Ecological aspects, introduction, comparative anatomical and ethnobotanical assessment of two species of the genus *Artemisia* L.

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Research

Abstract

Background: Species of the genus *Artemisia* L. are of considerable ethnobotanical, medicinal, and ecological importance in the flora of Uzbekistan. *Artemisia dracunculus* L. and *Artemisia vulgaris* L. are widely used in traditional medicine and are of interest for studying their distribution, adaptive potential, and structural characteristics under introduction conditions. The aim of the present study was to assess the ethnobotanical significance, ecological status, spatial distribution patterns, introduction performance, and leaf anatomical structure of two medicinal species of the genus *Artemisia* in the flora of Uzbekistan.

Methods: The study included an analysis of published ethnobotanical data, herbarium materials from the National Herbarium of Uzbekistan (TASH), field observations, and GIS-based mapping of the distribution of *A. dracunculus* and *A. vulgaris*. Spatial analysis was performed using ArcGIS 10.6.1, Google Earth, and SAS Planet. To assess altitudinal distribution, occurrence points were compared with a digital elevation model. Introduction observations were carried out under the conditions of the Tashkent Botanical Garden named after F.N. Rusanov. The anatomical structure of the leaves was studied on transverse sections taken from the middle part of the leaf blade, stained with methylene blue, and mounted in glycerol-gelatin. Quantitative anatomical parameters were statistically processed based on 30 measurements for each trait.

Results: GIS analysis revealed pronounced ecogeographical differentiation between the two species. *A. dracunculus* is characterized by a broad ecological amplitude and occurs within an altitudinal range of 500–2500 m a.s.l., covering both the mountainous regions of the Western Tien Shan, Western Hissar, Hissar-Darvaz, and Fergana-Alay, as well as the arid territories of Ustyurt and Kyzylkum. *A. vulgaris* has a more restricted distribution, mainly within 400–1800 m a.s.l., and is associated with mesophilic foothill areas, anthropogenically disturbed habitats, and synanthropic oases.

Ethnobotanical data confirm the use of *A. dracunculus* for inflammatory diseases, bruises, rheumatism, and sciatica, whereas *A. vulgaris* is used as an antipyretic, antiseptic, tonic, sedative, and anti-inflammatory agent. Under introduction conditions, *A. dracunculus* showed high seed germination, good survival, and active vegetative growth. *A. vulgaris* has been maintained for more than 30 years in the medicinal plant collection of the Tashkent Botanical Garden, where it flowers and fruits annually and regenerates by self-seeding.

The anatomical study revealed common leaf features in both species, including dorsiventral mesophyll, amphistomatic leaves, collateral vascular bundles, and the presence of T-shaped non-glandular trichomes. Species-specific features of *A. dracunculus* include two-layered palisade parenchyma, 5–6-layered spongy tissue, the presence of secretory ducts, and essential oils in the mesophyll. *A. vulgaris* is characterized by one-layered palisade parenchyma, 2–3-layered spongy tissue, the presence of subepidermal collenchyma and bast fibers, and the absence of distinct secretory ducts in the leaf.

Conclusions: obtained data show that *A. dracunculus* is an ecologically plastic species with a broad altitudinal and geographical amplitude, whereas *A. vulgaris* exhibits more pronounced ecological specialization and dependence on mesophilic and anthropogenically transformed habitats. The successful introduction of both species under the conditions of the Tashkent Botanical Garden confirms their adaptive potential and their prospects for conservation, further study, and sustainable use. The identified anatomical traits may be used for species diagnosis, assessment of adaptive strategies, and expansion of knowledge on the structural organization of medicinal plants of the genus *Artemisia.*

Keywords: *Artemisia dracunculus*, *Artemisia vulgaris*, ethnobotany, medicinal plants, GIS mapping, introduction, leaf anatomy, ecological plasticity, Uzbekistan.

Background

Medicinal plants of Uzbekistan are of considerable interest both for ethnobotanical research and for the study of biocultural heritage associated with traditional forms of natural resource use. In different regions of the country, local communities continue to use wild-growing plants for medicinal purposes, indicating the preservation of traditional knowledge and practices transmitted from generation to generation (Ulchenko *et al.* 2001; Khamraeva 2023; Sharopov *et al.* 2024; Khamraeva *et al.* 2026). This knowledge is of particular value under current ecological and social changes, as it reflects long-term interactions between humans and the natural environment and serves as an important source of information on the useful properties of the local flora.

Along with their ethnobotanical significance, many medicinal plants of Uzbekistan are of interest as rare or ecologically vulnerable species whose status requires special study. Studies on the ontogenetic structure of rare plants of the Ustyurt Plateau have shown that assessment of the age structure of populations is important for understanding their stability and for developing conservation measures (Rakhimova *et al.* 2020). At the same time, data on the phytocoenotic distribution of *Hulthemia persica* under different ecological conditions in Uzbekistan confirm that the distribution of rare species is closely related to habitat characteristics and the structure of plant communities (Rakhimova *et al.* 2024). This indicates the need to consider medicinal and rare plants not only as resources used by local populations, but also as important components of natural ecosystems that are sensitive to environmental change.

Species that combine several features are of particular interest: traditional use in folk medicine, restricted distribution, economic value, and potential for further biological and ethnobotanical studies. For example, published data on *Megacarpaea gigantea* show that this species is used in folk medicine and is also of interest due to its biological characteristics and the presence of valuable compounds in its seeds (Sharopov *et al.* 2024; Khamraeva *et al.* 2026). However, for such species, studies that integrate information on traditional use, ecological distribution, biological features, and significance for plant resource conservation remain insufficient.

Despite the existence of separate studies devoted to ethnobotany, population structure of rare plants, their ecological distribution, and individual biologically active properties, comprehensive investigations of medicinal plants of Uzbekistan remain limited. This is especially true for species that are simultaneously rare, culturally significant, and promising for practical use. In this regard, studies aimed at integrating ethnobotanical, ecological, and botanical data are of particular relevance for a more complete understanding of the role of such plants in local knowledge systems, natural communities, and the practice of sustainable use of plant resources (Rakhimova *et al.* 2021; Rakhimova *et al.* 2023; Saribaeva *et al.* 2023).

Representatives of the family Asteraceae Bercht. & J. Presl possess high medicinal value and are used as sources of anti-inflammatory, antimicrobial, antioxidant, wound-healing, hepatoprotective, spasmolytic, gastroprotective, and antiparasitic agents. These properties have been most extensively studied in the genera *Artemisia*, *Achillea*, and *Calendula*, as confirmed by published review and experimental studies (Bora & Sharma 2011; Saeidnia *et al.* 2011; Carvalho *et al.* 2018; Rolnik & Olas 2021; Sapkota and Kunwar 2024).

The genus *Artemisia* L. is widely distributed in Central Asia and is particularly characteristic of the arid and semi-arid ecosystems of Kazakhstan, Uzbekistan, Tajikistan, Kyrgyzstan, and Turkmenistan (Kapustina *et al.* 2001; Nurlybekova *et al.* 2022; Abduraimov *et al.* 2023). Representatives of the genus occur mainly in deserts, semi-deserts, steppes, dry foothills, and lower mountain belts, where they often form dominant plant communities. In the traditional medicine of Central Asia, *Artemisia* species are used mainly as gastrointestinal, choleretic, anti-inflammatory, anthelmintic, antiseptic, and tonic remedies; infusions and decoctions are used for diseases of the digestive organs, liver, respiratory tract, hemorrhoids, epilepsy, and other disorders.

