THE ROLE OF SHRUB AND SUBSHRUB SPECIES DISTRIBUTED IN THE SHUSHA REGION IN BIODIVERSITY AND THEIR PROSPECTS FOR UTILIZATION

Sardarova A.
PhD in Biology
Quliyeva L.
Azerbaijan State Agricultural University

Abstract

Shusha and its surrounding areas, located in the Lesser Caucasus, represent a unique montane-forest ecosystem characterized by a high diversity of shrub and subshrub life forms. These plants not only form structural components of the landscape but also perform essential ecological functions, including soil erosion prevention, slope stabilization, formation of phytocoenoses, and provision of food and shelter for local fauna. Through geobotanical route surveys conducted in the Shusha region, the distribution and biomorphological traits of shrub and subshrub species such as *Juniperus foetidissima*, *Corylus avellana*, *Rhamnus pallasii*, *Rubus subg. rubus*, *Prunus cerasifera*, *Prunus spinosa*, *Berberis vulgaris*, *Mespilus germanica*, *Rosa canina*, *Crataegus pentagyna*, *Ribes nigrum*, *Ribes uva-crispa*, *Euonymus velutinus*, and *Cornus mas* were documented. Many of these species are endemic, relict, and genetically valuable for the region, and their richness in bioactive compounds highlights their pharmacological and ethnobotanical importance. The results indicate that shrubs and subshrubs play a key role in ecosystem services, particularly in vegetation restoration and successional processes. This study provides a comprehensive assessment of the ecological, economic, and pharmacological significance of shrubs and subshrubs in the Shusha region, offering a scientific basis for their conservation and sustainable management.

Keywords: Shusha region, shrub and subshrub biodiversity, montane-forest ecosystems, phytocoenotic structure, bioactive compounds.

Introduction

The city of Shusha and its surrounding areas constitute one of the mountain-forest zones of the Lesser Caucasus with the highest levels of biodiversity. The region's rugged topography, diverse microclimatic conditions, mosaic soil cover, and intensity of anthropogenic disturbances have created favorable conditions for a rich variety of plant life forms (Table 1). Among this floristic diversity, shrubs and subshrubs occupy a particularly important place. They are not only structural components shaping the appearance of the landscape but also key functional groups that ensure ecosystem stability.

The ecological role of shrub and subshrub species includes regulating soil-carbon balance, reducing erosion, structuring phytocoenoses, and providing food and shelter for fauna. Many of the life forms distributed in the Shusha territory are endemic, relict, or rare species, which increases their genetic and taxonomic value.

Table 1.

Key Climatic and Topographic Indicators of the Shusha Region

Altitude above sea level	1,300-1,800 m
Annual temperature variations	min: -4 °C, max: +19 °C
Annual precipitation amount	700-800 mm

In recent years, in the context of restoration and reclamation activities carried out in Shusha, the ecosystem services provided by shrubs and subshrubs have become even more relevant. They play a leading role in soil regeneration and the recovery of vegetation cover during the initial stages of succession, thus contributing significantly to biodiversity conservation. Therefore, studying the ecological, biogeographical, and functional importance of Shusha's shrub and subshrub flora provides a scientific basis for the sound management of the region's natural resources and the development of sustainable restoration strategies (Botanika İnstitutu, 2025).

The city of Shusha and its surrounding territories, as part of the unique mountain-forest ecosystem of the Lesser Caucasus, are characterized by a rich shrub and subshrub flora (Qurbanov, 2024). These life forms play an essential role in preserving the region's biodiversity, ensuring ecological stability, and maintaining the resilience of phytocoenoses.

The role of shrubs and subshrubs distributed in the Shusha region in biodiversity and their utilization prospects can be summarized as follows:

1. Maintaining ecosystem stability

Shrubs and subshrubs possess strong root systems that prevent soil erosion and stabilize slopes. Representatives of the genera *Juniperus*, *Rosa*, *Berberis*, *Paliurus*, *Cotoneaster*, and *Spiraea* perform important ecological functions in reducing landslides on Shusha's steep terrain.

2. Key elements in the structure of phytocoenoses

These plants shape the mosaic structure of mountain-meadow and forest-edge phytocoenoses, ensuring both vertical and horizontal stratification of vegetation. Through their xenomorphic and psychromorphic adaptations, shrubs and subshrubs are capable of withstanding harsh mountain climates, thereby increasing the resilience of plant communities.

3. Carriers of genetic and taxonomic diversity

Numerous endemic and relict species occur

among the shrubs and subshrubs distributed in Shusha (e.g., *Juniperus foetidissima*, *Berberis vulgaris*, *Rhamnus pallasii*). These species provide insights into the region's paleobotanical past and are of special importance for the preservation of the gene pool.

4. Sources of habitat and food for fauna

Shrubs and subshrubs create favorable microhabitats for birds, small mammals, and insects. Species such as *Rosa canina*, *Berberis vulgaris*, and *Crataegus pentagyna* provide fruit that serves as food for birds and play an important role in seed dispersal (Əsgərov, 2016).

5. Ecological resilience to anthropogenic impacts

In the restored areas of Shusha, shrubs and subshrubs play a leading role during the initial stages of succession. They improve soil structure, accelerate humus accumulation, and facilitate the recovery of forest cover.

