ABS ACTA BIOLOGICA SIBIRICA
A journal on the biodiversity of Siberia and the adjacent lands

Acta Biologica Sibirica 10: 1305–1317 (2024)
doi: 10.5281/zenodo.14175442
http://journal.asu.ru

RESEARCH ARTICLE

Officinal medicinal plants of the Nakhchivan Autonomous Republic

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Academic editor: R. Yakovlev | Received 20 September 2024 | Accepted 17 October 2024 | Published 19 November 2024

http://zoobank.org/5E60864D-8561-44E3-A668-4D57060BB723

Citation: Ibrahimov AM, Matsyura AV (2024) Officinal medicinal plants of the Nakhchivan Autonomous Republic. Acta Biologica Sibirica 10: 1305–1317. https://doi.org/10.5281/zenodo.14175442

Abstract

The Nakhchivan Autonomous Republic, situated at the crossroads of Mediterranean, Western Asian, and Iranian floras, is home to a rich diversity of medicinal plants. Approximately 132 species of officinal medicinal plants have been identified, with 44 cultivated and 88 wild-growing species. This region's flora contributes significantly to both traditional and scientific medicine, with many species documented in pharmacopoeias over the past 137 years. The escalating global demand for herbal remedies and natural health products underscores the importance of these plants, yet they face threats from habitat destruction, over-harvesting, and climate change. This study aims to assess the species composition, distribution, and conservation status of medicinal plants in the Nakhchivan Autonomous Republic. It focuses on understanding their habitats, ecological conditions, and the traditional knowledge associated with their use. Field expeditions conducted from 2015 to 2021 involved the collection of herbarium specimens and the identification of species using established botanical references. The study employed Geographic Information Systems (GIS) for mapping plant distributions and assessing biodiversity hotspots. The Conservation Priority Index (CPI) was calculated for each species, incorporating biological scores and risk of use scores to classify species into three conservation categories. The study identified 132 officinal medicinal plant species across 47 families and 105 genera. The most represented families include Rosaceae, Asteraceae, and Fabaceae. Among these, several species are classified as endangered, including *Adiantum capillus-veneris* and *Juniperus sabina*. The research also documented the traditional uses of 59 species in folk medicine, highlighting their cultural significance.

Keywords
Nakhchivan Autonomous Republic, Azerbaijan, flora, officinal medicinal plants, habitats, rare species, Red Data Book

Introduction

Medicinal plants serve as vital reservoirs for novel drugs on a global scale (Farnsworth 1985). Approximately 60,000–75,000 plant species are harvested for medicinal usage in the world, while Asia accounts for over 38,660 species of medicinal plants (Astutik et al. 2019) and Europe – for more than 1,300 medicinal plant species. In developing nations, up to 80% of the population relies solely on herbal remedies for primary healthcare, while over a quarter of prescribed medications in developed countries are derived from wild plant species. Considering flora of the Caucasus, an estimated 1000 species have medicinal applications used in traditional folk medicines and approximately 180 species used in scientific medicine (Mamedov et al. 2015). The escalating demand for herbal remedies, natural health products, and medicinal plant metabolites is propelling the rapid expansion of medicinal plant usage worldwide.

Conservative estimates suggest that the current rate of plant species loss surpasses the natural extinction rate by a factor of 100 to 1000, resulting in the disappearance of at least one potentially significant medicinal resource every two years. Extensive research has been conducted on the conservation and sustainable utilization of medicinal plants, resulting in various recommendations. These include the implementation of systems for species inventorying and status monitoring, as well as the adoption of coordinated conservation approaches encompassing both in situ and ex situ strategies. For medicinal plants facing dwindling supplies, sustainable utilization of wild resources emerges as a viable conservation solution (Chen et al. 2016; Thedoridis et al. 2023).

The diverse flora of the Nakhchivan Autonomous Republic has evolved in close genetic connection with the Mediterranean, Western Asian, and Iranian floras. A comprehensive study of officinal medicinal plants listed in various editions of pharmacopoeias (International pharmacopoeia 1981–1990) has revealed that the Nakhchivan Autonomous Republic boasts 132 species of officinal medicinal plants from 48 families and 105 genera, with 44 cultivated and 88 wild-growing species (Talibov et al. 2018). Notably, eight wild-growing officinal medicinal plants have been consistently included in pharmacopoeias for over 137 years.