In the flora of Uzbekistan, the genus *Artemisia* is represented by 39 species: *A. dracunculus*, *A. dimoana*, *A. kelleri*, *A. scoparia*, *A. arenaria*, *A. songarica*, *A. sieversiana*, *A. tournefortiana*, *A. succulenta*, *A. annua*, *A. persica*, *A. aschurbajevii*, *A. rupestris*, *A. absinthium*, *A. vulgaris*, *A. santolinifolia*, *A. austriaca*, *A. rutifolia*, *A. santolina*, *A. leucodes*, *A. juncea*, *A. turanica*, *A. glanduligera*, *A. prasina*, *A. lehmanniana*, *A. schrenkiana*, *A. pauciflora*, *A. tenuisecta*, *A. scotina*, *A. sogdiana*, *A. porrecta*, *A. prolixa*, *A. kochiiformis*, *A. ferganensis*, *A. serotina*, *A. baldshuanica*, *A. halophila*, *A. terrae-albae*, and *A. diffusa*. Almost all *Artemisia* species contain essential oils, which give them their characteristic aroma. Some species, owing to their valuable essential oils, are used in the perfume and alcoholic beverage industries, as well as in cooking. In addition to essential oils, bitter substances, including glycosides and other compounds, have been reported in almost all *Artemisia* species; plants containing essential oils and bitter principles are used in medical practice (Flora of Uzbekistan 1962).

Artemisia dracunculus L. is among the species reliably recorded for the flora and ethnobotanical practice of Uzbekistan. In a review of ethnomedicinal plants of Uzbekistan, the species is included in the medicinal flora of the country (Khojimatov *et al.* 2020). More specific data are provided for the mountain population of the Kitab Region, where *A. dracunculus* is known by the local name Sherolg'in; in folk medicine, the aerial parts and leaves are used as an anthelmintic remedy, as well as for edema and scurvy (Kosimov *et al.* 2023). In addition, in a floristic review of wild relatives of cultivated plants in Uzbekistan, the species is characterized as a common perennial, confirming its actual occurrence in the natural flora of the republic (Abduraimov *et al.* 2023).

Artemisia vulgaris L. is one of the species used in the folk medicine of Uzbekistan. According to published ethnobotanical data, the stems, leaves, flowers, and roots of the plant are used for medicinal purposes. In traditional practice, the plant is used for gastric and duodenal ulcers, anemia, insomnia, various neurotic conditions, colds, malaria, influenza, and epilepsy, as well as a remedy stimulating appetite (Makhkamov *et al.* 2024). In the broader Central Asian ethnomedicinal context, *A. vulgaris* is also regarded as an astringent, anthelmintic, and diuretic agent used for fever, cough, sore throat, tachycardia, gastric and intestinal colic, headache, and toothache (Liu *et al.* 2020; Khamraeva *et al.* 2023).

Thus, the relevance of the present study is determined by the need to document traditional knowledge on medicinal plants of Uzbekistan, assess their biological and ecological specificity, and identify the importance of rare and valuable species in the context of biodiversity conservation and biocultural heritage. This approach makes it possible to consider medicinal plants not only as objects of applied use, but also as important elements of the interaction between nature and local communities.

Therefore, the aim of this study was to investigate the ethnobotanical significance, ecological status in the flora of Uzbekistan, and structural features under introduction conditions of the valuable medicinal plants *Artemisia dracunculus* and *Artemisia vulgaris*.

Materials and Methods

Study area

The study was conducted at the Tashkent Botanical Garden named after F.N. Rusanov, Institute of Botany, Academy of Sciences of the Republic of Uzbekistan. The Garden is one of the unique cultural heritage sites of Uzbekistan and covers an area of more than 65 ha. Its climate is sharply continental, characterized by hot dry summers, dry warm autumns, and moderately cold winters. The Garden is located in the north-eastern part of Tashkent at an altitude of approximately 450–

480 m a.s.l., near the foothills of the Western Tien Shan. The mean annual precipitation is 337–380 mm, most of which falls during the autumn-winter-spring period. The mean annual air temperature is about 13.8 °C; the absolute maximum reaches +44.6 °C, and the absolute minimum is –25.8 °C. The soil cover is represented by cultivated irrigated sierozems, which, together with the arid climatic conditions, creates a specific environment for the introduction and assessment of the adaptive potential of medicinal plants (Yusupova 2018; Volis *et al.* 2023).

Study species

The objects of the study were two medicinal species of the genus *Artemisia* L.: *Artemisia dracunculus* and *Artemisia vulgaris* (Fig. 1A, B).

Artemisia dracunculus is a perennial herbaceous plant used for medicinal and food purposes. Within Uzbekistan, the species grows on soft and stony slopes from the lower to the upper mountain belt and is distributed in Tashkent, Andijan, Fergana, Samarkand, and Surkhandarya regions. Outside Uzbekistan, it occurs in Central Asia, including Tarbagatai, Dzungarian Alatau, Tien Shan, and Pamir-Alay, as well as in Siberia, Western Europe, the Mediterranean region, Mongolia, Northern China, and North America.

The plant is characterized by numerous erect herbaceous stems, 40–80 cm tall, branched in the inflorescence region, ribbed, usually glabrous or sparsely pubescent in the upper part. The leaves are mainly entire, linear-lanceolate or linear, 1.5–8 cm long and 3–5(10) mm wide, mostly glabrous. The inflorescence is a loose panicle with numerous spherical, nodding capitula 2.5–4 mm in diameter. The involucral bracts are herbaceous, green or slightly reddish, with membranous margins. The flowers are pale yellow, sometimes with a reddish tint; the achenes are dark brown or blackish, slightly more than 1 mm long. The species flowers in June and fruits in September.

Artemisia vulgaris is also a perennial herbaceous plant. In Uzbekistan, it is distributed from the plains to the middle mountain belt, where it occurs mainly in anthropogenically disturbed habitats and often behaves as a weed. In a broader biogeographical context, the species is distributed in Central Asia, Siberia, the Caucasus, Western Europe, the Mediterranean region, Mongolia, Afghanistan, China, Japan, India, and North America.

The species is characterized by a solitary erect ribbed stem up to 1.5 m tall, green, purple, or violet in color, glabrous or sparsely pubescent in the lower part. The leaves are dark green, glabrous or slightly pubescent on the adaxial surface, and white-tomentose on the abaxial surface. The lower leaves are petiolate and pinnatisect, whereas the middle and upper leaves are sessile, dissected, or entire. The capitula are oblong-ovate, 3–5 mm long and 2–4 mm wide, arranged in a paniculate inflorescence. The involucral bracts are pubescent, with membranous margins. The marginal flowers are female and filiform-tubular, whereas the central flowers are bisexual, tubular, and reddish at the apex. The achenes are brownish, about 1 mm long. The species flowers in July and fruits in September.

Introduction experiment and anatomical study

Seeds were sown in small containers with a closed root system in late autumn, on 29 November 2024. Different substrate mixtures were used, including peat, coconut substrate, biohumus, and perlite.

Transverse sections of the middle part of leaves from the middle stem layer of the studied species were stained with methylene blue and mounted in glycerol-gelatin according to the generally accepted method (Barykina & Chubatova 2005). Cross-sections were photographed using an Olympus CX43 light microscope.

According to the traditional methodology of phenological observations (Methodology ..., 1975), the dates of the following phenophases were recorded: beginning of vegetation, beginning of budding, flowering period, fruit ripening, and end of the growing season.

Statistical processing of quantitative anatomical data was carried out according to the method of Zaitsev (1990) using MS Excel. For each anatomical parameter, 30 measurements were performed. The obtained results are presented as the mean value and standard error of the mean.



A B

Figure 1. General view of introduced plants of *Artemisia dracunculus* L. (A) and *Artemisia vulgaris* L. (B) under the conditions of the Tashkent Botanical Garden.

Data Collection and Herbarium Analysis

The primary occurrence data for *Artemisia dracunculus* and *A. vulgaris* were compiled through an extensive review of the National Herbarium of Uzbekistan (TASH) records and targeted field surveys. Each specimen was critically re-examined for taxonomic accuracy. Geographical data were standardized using the Gazetteer of Uzbekistan, ensuring a robust dataset for subsequent spatial modeling across the country's diverse floristic districts.