6. Potential for biocontamination resistance and climate-change adaptation

These life forms exhibit resilience to high-stress factors (drought, temperature fluctuations, soil salinity, and anthropogenic pollution). Such characteristics allow their use as bioindicators for ecological monitoring.

7. Significance for pharmacology and ethnobotany

Shrub and subshrub species widely distributed in Shusha - such as *Berberis*, *Rosa*, *Rubus*, *Crataegus*, *Corylus*, *Rhamnus*, *Prunus*, *Juniperus*, *Mespilus*, and *Ribes* - are rich in biologically active substances and have been traditionally used as medicinal plants. Their therapeutic properties enhance the region's phytotherapeutic potential (Sərdarova, 2022; Ibadullayeva, 2024).

Materials and Methods

The research was conducted in 2025 within the mountain-forest and subalpine landscapes of the city of Shusha and its surrounding territories (Figure 1). To study the vegetation cover, the geobotanical route method was applied (Shetekauri & Kikvidze, 2018; Müllerová et al., 2020).

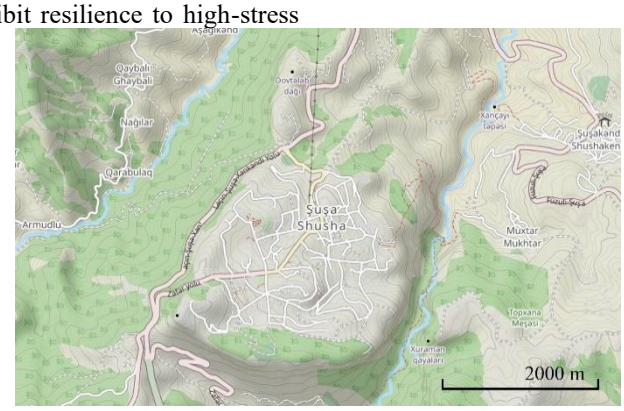

Figure 1. General Morphological Structure of Corylus avellana

1. Route organization.

Research sites were selected with consideration of the region's mosaic relief. The route was planned in the following sequence:

Shusha city - Dashalti gorge - Topkhana forest massif - Zarisli direction.

An elevation range of 1450-1750 m was covered along the route. Every 200-300 meters, the composition of the vegetation was visually assessed, and dominant and associated shrub and subshrub species were recorded.

2. Geobotanical observations.

At each observation point, the following parameters were documented:

- Dominant and subdominant shrub and subshrub species
- Biomorphological characteristics of plants (height, branching type, green biomass, condition of generative and vegetative organs)
- Phytocoenotic state and the structure of plant groupings

The geobotanical approach described by Shetekauri & Kikvidze (2018) served as the methodological basis for the observations.

3. Sample collection.

For optimal morpho-anatomical analysis, 3-5 individuals of each shrub or subshrub species encountered along the route were sampled. For each specimen, the following information was recorded:

- Geographic coordinates of the collection site
- Elevation
- Plant species and a brief morphological description

The collection process was carried out in accordance with field flora study principles described by Müllerová et al. (2020).

4. Preparation of herbarium specimens.

The collected materials were processed following classical herbarium methods (Bridson & Forman, 2019; Shipunov, 2019):

- Specimens were placed in field presses between sheets of paper.
- In the laboratory, they were dried completely in a ventilated dryer at 45-50 °C.
- A label was prepared for each specimen (species name, locality, date, collector).
- Completed herbarium specimens were coded and incorporated into the Herbarium Fund of the Department of Biology named after Valida Tutayuk at the Azerbaijan State Agricultural University.

***Corylus avellana* L.**

Figure 2. General Morphological Structure of Corylus avellana

Corylus avellana is a perennial shrub or small tree belonging to the family Betulaceae. Its natural distribution includes Europe, the Americas, and Asia Minor. This species grows at altitudes ranging from 10 to 1700 meters above sea level and is primarily shade-tolerant, preferring temperate and humid conditions. *C. avellana* can live for 80-100 years and reach a height of 3-9 meters. The canopy is dense and highly branched (Figure 2). The stem diameter ranges from 15 to 18 cm, while the leaves measure 5-9 cm in width and 6-12 cm in length. Leaves are rounded, ovate-rounded, or oval with serrated margins. The plant undergoes autumnal leaf shedding. Young shoots are light brown, and the bark of mature stems turns light gray.

Flowering occurs from February to March, producing monoecious flowers of various types. Fruit ripening takes place in August-September. While the plant naturally propagates through seeds, vegetative propagation is also possible.

The biochemical composition of *C. avellana* fruits includes fatty acids such as oleic, linoleic, palmitic, stearic, palmitoleic, and linolenic acids. Protein content ranges from 12.61% to 18.69%, with amino acids including glutamic acid, aspartic acid, alanine, serine, glycine, proline, tyrosine, arginine, leucine, valine, phenylalanine, isoleucine, threonine, lysine, histidine, and methionine. Vitamins present include fat-soluble vitamins such as retinol (vitamin A), α-tocopherol (vitamin E), γ-tocopherol, δ-tocopherol, and water-soluble vitamins such as vitamin C, niacin, B6 (pyridoxine), B1 (thiamine), B2 (riboflavin), folic acid, and biotin (Gunes et al., 2010; Shataer et al., 2021).

