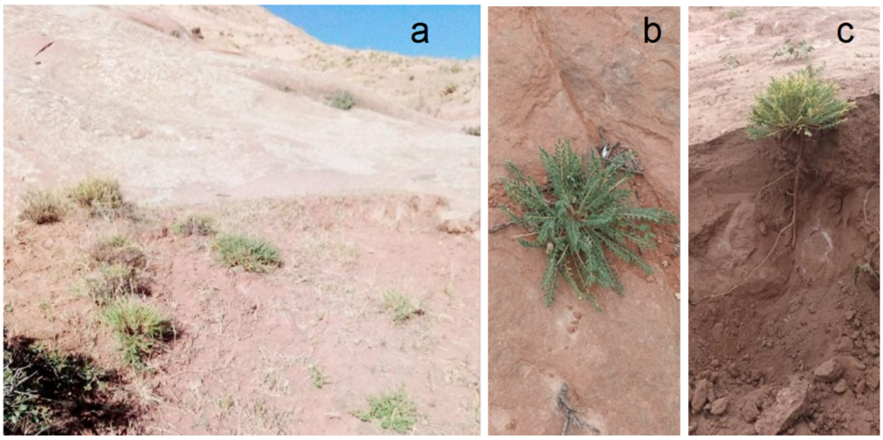

Figure 2. The *Astragalus babatagi* plant on the slope of Mount Babatag: a. Group of plants, b. Plant in the fruiting phase, c. Plant roots.

Seeds of plants from the genus *Astragalus* are hard to germinate. A significant portion of these seeds are classified as "hard seeds." Under normal temperature and humidity conditions, they do not swell or swell minimally, resulting in poor or negligible germination. In previous laboratory studies, it was found that treating *A. babatagi* seeds with sulfuric acid for 20 minutes increased germination rates to 41.3%, compared to 9.3% for untreated seeds (Kurbanova *et al* 2020).

Sowing of untreated (experimental variant) and sulfuric acid-treated seeds (control variant) was carried out on February 25, 2022. The results showed germination rates of 12.4% in the control group and 62.3% in the chemically treated group.

A key indicator of a species' adaptation to new conditions is its ability to pass through all phenological development phases.

The 2022 growing season began with heavy rainfall in March (189.3 mm) and an average temperature of 9°C, creating conditions for seed germination but slightly slowing further development. In April, the average temperature rose to +20.9°C, and precipitation decreased to 9.1 mm, providing optimal conditions for plant growth. Plants from untreated seeds developed with a delay: the first sprouts appeared on April 29, true leaves on May 6, and rosette branching began on May 20. By early July, with daytime temperatures of 35–40°C, growth ceased at the stage of 15–18 true leaves, and the plants died (Table 1). Scarified seeds germinated on March 28, with the first true leaves appearing on April 8, and rosette branching beginning in late April. During April and May, the plants exhibited intensive growth (juvenile phase). By July 11, the bushes reached heights of 30–35 cm and widths of 42–46 cm, forming dense crowns with an average of 23 branches (Fig. 2).

The growing season of *A. babatagi* lasted from March 28 to early May. Flowering began on June 3 (mass flowering on June 10), and fruiting started on July 11. The formation of the first buds on May 25 marked the transition to the generative phase. When comparing the biomass output of the control and experimental groups of plants, the following results were obtained:

the average weight of a single bush in the control group was 46 g of fresh weight and 5.5 g of dry weight, while in the experimental group, these indicators were significantly higher – 238.1 g and 77.5 g, respectively (Table 2).

Figure 3. Stages of Development of the *A. babatagi* Plant: a. Cotyledon leaves, b. First true leaf, c. 4–5 true leaves, d. Stemming phase, e. Flowering phase, f. Plants in the fruiting phase.

Table 1. Phenological Dates of Development of *A. babatagi* in Tashkent Conditions (2022 y)

Experiment Variant	**First Sprouts**	**First True Leaf**	**Rosette Branching**	**Budding**	**Start of Flowering**	**Mass Flowering**	**Fruiting**	**Mass Fruit Ripening**	**Dissemination**
Control	April 29	May 6	May 20	-	-	-	-	-	-
Scarification	March 28	April 8	April 22	May 25	June 3	June 10	June 27	July 11	July 22

The experimental plants demonstrated intensive growth and development, forming an average of 22.4 generative shoots per plant, 28.4 pods, and the seed weight per plant was 0.289 g.