GIS-Based Spatial Mapping

Spatial analysis was conducted using a *Geographic Information System* (GIS) framework. Georeferenced occurrence points were integrated into a spatial database using *ArcGIS* version 10.6.1, supplemented by *Google Earth* and *SAS Planet* for precise coordinate verification. This allowed for the generation of thematic distribution maps (Fig. 2) and the identification of core spatial clusters and distributional hiatuses.

Ecogeographical and Altitudinal Characterization

To assess vertical stratification, occurrence points were overlaid with a Digital Elevation Model (DEM), determining the hypsometric range (400–2500 m a.s.l.) across Uzbekistan's orographic gradients. The analysis integrated hydroclimatic data to evaluate environmental filtering (moisture availability and thermal continentality) and anthropogenic facilitation (proximity to irrigation networks). This synthesis provided a framework for evaluating the niche breadth and phenotypic plasticity of both taxa, from high-altitude "yaylau" (alpine pastures) to synanthropic oases.

Results

GIS-based Spatial Analysis and Altitudinal Stratification

The GIS-based analysis of herbarium records, as visualized in Fig. 2, demonstrates that *Artemisia dracunculus* and *A. vulgaris* exhibit distinct spatial partitioning across the floristic districts of Uzbekistan.

A. dracunculus displays an expansive ecological valence, with a hypsometric range extending from 500 to 2500 m a.s.l. Its distribution spans a broad ecological gradient, encompassing both mountainous regions (Western Tien Shan, Western Hissar, Hissar-Darvaz, and Fergana-Alay) and hyper-arid desert ecosystems (Ustyurt and Kyzylkum districts).

In contrast, *A. vulgaris* exhibits a more restricted distributional range, predominantly confined to lower altitudinal belts (400-1800 m a.s.l.). Its occurrence records are primarily localized in anthropogenically influenced habitats and mesic foothill zones of the Western Tien Shan, Western Hissar, and the Fergana Valley (including Central Fergana). Notably, the spatial clustering in the Bukhara and Kuhistan districts reveals a strong affinity for synanthropic oases. The divergence in their bioclimatic envelopes confirms that while *A. dracunculus* acts as a geographical generalist, *A. vulgaris* remains ecologically constrained by specific hygro-thermal requirements.

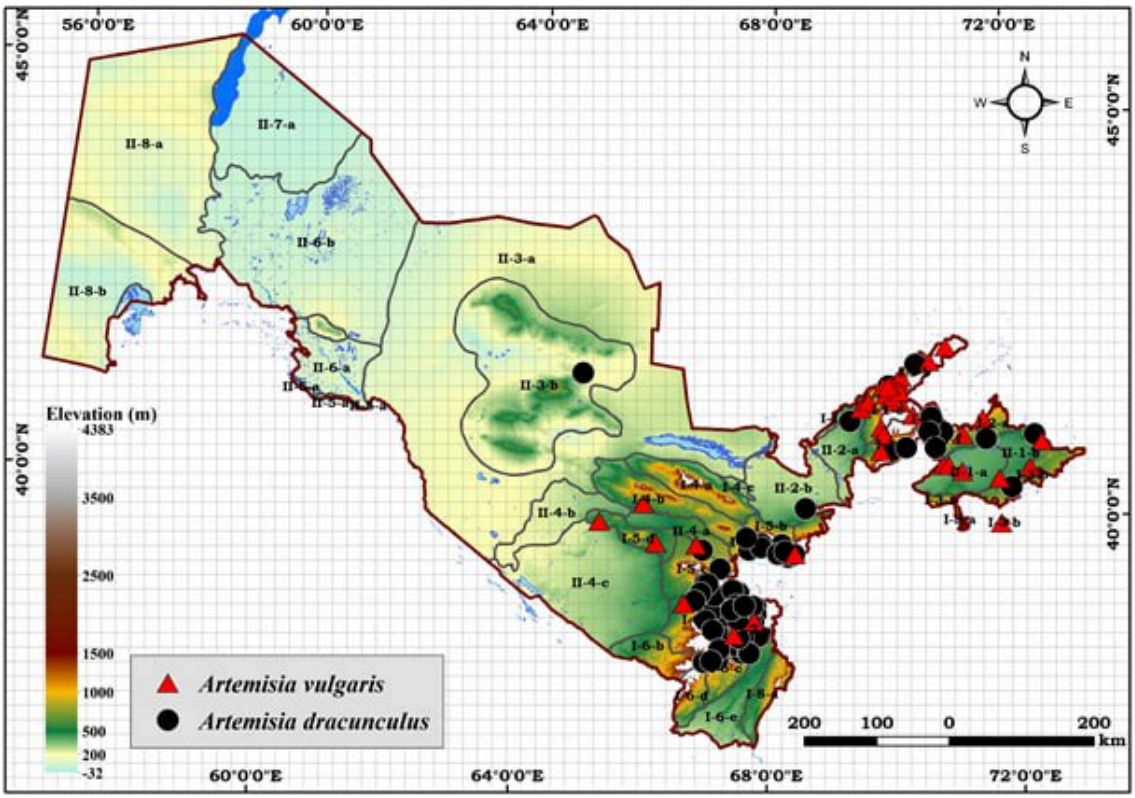


Figure 2. Spatial distribution of *Artemisia dracunculus* and *A. vulgaris* in Uzbekistan

Phytochemistry

Artemisia dracunculus: Essential oil 0.15-3.1%, in its composition (+)-sabinene, myrcene, methylhavicol 70%, 1,2-dimethoxy-4-allylbenzene, eugeiol, cis-ocimene, trans-ocimene, cis-alloocymene, trans-alloocymene, linalool, camphene, terpinolene, methylevgenol, elemycin, farnesene, spatulenol. Coumarins: 7-methoxycoumarin, 6,7-dimethoxycoumarin, scopoletin. Flavonoids 3.2%: 3-galactosylglucoside quercetin, quercetin, hyperoside, luteolin, kaempferol, bioquercetin, rutin, etc. (Sokolov 1993). The main component of essential oil was estragole, which was reaching 84.9% in plants cultivated at high altitude Armenian landscape (Bussmann *et al.* 2025)

Artemisia vulgaris: Essential oils (cineole, limonene, terpinolene, fenchone, citral a, citral b, geraniol, aromadendrene, linalool, thujone, a-pinene, p-pinene, myrcene, p-cymol, a-thujone, p-thujone, camphor, terpinol-4, a-copene, cariophyllene, a-terpineol, borneol, bornylacetate, y-cadinene, vulgarol, camphene, a-terpinene, artemisiaketone, isoborneol), sesquiterpenoids (psilostahyine, psilostahyIn B and C), tritertepoids (a-amyrine, fernenol), steroids (sitosterol, stimasterine), coumarines (esculine, esculetine, umbelliferone, scopoletine, methylenedioxycoumarine). (Bussmann *et al.* 2025)

Use of two species of the genus *Artemisia* in traditional medicine

Artemisia dracunculus: Ointment for connective tissue tumors, mixed with *Punica granatum* L. flowers - for stomatitis, gingivitis. In Transcaucasia (crushed - locally) for diseases of the oral mucosa, ointment (with honey – locally) enhancing potency. In Georgia (as part of the collection) for diseases of the nose with impaired sense of smell. The sap of the plant is used to strengthen the gums. A decoction of aerial parts has long been taken as an antipyretic, as well as for diseases of the gastrointestinal tract and rheumatism. Most frequently used food plants in the treatment of the heart and the circulatory system. Arthritis, high blood pressure and toothache as tea, for cold as tincture, for stomach disorders, sedative, appetizing. Joint pain. Ointment for connective tissue tumors, mixed with *Punica granatum* L. flowers - for stomatitis, gingivitis. In

Transcaucasia (crushed - locally) for diseases of the oral mucosa, ointment (with honey – locally) enhancing potency. In Georgia (as part of the collection) for diseases of the nose with impaired sense of smell. In Kazakhstan and other parts of Middle Asia the leaves are used as poultice for eczema and burns, and internally for tuberculosis, pneumonia, and bronchitis. In Kashmir, Jammu and Ladakh to intestinal disorders, indigestion, bladder irritation, as diuretic, for gynecological disorders, menstrual problems and toothache. (Bussmann *et al.* 2025). According to Dadabaeva (1996), in official medicine, a poultice prepared from fresh plants of *Artemisia dracunculus* is used for laryngitis and stomatitis. In folk medicine, a poultice made from the leaves and an infusion of the plant are used externally for bruises, rheumatism, and sciatica.