The fruits of *C. avellana* are of significant nutritional value and are widely used in confectionery production. Due to the durability of its wood, the species is also used as raw material for furniture, baskets, and other products.

***Rhamnus pallasii* Fisch. & C.A.Mey.**

Figure 3. General Morphological Structure of Rhamnus pallasii

Rhamnus pallasii is a low-growing shrub belonging to the family Rhamnaceae (Figure 3). The plant can reach up to 3 meters in height. Its branches are arranged alternately and bear thorns. Leaves are narrow and lanceolate, measuring 20-30 mm in length and 4-6 mm in width.

Flowering occurs in June, with clusters of 10-12

flowers emerging from the axils of the leaves. Flowers are small, grayish, and may be either petalled or apetalous. Fruits ripen in October, producing black berries with a diameter of 4-5 mm.

R. pallasii possesses a rich biochemical composition. The main classes of bioactive compounds identified in the plant include anthraquinones, flavonoids, naphthalene terpenoids, alkaloids, steroids, organic acids, and essential oils. From a pharmacological perspective, the plant exhibits anti-inflammatory, antibacterial, antifungal, antimalarial, antioxidant, antiproliferative, and cytotoxic properties. It is also used for wound healing, blood purification, improvement of circulation, treatment of sexually transmitted infections, digestive and liver disorders, and support of the endocrine and nervous systems (Nigussie et al., 2021).

Rubus subg. rubus

Figure 4. General Morphological Structure of Rubus subg. rubus

Rubus subg. *rubus*, belonging to the family Rosaceae, is a shrub species with a perennial root system. Under natural conditions, its stems grow densely and intertwined. Each stem is biennial: in the first year, it emerges and grows intensively, reaching a length of 3-9 meters and bending to creep along the ground. In the second year, the stem ceases elongation, and its buds develop into inflorescences. Flowering occurs in late spring and early summer. Flowers have five white or pale pink petals, with a total diameter of approximately 2 cm.

The leaves are compound in structure, typically consisting of 5-7 leaflets attached to the petiole by short stalklets (Figure 4). The plant possesses short, curved, very sharp thorns, located both on the stems and along the central vein on the lower surface of the leaflets. *Rubus* subg. *rubus* is a hardy plant capable of developing even in nutrient-poor soils.

A wide range of bioactive compounds has been identified in the plant, including alkaloids, flavonoids, tannins, saponins, glycosides, terpenoids, sterols, carbohydrates, polyphenols, anthocyanins, ellagic acid, salicylic acid, triterpenic acids, rubitic acid, and ascorbic acid (vitamin C). The roots are particularly rich in saponins and tannins, the leaves in flavonoids and tannins, and the fruits in polyphenols, anthocyanins, ellagic acid, salicylic acid, fiber, and other compounds (Verma et al., 2014).

From a pharmacological standpoint, the plant has antimicrobial properties and is used against infections. It exhibits anti-inflammatory effects, protects mucous membranes, and has a positive impact on the digestive system. The fruits are a strong source of antioxidants. The species contributes to the regulation of the blood and endocrine systems, the respiratory system, and demonstrates anticancer activity.

***Prunus cerasifera* Ahh.**

Figure 5. General Structure and Fruit Morphology of Prunus cerasifera

Prunus cerasifera is a shrub or small tree belonging to the family Rosaceae and can grow to a height of 8-12 meters. The leaves are ovate and measure 3-7 cm in length (Figure 5). The plant flowers in early spring,

before leaf formation. The flowers are white, composed of five petals, and measure 2-3 cm in diameter. Fruit ripening occurs from July to September. *P. cerasifera* has a wide natural distribution across various regions of Azerbaijan, including forested areas.

The biochemical components identified in *P. cerasifera* include protocatechuic acid, vanillic acid, rutin, gallic acid, catechin, chlorogenic acid, caffeic acid, syringic acid, p-coumaric acid, ferulic acid, o-coumaric acid, phloridzin, citric acid, malic acid, succinic acid, fumaric acid, vitamin C (ascorbic acid), and other compounds (Celik et al., 2017).

Due to its high content of phenolic compounds and other bioactive substances, the plant exhibits strong antioxidant properties. It is also a source of mineral elements such as potassium, copper, magnesium, iron, and zinc, which contribute to the regulation of metabolic processes. The fruits are rich in pectin components, which have positive effects on the digestive system and help reduce cholesterol levels (Dunaevskaya et al., 2021). The fruits of *P. cerasifera* are consumed fresh and are also used in the preparation of pastila and various jams.

***Prunus spinosa* L.**

Figure 6. General Structure and Fruit Morphology of Prunus spinosa

Prunus spinosa, a shrub or subshrub of the family Rosaceae, can grow up to 5 meters in height. Its branches are densely arranged and covered with stiff thorns. Leaves are oval, measuring 2-4.5 cm in length and 1.2-2 cm in width, with serrated margins. The plant flowers before leaf emergence, producing flowers approximately 1.5 cm in diameter, each with five cream-white petals. Fruits develop in autumn, reaching 10-12 mm in diameter and exhibiting a violet-blue coloration (Figure 6).

The species is native to Europe, Western Asia, and northwestern Africa and naturally occurs in various regions of Azerbaijan, particularly in forests and shrublands.