The modern biodiversity of the Nakhchivan Autonomous Republic's flora comprises 160 families, 910 genera, and 3020 species (Talibov et al. 2021), with approximately 1200 useful plants, including over 800 medicinal species (Talibov and Ibrahimov 2015). Among these, 132 species are recognized in the State Pharmacopoeia as officinal medicinal plants (The State 2007, 2014, 2018, Passport 2019). These plants are distributed across various ecosystems within the republic, includ-

ing forests, meadows, steppes, shrublands, semi-deserts, deserts, cultivated lands, gardens, and orchards. Research has extensively documented the rich diversity and distribution of medicinal plant species in Nakhchivan, spanning from mountainous regions to lowlands.

Despite their importance, medicinal plant populations face threats such as habitat destruction, over-harvesting, climate change, and unsustainable harvesting practices (Borrelli, Izzo 2000; Du et al. 2016). Ethnobotanical studies have shed light on the traditional uses of these plants by local communities, revealing remedies for various ailments and cultural practices associated with them (Bairagi et al. 2012; Fitzerald et al. 2020). Field surveys have assessed species richness, abundance, and distribution, while ethnobotanical surveys and interviews have documented traditional knowledge and uses. Geographic Information Systems (GIS) and remote sensing technologies have aided in mapping plant distributions, identifying biodiversity hotspots, and monitoring habitat changes. Additionally, ecological modeling has been employed to predict climate change impacts on medicinal plant populations and evaluate conservation strategies.

Our research focuses on the species composition of officinal medicinal plants in the Nakhchivan Autonomous Republic, providing detailed insights into their habitats.

Materials and methods

Botanical-geographical expeditions were conducted across various zones of the Nakhchivan Autonomous Republic from 2015 to 2021 to collect herbarium materials related to officinal medicinal plants. The identification of collected species was performed using references such as the "Flora of Azerbaijan" (1950–1961), "Flora of the Caucasus" (Grossheim 1939-1967), Grossheim (1946), Damirov et al. (1988), Mehdiyeva (2011), Bussmann et al. (2016), Ozturk et al. (2018), Dalar et al. (2018), Ibadullayeva (2020), Demir and Demir (2022). The classification of plant growth forms followed Hallow (1990) and Engemann et al. (2016). Taxon names and nomenclatural changes were updated according to the research by Talibov et al. (2021). The conservation statuses of rare and endangered species were assessed based on the criteria outlined in the IUCN Red List (2001), the Red Book of the Republic of Azerbaijan (2023), and the Red Book of the Nakhchivan Autonomous Republic (2010).

Species ranges were determined through a comparative analysis of personally collected samples, GPS data, and literature materials stored in the herbarium collection of the Institute of Bioresources (Nakhchivan) under the Ministry of Science and Education of the Republic of Azerbaijan. The officinal medicinal plants of the Nakhchivan Autonomous Republic underwent comprehensive study during these scientific expeditions, focusing on their ranges, primary habitats, ecological conditions, biomorphological features, and phytocenological structure.

To ensure adequate coverage of habitat and community variations, a representative number of stands measuring 20 x 20 m were sampled in each region. This area was chosen based on the species area curve as the minimal area needed for accurate sampling. The number of stands sampled was determined by the micro-variations in habitat within the study sites. Within each stand, data was collected on the presence of all species, the density of each species (calculated by dividing the stand area into four 10 x 10 m quadrats), and the species cover using the line intercept method with six lines measuring 10 m each. A total of 200 quadrats were utilized in the study, with 100 quadrats placed at each of the two designated sites. The sampling methodology involved setting up 10 lines, each spanning 50 meters, at both sites for the temporal evaluation of the Conservation Priority Index concerning medicinal plants. These lines were positioned perpendicular to the trails and main roads within the forest, deliberately steering clear of border regions and areas impacted by urban development. Spaced 10 meters apart, each sampling line had defined points at every 10-meter interval.

At each designated point along the sampling lines, the surrounding area was divided into four quadrants, each spanning 90 degrees. The diameter at ground level was measured for the plant specimen nearest to the vertex of each quadrant, encompassing individuals with a diameter at breast height (DBH) of 3 cm or more. Subsequently, the relative density (RD) of each plant species was calculated based on these measurements, a crucial component in determining the Conservation Priority Index.

In assessing conservation priorities for medicinal plants, we employed the Conservation Priority Index (CP), which considers both a Biological Score (BS) and a Risk of Use Score (RU) for each species. The criteria used in this calculation are detailed in Table 1. The CP was determined using the formula: CP = 0.5 (BS) + 0.5 (RU). The Biological Score (BS) was derived from the relative density of each taxon, calculated as BS = D x 10, where D is determined based on the relative density of each taxon (DRi) as outlined in Table 2. The relative density calculation included undamaged individuals and those partially cut but still capable of providing products.