Artemisia vulgaris: Traditionally *Artemisia vulgaris* is used in Middle Asia as anthelmintic, for intestinal colic, diarrhea and gastralgia. The extract and fresh leaves are also applied externally on wounds and burns. In the Altai extracts are used for testicle and uterus cancer. In Azerbaijan an extract is used to treat fractures. In the Ural, Northern Caucasus and parts of Middle Asia *Artemisia annua* leaves are used as anthelmintic, for respiratory infections, fever, dysentery, and externally for rheumatism and scabies. *Artemisia annua* is used as anti-malarial in the Himalayas. In Morocco, decoction of leaves is used to treat infection problems. Wounds. Leaves in infusion, used as herbal tea. In modern traditional medicine of Tajikistan and Uzbekistan juice of fresh leaves of a one-year sage-brush dermal diseases - scabies, pustular diseases, herpes treatment. From dry leaves prepare 10% ointment for treatment of an eczema. Scientific research taped anti-oxidatic, anti-inflammatory, analgetic, sedative, antibacterial, antiviral, hypolipidemic, antitumoral properties. In many countries the Annual Wormwood is an official antimalarial and anti-leishmaniasis agent. Its immunosuppressive, antirheumatic, contraceptive, anticholinesterase properties are perspective. In Kashmir, Jammu and Ladakh to treat jaundice. In Azerbaijan an extract is used to treat fractures. In the Ural, Northern Caucasus and parts of Middle Asia *Artemisia annua* leaves are used as anthelmintic, for respiratory infections, fever, dysentery, and externally for rheumatism and scabies, as anti-malarial in the Himalayas. There has been little used in popular herbal medicine before the last 2-3 decades, when Chinese traditional medicine became rather popular. In medieval Armenian medicine it was recommended to treat fevers, hemorrhoids, diseases of the stomach, liver, spleen, and bladder and kidney stones with *Artemisia* A decoction and extract as tea is used in to treat colds. Fresh crushed leaves, as well as their decoction and extract are used crushed and as soaking therapy for furuncles and abscess. A decoction and extract is used as tea in dysentery and fever. A decoction of the aboveground parts is used as anthelminthic A tea made from leaves of *Artemisia annua* helps to cure wounds, when applied as poultice and serves as insect repellant. (Bussmann *et al.* 2025). In Guba region, fresh crumpled upper parts of the inflorescences are used as a hemostatic agent for cuts. In Talysh, the green parts of the plant are used as a remedy for gastric diseases. The herb mixed with honey is an anthelminthic. Herbal decoction - for difficult childbirth and delayed menstruation. In Morocco, decoction of leaves is used for infection diseases. Decoction of aerial parts is used in cases of diabetes, digestive, skin and infection pathologies. In Algeria, this plant is used as antispasmodic, for diabetes and digestive pathologies. In Lebanon, juice of aerial parts is used for rheumatism. The plant is applied to tumors. Dried leaves in very small doses are given as anthelmintics. Leaves are used as anthelmintic and for skin diseases. Leaves and root are used for liver pain, stomach disorder. Extract of its young shoots is used to regulate monthly cycle. Leaf infusion is used for fever. Leaf extract is used for eye diseases Whole plant is used for cardiac problems. Leaves are used for stomach pain, hypertension, dysentery, scorpion sting and snakebites. The leaves are used for skin diseases. Decoction of leaves is used for diabetes. Used for stomach-ache, hypertension, dysentery and as poultice for scorpion stings. Used as topical antibiotic and for skin ailments. Also applied as anthelminthic. In Kashmir, Jammu and Ladakh to treat nosebleeds, cough and measles. Bad gums, brandy tincture, rinse mouth, general weakness, folk illness fright, digestive problems, diarrhea, tonic, bitter, eupeptic, antimicrobial, anti-inflammatory, indigestion, appetizer. (Bussmann *et al.* 2025). The aerial part of *Artemisia vulgaris* was used in official medicine as an antipyretic, antiseptic, and tonic agent (Kovaleva 1971). In addition, decoctions and infusions of the aerial part are used for urolithiasis and amenorrhea, and also as an abortifacient. In folk medicine, a decoction of the aerial part is taken internally for nervous disorders, tuberculous meningitis, various gynecological diseases, and flatulence. The plant juice is applied externally for dermatitis and exudative diathesis. An infusion of the aerial part is used internally for tuberculous meningitis and epilepsy, as a sedative, and also for pulmonary tuberculosis and bronchopneumonia (Sakhobiddinov 1948; Dadabaeva 1996).

Culinary uses

***Artemisia dracunculus*:** It is included in the daily diet along with other types of greens, such as cilantro, dill, green onions, parsley, etc. Both fresh and dried aerial parts before flowering are used as spices in the preparation of various meat dishes (bozbash, dolma) and soups. A soft drink and sherbet are prepared from fresh herbs. The leaves are used in cheese production, as spice and for salads, and to make lemonade. Phkhali, spice, beverage, sometimes eaten raw (Bussmann *et al.* 2025).

Artemisia vulgaris: The leaves are used as spice, especially to produce aromatic liquor, and as bitter agent in the production of beer and as spice for cooking. In Khevi many species are mixed together for Pkhali: (Bussmann *et al.* 2025).

Other uses

Artemisia dracunculus: Fodder for cattle, horses, camels. Planted also as ornamental. (Bussmann *et al.* 2025).

Artemisia vulgaris: Fodder for livestock, especially sheep. goats and camels. A yellow dye for wool is produced from the leaves. Planted as ornamental. (Bussmann *et al.* 2025).

Introduction of two species of the genus *Artemisia* under the conditions of the Botanical Garden

Seeds of *Artemisia dracunculus* were sown in small containers in late autumn 2024 and germinated on 24 March 2025. The average seed germination rate was 77–83%. The plants were transplanted into open ground on 23 April 2025. At the beginning of the summer season, plant survival was 73–85%. As of 2 June, the plants were in the virginal ontogenetic state.

The main shoot was anisotropic, and first-order lateral shoots were formed from the axils of sequentially arranged leaves in the middle part of the shoot. Stem length reached 27 cm. The leaves were sessile, narrowly lanceolate, 4–8 cm long and 6 mm wide. On 24 June 2025, stem length was 27–45 cm, and intensive development of first-order lateral shoots was observed. During observations on 5 August, the plants were still in the virginal state, and a sharp increase in the shoot system was recorded. In particular, the length of the prostrate main shoot was 54–70 cm, while first-order lateral shoots reached 15–45 cm in length.

The plants survived during the winter period. On 18 March 2026, the plants were in the virginal ontogenetic state, and their height was 17–35 cm. It was found that 2 to 12 shoots were formed at the root collar. Each shoot had 10 to 22 metamers. First-order lateral shoots were formed from the leaf axils according to the basitonic branching type. The leaves on the stem were arranged alternately and were sessile; the lower leaves were three-lobed, whereas the remaining leaves were narrow, linear-lanceolate, 4.5–7.5 cm long and 0.6–0.8 cm wide.