P. spinosa is rich in phenolic compounds, including chlorogenic acid, caffeic acid, rutin, gallic acid, catechin, protocatechuic acid, syringic acid, p-coumaric acid, ferulic acid, phloridzin, malic acid, citric acid, succinic acid, fumaric acid, and vitamin C (Celik et al., 2017). The high content of polyphenols and anthocyanins confers strong antioxidant and anti-inflammatory properties, aiding in the neutralization of free radicals and protection against oxidative stress. Its pharmacological activities include improvement of endothelial function, regulation of insulin sensitivity, reduction of diabetes risk, antidiarrheal, astringent, antidyenteric, antimicrobial, antiviral, anti-atherosclerotic, antithrombotic, and anticancer effects.

Fruits of *P. spinosa* are utilized in the food industry in both dried and fresh forms and can serve as natural colorants. Additionally, the species has been identified as suitable for soil restoration purposes (Bei et al., 2024).

***Juniperus foetidissima* Willd.**

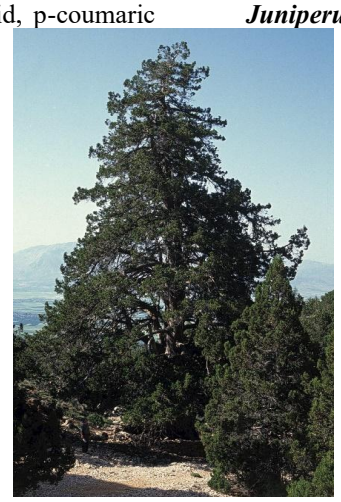

Figure 7. General Morphological Structure of Juniperus foetidissima

Juniperus foetidissima, a tree or shrub of the family Cupressaceae, can grow up to 5-6 meters in height (Figure 7). The species exhibits two types of leaves: on young, dark green shoots, the leaves are needle-like and 8-10 mm long, whereas on older stems, they are scale-like, rhombic in shape, and 2-3 mm in length. The cones of *J. foetidissima* begin to form from late April to early June, with maturation taking nearly two years. Mature cones are blue-black, 7-13 mm in diameter, and resemble berries in appearance. The species is naturally distributed in the eastern Greater Caucasus, the northern and southern parts of the Lesser Caucasus, and the mountainous regions of Nakhchivan in Azerbaijan.

J. foetidissima is rich in phenolic compounds, including catechin, epicatechin, quercitrin, rutin, and quercetin-3-O-glucoside. It also contains monoterpenes such as sabinene. Extracts of the plant exhibit antioxidant activity, neutralizing reactive oxygen and nitrogen species and inhibiting lipid peroxidation. Its anti-inflammatory properties make it useful in treating inflammatory conditions. Traditionally, the species has been used for the common cold, urinary tract and kidney infections, bronchitis and pneumonia, dysentery, stomach pain and diarrhea, as well as to regulate menstruation and relieve pain. Additionally, *J. foetidissima* is employed as an aromatic spice, in the production of alcoholic beverages, aromatherapy, perfumery, and other applications (Lesjak et al., 2013).

***Berberis vulgaris* L.**

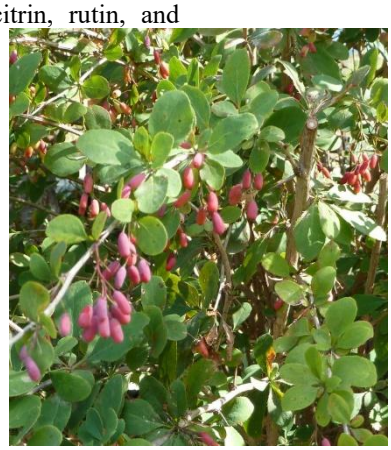

Figure 8. General Morphological Structure of Berberis vulgaris

Berberis vulgaris, a shrub belonging to the family Berberidaceae, can grow up to 1.5-2.5 meters in height. Young shoots are yellow-brown, while older stems are gray. Thorns on the stem can reach up to 2 cm in length. Leaves are delicate, elliptic or obovate, light green in color, with ciliate-serrated margins.

Flowering occurs from May to June. Flowers are pale yellow and form racemose clusters up to 6 cm in length. Fruits mature in August-September, producing berries that are bright red or sometimes yellowish-red, approximately 12 mm long (Figure 8).

B. vulgaris is a mesoxerophytic plant growing at altitudes up to 1800 meters, commonly found in forests, forest edges, and shrublands. Its natural distribution spans Europe and Asia Minor, and within Azerbaijan, it occurs from lowlands to the middle mountain zone.

The plant contains a variety of bioactive compounds in different organs, including phenolics, flavonoids, tannins, glycosides, saponins, steroids, terpenoids, vitamins C, K, and A, and major alkaloids such as chlorogenic acid, berberine, oxyaconthine, berbamine, berberubine, columbamine, catechin, caffeic acid, gallic acid, and anthocyanins. Berberine is the principal alkaloid, exhibiting antioxidant, anti-inflammatory, hypoglycemic, and hypolipidemic activities.

Traditionally, *B. vulgaris* has been used to treat fever, cough, liver diseases, depression, hyperlipidemia, and hyperglycemia. Pharmacologically, it possesses anticancer, anti-inflammatory, antidiabetic, antioxidant, antibacterial, analgesic, antinociceptive, and hepatoprotective properties. The fruits are also utilized in the food industry for producing juices, jams, and marmalades (Rahimi-Madiseh et al., 2017; El-Zahar et al., 2022).

