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UTILIZATION AND REPRODUCTIVE BIOLOGY OF SILENE VULGARIS IN THE NURATA AND KOHISTAN BOTANICAL–GEOGRAPHICAL DISTRICTS OF UZBEKISTAN

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ABOUT ARTICLE

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Abstract: Medicinal plants represent an essential component of natural ecosystems and play a crucial role in traditional medicine and biodiversity conservation. However, increasing anthropogenic pressure and habitat degradation threaten many wild medicinal species in arid and semi-arid ecosystems of Central Asia. One such species is Silene vulgaris (Moench) Garcke (Caryophyllaceae), a perennial herb widely distributed in Eurasia and known for its medicinal and pharmacological properties. The present study investigates the ecological distribution, reproductive biology, and traditional uses of Silene vulgaris populations occurring in the Nurata and Kohistan botanical–geographical districts of Uzbekistan. Field surveys, morphological analysis, and literature review were employed to evaluate the population status and reproductive strategies of the species. The results indicate that S. vulgaris occurs mainly in open habitats such as foothill pastures, roadside communities, and rocky or sandy substrates under moderately continental climatic conditions. The species demonstrates both generative and vegetative reproduction, with seed production playing a key role in

maintaining population stability. Phytochemical analyses reported in previous studies reveal the presence of biologically active compounds including flavonoids, saponins, and phenolic substances, which contribute to its medicinal value. Traditional medicine utilizes different plant parts for treating gastrointestinal disorders, rheumatism, helminth infections, and dermatological conditions. Despite its ecological adaptability, increasing grazing pressure, land transformation, and uncontrolled harvesting may negatively affect the natural populations of the species. Therefore, monitoring population dynamics and developing sustainable harvesting strategies are essential for long-term conservation of this medicinal plant.

Introduction. Medicinal plants constitute an important natural resource for both traditional and modern pharmacology. Globally, approximately 50–60% of pharmaceutical compounds originate from natural products, including plant-derived secondary metabolites (Newman & Cragg, 2020). In arid and semi-arid ecosystems of Central Asia, wild medicinal plants play a particularly important role in local healthcare systems and traditional ethnobotanical practices (Tojibaev et al., 2017).

The genus Silene L. (Caryophyllaceae) includes more than 700 species distributed mainly across temperate regions of the Northern Hemisphere (Jafari et al., 2020). Several species of this genus possess medicinal properties due to the presence of flavonoids, saponins, phenolic compounds, and other biologically active metabolites (Mamadalieva et al., 2014). Among them, Silene vulgaris (Moench) Garcke is one of the most widespread species and is traditionally used in various herbal medicines.

In Central Asian traditional medicine, S. vulgaris has been used for the treatment of gastrointestinal disorders, rheumatism, helminth infections, and dermatological diseases (Sultanova et al., 2018). Pharmacological studies have demonstrated antimicrobial, antioxidant, and anti-inflammatory properties of its extracts (Mamadalieva et al., 2014). Recent phytochemical analyses have identified more than 30 compounds in leaf extracts, including several flavonoids such as hyperoside, isoquercitrin, avicularin, and rutin.

Despite its medicinal significance, ecological information on the population structure and reproductive biology of S. vulgaris in the mountainous regions of Uzbekistan remains limited. The Nurata and Kohistan botanical–geographical districts represent important biodiversity hotspots where numerous endemic and medicinal plant species occur (Kamelin,

2015). Understanding the ecological characteristics and regeneration strategies of S. vulgaris populations in these regions is therefore essential for sustainable resource management and conservation planning.

The aim of this study was to investigate the ecological distribution, reproductive strategies, and traditional uses of Silene vulgaris populations occurring in the Nurata and Kohistan botanical–geographical districts of Uzbekistan.