During observations on 21 April 2026, the plants remained in the virginal state, and their height reached 82–157 cm. It was established that each shoot had up to 40–50 metamers, while the length of first-order lateral shoots was 18–29 cm. The branching type was meso-basitonic. Leaf length was 5–9 cm, and leaf width was 0.7–1.0 cm.

Artemisia vulgaris has been growing for more than 30 years in the medicinal plant collection of the Tashkent Botanical Garden. The species flowers annually from late August to late October, and fully developed seeds mature in October–November. Its presence in the collection is maintained by self-seeding, and the plants sometimes behave as weeds within the territory of the Garden.

Anatomical structure of the leaves of two species of the genus *Artemisia*

***Artemisia dracunculus*.** In transverse section, the leaf is laminar and amphistomatic. In the region of the central vascular bundle, it is convex on the abaxial side and rounded-triangular in shape (Fig. 3 a–c). The epidermis is single-layered; its cells are more or less uniform, although some larger cells are present. Both the adaxial and abaxial surfaces are pubescent with T-shaped non-glandular trichomes consisting of a multicellular base (Table 1). The adaxial epidermal cells are slightly larger than the abaxial epidermal cells. Their outer walls are slightly thickened.

The mesophyll is dorsiventral. The palisade layer is densely arranged and two-layered, with elongated columnar cells (Table 1). The spongy parenchyma is 5–6-layered, composed of rounded cells with small intercellular air spaces. In the central part of the leaf, the palisade parenchyma is continuous, whereas the spongy parenchyma is interrupted beneath the central vascular bundle.

Near the xylem of the central bundle, one secretory duct is located on each side. These ducts contain 8–9 epithelial cells, and in some cases their walls are collapsed or disrupted. The main vascular bundle is collateral, large, and occupies the central part of the leaf. The vessels are arranged in rows or chains (Fig. 3 a). The phloem is extensive and contains inclusions in its cells.

Water-storage parenchyma surrounds the vascular bundle on both the outer and inner sides; on the abaxial side, this parenchyma is the most voluminous and multilayered. Lateral vascular bundles are located within the spongy parenchyma; they are small and numerous and are surrounded by bundle sheath cells, which sometimes also contain inclusions (Fig. 3 b).

At the leaf margins, two vascular bundles are present, one large and one small, each accompanied by a secretory duct corresponding to its size, with 7–9 epithelial cells (Fig. 3 c). Essential oils in the form of granules are present in the leaf mesophyll.

***Artemisia vulgaris*.** In transverse section, the leaf is laminar and amphistomatic. In the region of the central vascular bundle, it is biconvex and oval in shape, with a more expanded abaxial side (Fig. 4 a–c). The epidermis is single-layered, and its cells are more or less uniform. On the abaxial side, the epidermis is strongly ribbed and pubescent with T-shaped non-glandular trichomes consisting of a multicellular base (Table 1). The adaxial epidermal cells are slightly larger than the abaxial epidermal cells. Their outer walls are slightly thickened.

The mesophyll is dorsiventral. The palisade layer is densely arranged and one-layered, with elongated columnar cells (Table 1). The spongy parenchyma is 2–3-layered and consists of rounded, loosely arranged cells. In the central part of the leaf, both the palisade and spongy parenchyma are interrupted beneath the central vascular bundle. On the abaxial side, a small group of collenchyma cells is located beneath the epidermis (Fig. 4 b).

The main vascular bundle is collateral, very large, and occupies the central part of the leaf. The vessels are arranged in rows or chains (Fig. 4 c). The phloem is poorly developed and accompanied by bast fibers. Water-storage parenchyma surrounds the vascular bundle on both the outer and inner sides; on the abaxial side, this parenchyma is the most voluminous and multilayered. Lateral vascular bundles are located within the spongy parenchyma; they are small and numerous and are surrounded by bundle sheath cells, which sometimes contain inclusions (Fig. 4 d).

Table 1. Anatomical parameters of leaves of introduced medicinal plants of the genus *Artemisia*

№	Character	*Artemisia dracunculus*	*Artemisia vulgaris*
1	Height of abaxial epidermal cells	19,3±0,8	16,2±0,8
2	Width of abaxial epidermal cells	17,8±0,8	17,0±0,7
3	Height of adaxial epidermal cells	24,4±0,7	22,5±0,5
4	Width of adaxial epidermal cells	26,5±0,9	24,7±0,8
5	Height of palisade cells	50,6±1,1	48,9±1,6
6	Width of palisade cells	18,6±0,8	12,8±0,5
7	Thickness of spongy tissue	151,3±2,6	68,4±1,8

Discussion

Adaptive Strategies and Niche Breadth

The spatial divergence between *Artemisia dracunculus* and *A. vulgaris* reflects fundamental differences in their adaptive radiation and niche breadth. The expansive occurrence of *A. dracunculus* across diverse floristic districts – from the high-altitude "yaylau" zones of the Western Tien Shan to the hyper-arid, skeletal soils of the Ustyurt and Kyzylkum – demonstrates high phenotypic plasticity. As an ecological generalist, it effectively bypasses severe environmental filters such as thermal continentality and seasonal moisture deficits. Its wide hypsometric range (500–2500 m a.s.l.) implies a robust physiological resilience, which correlates with its specialized anatomical adaptations for water retention, distinguishing it as a dominant component of both montane and desert ecosystems.

Environmental Filtering and Anthropogenic Facilitation

Conversely, *A. vulgaris* is governed by strict hygro-thermal filtering. Its confinement to lower altitudinal belts (400–1800 m a.s.l.) and strong affinity for synanthropic habitats in the Fergana, Bukhara, and Kuhistan districts suggests a reliance on artificial refugia. Human-mediated landscape modifications, particularly irrigation networks, allow the species to bypass the natural edaphic barriers of the arid Central Asian climate. From an ethnobotanical perspective, this proximity to settlements explains its higher accessibility and prevalence in local pharmacopoeias, as opposed to the more remote, montane-restricted populations of *A. dracunculus*.

Adaptive Potential and Resilience under Environmental Shifts

The marked distributional hiatus of *A. vulgaris* in northwestern Uzbekistan confirms its stenotopic nature and acute sensitivity to hyper-arid conditions. Given its strict dependence on stable moisture regimes, this species exhibits a high vulnerability to regional aridification, which limits its expansion and potentially leads to niche contraction. In contrast, the expansive ecological valence and altitudinal plasticity (500–2500 m a.s.l.) of *A. dracunculus* identify it as a resilient taxon

capable of enduring extreme thermal fluctuations and prolonged water stress. These divergent patterns underscore the role of Eastern Uzbekistan's montane zones as critical ecological refugia, pivotal in safeguarding the genetic and phytochemical diversity of these *Artemisia* species amidst ongoing environmental shifts.