***Mespilus germanica* L.**

Figure 9. General Structure and Fruit Morphology of Mespilus germanica

Mespilus germanica, a large shrub or small tree of the family Rosaceae, ranges from 1.5 to 4 meters in height. The stem is thorny with grayish-brown bark. Leaves are dark green, elliptic, measuring 8-15 cm in length and 3-5 cm in width. The species is deciduous, with foliage turning red in autumn. Flowering occurs from May to June. Flowers have five heart-shaped white petals, with a diameter of 2-5 cm. Fruits mature in late autumn, measuring 2-3 cm in diameter, with a red-brown coloration (Figure 9). *M. germanica* is found at altitudes up to 1100 meters and naturally occurs in the Caucasus, Asia Minor, and southeastern parts of the Balkan Peninsula.

The fruits, leaves, bark, and seeds are rich in bioactive compounds, including pectin, amino acids, carbohydrates (glucose, fructose, sucrose), organic acids (malic, citric, ascorbic, quinic acids), fatty acids (oleic, linoleic, palmitic, stearic acids), chlorogenic acid, caffeic acid, gallic acid, catechin, epicatechin, quercetin, kaempferol derivatives, phenolic tannins, antioxidant compounds, triterpenes, carotenoids, and minerals. Leaf extracts are particularly high in phenolic content. Different plant parts have been shown to exhibit antioxidant, antidiabetic, antimicrobial, anti-inflammatory, and anthelmintic activities (Nistor et al., 2024).

Traditionally, *M. germanica* has been used for treating menstrual disorders, alleviating cold and flu symptoms, addressing kidney and urinary tract issues, supporting liver and kidney function, and treating enteritis and intestinal inflammations. The fruits can be consumed fresh or processed into molasses, marmalade, compote, jam, and other products. They are also a high-quality source of pectin. The seed oil can be used as biofuel and in cosmetics. Additionally, the species is cultivated as an ornamental shrub in parks and gardens.

***Rosa canina* L.**

Figure 10. General Structure and Fruit Morphology of Rosa canina

Rosa canina, a shrub of the family Rosaceae, reaches a height of 1.5-2.5 meters. Its branches bear numerous rigid thorns. Leaves are compound, typically composed of seven leaflets, with a total leaf length of 7-9 cm. Leaflets are smooth, mostly elliptic, measuring 2-2.5 cm in length and 1-1.5 cm in width.

Flowering occurs in May, producing pale pink to whitish petals, 4-6 cm in diameter, arranged in clusters of 3-5 flowers. Fruit ripening takes place in June-July, yielding obovate to broad-oval, sometimes globular hips, 15-26 mm in length (Figure 10).

R. canina thrives in shrublands, forest edges, riverbanks, and similar habitats. In Azerbaijan, it is naturally distributed across many regions of the Greater and Lesser Caucasus.

The fruits are particularly rich in vitamin C and also contain vitamins A, B1, B2, B6, D, E, and K. Organic acids such as quinic, tartaric, and citric acids are present. The plant contains flavonols such as catechin, anthocyanins like cyanidin-3-glucoside, phenolic acids such as galloylquinic acid, and carotenoids including β-carotene, lycopene, β-cryptoxanthin, rubixanthin, gazaniaxanthin, and zeaxanthin (Peña et al., 2023).

Therapeutically, *R. canina* exhibits antioxidant activity by protecting cells from free radicals and reducing oxidative stress. Its anti-inflammatory properties help mitigate inflammation. Certain phenolic and flavonoid compounds present in the plant confer anticancer and antimicrobial effects. The species is utilized in the food industry for teas, juices, jams, and in the

cosmetic industry for skincare products.

***Crataegus pentagyna* Waldst. & Kit. ex Willd.**

Figure 11. General Structure and Fruit Morphology of Crataegus pentagyna

Crataegus pentagyna, a tree or shrub of the family Rosaceae, reaches 5-6 meters in height. Its branches have gray bark and thorns measuring 5-10 mm in length. Leaves are dark green on the upper surface and lighter green on the underside, with 3-5 lobes that are broad and either blunt or pointed (Figure 11). Flowering occurs in May, producing flowers in complex corymb inflorescences. Flowers measure 1.2-1.7 cm in diameter and have white petals. Fruit development takes place from September to October, yielding black or dark purple fruits 8-12 mm in diameter.

The species is widely distributed in Azerbaijan, from lowlands to middle mountain zones of the Lesser and Greater Caucasus. It is commonly found in sparse forests and shrublands, growing both in groups and as isolated individuals.

Fruits, leaves, and roots of *C. pentagyna* are rich in phenolic compounds, including apigenin, caffeoyl quinic acid derivatives, salicylic acid, naringenin-6-C-glucoside, and naringenin (Taleghani et al., 2024). Additionally, the plant contains terpenes, lipophilic compounds, anthocyanins, hydrocarbons, fatty acids, and their derivatives. Extracts from fruits, leaves, and roots exhibit antioxidant activity, neutralizing free radicals. They also demonstrate antimicrobial efficacy, showing bactericidal and bacteriostatic effects against both Gram-positive and Gram-negative bacteria. Due to its flavonoid and phenolic acid content, the plant supports vascular function, promotes vasodilation, exhibits anti-atherosclerotic and antihypertensive effects, and plays a cardioprotective role. Furthermore, it contributes to reducing oxidative stress and has anti-inflammatory properties. Fruit, leaf, and root extracts, owing to their antioxidant and antimicrobial activities, can also be used as additives in the preservation of processed foods.