Table 1. Criteria used for scoring the relative density, collection risks, local importance and diversity of use of medicinal plants (modified by Dzerefos & Witkowski 2001; Albuquerque et al. 2011b)

Criteria	Scores
Relative Density	
None recorded – very low (0-1)	10
Low (1 < 3.5)	7
Medium (3.5 < 7)	4
High (≥ 7)	1

Criteria	Scores
Collection Risk	
Destructive plant collection or over-exploitation of roots or bark. The collection involves the removal of the individual	10
Aerial structures, such as bark and roots, and removal of part of the stem for extraction of latex, which are collected without causing death to the individual	7
Permanent aerial structures such as leaves that are removed, potentially affecting plant energy investment, survival and long-term reproductive success	4
Removal of transient aerial structures, such as flowers and fruits. Regeneration of the population can be altered in the long term by removal from the seed bank, but the individual plant is not affected	1
Local Importance	
Very high (listed by > 75% of local informants)	10
Moderately high (50-75% of local informants)	7
Moderately low (25-50% of local informants)	4
Very low (< 25% of local informants)	1
Diversity of use	
One point is added for each medicinal use up to the maximum of 10	1–10
Associated Timber Use	
For species with timber use 10 points are added to the formula	10

The Risk of Utilization Score (RU) was determined by evaluating the value of use (U) and the collection risk (H), with RU reaching a maximum value of 100. The RU was calculated using the formula: RU = 0.5 (H) + 0.5 (U) x 10. The collection risk value (H) is based on the biological impact of collection, considering the plant part removed as specified in Table 2. The local importance (L) and the diversity of use (V) were factors influencing the value of use (U).

To address limitations in the conservation priority calculation, additional considerations were made by Albuquerque et al. (2011b). They introduced a variable "associated timber uses" (AT) to account for multiple uses of woody medicinal plants, especially those used by the local people, which may face additional pressures. The revised formula is presented as: PC = 0.5 (BS) + 0.5 (RU) x 10, with timber use factored in only when relevant. The Conservation Priority Index was computed for each sampled species, leading to their classification into three categories: Category 1 (CP ≥ 80) comprising species of high conservation priority requiring sustainable collection practices; Category 2 (60 < CP < 80) for species with potential for collection under specific conditions; and Category 3 (CP ≤ 60) encompassing species suitable for high-impact collection practices.

Results and discussion

The modern biodiversity of the flora in the Nakhchivan Autonomous Republic comprises 160 families, 910 genera, and 3020 species of gymnosperms and angiosperms (Talibov et al. 2021). From our study, we identified 132 plant species belonging to 47 families and 105 genera as officinal medicinal plants in the flora of the Nakhchivan Autonomous Republic. Among these, 44 species are cultivated, while 88 species are wild plants (Talibov et al. 2018). *Adiantum capillus-veneris* L. (NT), *Dryopteris filix-mas* (L.) Schott (NT), *Juniperus communis* L. (NT), *Juniperus sabina* L. (EN B1ab(ii,iii)), *Ephedra aurantiaca* Takht. et Pachom (LR), *Orchis mascula* (L.) L. (VU A2cd), *Platanthera chlorantha* Reichenb (VU A1acd), *Betula pendula* Roth. (VU A2cd), *Viola tricolor* L. (LR), *Punica granatum* L. (CR C2a(ii)), and *Vinca minor* L. (LR). Additionally, nine species including *Adiantum capillus-veneris* L. (VU D2), *Orchis mascula* (L.) L. (LC), *Platanthera chlorantha* Reichenb (EN B2b(iii)c(v)), *Padus avium* Mill. (EN B2b(ii,iii,v)), *Rosa zangezura* P. Jar. (VU B1ab(ii)+2ab(ii,iii,iv)), *Punica granatum* L. (VU B1ab(i,ii,iii)), *Menyanthes trifoliata* L. (EN B1ab(i,ii,iii,v)), *Tanacetum coccineum* (Willd.) Grierson (Pyrethrum coccineum (Willd.) Worosch.) (EN B1ab(i,iii)), and *Digitalis ferruginea* L. (VU D1) are classified as endangered. Thus, the areas of rare and endangered species have been clarified (Fig. 1).

