PLANT SCIENCE TODAY
ISSN 2348-1900 (online)
Vol 12(2): 1-16
https://doi.org/10.14719/pst.3710

HORIZON
e-Publishing Group
HePG

RESEARCH ARTICLE

The current state of natural resources *Ferula tadshikorum* Pimenov in Uzbekistan

Maxmudov Azizbek*, Tojibaev Komiljon, Abduraimov Ozodbek, Mavlanov Bekzod & Allamurotov Akmal

Department of Population Biology and Plant Ecology, Institute of Botany Academy Sciences Republic of Uzbekistan, Tashkent 100125, Uzbekistan

*Email: azizbek.mahmudov@inbox.ru

OPEN ACCESS

ARTICLE HISTORY

Received: 10 June 2024
Accepted: 20 December 2024

Available online
Version 1.0 : 28 February 2025
Version 2.0 : 01 April 2025

Check for updates

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc
See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

CITE THIS ARTICLE

Maxmudov A, Tojibaev K, Abduraimov O, Mavlanov B, Allamurotov A.. The current state of natural resources *Ferula tadshikorum* Pimenov in Uzbekistan. Plant Science Today. 2025; 12(2): 1-16. https://doi.org/10.14719/pst.3710

Abstract

The article is devoted to studying natural reserves of raw materials of the endemic of Southwestern Pamir-Alai *Ferula tadshikorum* in the territory of the Republic of Uzbekistan. Due to excessive harvesting, the population of *F. tadshikorum* in the Republic of Uzbekistan is in a critical condition; the area of thickets and reserves of raw materials continues to decline. Compared with the indicators of 2020-2023, the presence of individuals in the monitoring sites (10 × 10 m^2) of *F. tadshikorum* in the territory of Kashkadarya region revealed a decrease in the total number of individuals by 56.1%. Accordingly, these indicators correlate with operational individuals since by 2023, the maturity of the plants was reduced by 65.3% and operational by 71%. These indicators in the Surkhandarya region were reduced from 57.3% to 75%. Compared to resource indicators in 2015, in 2023, the area of commercial thickets decreased by 96% and the stock of raw materials decreased by 83%. Indicators of resource value *F. tadshikorum* in Uzbekistan is a biological reserve, and these reserves are not subject to exploitation today. Currently, the populations of the species are mainly preserved in the border zone, or the neutral zone of the state border of the republic and in some areas of forestry.

Keywords

endemic; *Ferula tadshikorum*; phytocenotic characteristics; population; resources; Southwestern Pamir-Alai

Introduction

Climate change harms plant species, especially those with limited ecology and distribution areas. For plant phenology, the overall prevalence of patterns, concomitant and counter-gradients is crucial, as this will determine the extent to which local adaptation will enhance or weaken phenological responses to temporary climate shifts. Depending on the environmental gradients in space, the relative predominance of controversies gradient variations in spring compared to autumn will be critically important. To change the impact of climate change on the duration of the lesson for the entire ecological community. In general, geographical variation in the period of activity will be maximal when events in autumn and spring differ in whether they follow patterns with or against gradient variation (1, 2). Climate change is changing the structure of biodiversity around the world. Among the key responses to spatial and seasonal changes in environmental temperature are changes in phenology, that is, changes in seasonal life cycle events. Spring events usually occur in the middle and high latitudes in the Northern Hemisphere. Earlier autumn events occur later, mainly due to rising temperatures. In general, responses

are expected to be faster and more distinct the higher the latitude or altitude above sea level, i.e. the lower the average temperatures (3, 4). Phenological dynamics is recognized as one of the most reliable bioindicators of species' response to conditions of ongoing warming (5).

Species of the genus *Ferula* are perennial monocarpic and polycarpic taproot herbaceous plants, usually with a tall and thick stem and a powerful root system (6). About 170 species currently belong to the genus *Ferula* (7-10). They are widespread in Central Asia, Western Siberia, the Caucasus and the Mediterranean in North Africa, Asia Minor, Iran, Afghanistan, China (Xinjiang) and India. Of these, 105 species have been recorded in Central Asia and Kazakhstan (11). From west to east, species of the genus *Ferula* are found in the following areas: Sicily, the south of the Apennine Peninsula (Calabria), the Balkan Peninsula (Greece, Bulgaria, Romania), in Western and Minor Asia (Turkey, Iran, Syria, Lebanon, Iraq, Afghanistan), in the Caucasus (western, eastern and southern Transcaucasia), in Central Asia (Kopetdag, Pamir-Alai, western Tien-Shan), as well as in Central Asia (Kashgaria, Kashmir). About 60 species of the genus *Ferula* grow on the territory of the Republic of Uzbekistan and 37 species of the genus *Ferula* on the territory of Tajikistan, many of which have medicinal properties and are also a source of valuable raw materials for the pharmaceutical industry not only in the CIS countries, but also abroad (7).

Safina and Pimenov argued that species of the genus *Ferula* are distributed mainly in the Iran-Turanian phytogeographical region. They also emphasize that the genus is characterized by the presence of two centres of speciation: 1) western (from Turkey to western Iran, including Syria), containing most species and 2) eastern (eastern Iran, Afghanistan to Central Asia), in which most species are endemic with minimal areas of distribution (11). According to taxonomy, the genus *Ferula* belongs to the tribe Peucedarteae Dumort. Subfamilies Apioideae Drude family Apiaceae Lindl. (Umbelliferae Juss.). It occupies an exceptional place not only among the family Apiaceae, but also in the entire flora of Central Asia. On the one hand, plants of this genus have wide practical significance, on the other-scientific, since they are important for the development of the phylogenetic system of Umbrella and botanical-geographical analysis of the Ancient Mediterranean and Iranian-Turanian floras. Ferules are an excellent model object for solving several questions in plant evolutionary morphology and anatomy (11).

Among the representatives of the genus, almost all species are of great economic importance (6). *F. mogoltavica* Lipsky ex Korov., *F. tadshikorum* Pimenov, *F. kuhi-stanica* Korov., *F. fedtschenkoana* Koso-Pol., *Ferula moschata* (H.Reinsch) Koso-Pol., *F. kirialovii* M. Pimen, *F. tenuisecta* Korov., *F. penninervis* Regel et Schmaih. were used in folk and official medicine (12-16). Since ancient times, *F. tadshikorum* has been used in folk medicine to treat many diseases. The medicinal raw material is both the underground (air-hardened milky sap of the roots) and the plants' above-ground parts (17-19). *F. tadshikorum* was described by Pimenov in 1974 as a new species of *Ferula* from the subgenus Narthex (Falcon.) Drude. He stated that one of the widespread species of the genus *Ferula* L. in Central Asia is *F. foetidissima* Regel et Schmalh. - turned out to be heterogeneous. From the closest relationship of *F. foetidissima*, a mountain plant of Zerafshan, Alai and eastern Fergana, the author identified a new species distributed in southern Tajikistan (20, 21).

Unfortunately, the studies of Yaqoob and Nawchoo omitted *F. tadshikorum* from the species of the genus *Ferula* in the former USSR or CIS countries (22). This species is endemic to Central Asia. Its habitat covers Southern Uzbekistan and Southern Tajikistan (southwestern Pamir-Alai) (6,23). *F. tadshikorum* is a critically endangered herbaceous medicinal plant experiencing declining populations in southern Tajikistan (24). *F. tadshikorum* is endemic to southern Uzbekistan (Southwestern Pamir-Alai, western spurs of the Gissar Range, Kugitang, Babatag), outside Uzbekistan: Southern Tajikistan (25, 26).

Approximately 150 tons of gum resin from *F. tadshikorum* are exported from Tajikistan annually, a worsening condition that has put *F. tadshikorum* at risk. Additionally, due to global climate change, overexploitation, habitat degradation, land reclamation and overgrazing in recent years, *F. tadshikorum* populations have rapidly declined. Notably, this species was recently listed in the Red Book of the Republic of Tajikistan (24, 27). In the last two decades, most natural populations in Uzbekistan have been subjected to increased exploitation due to the collection of gum (resin) from underground organs, mainly from adult virginal individuals. As a result, many plants, not reaching the generative state, were exhausted and lost their viability. As a result, due to the lack of seed replenishment, natural areas of the valuable medicinal plant *F. tadshikorum* are currently on the verge of complete extinction. In this regard, it is recommended to include the species *F. tadshikorum* with the 3rd category in the list of plants of the next edition of the Red Book of the Republic of Uzbekistan (28-30). Considering the sharp reduction in natural resources of the highly sought-after *F. tadshikorum*, several scientific studies are being conducted to develop the cultivation of the plant based on the research and analysis of bioecological characteristics under conditions of introduction (28, 31).

Materials and Methods

Ferula tadshikorum is a perennial monocarpic plant, 1.5 -1.8 m tall, with a strong garlic odour. The root is thick with a vertical rhizome. The caudex is simple. Stems are solitary, 5-9 cm in diameter at the base, purple, glabrous, erect. The leaves are soft, soon withering, almost bare above, greyish pubescent below; basal and lower stem petioles, petioles bare or briefly pubescent, made, cyclic structure, with numerous vascular bundles, the plate is large, up to 40 cm in length, about 30 cm in width, elliptical in outline, trifoliate, segments of the 1st order twice- thrice pinnately dissected; the upper stem leaves are without petioles, the lower ones are similar to the basal leaves, but smaller in size, the terminal lobes are large, about 20 cm long, 7-9 cm wide, lanceolate or ovate-

lanceolate, pointed, crenate along the edge. The inflorescence is a wide panicle. Umbrellas are numerous, all fruiting, central on thickened stalks, often forming a false whorl, 20-30 ray; rays 3-6 cm long, violet, almost equal. Umbrellas 10-15-flowered, without involucres. The pedicels are short, 0.5-0.8 cm. The calyx teeth are small and triangular. Petals are yellow, 2-2.5 mm long, oblong-elliptical, obtuse, with apex curved inward. The sub-pillars are cup-shaped. Fruits are 1.9-2.7 cm long, 0.9-1.2 cm wide, obovate, oblong-ovate, oval or elliptical, compressed at the back, flat and glabrous. The dorsal ribs are filamentous; the marginal ribs are broadly wing-shaped. The secretory tubules in the hollows are single, 4 in number, and large, on the commissural side there are 4-6 of them, costal tubules 1 in the dorsal ribs and 3-4 in the marginal ones. Blooms in April-May; bears fruit in June-July (34, 35) (Fig. 1).