***Ribes nigrum* L.**

Figure 12. General Structure and Fruit Morphology of Ribes nigrum

Ribes nigrum, a medium-sized shrub of the family Grossulariaceae, can grow up to 1.5 meters in height and diameter. Simple leaves, 3-5 cm wide, are arranged alternately along the stem. Flowering occurs from May to June, producing inflorescences up to 8 cm long, each bearing 10-20 flowers. Individual flowers are 4-6 mm in diameter, with small, inconspicuous, oval petals. Fruit development occurs in July, yielding mature berries approximately 1 cm in diameter, dark purple to black in color (Figure 12). The species naturally occurs throughout Europe, Russia, Kazakhstan, northern China, Mongolia, and several regions of Azerbaijan.

R. nigrum is rich in flavonols, phenolic acids, proanthocyanidins, and anthocyanins, which give the fruits their dark color. Fruits are also abundant in vitamin C, vitamin E, various minerals, organic acids, and pectins. Seeds contain omega-3 and omega-6 fatty acids, gamma-linolenic acid, stearidonic acid, and tocopherols (vitamin E). Polyphenols and anthocyanins exhibit strong antioxidant activity by neutralizing free radicals and reducing oxidative stress. The plant also demonstrates anti-inflammatory, immunomodulatory, and antimicrobial effects. Flavonoids and polyphenols contribute positively to cardiovascular health and metabolic processes related to glucose and lipids. In the food industry, the fruits of *R. nigrum* are used for juices, compotes, jams, ice creams, and other products. Due to their anthocyanin content, the fruits can also serve as

natural colorants and flavoring agents (Ejaz et al., 2023).

***Euonymus velutinus* Fisch. & C.A.Mey.**

Figure 13. General Structure and Fruit Morphology of Euonymus velutinus

Euonymus velutinus, a shrub of the family Celastraceae, reaches 1.5-4 m in height (Figure 13). Its leaves are oblong-elliptic or obovate, measuring 2-8 cm in length and 1-3.5 cm in width.

Flowering occurs from May to June, with small, greenish flowers arranged in umbels. Each flower has four elongated petals. Fruits mature in August; the seeds are ovate and fully enclosed by the fruit covering.

E. velutinus naturally occurs in Iran, Central Asia, and Azerbaijan, including the central and southern parts of the Lesser Caucasus, the western and eastern parts of the Greater Caucasus, and the Kura-Araz lowlands. It grows mainly at elevations of 1500-1800 m in sparse forests, forest edges, and similar habitats.

Biochemically, *E. velutinus* contains alkaloids such as euonymin, evomonin, evonin, and velutin; terpenoids including triterpenes (β-amyrin, lupeol) and sesquiterpenes; phenolic compounds such as flavonoids and phenolic acids (caffeic acid, ferulic acid); lignans including sesamin derivatives; fatty acids and phytosterols; anthocyanins and carotenoid pigments; and evonates (Sharma et al., 2012).

Pharmacologically, the plant exhibits antioxidant, antibacterial, antifungal, antidiabetic, anti-inflammatory, cardiotonic, anticancer, sedative, and mild neuroprotective effects. In traditional medicine, it is used for rheumatism and joint pain, digestive disorders, and as anthelmintic. Other applications include landscaping in parks and gardens, use of its wood in industry, and extraction of natural dyes from its fruits and seeds.

***Cornus mas* L.**

Figure 14. General Structure and Fruit Morphology of Cornus mas

Cornus mas, a shrub or small tree of the family Cornaceae, reaches a height of 2-4 m. Its leaves are opposite, simple, ovate to ovate-elliptic, measuring 4-10 cm in length and 3-5 cm in width, with entire margins.

Flowering occurs in February-March, before leaf emergence. Small, golden-yellow flowers are arranged in umbels of 15-25 flowers. Fruit ripening takes place from August to September. Fruits are elongated, each containing a single large seed, and turn red upon maturity, measuring 10-30 mm in length (Figure 14).

C. mas naturally grows at the foothills of the Greater and Lesser Caucasus Mountains, forming small forests or growing individually.

The fruits contain phenolic compounds, anthocyanins such as cyanidin-3-glucoside and pelargonidin derivatives, flavonoids including quercetin and kaempferol derivatives, phenolic acids (gallic acid, chlorogenic acid, caffeic acid, ellagic acid), triterpenes and iridoids (ursolic acid, oleanolic acid, cornuside, loganin, sweroside), and vitamin C. Pharmacologically, the species exhibits antioxidant, anti-inflammatory, antidiabetic, insulin-sensitizing, cardioprotective, hepatoprotective, anticancer, antimicrobial, and antiviral effects (Sevindik et al., 2024).

The fruits are used in the food industry for jams, preserves, and compotes, as well as in dried form in various dishes. Due to their high anthocyanin content, the fruits serve as natural colorants. In cosmetics, they are used as antioxidant-rich ingredients in creams. *C. mas* also plays an important role in preventing soil erosion. Additionally, early spring flowering makes it a valuable species for beekeeping.