Study Area

The study was conducted in the Nurata and Kohistan botanical–geographical districts located in the central and northeastern parts of Uzbekistan. These regions belong to the mountainous and foothill zones of the Nuratau and Turkestan mountain systems and represent important biodiversity centers of the Irano–Turanian floristic region (Kamelin, 2015). The territory is characterized by complex geomorphological conditions, including rocky slopes, foothill plains, and fragmented mountain valleys.

The climate of the study area is strongly continental, with hot summers and relatively cold winters. The average annual precipitation ranges from approximately 400 to 500 mm, most of which falls during spring and early summer (Sultanova et al., 2018). The mean annual temperature varies between 8–12 °C depending on altitude and local relief conditions. Such climatic features create favorable conditions for the development of xerophytic and mesoxerophytic vegetation typical of Central Asian mountain ecosystems.

Soils in the region are predominantly calcareous and sandy–loamy, often derived from limestone and marl parent materials. These soils are generally well-drained and moderately fertile, supporting diverse herbaceous communities and shrub vegetation. The vegetation cover consists mainly of steppe-like plant communities, foothill pastures, and open rocky habitats. These ecological conditions provide suitable environments for various medicinal and wild plant species including Silene vulgaris.

Silene vulgaris populations in the study area are typically found in open habitats such as foothill slopes, roadside vegetation, pastures, and disturbed areas. The species demonstrates a relatively broad ecological amplitude, tolerating dry and nutrient-poor soils while maintaining stable populations in moderately disturbed environments. However, increasing grazing pressure and land-use changes in some parts of the region may influence the long-term sustainability of these populations.

Materials and methods. Field Survey and Data Collection**,** Field investigations were carried out during the vegetation seasons of 2023–2024 in selected localities within the Nurata and Kohistan botanical–geographical districts. Several natural populations of Silene vulgaris

were identified through field observations and herbarium records. Sampling sites were selected to represent different ecological conditions including foothill pastures, rocky slopes, and roadside habitats.

At each site, detailed observations were conducted to document the morphological characteristics, population structure, and habitat conditions of the species. Plant specimens were collected following standard botanical procedures and later verified using regional floristic manuals and herbarium materials. Taxonomic identification was performed according to the classification systems provided in the floristic works of Central Asia and Uzbekistan (Kamelin, 2015; Tojibaev et al., 2017).

The results indicate that S. vulgaris occurs mainly in open habitats such as foothill pastures, roadside communities, and rocky or sandy substrates under moderately continental climatic conditions. The species demonstrates both generative and vegetative reproduction, with seed production playing a key role in maintaining population stability. Phytochemical analyses reported in previous studies reveal the presence of biologically active compounds including flavonoids, saponins, and phenolic substances, which contribute to its medicinal value. Traditional medicine utilizes different plant parts for treating gastrointestinal disorders, rheumatism, helminth infections, and dermatological conditions. Despite its ecological adaptability, increasing grazing pressure, land transformation, and uncontrolled harvesting may negatively affect the natural populations of the species. Therefore, monitoring population dynamics and developing sustainable harvesting strategies are essential for long-term conservation of this medicinal plant.

Morphological Analysis

Morphological features of Silene vulgaris individuals were studied in order to describe the diagnostic characteristics of the species in the investigated region. Measurements included plant height, leaf size and shape, flower morphology, and fruit structure. Morphological parameters were recorded using standard botanical measurement techniques.

The species is characterized as a perennial herb reaching 30–60 cm in height with erect stems that may be smooth or slightly pubescent. Leaves are opposite, simple, and usually elliptic to lanceolate in shape. Flowers are bisexual and typically white or pale pink, arranged either singly or in loose inflorescences. The calyx is inflated and tubular, consisting of five fused sepals. The androecium contains ten stamens, while the gynoecium is composed of a superior ovary with three styles. The fruit is a capsule that opens by apical teeth releasing numerous small kidney-shaped seeds.