F. tadshikorum grows in the ephemeral-shrub belt: in bluegrass, barley, pistachio, almond, redbuds (*Cercis griffithii* Boiss.), along the edges of maple (*Acer regelii* Franch., *A. ovchinnikovii* Zaprjagaeva), in groups of parfolia, zoster, cherry, sootings. As part of the plant community *Inula grandis* Schrenk ex Fisch. & C.A. Mey., *Phlomis thapsoides* Bunge, *Crambe cordifolia* subsp. *kotschyana* (Boiss.) Jafri, *Rosa ecae* Aitch., *Iris svetlanae* (Vved.) T.Hall & Seisums, *Hedysarum magnificum* Kudr., *Eremurus soogdianus* (Regel) Benth. & Hook.f., *Prangos pabularia* Lindl., often an edificator or subedificator; on loess and fine-earth-gravelly slopes, limestone, variegated flowers, along dry river valleys and terraces; at altitude: 400-1800 m (34).

We collected data on the distribution of *F. Tadshikorum* within the Republic of Uzbekistan from field studies from 2019 to 2023. The distribution area of *F. tadshikorum* within the Republic of Uzbekistan: Southwestern Pamir-Alai, western spurs of the Gissar range, Kugitang, Babatag (Kashkadarya and Surkhandarya regions). The study area includes the Kashkadarya and Surkhandarya regions, located in the southernmost part of the republic. The region borders the Samarkand and Bukhara regions from the north, Tajikistan from the east, Turkmenistan from the west and Afghanistan from the south. The southern border of the region runs along the Amu Darya River, which is also the border between Uzbekistan and Afghanistan (Fig. 2). In this area, several studies have been carried out to study and assess the current state of coenotic populations of various plants of the flora of Uzbekistan (36-40).

Determination of plant resources

The manual on Resource Studies and Standardization of Medicinal Plant Raw Materials was used to determine the natural resources of plants within the Republic of Uzbekistan (41). Raw material reserves were determined during the plants' growing season (March-June). The operational reserve of raw materials was calculated as the product of the average yield of key areas by the area occupied by commercial thickets. The volume of possible procurement of raw materials was calculated as the fraction of operational reserves of raw materials per procurement turnover, including the year of procurement and the duration of the period of restoration of the thicket. The collection of raw gum materials (resin) was calculated at a rate of 50 grams per plant. The amount of raw materials collected depends on external factors, such as the age of the plant, weather conditions and collection methods.

Phytocenotic analysis

Analysis of phytocenoses per 100 m^2 area with the participation of *F. tadshikorum* was carried out using the generally accepted methodology (42). In identifying and determining the life forms of plants, the 10-volume monograph "Identifier of Plants of Central Asia" (1968-1993) was used (43,44). Plant names are presented according to http://www.plantsoftheworldonline.org/, http://www.theplantlist.org/, www.ipni.org (45-47). The Shannon biodiversity index of *F. tadshikorum* coenotic populations was determined as follows. The probability p (i) depends on which edificator is being implemented at the moment and then we denote it as p(*i/j*), the Shannon index $H^1(i/j)$ is defined as follows in Equation 1

$$H'(i/j) = -\sum_{ij} p(i/j) * \log p(i/j) \quad \text{.....(Eqn. 1)}$$

Data processing

The Farmis application (One Software App) was used to determine the area of thickets, based on the allocation of the GPS coordinates of the survey sites. The results obtained were statistically processed in the Past3 and Sigma15 programs. At the same time, some studies were used to assess the state of the cenotic population of the *genus Ferula* (48-50).

Results

Studies to determine the natural reserves of raw materials were conducted in Kashkadarya (Buztepa, Hudjaipok, Akbash, Sargayata, Kansai, Usmondara, Kurgantas, Tarkapchigai, Karadakhana, Ilondara: altitude above sea level is on average 800-1500 m) and Surkhandarya (Huzhaakhsar, Khamkon, Hazratbobo, Chagam, Dukhona, Huzhakulsin, Madaniturmush, Bibichakka, Besharcha, Sementkuduk: altitude above sea level is on average 1000-1700 m) regions. 10 monitoring sites were allocated in each area (Fig. 3).

Phytocenotic characteristics of the studied regions

As a result of field research, we identified 10 cenopopulations (hereinafter - CP) in the territory of the Kashkadarya region and 10 CP in the Surkhandarya region with the participation of *F. tadshikorum* (Fig. 4). In the identified coenotic populations of the Kashkadarya region, 61 species of higher plants were identified. CP-1 is isolated on the territory of Buztepa and consists of diverse grass and shrub communities, 24 species have been identified, and the dominant species is the genus *Tamarix*, with projective coverage 60-65%. CP-2 is identified on the territory of Khuzhaipok and is a forb-bluegrass community. The grass cover is about 80-95% and the community composition consists of 21 species of vascular plants. CP-3, isolated from the Akbash territory, is a forb-shrub -juniper community comprised of 41 species of higher plants.

Fig. 1. *F. tadshikorum*: A - mature vegetative plant; B - flowering plants; C - inflorescences; D - fruit-bearing plants; E - seeds, F - resin extracted from the root; G - Collected resin.

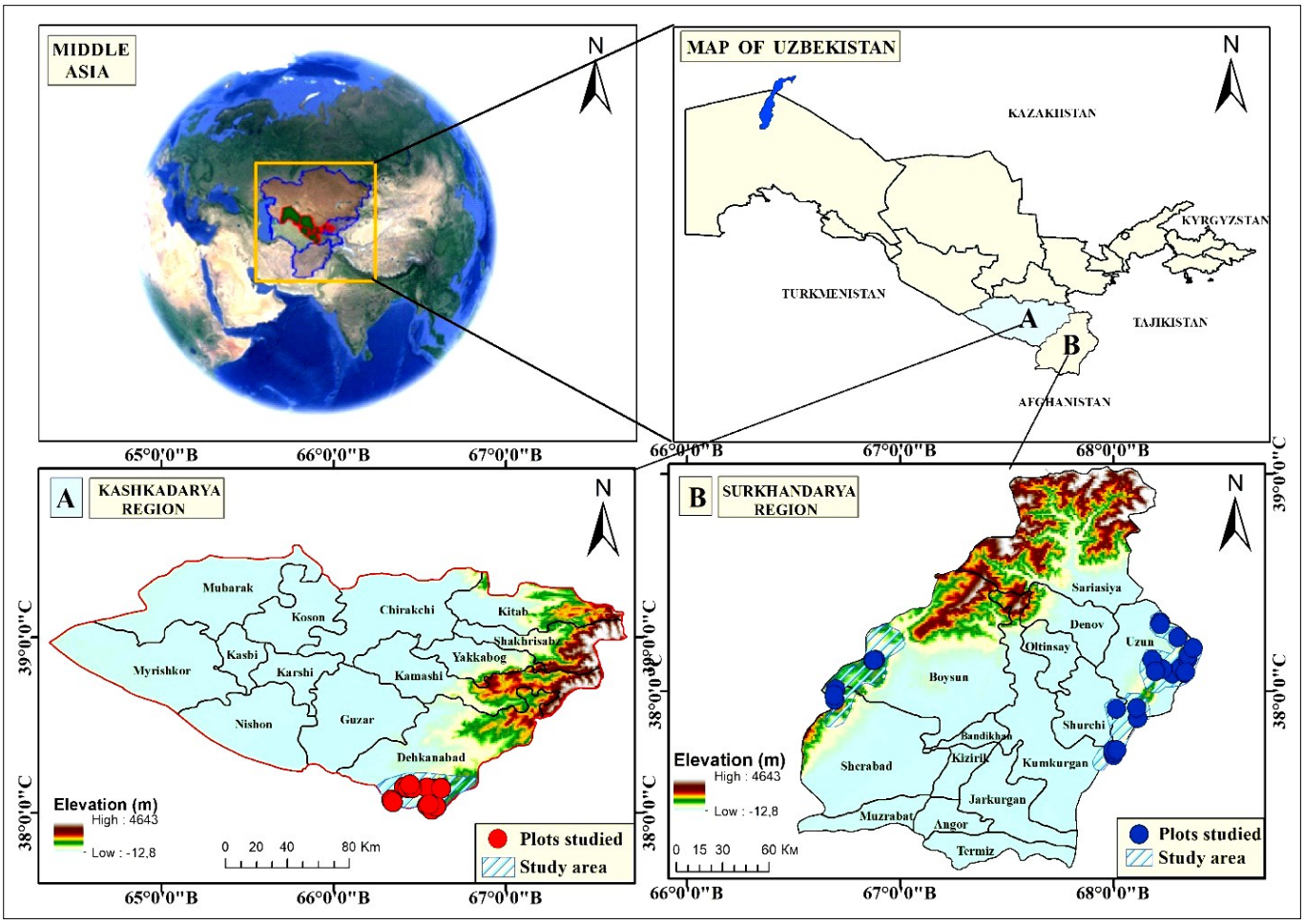
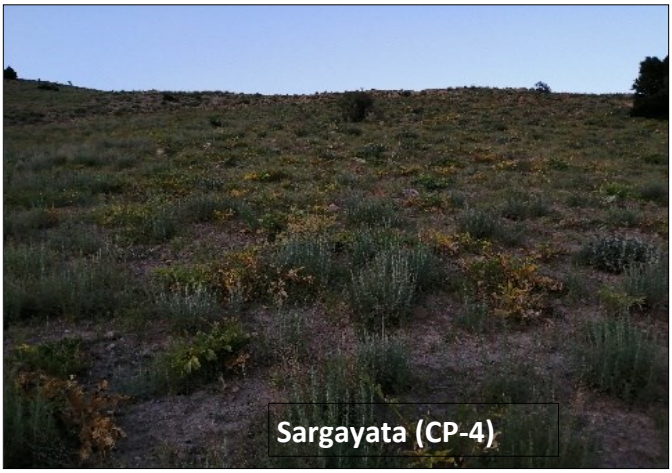
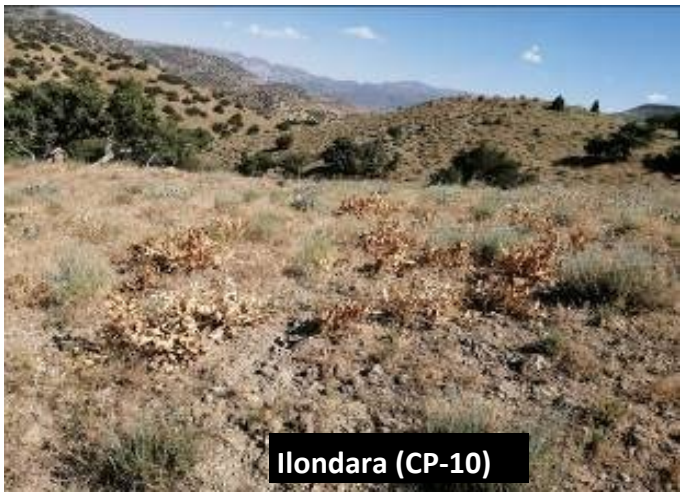