***Ribes uva-crispa* L.**

Figure 15. General Structure and Fruit Morphology of Ribes uva-crispa

Ribes uva-crispa, a shrub of the family Grossulariaceae, grows up to 1 m in height. Its shoots are covered with simple spines approximately 2.5 cm long. Leaves are round, 6 cm long and 3-5 cm wide, with 3-5 lobed margins. Flowering occurs in May-June, with 1-3 flowers forming racemes. Flowers have five petals, greenish or reddish in color. Fruit development occurs from June to August. The resulting berries are oval or semi-spherical, about 12 mm in diameter, covered with fine hairs, and turn green, yellow, or dark red when mature (Figure 15). *R. uva-crispa* naturally grows mainly in shaded forests. The species is distributed in Azerbaijan (Nakhchivan and parts of the Lesser Caucasus), as well as in Central and Southern Europe and North America.

The plant is rich in phenolic compounds, including flavonoids (quercetin, kaempferol derivatives), phenolic acids (chlorogenic acid, caffeic acid, gallic acid), anthocyanins (cyanidin-3-glucoside), vitamins (C, A, B1, B2, B6), sugars (glucose, fructose), organic acids (malic, citric, tartaric), pectin, minerals, volatile and non-volatile compounds. It exhibits antioxidant, anti-inflammatory, antidiabetic, hypoglycemic, and antimicrobial activities, making it an important therapeutic agent in both traditional and modern medicine (Orsavová et al., 2019).

Additionally, *R. uva-crispa* supports lipid metabolism, reducing cholesterol and triglycerides. Its high fiber content improves digestion and alleviates bloating. The elevated vitamin C content strengthens the immune system. In the food industry, its fruits are used for jams, preserves, wines, and compotes, and the pectin content allows for jellies and gels. In cosmetics, it is used in anti-aging products. The plant is also cultivated as an ornamental fruit-bearing shrub in gardens.

Conclusion

The analyses indicate that Shusha and its surrounding areas host a unique mountain-forest ecosystem distinguished by a high diversity of shrub and semi-shrub life forms. These plants are not only dominant components of the region's phytosociological structure, shaping the visual landscape, but also constitute essential biological groups that ensure the functional stability of the ecosystem. Their robust root systems prevent soil erosion, stabilize slopes, and accelerate soil regeneration during early successional stages, thereby facilitating forest cover restoration.

Many of the shrubs and semi-shrubs found in Shusha are endemic, relict, or ecologically adapted species. They play a crucial role in preserving genetic diversity, providing food and shelter for local fauna, and maintaining ecological balance. In addition, the bioactive compounds present in these plants enhance the region's pharmacological and ethnobotanical significance.

Thus, the role of shrubs and semi-shrubs in Shusha's ecosystem is multifaceted. Their conservation, integration into ecological monitoring, and prioritization in restoration programs provide a scientific foundation for the sustainable management of regional ecosystems. Comprehensive research and protection of these plant groups are of decisive importance for ensuring the long-term ecological health and stability of Shusha.

References

1. Bei, M. F., Apahidean, A. I., Budău, R., Rosan, C. A., Popovici, R., Memete, A. R., Domocoș, D., & Vicas, S. I. (2024). An overview of the phytochemical composition of different organs of *Prunus spinosa* L., their health benefits and application in food industry. *Horticulturae, 10*(1), 29. https://doi.org/10.3390/horticulturae10010029

2. Botanika İnstitutu. (2025). *Qarabağ florası* [*Flora of Karabakh*]. CBS Polygraphic Production.

3. Bridson, D., & Forman, L. (2019). Herbarium Handbook. Royal Botanic Gardens, Kew.

4. Celik, F., Gundogdu, M., Alp, S., Muradoglu, F., Ercişli, S., Gecer, M. K., & Canan, I. (2017). Determination of phenolic compounds, antioxidant capacity and organic acids contents of *Prunus domestica* L., *Prunus cerasifera* Ehrh. and *Prunus spinosa* L. fruits by HPLC. *Acta Chromatographica, 29*(4), 507-510. https://doi.org/10.1556/1326.2017.00327

5. Dunaevskaya, E. V., Gorina, V. M., Melkozerova, E. A., Khetagurov, Kh. M., & Kozyrev, A. Kh. (2021). *Prunus cerasifera* Ehrh. fruits are a

source of biologically active substances and high-quality feedstock for Food for Specific Health Use. *E3S Web of Conferences, 282*, 04008. https://doi.org/10.1051/e3sconf/202128204008

6. Ejaz, A., Waliat, S., Afzaal, M., Saeed, F., Ahmad, A., Din, A., Ateeq, H., Asghar, A., Shah, Y. A., Rafi, A., & Khan, M. R. (2023). Biological activities, therapeutic potential, and pharmacological aspects of blackcurrants (*Ribes nigrum* L.): A comprehensive review. *Food Science & Nutrition, 11*(10), 5799-5817. https://doi.org/10.1002/fsn3.3592

7. El-Zahar, K. M., Al-Jamaan, M. E., Al-Mutairi, F. R., Al-Hudiab, A. M., Al-Einzi, M. S., & Mohamed, A. A. (2022). Antioxidant, antibacterial, and antifungal activities of the ethanolic extract obtained from *Berberis vulgaris* roots and leaves. *Molecules, 27*(18), 6114. https://doi.org/10.3390/molecules27186114

8. Əsgərov, A.M. (2016) *Azərbaycanın bitki aləmi* [*The flora of Azerbaijan*]. Teas Press.