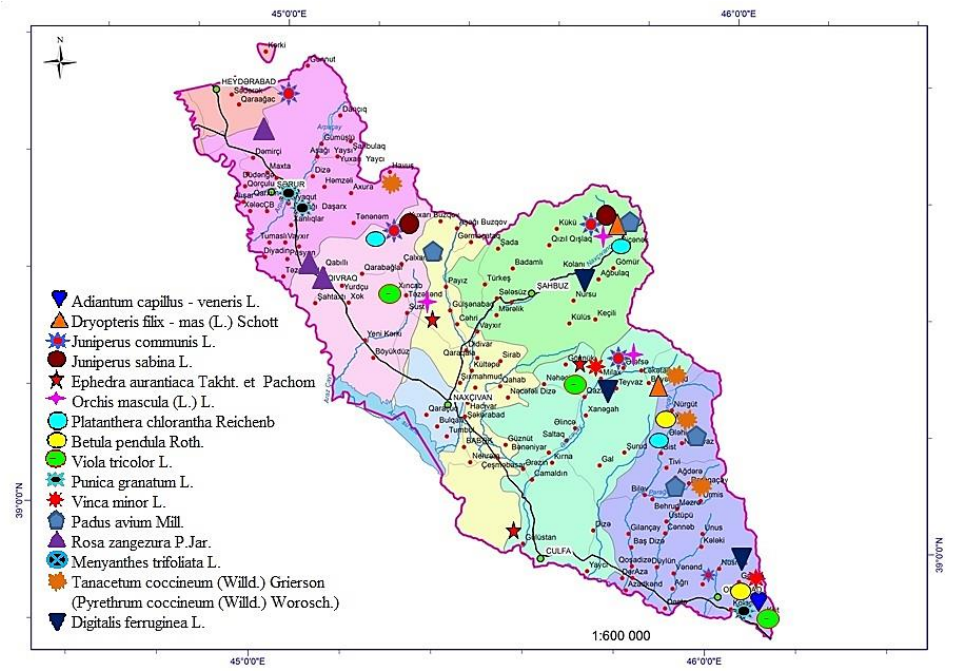

Figure 1. Distribution areas of the species listed in the Red Book of Nakhchivan Autonomous Republic and the Republic of Azerbaijan.

When categorizing officinal medicinal plants based on their life form, we found 24 tree species (12 cultivated), 21 shrub species (8 cultivated), 62 perennial herb species (7 cultivated), and 25 annual-biennial herb species (17 cultivated). Out of the 88 wild-growing officinal medicinal plants, 30 exhibit a substantial natural abundance (Table 2).

Based on the beneficial properties of 30 types of officinal medicinal plants from the local flora, employees of the Institute have created 16 combinations of mixtures for the prevention and treatment of various systemic human diseases (Talibov et al. 2012). The most represented families by species number include Rosaceae, Asteraceae, Fabaceae, Lamiaceae, Apiaceae, Matricaria, Solanaceae, Malvaceae, Poaceae, Polygonaceae, Violaceae, and Salicaceae.

According to the classification by I.G. Serebryakov (1964), the officinal medicinal plants consist of 25 annual-biennial herbs, 62 perennial herbs, 21 shrubs, and 24 trees. Through literature sources (Ibragimov and Nabiyeva 2010; Mehdiyeva 2014; Talibov et al. 2021; Ozturk et al. 2018) and interviews with the local population during expeditions, we discovered that 59 out of the 132 officinal medicinal plant species are currently used in folk medicine, with 41 species utilized in various forms like fresh or dried, and in the preparation of beverages, jams, and jellies. For a detailed list of officinal medicinal plants of the Nakhchivan Autonomous Republic, please refer to Table 2 and Suppl. material 1: Table S1.

Table 2. Biological reserve of medicinal plants in the Nakhchivan Autonomous Republic

No	Species	Total area, ha	Biomass, t		
			Biological resource	Operational reserve	Annual supply volume
1	*Equisetum arvense* L.	56350	32472.74	19483.64	9741.82
2	*Berberis vulgaris* L.	746	458.25	274.95	137.47
3	*Percicaria hidropyper* (L.) Spach	13566	3992.15	2395.29	1197.64
4	*Polygonum aviculare* L.	38682	82508.59	49505.16	24752.58
5	*Althaea officinalis* L.	12820	514.03	308.42	154.21
6	*Urtica dioica* L.	16338	6689.57	4013.74	2006.87
7	*Crataegus monogyna* Jacq.	10816	17363.67	10418.20	5209.10
8	*Crataegus pentagyna* Waldst. et Kit.	11769	19903.74	11942.24	5971.12
9	*Crataegus sanguinea* Pall.	347	30.39	18.23	9.12
10	*Malus orientalis* Uglitzk.	11530	30346.92	18208.15	9104.08
11	*Prunus divaricata* Ledeb.	10213	20425.04	12255.03	6127.51
12	*Rosa canina* L.	11161	7877.33	4726.40	2363.20
13	*Rosa corymbifera* Borkh.	1371	966.76	580.05	290.03
14	*Astragalus microcephala* (Willd.) Podlech	83131	6268.38	3761.03	1880.52