Fig. 2. Study area.

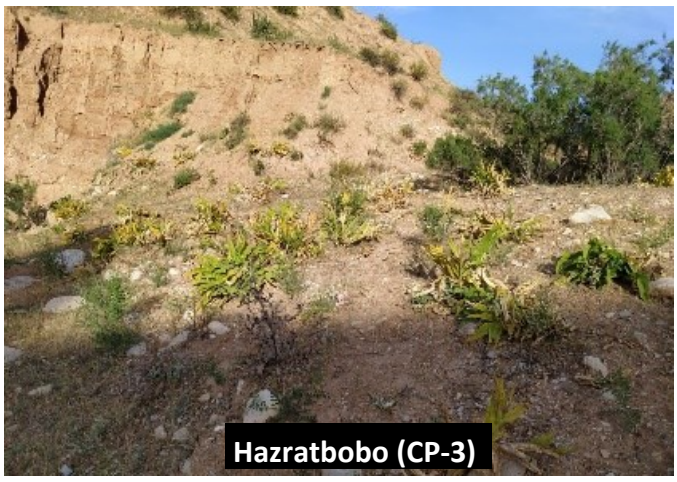
Fig. 3. Monitoring sites of *F. tadshikorum*.

Kashkadarya region





Surkhandarya region



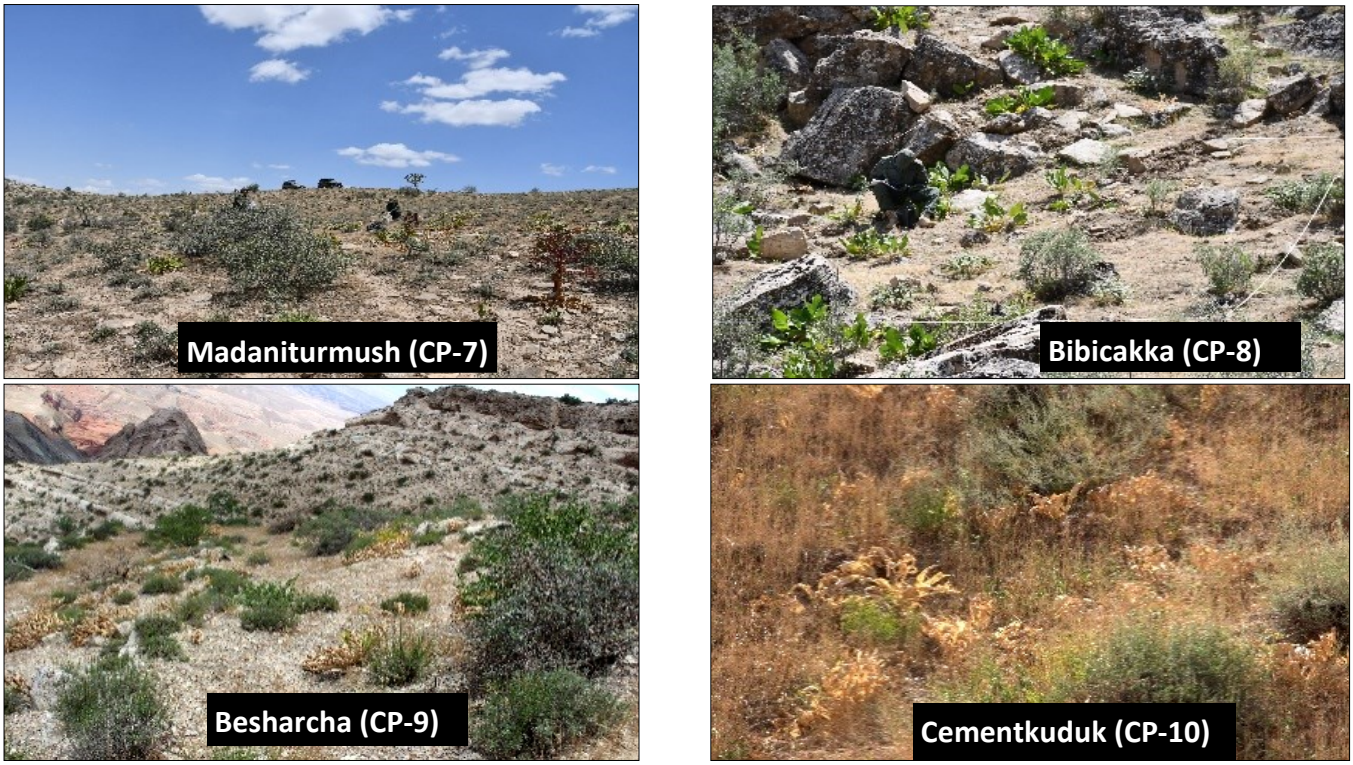


Fig. 4. Identified coenopopulations of *F. tadshikorum* in Uzbekistan.

The dominant species are *Juniperus seravschanica* and *Ephedra intermedia*. Grass cover 40%. CP-4 is allocated on the territory of Sargayata. This coenopopulation is a forb-worm wood community, and its botanical composition is 33 species. Projective coverage is about 65-70%. CP-5 is isolated on the territory of Kansai and consists of a forb-bluegrass community. The projective cover is about 65-75% and 34 species are noted in this coenopopulation. CP-6 was isolated from the territory of Usmondara and this coenopopulation is a forb-shrub community. The botanical composition of this CP consists of 37 species. Projective coverage is about 60-65%. CP -7 is isolated on the territory of Kurgantash and this coenopopulation is a forb-ferule-shrub community. The projective cover is about 65-70% and the community composition consists of 33 species of higher plants. CP-8 is isolated on the territory of Tarkapchigay and consists of a forb -tamarica community. The dominant species is the genus *Tamarix* and 36 species have been identified. Projective coverage 65-75%. CP-9 is isolated on the territory of Karadakhana; it is a forb-shrub juniper community consisting of 35 species of vascular plants. Projective coverage is about 60-65%. CP-10 is isolated on the territory of Ilondara; it is a forb-shrub-juniper community consisting of 30 species of higher plants. Projective coverage is about 65-75% (Table 1).

In the Surkhandarya region, 71 species of vascular plants were identified in the selected cenopopulations. CP-1 was isolated from the territory of Khuzhaakhsar and this coenopopulation is a forb-wormwood-shrub community. The botanical composition of this territory is not very rich, since 14 species of vascular plants have been identified. Projective coverage is about 15-18%. CP-2 was isolated on the territory of Khamkon, a forb-wormwood-salsola community consisting of 28 species of vascular plants. Projective coverage is about 25-35%. CP-3 was isolated from the territory of Hazratbobo and this CP is a forb-bluegrass community. This community consists of 40 species of vascular plants and the degree of vegetation coverage is 60-65%. CP-4 is identified on the territory of Chagam and is a forb-wormwood community. The botanical composition of this territory is not very rich, since 38 species of vascular plants have been identified. In this CP, the dominant species is *Cullen drupaceum* (Bunge) C.H.Stirt. and projective coverage 55-60%. CP-5 was isolated from the territory of Dukhona, which is a forb-bluegrass community. The grass cover is about 80-95% and the community composition consists of 46 species of higher plants. CP-6 was isolated in the territory of Khuzhakulsin and this coenopopulation is a forb-bluegrass community. The grass cover is about 25-35% and the community composition consists of 39 species of vascular plants. CP-7 was isolated on the territory of Madaniturmush and this coenopopulation is a forb-bluegrass community. The grass cover is about 60-65% and the community composition consists of 43 species of vascular plants. CP-8 is identified in the territory of Bibichakka, which is a forb-pistachio community.