Plants are short-lived perennials, smooth, sparsely pubescent, glaucous; taproot thick; caudex woody. Stems several to many, erect, branched and decumbent at the base, rarely simple, 20–80 cm. Leaves predominantly cauline, 2 per node, sessile, subclasping, reduced proximal to the inflorescence, leaf blade broadly oblong to oblanceolate or lanceolate, rarely ± linear, 2–8 cm × 5–30 mm, base rounded, apex acute to acuminate. Inflorescences open dichasial cymes, 5–40-flowered, with bracts; bracts strongly reduced, lanceolate. Pedicels 0.5–3 cm. Flowers bisexual and unisexual, some plants have bisexual flowers, others have pistillate unisexual flowers, 15–20 mm in diameter; Calyx pale green, rarely purple, bell-shaped, not tapering at the base, inflated, 9–12 mm in flower, 12–18 × 7–11 mm in fruit, herbaceous, papery, venation indistinct, reticulate, without noticeable light commissures, margins serrated, lobes broadly triangular, 2–3 mm, smooth; petals white, about 2 times as long as calyx; margin obovate, notched to 2-lobed; stamens protruding 2–4 mm; Styles 3, cream to greenish, at most slightly pinkish, twice as long as the calyx. Capsules ovoid to spherical, equal in size to the calyx, dehiscing with 6 teeth; rudiment 2–3 mm. Seeds black or nearly black, spherical-reniform, 1–1.5 mm, finely tuberculate. 2n = 24.

Phenology

June–August (summer), September–November (fall)

Altitude range

0–2000 m;

Results. Population structure and density were evaluated using standard geobotanical survey methods. Quadrat sampling was applied to estimate population density and the distribution of individuals within each community. The number of individuals per unit area was recorded, and the proportion of flowering plants was determined.

In addition, ontogenetic stages of the individuals were assessed to determine the population age structure. Individuals were categorized into juvenile, immature, vegetative, and generative stages following commonly accepted ontogenetic classification methods used in plant population ecology.

Literature Analysis. In addition to field observations, a comprehensive literature review was conducted to evaluate the medicinal properties and traditional uses of Silene vulgaris. Previous phytochemical and pharmacological studies were analyzed in order to identify the biologically active compounds present in the species. Particular attention was given to flavonoids, saponins, and phenolic compounds reported in earlier studies (Mamadalieva et al., 2014; Newman & Cragg, 2020).

Reproductive Strategies

The reproductive biology of Silene vulgaris includes both generative (seed-based) and vegetative reproduction. Field observations indicated that seed reproduction plays the primary role in maintaining population persistence.

The species produces numerous seeds within each capsule, which facilitates effective dispersal and colonization of disturbed habitats. Seed germination occurs mainly during spring when soil moisture levels are relatively high.

Vegetative regeneration was occasionally observed in mature individuals through the formation of additional shoots from the root system. However, this mechanism appears to be less significant compared with generative reproduction.

The presence of multiple reproductive strategies increases the ecological adaptability of the species and allows it to persist in fluctuating environmental conditions.

Medicinal and Ethnobotanical Uses

Traditional medicinal knowledge in Central Asia recognizes Silene vulgaris as a valuable medicinal plant. Various plant parts including leaves, roots, and stems are used in traditional herbal remedies.

Ethnobotanical records indicate that the plant has been used to treat gastrointestinal disorders, rheumatism, helminth infections, and skin diseases. Extracts of the plant have demonstrated antimicrobial and antioxidant activities in several pharmacological studies (Mamadalieva et al., 2014).

Phytochemical analyses revealed the presence of several biologically active compounds, particularly flavonoids and saponins. Among the identified flavonoids are hyperoside, isoquercitrin, avicularin, and rutin, which are known for their antioxidant and anti-inflammatory properties.

These pharmacological characteristics contribute to the medicinal significance of the species and highlight its potential value for future phytochemical and pharmaceutical research.

Discussion. The present study provides new ecological and biological insights into Silene vulgaris populations occurring in the Nurata and Kohistan botanical–geographical districts of Uzbekistan. The observed morphological characteristics correspond well with previous taxonomic descriptions reported in regional floristic studies (Kamelin, 2015).