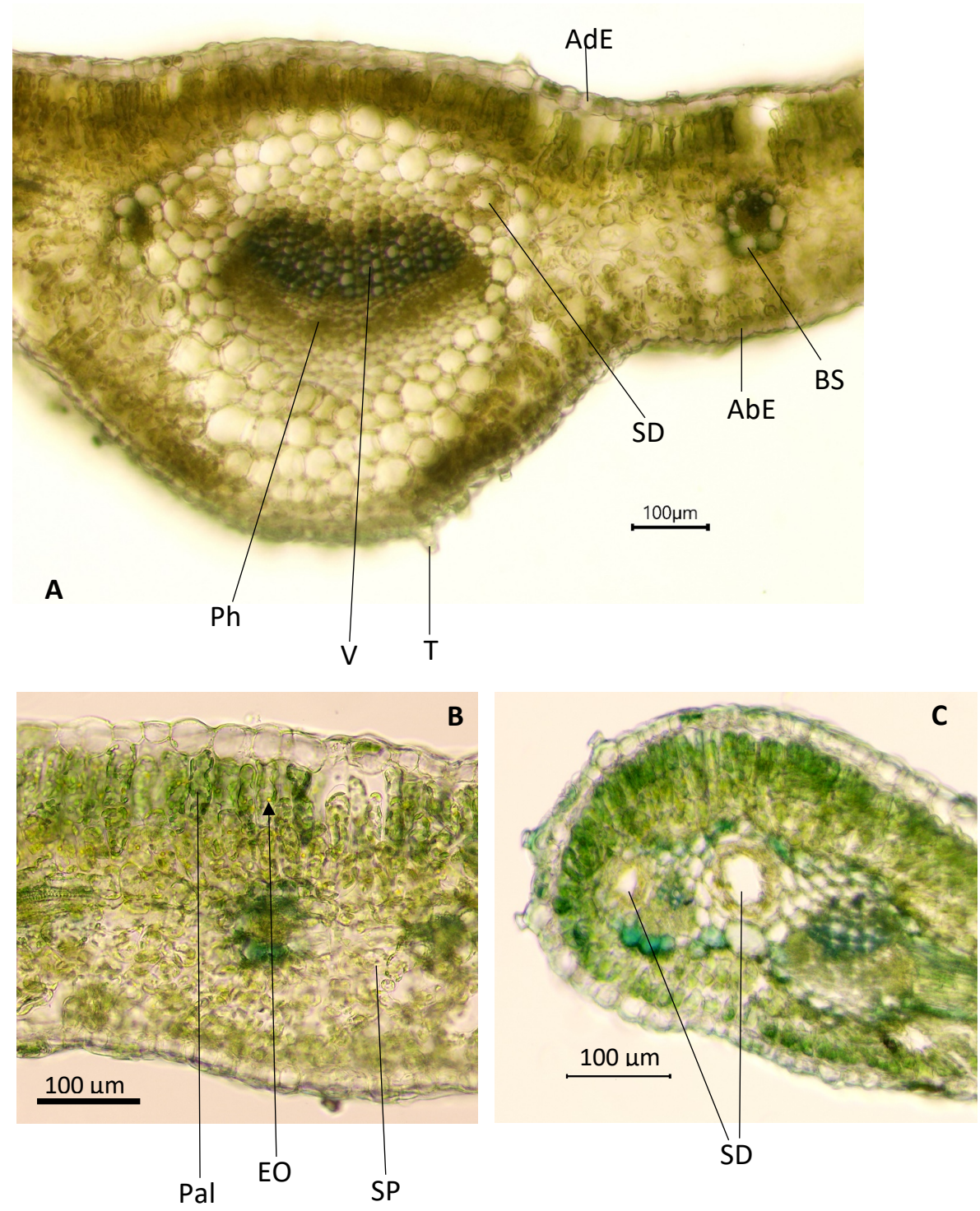


Figure 3. Anatomical structure of the leaf of *Artemisia dracunculus*. a – the region of the central vascular bundle, b – the lateral part of the leaf, c – edge of the leaf.

AbE – abaxial epidermis, AdE – adaxial epidermis, Ph – phloem, BS – bundle sheath, Col – collenchyma, EO – essential oil, Pal – palisade, Scl – sclerenchyma, SD – secretory duct, SP – spongy parenchyma, T – trihome, V – vessels.

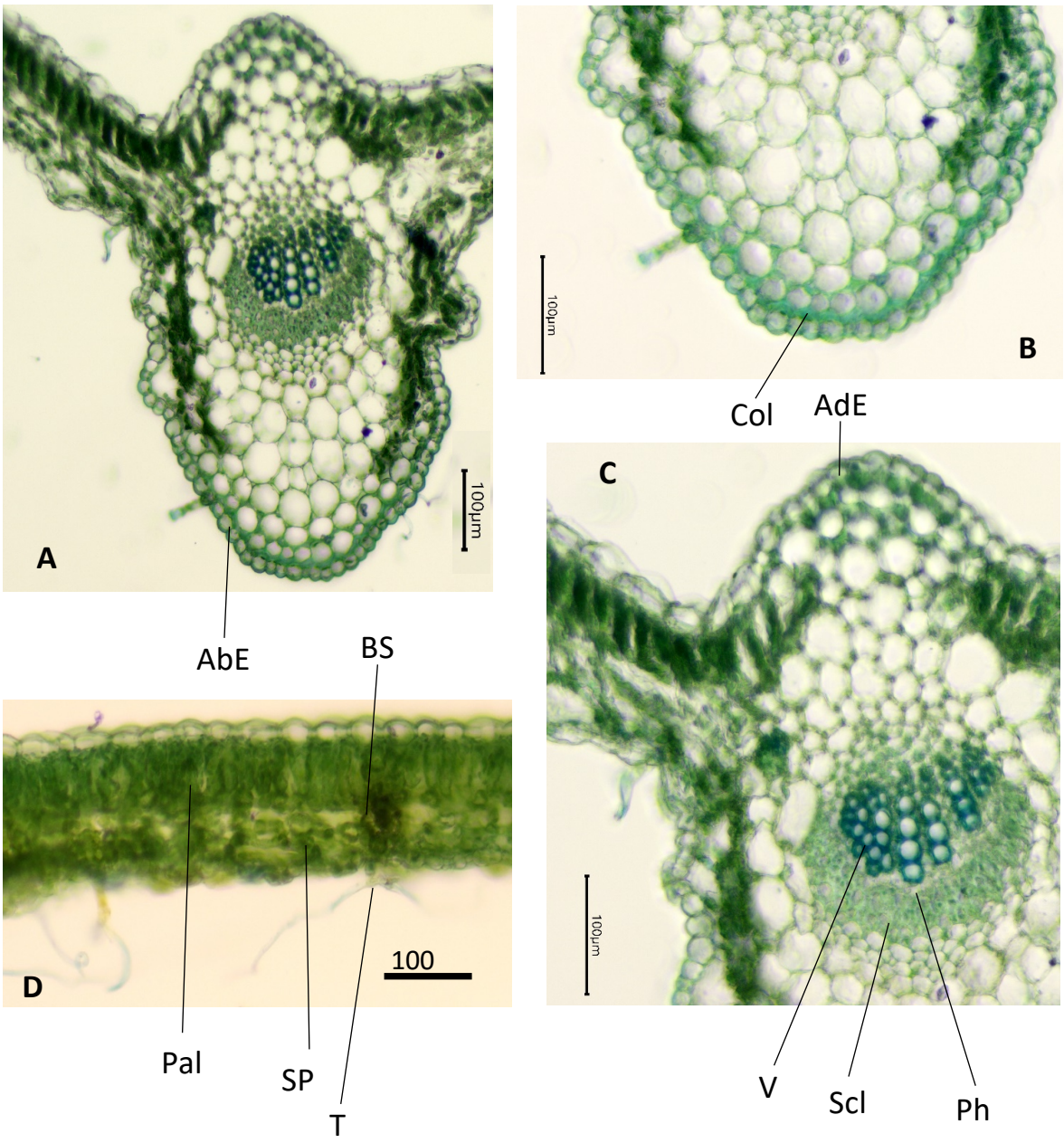


Figure 4. Anatomical structure of the leaf of *Artemisia vulgare*. a – the region of the central vascular bundle, b – the lower part of this bundle, c – the upper part of this bundle, d – the lateral part of the leaf.
AbE – abaxial epidermis, AdE – adaxial epidermis, Ph – phloem, BS – bundle sheath, Col – collenchyma, Pal – palisade, Scl – sclerenchyma, SP – spongy parenchyma, T – trihome, V – vessels.

Comparative leaf anatomy and adaptive significance of secretory and protective structures in *Artemisia dracunculus* and *A. vulgaris*

To identify the most important anatomical features and specialized secretory structures, including glandular trichomes and secretory ducts producing essential oils, a comparative anatomical analysis of the leaves of *Artemisia dracunculus* and *A. vulgaris* was carried out. The results showed that several anatomical traits are common to both species, including dorsiventral mesophyll, amphistomatic leaves, collateral vascular bundles, and larger adaxial epidermal cells.