The botanical composition of the community consists of 33 species of higher plants and a projective cover of about 20-25%. CP-9 was isolated on the territory of Besharcha and this coenopopulation is a forb-ferule-shrub community. The botanical composition is 39 species of vascular plants and the projective cover is about 35-40%. CP-10 is identified on the territory of Sementkuduk and is a forb-shrub community. The botanical composition consists of 32 species of higher plants and the projective coverage is about 30-35% (Table 1). For better visualization of coenopopulations, an analysis of the biodiversity of communities was carried out using the Shannon index. For this purpose, the number, participation and abundance of species in the studied coenopopulations were calculated. According to the Shannon Index, the coenotic populations of the Kashkadarya region were 4.039 and in the Surkhandarya region 4.165 (Table 1). The highest abundance of *F. tadshikorum* in the studied coenotic

Table 1. Shannon biodiversity index of coenotic populations of *F. tadshikorum* in Uzbekistan

No.	Species	Frequency (n=10 SP)	pi	No	Species	Frequency (n=10 SP)	pi
	Kashkaqarya region				**Surkhandarya region**		
1	*Juniperus seravschanica* Kom.	7	0,024	1	*Juniperus seravschanica* Kom.	2	0,008
2	*Prunus bucharica* (Korsh.) Hand. -Mazz.	5	0,017	2	*Pistacia vera* L.	4	0,017
3	*Prunus cerasifera* Ehrh.	4	0,013	3	*Prunus bucharica* (Korsh.) Hand. -Mazz.	4	0,017
4	*Ephedra intermedia* Schrenk & C.A.Mey.	5	0,017	4	*Atraphaxis pyrifolia* Bunge	2	0,008
5	*Rosa kokanica* (Regel) Regel ex Juz.	6	0,020	5	*Cotoneaster nummularioides* Pojark.	3	0,013
6	*Rosa webbiana* Wall. ex Royle	2	0,006	6	*Prunus spinosissima* (Bunge) Franch.	4	0,017
7	*Spiraea pilosa* Franch.	5	0,017	7	*Salsola arbusculaformis* Drobow	4	0,017
8	*Tamarix aralensis* Bunge	9	0,031	8	*Zygophyllum atriplicoides* Fisch. & C.A.Mey.	4	0,017
9	*Tamarix elongata* Ledeb.	9	0,031	9	*Acantholimon erythraeum* Bunge	3	0,013
10	*Tamarix hispida* Willd.	7	0,024	10	*Artemisia ferganensis* Krasch. ex Poljakov	6	0,026
11	*Tamarix meyeri* Boiss.	5	0,017	11	*Salvia bucharica* Popov	4	0,017
12	*Artemisia ferganensis* Krasch. Ex Poljakov	7	0,024	12	*Acanthophyllum gypsophiloides* Regel	4	0,017
13	*Allium giganteum* Regel	4	0,013	13	*Achillea arabica* Kotschy	2	0,008
14	*Allium majus* Vved.	3	0,010	14	*Alhagi canescens* (Regel) Shap.	2	0,008
15	*Anemone baissunensis* Juz. ex M.M.Sharipova	4	0,013	15	*Allium giganteum* Regel	2	0,008
16	*Bromus inermis* Leyss.	6	0,020	16	*Allium griffithianum* Boiss.	2	0,008
17	*Lactuca orientalis* (Boiss.) Boiss.	4	0,013	17	*Allium gypsaceum* Popov & Vved.	2	0,008
18	*Alhagi pseudalhagi* (M.Bieb.) Desv. ex Wangerin	3	0,010	18	*Allium oschaninii* O.Fedtsch.	2	0,008
19	*Arctium anomalum* (Franch.) Kuntze	4	0,013	19	*Anemone baissunensis* Juz. ex M.M.Sharipova	3	0,013
20	*Capparis spinosa* L.	5	0,017	20	*Anemone petiolulosa* Juz.	4	0,017
21	*Cichorium intybus* L.	3	0,010	21	*Arctium refractum* (Bornm.) S.López, Romasch., Susanna & N.Garcia	4	0,017
22	*Convolvulus arvensis* L.	5	0,017	22	*Artemisia oliveriana* J.Gay ex Besser	2	0,008
23	*Crambe cordifolia* subsp. *kotschyana* (Boiss.) Jafri	7	0,024	23	*Carex pachystilis* J. Gay	4	0,017
24	*Crocus korolkowii* Maw & Regel	5	0,017	24	*Corydalis popovii* Nevski ex Popov	2	0,008
25	*Cynodon dactylon* (L.) Pers.	6	0,020	25	*Cousinia hamadae* Juz.	5	0,021
26	*Delphinium semibarbatum* Bien. ex Boiss.	8	0,027	26	*Cousinia lanata* C.Winkl.	3	0,013
27	*Echinops leucographus* Bunge	3	0,010	27	*Crocus korolkowii* Maw & Regel	3	0,013
28	*Elwendia capusii* (Franch.) Pimenov & Kljuykov	3	0,010	28	*Eremurus kaufmannii* Regel	2	0,008
29	*Elwendia intermedia* (Korovin) Pimenov & Kljuykov	3	0,010	29	*Eremurus regelii* Vved.	6	0,026
30	*Eremurus luteus* Baker	6	0,020	30	*Ferula kuhistanica* Korovin	5	0,021
31	*Eremurus pubescens* Vved.	3	0,010	31	*Ferula nevskii* Korovin	1	0,004
32	*Ferula tadshikorum* Pimenov	10	0,034	32	*Ferula tadshikorum* Pimenov	10	0,043
33	*Ferula kuhistanica* Korovin	7	0,024	33	*Gagea chomutowae* (Pascher) Pascher	4	0,017
34	*Ferula moschata* (H.Reinsch) Koso-Pol.	4	0,013	34	*Gagea gageoides* (Zucc.) Vved.	4	0,017
35	*Geranium linearilobum* DC.	3	0,010	35	*Gagea kunawurensis* (Royle) Greuter	2	0,008
36	*Haplophyllum bucharicum* Litv.	3	0,010	36	*Gagea vegeta* Vved.	2	0,008
37	*Haplophyllum versicolor* Fisch. & C.A.Mey.	4	0,013	37	*Haplophyllum acutifolium* (DC.) G.Don	3	0,013
38	*Hordeum bulbosum* L.	7	0,024	38	*Inula rhizocephala* Schrenk	4	0,017
39	*Hypericum scabrum* L.	4	0,013	39	*Iris halophila* var. *sogdiana* (Bunge) Skeels	2	0,008
40	*Inula grandis* Schrenk ex Fisch. & C.A.Mey.	9	0,031	40	*Iris songarica* Schrenk	2	0,008
41	*Iris parvula* T.Hall & Seisums	3	0,010	41	*Iris stolonifera* Maxim.	4	0,017
42	*Mediasia macrophylla* (Regel & Schmalh.) Pimenov	4	0,013	42	*Ixiliorion tataricum* (Pall). Schult& Schult	5	0,021
43	*Lepidium ferganense* Korsh.	4	0,013	43	*Malva neglecta* Wallr.	3	0,013
44	*Poa bulbosa* L.	6	0,020	44	*Mediasia macrophylla* (Regel & Schmalh.) Pimenov	2	0,008
45	*Phlomoides labiosa* (Bunge) Adylov, Kamelin & Makhm.	3	0,010	45	*Phlomis bucharica* Regel	3	0,013
46	*Rheum maximowiczii* Losinsk.	7	0,024	46	*Phlomis thapsoides* Bunge	2	0,008
47	*Tragopogon malikus* S.A.Nikitin	3	0,010	47	*Poa annua* L.	2	0,008
48	*Tulipa carinata* Vved.	3	0,010	48	*Poa bulbosa* L.	7	0,030
49	*Sibbaldianthe orientalis* (Juz. ex Soják) Mosyakin & Shiyan	4	0,013	49	*Poa pratensis* L.	4	0,017
50	*Ziziphora pedicellata* Pazij & Vved.	5	0,017	50	*Primula fedtschenkoi* Regel	2	0,008
51	*Onopordum acanthium* L.	5	0,017	51	*Rumex conglomeratus* Murray	2	0,008
52	*Aegilops crassa* Boiss. ex Hohen.	5	0,017	52	*Scorzonera circumflexa* Krasch&Lipsch.	2	0,008
53	*Aegilops triuncialis* L.	3	0,010	53	*Taraxacum officinale* F.H.Wigg.	5	0,021
54	*Artemisia annua* L.	5	0,017	54	*Tulipa korolkowii* Regel	3	0,013
55	*Avena fatua* L.	4	0,013	55	*Tulipa lanata* Regel	2	0,008
56	*Ceratocarpus arenarius* L.	3	0,010	56	*Tulipa tubergeniana* Hoog	7	0,030
57	*Lactuca serriola* L.	3	0,010	57	*Tulipa turkestanica* (Regel) Regel	5	0,021
58	*Medicago lanigera* C.Winkl.&B.Fedtsch.	3	0,010	58	*Arctium umbrosum* (Bunge) Kuntze	3	0,013

59	*Medicago minima* (L.) Bartal.	3	0,010	59	*Artemisia scoparia* Waldst. & Kit.	4	0,017
61	*Papaver refractum* (DC.) K.-F.Günther	4	0,013	61	*Arnebia decumbens* (Vent.) Coss. & Kralik	3	0,013
				62	*Artemisia annua* L.	2	0,008
				63	*Astragalus ammophilus* Kar. & Kir.	3	0,013
				64	*Astragalus baissunensis* Lipsky	3	0,013
				65	*Eremopyrum bonaepartis* (Spreng.) Nevski	2	0,008
				66	*Erodium ciconium* (L.) L'Hér.	3	0,013
				67	*Erodium cicutarium* (L.) L'Hér.	2	0,008
				68	*Leptaleum filifolium* (Willd.) DC.	2	0,008
				69	*Papaver refractum* (DC.) K.-F.Günther	3	0,013
				70	*Ziziphora persica* Bunge	2	0,008
				71	*Ziziphora tenuior* L.	2	0,008
	Σ	290	1		Σ	229	1
	Shannon index (H_1)		4,039		Shannon index (H_1)		4,165

populations was noted in the Kashkadarya region in the territories of Khuzhaipok and Ilondara, averaging 5% abundance. The lowest abundance was found in the Surkhandarya region in Khuzhaakhsar, Chagam and Bibichakka, with an average of 1%. Accordingly, these indicators correlate with the number of *F. tadshikorum* individuals on census plots of 10×10 m^2 (Fig. 5).