The ecological distribution of the species indicates a preference for open and moderately disturbed habitats. Similar ecological patterns have been documented in other Eurasian regions where S. vulgaris commonly occurs in grasslands, roadside vegetation, and agricultural margins (Jafari et al., 2020).

The ability of S. vulgaris to thrive in disturbed environments may be related to its effective seed production and high reproductive capacity. Seed-based reproduction allows the species to rapidly colonize newly available habitats and maintain stable populations under fluctuating environmental conditions.

However, increasing anthropogenic pressure such as overgrazing, habitat fragmentation, and uncontrolled harvesting of medicinal plants may negatively affect natural populations in the long term. In arid mountain ecosystems, these disturbances can significantly alter plant community structure and reduce species diversity (Tojibaev et al., 2017).

The ethnobotanical significance of S. vulgaris further emphasizes the need for sustainable management strategies. The presence of biologically active compounds such as flavonoids and saponins supports its medicinal use and pharmacological potential (Mamadalieva et al., 2014).

Given the ecological adaptability and medicinal importance of the species, conservation measures should focus on monitoring population dynamics and regulating the harvesting of plant material from wild populations. Establishing cultivation practices for medicinal plant species may also help reduce pressure on natural populations.

Conclusion. The present study investigated the ecological characteristics, reproductive biology, and ethnobotanical significance of Silene vulgaris populations in the Nurata and Kohistan botanical–geographical districts of Uzbekistan. The results demonstrate that S. vulgaris is a perennial herbaceous species well adapted to open and moderately disturbed habitats such as foothill slopes, pastures, and roadside vegetation. The species shows a relatively broad ecological amplitude and can grow on sandy or calcareous soils under the strongly continental climatic conditions typical of Central Asian mountain regions.

Morphological analysis confirmed that the species possesses typical diagnostic characteristics of the genus Silene, including opposite leaves, inflated tubular calyx, and capsule fruits containing numerous small seeds. The reproductive strategy of S. vulgaris is primarily based on generative reproduction through seed production, although limited vegetative regeneration may also occur in mature individuals. The production of a large number of seeds enhances the dispersal capacity of the species and contributes to its ability to colonize disturbed habitats.

Ethnobotanical information indicates that S. vulgaris is an important medicinal plant used in traditional medicine for the treatment of gastrointestinal disorders, rheumatism, helminth infections, and dermatological diseases. Previous phytochemical studies have

revealed the presence of various biologically active compounds, particularly flavonoids and saponins, which contribute to its pharmacological properties.

Despite its ecological adaptability, natural populations of S. vulgaris may be vulnerable to increasing anthropogenic pressures such as overgrazing, land-use change, and uncontrolled harvesting of medicinal plant material. Therefore, continuous monitoring of population dynamics and the development of sustainable resource management strategies are necessary to ensure the long-term conservation of this species in the mountainous ecosystems of Uzbekistan.

The findings of this study have several important practical implications for biodiversity conservation and sustainable use of medicinal plant resources in Central Asia.

First, ecological information about the distribution and population structure of Silene vulgaris contributes to a better understanding of the dynamics of medicinal plant populations in mountain ecosystems. Such knowledge is essential for developing effective conservation and management strategies.

Second, the documented medicinal properties and phytochemical composition of the species highlight its potential importance for pharmacological research and the development of plant-based medicinal products. Future studies may focus on detailed phytochemical screening and evaluation of pharmacological activity.

Third, sustainable harvesting practices should be introduced in order to prevent excessive collection of wild plant material. Cultivation of medicinal plant species, including S. vulgaris, may represent an effective strategy for reducing pressure on natural populations while maintaining the availability of plant resources for traditional medicine.

Finally, long-term ecological monitoring of plant populations in the Nurata and Kohistan regions is recommended to evaluate the impact of environmental changes and anthropogenic disturbances on plant biodiversity.

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