However, a number of species-specific anatomical characters were also revealed. In *Artemisia dracunculus*, the palisade and spongy parenchyma of the mesophyll are composed of a greater number of layers; secretory ducts are present; essential oils occur as granules in the leaf mesophyll; both leaf surfaces are pubescent with T-shaped non-glandular trichomes; and the leaf has a rounded-triangular shape in transverse section.

In *Artemisia vulgaris*, the species-specific features include the presence of subepidermal collenchyma, the absence of secretory ducts in the leaves, pronounced ribbing and pubescence with T-shaped non-glandular trichomes on the abaxial surface, the presence of bast fibers above the phloem, and an oval leaf shape in transverse section.

The adaptive significance of T-shaped non-glandular trichomes lies in the formation of a dense, sometimes silvery-tomentose indumentum on the leaves, which contributes to water conservation and reflection of solar radiation. *Artemisia vulgaris* often grows under dry conditions, and the strong thickening of cell walls around the phloem can be regarded as an adaptive trait that prevents collapse of conducting tissues under severe water loss and protects them from mechanical damage.

Conclusion

The present study provides a comprehensive GIS-based ecological assessment of *Artemisia* dracunculus and *A. vulgaris* in Uzbekistan, revealing significant ecogeographical differentiation and niche specialization between these two ethnobotanically important species. Our findings demonstrate that while *A. dracunculus* functions as a eurytopic generalist with an expansive ecological valence – spanning from high-altitude montane zones to the hyper-arid deserts of Ustyurt and Kyzylkum – *A. vulgaris* remains an ecologically specialized taxon, largely confined to mesic, anthropogenically influenced landscapes and synanthropic oases. The identified altitudinal stratification (400–2500 m a.s.l.) and distinct spatial patterns across the floristic districts of Uzbekistan underscore the critical role of orographic and hydroclimatic factors in shaping the contemporary distribution and adaptive strategies of these taxa. Furthermore, the pronounced phenotypic plasticity of *A. dracunculus* suggests a superior resilience to regional aridification, whereas the stenotopic tendencies of *A. vulgaris* indicate a higher vulnerability to environmental shifts, positioning the mountainous provinces of Eastern Uzbekistan as vital ecological refugia for safeguarding their genetic and phytochemical diversity. Ultimately, this research establishes a rigorous biogeographical and ecological foundation for the sustainable harvesting and pharmacological exploitation of these *Artemisia species*, ensuring that their utilization is aligned with their specific environmental requirements and regional conservation needs.

The species of the genus *Artemisia* possess a broad spectrum of therapeutic properties. *Artemisia dracunculus* is used mainly as an anti-inflammatory and local analgesic remedy, particularly for diseases of the oral cavity, rheumatism, and bruises. *Artemisia vulgaris* has a more complex profile of medicinal use, ranging from antiseptic and antipyretic applications in official medicine to the treatment of severe systemic disorders, including tuberculosis, epilepsy, nervous diseases, and gynecological conditions in folk practice.

The introduction of *Artemisia dracunculus* and *A. vulgaris* in the Tashkent Botanical Garden is characterized by successful survival and active vegetative growth. To date, two-year-old plants of *A. dracunculus* remain in the virginal ontogenetic state. Since this species flowers in nature in June, it is highly probable that the introduced plants may enter the generative stage during the summer period. *Artemisia vulgaris*, which has been successfully introduced and maintained in the medicinal plant collection of the Botanical Garden for several decades, reproduces well by seeds and produces annual self-seeding.

The studied *Artemisia* species are characterized by bifacial leaves with dense T-shaped non-glandular trichomes and specialized secretory structures, including secretory ducts producing essential oils. Owing to their valuable medicinal properties, many species of the genus *Artemisia* have been studied from morphological, anatomical, phytochemical, and other perspectives (El-Sahhar et al., 2010; Konowalik, Kreitschitz, 2012; Adekenov et al., 2020; Janaćković et al., 2021). Janaćković *et al.* (2019) conducted a comparative anatomical analysis of the vegetative organs of *Artemisia campestris* L., *A. absinthium* L., *A. arborescens* L., *A. judaica* L., and *A. herba-alba* Asso in order to identify valid taxonomic characters. As a result, the authors revealed qualitative traits that allowed the studied species to be anatomically distinguished from one another. The data presented in the present study may also be used for accurate species identification and make a certain contribution to the anatomical knowledge of the genus *Artemisia*.

Overall, this research establishes a biogeographical, ecological, ethnobotanical, introduction-based, and anatomical foundation for the further study, conservation, and sustainable use of *Artemisia dracunculus* and *A. vulgaris* in Uzbekistan.

Declarations

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Literature cited

Abduraimov OS, Li W, Shomurodov HF, Feng Y. 2023. The Main Medicinal Plants in Arid Regions of Uzbekistan and Their Traditional Use in Folk Medicine. Plants 12:2950:1-15.

Abduraimov OS, Maxmudov AV, Kovalenko I, Allamurotov AL, Mavlanov BJ, Shakhnoza SU, Mamatkasimov OT. 2023. Floristic diversity and economic importance of wild relatives of cultivated plants in Uzbekistan (Central Asia). Biodiversitas 24(3):1668-1675.

Adekenov SM, Shaimerdenova ZR, Ermekkyzy A. 2020. Anatomical study and histochemical analysis of *Artemisia leucodes* Schrenk. Fitoterapia 146(2):104721.

Barykina R.P., Chubatova N.V. 2005. A Comprehensive Practicum in Botany. Ecological Anatomy of Flowering Plants. Moscow: KMK Scientific Press Ltd. 77 p. (in Russian)

Bora KS, Sharma A. 2011. The Genus *Artemisia*: A Comprehensive Review. Pharmaceutical Biology 49(1):101-109.
Carvalho ARJr, Diniz RM, Suarez MAM, Figueiredo CSS, Zagmignan A, Grisotto MAG, Fernandes ES and Silva LCN. 2018. Use of Some Asteraceae Plants for the Treatment of Wounds: From Ethnopharmacological Studies to Scientific Evidences. Frontiers in Pharmacology 9(784):1-11.

Bussmann RW, Paniagua-Zambrana NY, Khutsishvili M, Kikvidze Z, Müller L, Mehdiyeva N, Alizade VM, Mursal N, Salimov R, Batsatsashvili K, Sikharulidze S, Tchelidze D, Maisaia I, Aliev Muradalievich A, Vagabova Askeralievna F, Fayvush G, Aleksanyan A, Khamraeva DT, Khojimatov OK. 2025. *Artemisia absinthium* L., *Artemisia annua* L., *Artemisia campestris* L., *Artemisia chamaemelifolia* Vill., *Artemisia dracunculus* L., *Artemisia fragrans* Willd., *Artemisia leucodes* Schrenk, *Artemisia marschalliana* Spreng., *Artemisia scoparia* Waldst. & Kit., *Artemisia splendens* Willd., *Artemisia szovitsiana* (Besser) Grossh., *Artemisia vulgaris* L., *Eclipta prostrata* (L.) L. - ASTERACEAE in: Bussmann RW, Paniagua-Zambrana NY, Kikvidze,Z. (eds). Ethnobotany of Mountain Regions - Ethnobotany of the Caucasus, doi: 10.1007/978-3-031-91369-3_127, pp. 855-900.

Dadabaeva O. 1996. Wild Medicinal Plants of the Flora of Tajikistan. Khujand. 586 p. (in Russian)

El-Sahhar KF, Nassar Rania M, Farag Hend M. 2010. Morphological and anatomical studies of *Artemisia vulgaris* L. (Asteraceae). Journal of American Science 6(9):806-814.