Resources

The territory of the Kashkadarya and Surkhandarya regions, the presence of 33422.3 ha. of wild thickets was established, the presence of 104.45 tons of raw materials was determined for possible annual procurement. The indicators of individuals on survey plots of 10 × 10 m in the Surkhandarya region were as follows: the total number of plants varies from 22 to 45 pcs., of which mature individuals from 7 to 17 pcs., for renewal from 4 to 7 pcs. and for operational individuals from 4 to 7 pcs. These indicators in the Kashkadarya region amounted to 30-32/12-13/6-7/6 units (32). Our research from 2020 to 2023 revealed a sharp reduction in the presence of ha. of commercial thickets and, accordingly, the presence of individuals in monitoring sites. To better visualize the resource indicators of *F. tadshikorum* in Uzbekistan, we analyzed the average indicators in the context of the studied cenotic populations isolated in the Kashkadarya and Surkhandarya regions. In 2020, the area of resource significance in the Kashkadarya region amounted to 7620.0 ha. In the context of the studied coenotic populations, the highest indicators were noted on CP-2, CP-9 and CP-10 with an average 1000.0 ha. In 2023, the remaining areas of resource value in these coenopopulations amounted to only 6.36% compared to 2020, an average of 66.6 ha. for each coenopopulation. Accordingly, in the Surkhandarya region, there is a tendency to reduce areas of resource significance, since in 2020 it amounted to 10000.0 ha. and in 2023 these areas decreased by 1200.0 ha. (Fig. 6).

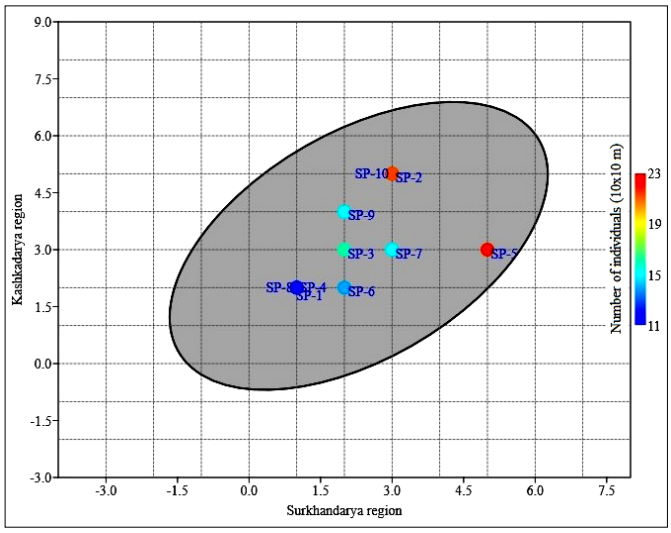


Fig. 5. Abundances of *F. tadshikorum* in the studied cenopopulations in Uzbekistan (%).

The presence of individuals in monitoring sites (10×10 m) of *F. tadshikorum* in the territory Kashkadarya region in 2020 averaged 29.2-32.6 pcs. and in 2023 these figures decreased to 10.5-13.8 units. In the Surkhandarya region, the total number of individuals in 2020 averaged 25.9-30.9

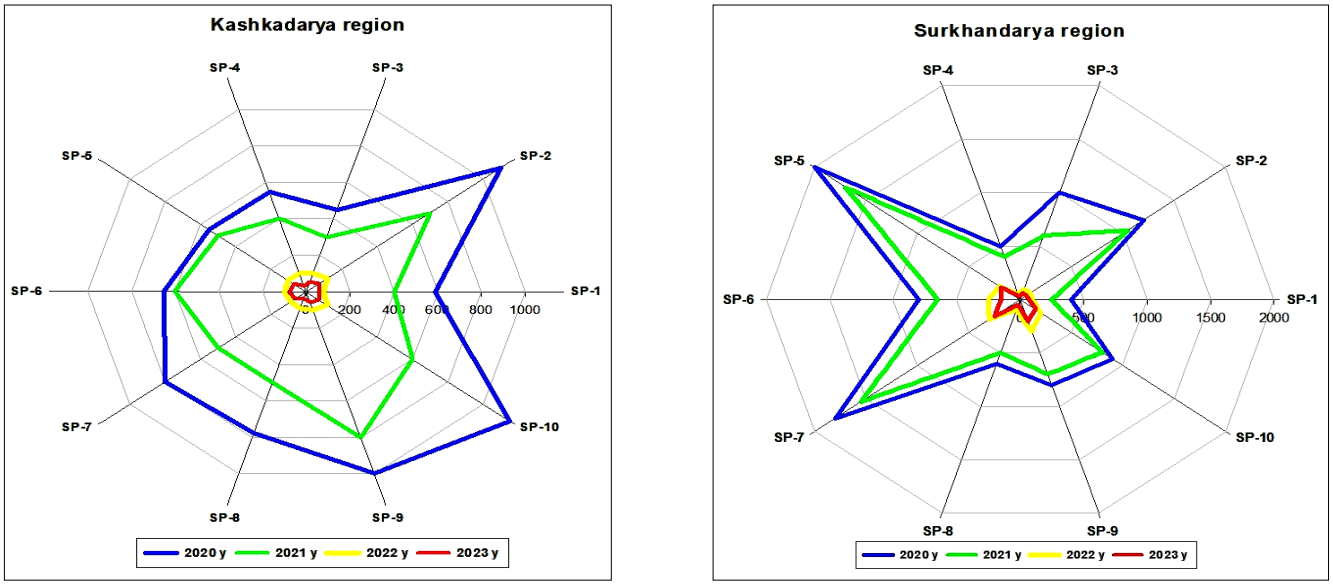


Fig. 6. Dynamics of reduction of areas of resource value of *F. tadshikorum* in Uzbekistan.

pieces. and in 2023, these figures decreased to 9.5-13.2 units. 2020-2023, in both regions, operating individuals decreased on average from 6.2±0.25 units. up to 0.4±0.16 pcs. This means that in Uzbekistan, the operational reserves of *F. tadshikorum* raw materials have been completely reduced (Table 2). Based on field studies from 2020 to 2023, it was found that the stocks of *F. tadshikorum*, due to their increased exploitation, have been almost undermined over the past 10 years. The sites of the former distribution of *F. tadshikorum* are visible to the naked eye since the soil surface is dotted with pits left after harvesting the roots' raw materials (resin). In addition, in all the studied areas, there are a shepherds' shed and a shepherds' house, and a significant number of small and large livestock (about 300-400 heads) are grazed on the territory of the tract; as a result, the slopes are heavily damaged. Most importantly, no specimen of fruiting individuals has been found in the natural distribution area of *F. tadshikorum* in Uzbekistan for 4 yr. (Fig. 7).

Considering the above and the analysis of research results, the current state of *F. tadshikorum* resources in Uzbekistan was established. To date, the area of resource value in the territory of Kashkadarya region averages 600.0 ha. and in the territory of Surkhandarya region on average 1200.0 ha. In turn, the reserves of raw materials in the Kashkadarya region are 3.2 tons and in the Surkhandarya region, 5.3 tons. Accordingly, these indicators correlate with the indicators of monitoring sites (presence and condition of individuals) studied in the context of coenotic populations (Table 2). Considering that the indicators of the resource

Fig. 7. Changes in natural thickets of *F. tadshikorum* in Uzbekistan.

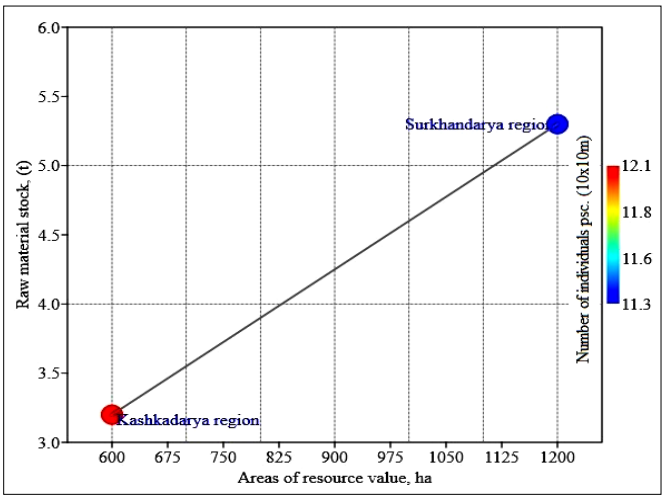


Fig. 8. Resources of *F. tadshikorum* in Uzbekistan (2023).

value of *F. tadshikorum* in Uzbekistan are biological reserves, these reserves are not subject to exploitation (Fig. 8).