9. Gunes, N. T., Köksal, A. İ., Artık, N., & Poyrazoğlu, E. (2010). Biochemical content of hazelnut (*Corylus avellana* L.) cultivars from West Black Sea Region of Turkey. *European Journal of Horticultural Science*, 77-84. https://doi.org/10.1079/ejhs.2010/1430861

10. Ibadullayeva, S.J. (2024). *Traditional folk medicine of Azerbaijanis*. Savad.

11. Lesjak, M. M., Beara, I. N., Orčić, D. Z., Ristić, J. D., Anačkov, G. T., Božin, B. N., & Mimica-Dukić, N. M. (2013). Chemical characterisation and biological effects of *Juniperus foetidissima* Willd. 1806. *LWT - Food Science and Technology, 53*(2), 530-539. https://doi.org/10.1016/j.lwt.2013.03.010

12. Müllerová, J., et al. (2020). Field survey methods in modern vegetation science. Journal of Vegetation Science, 31(4), 684-696.

13. Nigussie, G., Melak, H., & Endale, M. (2021). Traditional medicinal uses, phytochemicals, and pharmacological activities of genus *Rhamnus*: A review. *JOTCSA, 8*(3), 899-932. https://doi.org/10.18596/jotcsa.929188

14. Nistor, D. I., Marc, R. A., & Mureșan, C. C. (2024). Phytochemistry, nutritional composition, health benefits and future prospects of *Mespilus germanica* L. (Medlar): A review. *Food Chemistry: X, 22,* 101334. https://doi.org/10.1016/j.fochx.2024.101334

15. Orsavová, J., Hlaváčová, I., Mlček, J., Snopek, L., & Mišurcová, L. (2019). Contribution of phenolic compounds, ascorbic acid and vitamin E to antioxidant activity of currant (*Ribes* L.) and gooseberry (*Ribes uva-crispa* L.) fruits. *Food Chemistry, 284*, 323-333. https://doi.org/10.1016/j.foodchem.2019.01.072

16. Peña, F., Valencia, S., Tereucán, G., Nahuelcura, J., Jiménez-Aspee, F., Cornejo, P., & Ruiz, A. (2023). Bioactive compounds and antioxidant activity in the fruit of rosehip (*Rosa canina* L. and *Rosa rubiginosa* L.). *Molecules, 28*(8), 3544. https://doi.org/10.3390/molecules28083544

17. Qurbanov, E. M. (2024). *Azərbaycanın bitki örtüyü* [*Vegetation of Azerbaijan*] (Monograph). Elm.

18. Rahimi-Madiseh, M., Lorigoini, Z., Zamani-Gharaghoshi, H., & Rafieian-Kopaei, M. (2017). *Berberis vulgaris*: Specifications and traditional uses. *Iranian Journal of Basic Medical Sciences, 20*(5), 569-587. https://doi.org/10.22038/IJBMS.2017.8690

19. Sərdarova, A.S. (2022). *Əczaçılıq botanikası* [*Pharmaceutical botany*]. Elm.

20. Sevindik, M., Khassanov, V. T., Sevindik, E., Uysal, I., & Mohammed, F. S. (2024). *Cornelian Cherry (Cornus mas L.): A comprehensive review on its usage areas, biological activities, mineral, phenolic and chemical contents and applications. Applied Fruit Science, 66*, 2061-2071. https://doi.org/10.1007/s10341-024-01151-3

21. Sharma, A., Sati, S. C., Sati, O. P., Sati, M. D., & Kothiyal, S. K. (2012). Genus *Euonymus*: Chemical and pharmacological perception. *Mini-Reviews in Organic Chemistry, 9*(4), 341-351. https://doi.org/10.2174/157019312804699500

22. Shataer, D., Li, J., Duan, X. M., Liu, L., Xin, X. L., & Aisa, H. A. (2021). Chemical composition of the hazelnut kernel (*Corylus avellana* L.) and its anti-inflammatory, antimicrobial, and antioxidant activities. *Journal of Agricultural and Food Chemistry, 69*(14), 4111-4119. https://doi.org/10.1021/acs.jafc.1c00297

23. Shetekauri, D., & Kikvidze, Z. (2018). Mountain vegetation research methods in the Caucasus. Caucasus Botanical Journal, 3(2), 45-59.

24. Shipunov, A. (2019). *How to make herbarium: a short manual.* ND Minot State University.

25. Taleghani, A., Eghbali, S., Moghimi, R., et al. (2024). *Crataegus pentagyna* Willd. fruits, leaves and roots: Phytochemicals, antioxidant and antimicrobial potentials. *BMC Complementary Medicine and Therapies, 24*, 126. https://doi.org/10.1186/s12906-024-04430-4

26. Verma, R., Gangrade, T., Punasiya, R., & Ghulaxe, C. (2014). *Rubus fruticosus* (blackberry) use as an herbal medicine. *Pharmacognosy Reviews, 8*(16), 101-104. https://doi.org/10.4103/0973-7847.134239