Flora of Uzbekistan. 1962. The genus Artemisia Bondarenko ON. and Butkov AYa. Publishing House of the Academy of Sciences of the Uzbek SSR:154-188. (in Russian)

Janaćković P, Gavrilović M, Rančić D, Dajić-Stevanović Z, Giweli A, Marin p. 2019. Comparative anatomical investigation of five *Artemisia* L. (Anthemideae, Asteraceae) species in view of taxonomy. Brazilian Journal of Botany 42:135-147

Janaćković P, Gavrilović M, Rančić D, Stešević D, Dajić-Stevanović Z, Marin PD. 2021. Anatomical traits of *Artemisia umbelliformis* subsp. *eriantha* (Asteraceae) alpine glacial relict from Mt. Durmitor (Montenegro). Botanica Serbica 45(1):23-30.

Kapustina LA, Torrell M, Vallès J. 2001. *Artemisia* communities in arid zones of Uzbekistan (Central Asia). USDA Forest Servis Proceedings RMRS-P-21:104-112.

Khamraeva DT, Khojimatov OK, Bussmann RW. 2023. *Artemisia absinthium* L., *Artemisia annua* L., *Artemisia dracunculus* L., *Artemisia frigida* Willd., *Artemisia leucodes* Schrenk, *Artemisia scoparia* Waldst. & Kit., *Artemisia sieversiana* Ehrh. ex Willd., *Artemisia vulgaris* L., *Eclipta prostrata* (L.) L. – *Asteraceae*. in: Khojimatov OK, Gaffrov Y, Bussmann RW. (eds). Ethnobiology of Uzbekistan, Springer Nature Publishing, Cham, pp. 147-171. doi: 10.1007/978-3-031-23031-8_13

Khamraeva DT, Rakhimova NK, Bussmann RW, Khalkuzieva MA. 2026. Biological characteristics of *Megacarpaea gigantea* Regel fruits and their use in traditional medicine of Uzbekistan. Ethnobotany Research and Applications 33(1):1-13. doi: 10.32859/era.33.1.1-13

Khamraeva DT. 2023. New Findings in the Ethnobotany of Uzbekistan. The Eurasia Proceedings of Health, Environment and Life Sciences. 10:55-58.

Khojimatov OK, Khamraeva DT, Khujanov AN, Bussmann RW. 2020. An overview of Ethnomedicinal plants of Uzbekistan. Ethnobotany Research and Applications 20:1-19. doi: 10.32859/era.20.8.1-19

Konowalik K, Kreitschitz A. 2012. Morphological and anatomical characteristics of *Artemisia absinthium* var. *absinthium* and its Polish endemic variety *A. absinthium* var. *calcigena.* Plant Syst Evol. 298:1325-1336.

Kosimov ZZ, Khojimatov OK, Bussmann RW. 2023. Quantitative Ethnobotany of medicinal plants used by the mountain population of the Kitab Region, Uzbekistan. Ethnobotany Research and Applications 26(37):1-13. doi: 10.32859/era.26.37.1-13

Kovaleva NG. 1971. Treatment with Plants. Moscow: Meditsina. 357 p. (in Russian)

Liu B, Bussmann RW, Batsatsashvili K, Kikvidze Z. 2020. *Artemisia absinthium* L., *Artemisia annua* L., *Artemisia dracunculus* L., *Artemisia frigida* Willd., *Artemisia leucodes* Schrenk, *Artemisia scoparia* Waldst. & Kit., *Artemisia sieversiana* Ehrh. ex Willd., *Artemisia vulgaris* L., *Eclipta prostrata* (L.) L. – *Asteraceae*. In: In: Batsatsashvili K, Kikvidze Z, Bussmann RW. (eds) Ethnobotany of Mountain Regions Central Asia and Altai. Springer International Publishing International Publishing. doi: 10.1007/978-3-319-77087-1_23-1

Makhkamov T, Eshonkulov A, Bussmann RW, Khojimatov O, Zafar M, Ahmad M, Ruzmetov U, Ergasheva N, Sattarov A, Polatova A, Karieva G, Asadullina N and Khakimova D. 2024. Ethnobotanical knowledge of medicinal plants from Bukhara Region of Uzbekistan. Ethnobotany Research and Applications 27(26):1-46. doi: 10.32859/era.27.26.1-46

Nurlybekova A, Kudaibergen A, Kazymbetova A, Amangeldi M, Baiseitova A, Ospanov M, Aisa HA, Ye Y, Ibrahim MA and Jenis J. 2022.Traditional Use, Phytochemical Profiles and Pharmacological Properties of *Artemisia* Genus from Central Asia. Molecules 27(5128):1-38.

Rakhimova NK, Rakhimova T, Shomurodov KhF and Sharipova VK. 2023. The status of coenopopulations of *Xylosalsola chiwensis* (Popov) Akhani & Roalson and *Scorzonera bungei* Krasch. & Lipsch. on the Ustyurt plateau (Uzbekistan). Arid Ecosystems 13(2):189-195.

Rakhimova T, Rakhimova N, Sharipova V, Beshko N, Hayitov R. 2021. Current state of coenopopulations of some rare endemic species in Navoi region, Uzbekistan. Ekológia (Bratislava) 40(4):357-363.

Rakhimova T, Rakhimova NK, Sharipova VK, Rakhimova NK, Temirov EE. 2024. Phytocoenotic Distribution of *Hulthemia persica* (Michx. ex Juss.) Bornm. (Rosaceae) under Different Ecological Conditions in Uzbekistan. Plant Sciences Today 11(1):626-633.

Rakhimova T, Rakhimova NK, Shomurodov KhF, Abduraimov OS. 2020. Ontogenetic structure of rare plant species on the Usturt Plateau in Uzbekistan. Arid Ecosystems 10(3):238-243.

Rolnik A, Olas B. 2021. The Plants of the Asteraceae Family as Agents in the Protection of Human Health. International Journal of Molecular Sciences 22(6):3009.

Saeidnia S, Gohari AR, Mokhber-Dezfuli N, Kiuchi F. 2011. A review on phytochemistry and medicinal properties of the genus *Achillea*. DARU Journal of Pharmaceutical Sciences 19(3):173-186.

Sakhobiddinov S.S. 1948. Wild Medicinal Plants of Central Asia. Tashkent: Gosizdat. 216 p. (in Russian)

Sapkota B, Kunwar P. 2024. A Review on Traditional Uses, Phytochemistry and Pharmacology of *Calendula officinalis* Linn. Natural Product Communications 19(6):1-22.

Saribaeva ShU, Allamuratov A, Mavlanov B. & Mamatkosimov O. 2023. Assessment of the State of the *Allium praemixtum* Vved. Cenopopulation (*Amaryllidaceae*) on the Ridges of Uzbekistan. Arid Ecosystems 13(4):419-424.

Sharopov FS, Gulmurodov IS, Bakri M, Numonov SR, Aisa HA. 2024. N-Containing Constituents of Essential Oil from *Megacarpaea gigantea* and its Antimicrobial Activity. Chemistry of Natural Compounds. 60(2):365-366.

The methodology of phenological observatons in the botanical gardens of the USSR. 1975. Moscow. 27 p. (in Russian)

Ulchenko NT, Bekker NP, Glushenkova AI, Akhmedzhanov IG. 2001. Lipids of *Crambe kotschyana* and *Megacarpaea gigantea* Seeds. Chemistry of Natural Compounds. 37(3):285-286.

Volis S, Belolipov IV, Asatulloev T, Turgunov M. 2023. Role of Endemism and Other Factors in Determining the Introduction Success of Rare and Threatened Species in Tashkent Botanical Garden. Journal of Zoological and Botanical Gardens 4(2): 325-334.

Yusupova DM. 2018. Comparative Anatomical Structure of the Leaf of *Allium suworowii* Regel (Amaryllidaceae) in Different Ecological Conditions. American Journal of Plant Sciences 9:2676-2683.

Zaitsev GN. 1990. Mathematics in experimental botany. Moscow: Nauka. 120 c. (in Russian)