Discussion

The highest abundance rates of *F. tadshikorum* in the studied coenotic populations were observed in forb-bluegrass and forb-shrub-juniper communities. According to the analysis of constant and differential species in the studied coenotic populations in the Kashkadarya region, the highest indicators were noted in CP-3 and CP-8. In these coenopopulations, the number of constant species averaged 16-18 and differential species averaged 22-23. These indicators in the Surkhandarya region were noted at CP-5 and CP-7, where the number of constant species was reported on average 18-19 and differential species on

Table 2. Indicators of reduction in the presence of *F. tadshikorum* individuals in monitoring sites

Years	Number of individuals 10×10 m (pcs.)	Monitoring sites									
		CP-1	CP-2	CP-3	CP-4	CP-5	CP-6	CP-7	CP-8	CP-9	CP-10
Kashkadarya region											
2020	Total quantity	31.4±0.54	30.8±0.81	32.6±0.72	29.2±0.81	30.6±0.75	30.9±1.09	30.4±1.19	31.6±0.73	29.9±2.27	31±0.93
	Mature	16.1±0.35	13.1±0.55	14.3±0.45	14.4±0.91	13.5±0.56	12.9±0.59	13.1±0.66	13.1±0.55	12.5±0.82	13.6±0.60
	For resumption	10.4±0.27	7.1±0.41	8±0.37	8.1±0.57	7.5±0.43	7.1±0.41	7.3±0.45	7.1±0.41	6.9±0.46	7.7±0.50
	For use	5.5±0.17	6±0.21	6.2±0.25	6.3±0.37	6±0.21	5.8±0.29	5.8±0.29	6±0.21	5.6±0.45	5.9±0.23
2021	Total quantity	30.1±1.99	29.2±1.78	30.9±1.10	28.1±1.82	28.8±1.74	28.7±1.81	27.1±1.81	30.4±1.79	24.6±0.87	22.4±1.50
	Mature	12.6±0.75	12.8±063	13.2±0.55	12.9±0.59	12.2±0.33	12.1±0.31	11.8±0.55	12.6±0.75	11.6±0.48	11.7±0.56
	For resumption	7.4±0.50	7±0.72	7.3±0.40	7.1±0.41	7.1±0.38	6.9±0.23	6.9±0.41	6.9±0.46	6.7±0.26	6.6±0.22
	For use	5.2±0.33	5.8±0.29	5.9±0.23	5.8±0.29	5.5±0.27	5.2±0.25	4.9±0.28	5.7±0.37	4.9±0.31	5.1±0.46
2022	Total quantity	28.9±0.95	23.7±0.72	22.7±1.11	19.1±0.60	19.4±0.70	19.7±0.75	16.9±0.71	18.3±0.60	15.3±0.67	16.2±0.55
	Mature	11.7±0.26	10.8±0.39	10.8±0.49	9.6±0.45	9.2±0.25	9.1±0.38	7.7±0.52	8.1±0.50	6.4±0.50	7.4±0.45
	For resumption	7.5±0.17	6.6±0.22	6.7±0.33	5.7±0.30	5.9±0.10	5.8±0.20	5.1±0.23	5.2±0.25	4.6±0.27	5±0.21
	For use	4.8±0.29	4.2±0.20	4.1±0.23	3.9±0.18	3.2±0.25	3.3±0.21	2.6±0.31	2.9±0.28	1.8±0.25	2.4±0.27
2023	Total quantity	13.8±0.5	15.1±0.69	13.3±0.50	12.2±0.42	11.6±0.37	11.7±0.42	11.8±0.55	12.7±0.52	10.9±0.53	10.5±0.50
	Mature	5.6±0.45	5.4±0.37	4.9±0.28	4.8±0.25	4.6±0.22	4.1±0.31	3.6±0.22	5.2±0.29	3.9±0.31	3.8±0.36
	For resumption	4±0.26	3.9±0.23	3.8±0.20	3.6±0.16	3.5±0.17	3±0.26	2.6±0.22	4±0.15	3.1±0.23	3.1±0.23
	For use	1.6±0.22	1.5±0.17	1.1±0.10	1.2±0.13	1.1±0.10	1.1±0.10	0.8±0.13	1.3±0.15	0.8±0.13	0.7±0.15
Surkhandarya region											
2020	Total quantity	30.9±0.74	31.9±0.48	30.4±0.22	28.5±0.52	25.9±0.64	31.2±0.59	30.1±1.02	30.9±0.77	30.6±1.00	29.3±1.15
	Mature	15.8±0.44	16.5±0.31	14.8±0.39	15.9±0.59	16.2±0.36	15.8±0.47	16.8±0.36	16.4±0.45	15.9±0.41	15.5±0.60
	For resumption	10.4±0.27	10.6±0.27	9.6±0.37	12.9±3.01	10.3±0.30	10.2±0.36	10.4±0.27	10.5±0.27	10.4±0.27	10±0.42
	For use	5.2±0.25	5.7±0.15	5.3±0.26	6±0.54	5.7±0.21	5.4±0.16	6.2±0.36	5.7±0.30	5.3±0.21	5.5±0.17
2021	Total quantity	26.8±0.49	23.8±0.66	23.1±0.57	23.3±0.52	20.6±0.92	22.9±0.67	23.3±0.79	25.1±0.67	23.2±0.81	23.5±0.60
	Mature	14.3±0.54	13.3±0.40	13.2±0.36	13.3±0.42	10.6±0.40	11.5±0.64	10.7±0.42	11.3±0.40	11.6±0.56	12.6±0.67
	For resumption	9.2±0.29	9.1±0.35	9.1±0.31	9.1±0.35	6.7±0.26	7±0.42	6.4±0.22	6.7±0.21	6.9±0.41	7.5±0.50
	For use	5.1±0.38	4.2±0.20	4.1±0.10	4.2±0.13	4.1±0.28	4.5±0.27	4.4±0.31	4.6±0.22	4.7±0.21	5.1±0.23
2022	Total quantity	17.6±0.56	14.2±0.66	15.3±0.45	15.7±0.52	14.4±0.86	15.5±0.79	15.1±0.71	17.1±0.46	16.6±0.52	16.2±0.76
	Mature	9.5±0.34	7.9±0.41	7.5±0.45	8.2±0.47	6.6±0.40	6.9±0.48	7.3±0.68	9.1±0.48	8.2±0.68	7.4±0.56
	For resumption	5.8±0.13	5.3±0.21	5±0.26	5.3±0.21	4.5±0.27	4.7±0.26	4.9±0.28	5.5±0.27	5.2±0.29	5.1±0.28
	For use	3.7±0.26	2.6±0.22	2.5±0.22	2.9±0.28	2.1±0.18	2.2±0.25	2.4±0.43	3.5±0.27	3±0.42	2.3±0.30
2023	Total quantity	13.2±0.57	11.5±0.48	10.4±0.31	10.2±0.33	9.5±0.43	9.8±0.51	11.4±0.54	11.5±0.43	10.2±0.42	10.7±0.40
	Mature	5.2±0.29	4.3±0.30	4.7±0.30	3.6±0.31	3.4±0.34	3.6±0.37	4.3±0.37	4.1±0.31	3.7±0.45	4.3±0.30
	For resumption	3.9±0.18	3.4±0.16	3.7±0.15	3.1±0.18	3±0.21	3.1±0.23	3.7±0.22	3.3±0.15	3±0.26	3.4±0.16
	For use	1.3±0.15	0.9±0.18	1.1±0.18	0.5±0.17	0.4±0.16	0.5±0.17	0.9±0.18	0.8±0.20	0.7±0.21	0.9±0.18

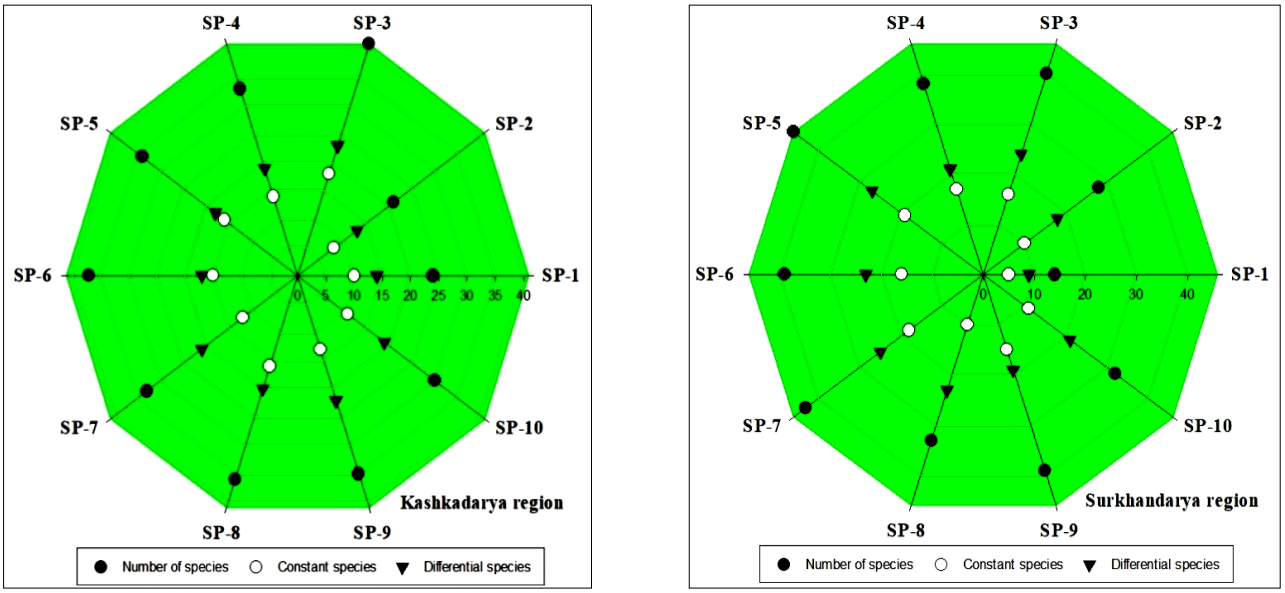


Fig. 9. Constant and differential types of the studied CP with the participation of *F. tadshikorum.*

average 25-27. In turn, it should be noted that annual plants in the studied coenotic populations are not permanent species (Fig. 9). According to the analysis of constant species in the studied coenotic populations in the context of the Kashkadarya and Surkhandarya regions, seven constant species were identified, such as *Juniperus seravschanica, Prunus bucharica, Allium giganteum, Crocus korolkowii, Ferula kuhistanica, Mediasia macrophylla, Poa bulbosa.* The discovery of these species in both regions indicates that the phytocenoses of *F. tadshikorum* growing are ecologically similar in soil type (fine gravel) (34).