No	Species	Total area, ha	Biomass, t		
			Biological resource	Operational reserve	Annual supply volume
15	*Glycirrhysa glabra* L.	13304	5290.57	3174.34	1587.17
16	*Melilotus officinalis* L.	46496	6033.15	3619.89	1809.94
17	*Peganum harmala* L.	25630	3356.61	2013.97	1006.98
18	*Rhamnus cathartica* L.	1303	163.82	98.29	49.15
19	*Arctium lappa* L.	22923	3029.65	1817.79	908.90
20	*Artemisia absinthium* L.	40255	8156.41	4893.85	2446.92
21	*İnula helenium* L.	6457	2091.93	1255.16	627.58
22	*Lepidotheca suaveolens* (Pursch) Nutt.	4643	612.78	367.67	183.83
23	*Taraxacum officinale* Wigg.	43925	9242.53	5545.52	2772.76
24	*Tussilago farfara* L.	6399	1699.74	1019.84	509.92
25	*Datura stramonium* L.	3229	81.26	48.75	24.38
26	*Hyoscyamus niger* L.	4874	432.59	259.55	129.78
27	*Plantago major* L.	28770	4088.84	2453.31	1226.65
28	*Leonurus cardiaca* L.	4688	650.18	390.11	195.06
29	*Origanum vulgare* L.	28770	3448.12	1034.44	1034.44
30	*Salvia sclarea* L.	3202	84.21	50.53	25.26

Discussion

The research conducted in the Nakhchivan Autonomous Republic of Azerbaijan over the past two decades has focused on managing and safeguarding officinal medicinal plants, addressing key areas such as conservation, sustainable utilization, biodiversity, ethnobotanical knowledge, and policy frameworks. Conservation efforts have emphasized the importance of protecting the diversity of medicinal plants through evaluating endangered species, identifying biodiversity hotspots, and proposing conservation strategies.

Sustainable use of medicinal plants has been central to these efforts, with studies exploring harvesting methods, population regeneration, and sustainable practices to ensure the long-term availability of these vital resources (Kumar et al. 2016). Traditional knowledge held by local communities regarding medicinal plants has been extensively studied, documenting traditional uses, cultural significance, and the impact of local practices on plant conservation (Mikulic-Petkovsek et al. 2016). Policy frameworks and governance structures related to medicinal plant management have also been examined, covering legal frameworks, institutional setups, and

community engagement in decision-making processes (Graças Lins Brandão & Oliveira 2015; Uritu et al. 2018).

Officinal medicinal plants in the Nakhchivan Autonomous Republic play a significant role in honey and pollen production, as well as serving as raw materials for various products like beverages, essential oils, and tinctures (Guliyev 2014; Talibov and Ibrahimov 2015). Proposed conservation strategies include establishing protected areas, promoting sustainable harvesting practices, cultivating medicinal plants, and integrating traditional knowledge into conservation plans (Graças Lins Brandão & Oliveira 2015; Uritu et al. 2018).

Suggestions for policy enhancements include developing regulations for sustainable harvesting, providing conservation incentives to local communities, and incorporating traditional knowledge into biodiversity conservation policies.

Despite progress, there are research gaps that require further exploration to ensure the long-term sustainability of these resources (Palhares et al. 2015; Sandru et al. 2016; Nađpal et al. 2018; Whaley et al. 2023). Longitudinal studies are needed to monitor trends in medicinal plant populations and assess the effectiveness of conservation efforts over time (Yakovlev et al. 2013). Further research should evaluate the impacts of climate change on plant species' distribution, phenology, and medicinal properties in Nakhchivan. Understanding the cultural significance of medicinal plants and traditional practices in biodiversity conservation, as well as exploring the economic value of these plants, are crucial for sustainable management (WHO 2011; Pesic 2015). Efforts to bridge traditional knowledge with scientific research are essential to inform effective management and conservation strategies. The literature on managing and safeguarding officinal medicinal plants in the Nakhchivan Autonomous Republic reflects a growing recognition of the importance of conserving biodiversity, sustainable resource utilization, traditional knowledge, and robust policy frameworks.

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Supplementary material 1

Table S1. List of officinal medicinal plants of the Nakhchivan Autonomous Republic

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Data type: table

Link: http://journal.asu.ru/biol/article/view/16317/13858