Table 2. Productivity indicators of the aerial part of *Astragalus babatagi*

Experimental Variant	Fresh weight per 1 bush (g)	Dry weight per 1 bush (g)	Number of generative shoots per plant	Number of pods per plant	Seed yield per 1 bush (g)
Control	46±2.28	5.5±0.97	-	-	-
Scarification	238.1±2.04	77.5±2.16	22.4±1.65	28.4±1.35	0.289±0.01

An important indicator of medicinal plants is the micronutrient composition of plant raw materials (Boyarskykh I.G & Siromlya 2022). We conducted a comparative analysis of the elemental composition of the roots and aerial parts of wild and cultivated *A. babatagi* plants. Table 3 presents data on the content of major biogenic elements in various plant organs that are of nutritional value to humans. It was found that the content of Fe in the aerial part of the wild plant was higher than in the roots, with values of 2329.137 mg/kg and 565.376 mg/kg, respectively, while in the biomass of introduced plants, it was higher in the roots at 3325.510 mg/kg, and significantly lower in the stems at 559.953 mg/kg. This same pattern was observed for the macronutrients N, Ca, Mg, and K.

Species of the genus *Astragalus* are known for its ability to accumulate selenium (Birringer *et al*. 2002, Freeman *et al*. 2006). It was found that the selenium content in the aerial part of the wild plant was 0.087 mg/kg, and in the roots, it was significantly higher at 0.240 mg/kg, while in the cultivated plants, the levels in the roots and aerial parts were nearly the same at 0.171 mg/kg.

Table 3. Elemental composition of *Astragalus babatagi*

Element	**Wild *A. babatagi* (aerial part)**	**Wild *A. babatagi* (root)**	**Cultivated *A. babatagi* (aerial part)**	**Cultivated *A. babatagi* (root)**
B	6.652	7.639	26.830	11.878
Na	1067.800	202.900	209.309	1567.309
Mg	3198.156	1949.519	1574.937	4894.894
P	18061.460	23630.045	227780.790	25601.025
S	55.414	-227.486	-554.470	-378.959
K	2179.920	23077.687	28091.198	1767.367
Ca	13117.677	3537.201	8459.868	146451.401
Mn	16.052	4.203	10.820	29.695
Fe	2329.137	565.376	559.953	3325.510
Cu	0.542	0.652	0.723	1.899
Zn	0.814	2.309	2.013	1.342
Se	0.087	0.240	0.175	0.171

Conclusions

The area of distribution of the endemic species *Astragalus babatagi* M. Pop. in the Republic of Uzbekistan was studied, and a distribution map was created.

The species *A. babatagi* demonstrated a high ability to adapt to urban conditions. The sowing of scarified seeds at the end of February allowed the plants to complete the full development cycle from germination to fruiting. The development phases of the plant were precisely determined, allowing for the creation of a detailed phenological calendar for this species in the conditions of Tashkent.

The plants in the experimental variant produced viable seeds, indicating the completion of the full developmental cycle and the species' ability to reproduce under the studied conditions. The comparative analysis of the elemental composition of wild and cultivated plants revealed some differences caused by the variation in soil composition.

Declarations

Ethics Approval: Not applicable - no participants involved.
Consent for publication: Not applicable - no participants involved.
Data availability: All data inckluded in the paper.
Author Contributions: R.P. Zakirova led the experimental part of the study, analyzed the obtained data, and contributed to the literature review and article writing.
E.R. Kurbanova monitored plant growth and development throughout the growing season. The collected data was subjected to detailed statistical analysis, and she drew sound conclusions based on the results. B.Z. Ergashev systematized the data obtained from growing plants in new conditions. Data analysis allowed him to identify patterns in plant development. Egamberdiev and A.M. Nigmatullaev participated in expeditions, collecting data on the reserves of the studied plant. Based on the collected data, they contributed to creating a map. O.K. Khojimatov and Rainer W. Bussmann participated in the discussion of experimental results, contributed to the preparation and writing of the literature review, and advised, reviewed, and approved the final manuscript.
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Conflicts of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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