Unreliable materials on the study of F. tadshikorum in Uzbekistan

There are some unreliable materials on the state of natural resources of *F. tadshikorum* in Uzbekistan. During the growing season of 2021, the biological stock of the plant in the Kashkadarya and Surkhandarya regions of the republic was about 22000 tons. Accordingly, the operational stock of raw materials is 2.9 tons (29). Unfortunately, researchers did not follow any methodology or present reliable materials; information is provided on the state of raw materials reserves in Uzbekistan. In particular, without referring to more than one method for determining the resources of plant raw materials, the authors established the presence of plant individuals of different ages on registration plots of 10 × 10 m^2 in the territory of the Kashkadarya region. There is no information on the status of *F. tadshikorum* individuals in the Surkhandarya region since the study of determining the habitats and stocks of *F. tadshikorum* in the flora of the Kashkadarya and Surkhandarya regions of the Republic of Uzbekistan. In addition, the data presented on the accounting of raw materials inventories are primary materials and have not been processed. The authors did not hesitate to copy texts from different sources entirely without the slightest change and reference (32). The study did not determine resources for *F. tadshikorum* and raw plant materials. This also requires specific considerations on the part of the journals' editors.

Accordingly, unreliable materials similar to the above are noted in the work (33). This article shows explicitly that the author did not know any methods in the field of plant study and could not even write the scientific name of the plant correctly, in addition, it is not clear what language the article is written in since the data is presented in four (Uzbek, Tajik, Russian and English) languages. This also requires specific justification from the author and proceedings from the journals' editorial board. Considering the above, it is necessary to present reliable scientific results on the state of natural resources of *F. tadshikorum* in Uzbekistan. Compared with the indicators of 2020-2023, the presence of individuals in monitoring sites (10 × 10 m^2) of *F. tadshikorum* in the territory of the Kashkadarya region revealed a decrease in the total number of individuals by 56.1%. Accordingly, these indicators correlate with operational bushes. Since 2023, the number of mature plant individuals has been reduced by 65.3% and the number of operational ones has been reduced by 71%. These indicators in the Surkhandarya region were reduced from 57.3% to 75%. The main factors for the reduction in the number of *F. tadshikorum* individuals in the studied areas are anthropogenic impacts (collection of resin and seeds, grazing, etc.) (Fig. 10). The Institute of Botany of the Academy of Sciences of the Republic of Uzbekistan is the only organization in the field of studying plant resources in Uzbekistan. Analyze the results of scientific research to determine the reserves of wild thickets of raw materials *F. tadshikorum*. Over the past 9 years, a trend has been established for a sharp reduction in reserves of raw materials and the area of plant thickets. Compared to the resource indicators in 2015, in 2023, the area of commercial thickets decreased by 96%. The stock of raw materials decreased by 83% (Fig. 11). Despite the declared moratorium for three years on the use of natural resources of *F. tadshikorum* in Uzbekistan, based on Decree of the President of the Republic of Uzbekistan No. 24 dated February 16, 2023, in 2023 mass collections of raw materials (resin) of plants were identified in places of natural distribution (Fig. 12). Considering the above facts, urgent strengthening of control over the use of natural thickets of *F. tadshikorum* by environmental organizations is required.

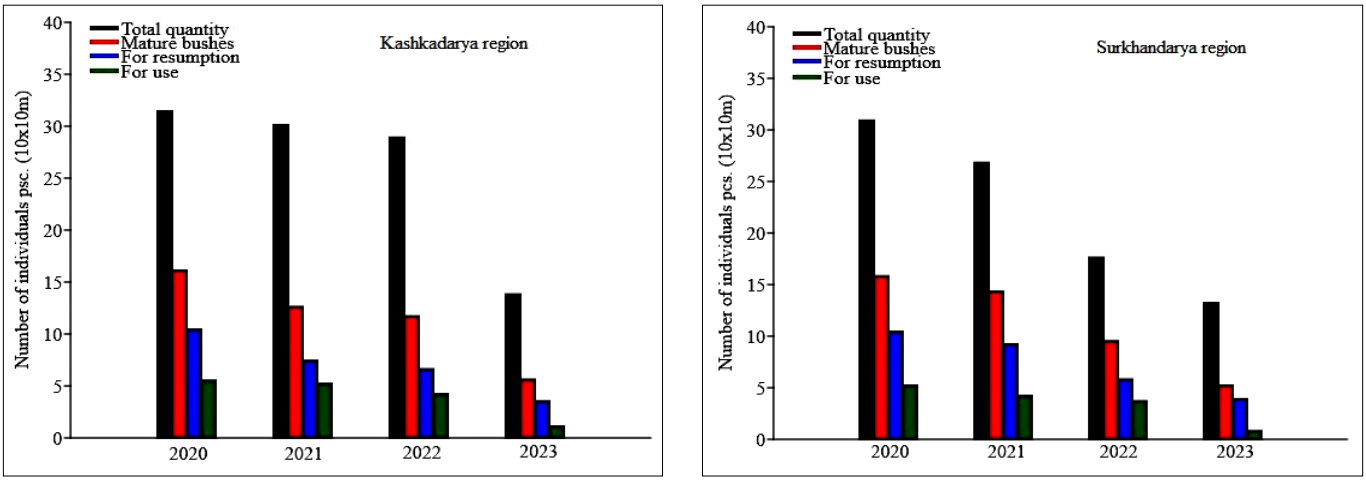


Fig. 10. Dynamics of population decline of *F. tadshikorum* in Uzbekistan.

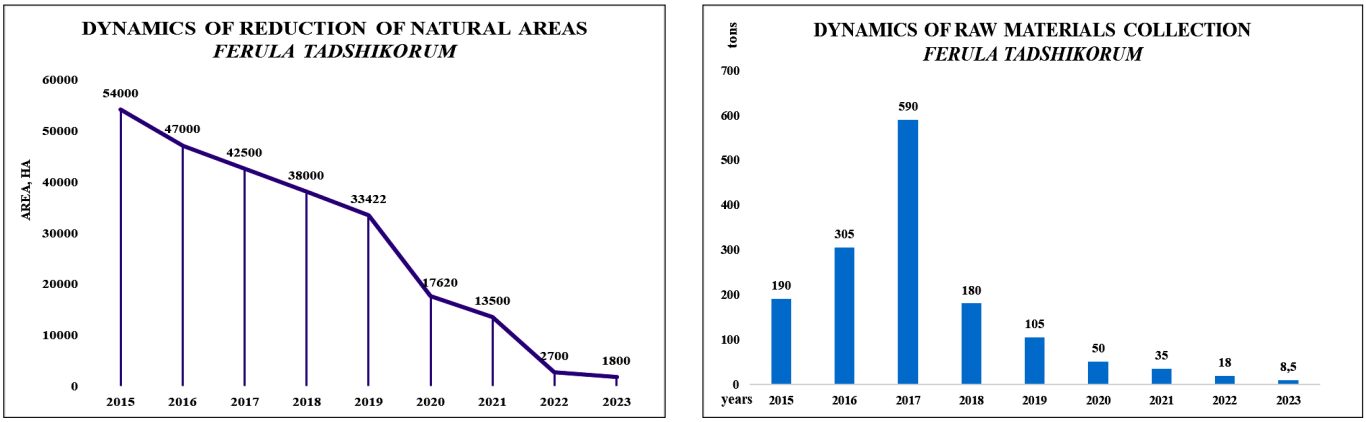


Fig. 11. Dynamics of reduction in raw material reserves and area of *F. tadshikorum* thickets in Uzbekistan.

Kashkadarya region (Buztepa CP-1)

Surkhandarya region (Hazratbobo CP-3)

Fig. 12. Samples of *F. tadshikorum* marked in 2023 for the collection of raw materials at places of natural distribution in Uzbekistan.

Conclusion

Analyzing the long-term scientific results, the operational reserves of *F. tadshikorum* raw materials in Uzbekistan have been drastically reduced. Currently, the populations of the species are mainly preserved in the border zone, or the neutral zone of the state border of the republic and in some areas of forestry. The only way to protect and restore natural populations of *F. tadshikorum* is a complete ban on the procurement of raw materials (resin) for 8-10 yr and given that this type of *Ferula*, which is a monocarp, should be prohibited from collecting seeds for 5 years. The continuation of using natural resources for this species will be the basis for increasing its status in the "Red Book" of the Republic of Uzbekistan. In the end, the species will be lost entirely from the flora of Uzbekistan. To ensure the valuable raw materials of *F. tadshikorum*, we recommend sapling plantations in places of natural regeneration. This will undoubtedly reduce the burden on natural populations and ensure the requirements for plant raw materials.

Acknowledgements

The work was carried out within the framework of the state scientific and technical program Assessment of the current state of populations and the creation of a living collection of economically valuable species of wild relatives of cultivated plants of the flora of Uzbekistan of the laboratory"Population Biology and Plant Ecology, Grid mapping of the flora of South -West Gissar, Gissar-Darvaz and Pripyanj districts (within the Surkhandarya region) of the laboratory Flora of Uzbekistan, project AL-5822012274, Development of optimal technology for sowing medicinal species *Ferula* L. in the Navoi region and economic agreements between environmental entities and the Institute of Botany of the Academy of Sciences of the Republic of Uzbekistan.

Authors' contributions

All the authors conducted equally fieldwork, data collection, data analysis, data generation and manuscripts. All authors read and approved the manuscript.

Compliance with ethical standards

Conflict of interest: The author declares that the provided information has no conflict of interest.

Ethical issues: None

References

1. Delgado MdM, Roslin T, Tikhonov G, Meyke E, Lo C, Gurarie E, et al. Differences in spatial versus temporal reaction norms for spring and autumn phenological events. Proceedings of the National Academy of Sciences. 2020;117(49):31249–58. https://doi.org/10.1073/pnas.2002713117
2. Mahmudov AV, Abduraimov OS, Erdonov ShB, Gayibov UG, Izotova LYu. Bioecological features of *Nigella sativa* L. in different conditions of Uzbekistan. Plant Science Today. 2022;9(2):421–6. https://doi.org/10.14719/pst.1510
3. Roslin T, Antao L, Hällfors M, Meyke E, Lo C, Tikhonov G, et al. Phenological shifts of abiotic events, producers and consumers across a continent. Nature Climate Change. 2021;11(3):241–8. https://doi.org/10.1038/s41558-020-00967-7
4. Mahmudov AV, Abduraimov OS, Erdonov ShB, Allamurotov AL, Mamatkasimov OT, Gayibov UG, Izotova LYu. Seed productivity of *Linum usitatissimum* L. in different ecological conditions of Uzbekistan. Plant Science Today. 2022;9(4):1090–101. https://doi.org/10.14719/pst.1792
5. Ovaskainen O, Meyke E, Lo C, Tikhonov G, Delgado MdM, Roslin T, et al. Chronicles of nature calendar, a long-term and large-scale multitaxon database on phenology. Scientific Data. 2020;7(1):47. https://doi.org/10.1038/s41597-020-0376-z
6. Raxmonov X. Biology and resources *Ferula tadshikorum* M. Pimen. in South Tajikistan. PhD [dissertation]. Dushande: Tadjikistan; 2017.
7. Pimenov MG. Updated checklist of the Umbelliferae of Middle Asia and Kazakhstan: nomenclature, synonymy, typification, distribution. Turczaninowia. 2020;23(4):127–257. https://doi.org/10.14258/turczaninowia.23.4.12
8. Raximov S. Peculiarities of ontogeny of some representatives of the flora of the semi-savannans of the Western Pamir-Alai. [Abstract of the dissertation of a doctor of sciences]. Novosibirsk: Russian; 2007
9. Raximov S. Biological and morphological features of ferula (*Ferula* L.) in Tajikistan. PhD [dissertation]. Dushanbe: Tadjikistan; 2010.
10. Beknazarova X, Navruzshoev D. Biological and morphological features of *Ferula gigantea* V. Fedch. in the conditions of the Pamir botanical garden. Reports of the Academy of Sciences of the Republic of Tajikistan. 2014;57:321–6.
11. Safina L, Pimenov M. Ferulas of Kazakhstan. Alma-Ata. The Science. 1984;160.
12. Kiryalov N. A new coumarin from the roots of *Ferula pseudooreoselinum*. Chemistry of Natural Compounds. 1973;3:425–7. https://doi.org/10.1007/BF00565702
13. Kiryalov N. On the structure of samarkandin and samarkandu-on-coumarin compounds of *Ferula samarkandica*. Chemistry of Natural Compounds. 1968;2:73–6.
14. Kiryalov N. Coumarin from plants of the genus *Ferula* L. Plant Raw Materials. 1965;12:82–91.
15. Kiryalov N. Dihydroconferin from *Ferula tadshikorum*. Chemistry of Natural Compounds. 1980;1:122–3.
16. Saxobiddinov S. Wild medicinal plants of Central Asia. Tashkent (Uzbekistan);1948.
17. Sadykov Y. Biologically active substances of wild medicinal plants in Tajikistan: Content, biosynthesis and practical use. PhD [dissertation]. Dushanbe: Tadjikistan; 2023.
18. Small E. Top 100 exotic food plants. CRC Press; 2011. https://doi.org/10.1201/b11391
19. Sharopov FS, Khalifaev PD, Satyal P, Sun Y, Safomuddin A, Musozoda S, et al. The chemical composition and biological activity of the essential oil from the underground parts of *Ferula tadshikorum* (Apiaceae). Records of Natural Products. 2019;13(1):18–23. https://doi.org/10.25135/rnp.65.18.02.089
20. Pimenov M. New species of *Ferula* from the subgenus Narthex (Falcon.) Drude. Biulleten. 1974.
21. Avalbaev O. The biology of flowering of some Pamir-Alai species of the genus *Ferula* L. American Journal of Plant Sciences. 2018;9(8):1740–6. https://doi.org/10.4236/ajps.2018.98126
22. Yaqoob U, Nawchoo IA. Distribution and taxonomy of *Ferula* L. A review: Journal of Botany. 2016;5(3):15–23.

23. Pimenov M, Tojibaev K, Sennikov A, Khassanov F, Beshko N. Taxonomic and nomenclatural inventory of the Umbelliferae in Central Asia, described on the basis of collections of the National Herbarium of Uzbekistan. Plant Diversity of Central Asia. 2022;1 (1):21. https://doi.org/10.54981/PDCA/vol1_iss1/a2
24. Yang L, Hisoriev H, Kurbonova P, Boboev M, Bobokalonov K, Feng Y, et al. High genetic diversity and low differentiation of endangered *Ferula tadshikorum* Pimenov in Tajikistan. Global Ecology and Conservation. 2021;28:e01627. https://doi.org/10.1016/j.gecco.2021.e01627
25. Khassanov F. The Red Data Book of the republic of Uzbekistan. Tashkent: Uzbekistan. 2019; 356 p.
26. The Red Data Book of the Republic of Tajikistan. Dushanbe: Tajikistan. 1988; 336 p.
27. Hisoriev H. The Red Data Book of Tajikistan. Second addition. Dushanbe: Tajikistan. 2015; 230 p.
28. Khamraeva D, Khojimatov O, Uralov A. Growth and development of *Ferula tadshikorum* Pimenov in culture. Acta Biologica Sibirica. 2019;5(3):172–7. https://doi.org/10.14258/abs.v5.i3.6588
29. Urinova A, Tulaev J, Choriev B, editors. Determination of distribution areas and reserves for state accounting of Tajik Kavrak (*Ferula tadshikorum* Pimenov) resources in the flora of Surkhandarya and Kashkadarya provinces, Uzbekistan. E3S Web of Conferences; 2023. 376:02011. https://doi.org/10.1051/e3sconf/202337602011
30. Halkuzieva M, Abduazizov B, Sobirova M, Usmonova B. Growth and development of *Ferula foetida* Regel (Bunge) and *Ferula tadshikorum* Pimenov species in different environments. E3S Web of Conferences. 2023;421:04006. https://doi.org/10.1051/e3sconf/202342104006
31. Khamraeva D, Tukhtaeva D, Khojimatov O, Bussmann RW. *Ferula tadshikorum* Pimenov-introduction, chemical composition and use in folk medicine. Ethnobotany Research Applications. 2023;25:1–10. http://dx.doi.org/10.32859/era.25.24.1-10
32. Khojimatov OK, Khamraeva DT, Malsev I. Atlas of wild medicinal plants of Uzbekistan. Tashkent: Uzbekistan [internet]. 2019. Available from: https://planta-medica.uz/ferula-tadshikorum-pimenov-ferula-tadzhikov/].
33. Sharipov A. *Ferula tadshikorum* Pimenov geographical distribution modeling and climate change impact assessment on the distribution area of the species. International Journal of Biological Engineering and Agriculture. 2023;2(4):1–11. https://inter-publishing.com/index.php/IJBEA/article/view/1395
34. Khojimatov OK, Xamraeva DT, Maxmudov AV, Xujanov A. Instructions for seed cultivation of *Ferula tadshikorum* Pimenov in the conditions of southern Uzbekistan. Tashkent: Uzbekistan: Muxr Press; 2019. 24 p.
35. Khojimatov OK, Bussmann RW. Ethnobiology of Uzbekistan: Springer Science and Business Media LLC; 2023. https://doi.org/10.1007/978-3-031-23031-8
36. Beshko NY, Abduraimov OS, Kodirov UK, Madaminov F, Mahmudov AV. The current state of cenopopulations of some endemic and rare species of the genus *Tulipa* L.(Liliaceae) in the Tashkent region (Uzbekistan). Arid Ecosystems. 2023;13(3):294–304. https://doi.org/10.1134/S2079096123030034
37. Abduraimov OS, Maxmudov AV, Kovalenko I, Allamurotov AL, Mavlanov BJ, Saribaeva US, Mamatkasimov OT. Floristic diversity and economic importance of wild relatives of cultivated plants in Uzbekistan (Central Asia). Biodiversitas Journal of Biological Diversity. 2023;24(3). https://doi.org/10.13057/biodiv/d240340
38. Saribaeva SU, Shomurodov KF, Abduraimov OS. Ontogenesis and ontogenetic structure of local populations of the *Astragalus holargyreus* Bunge (Fabaceae) of the narrow-local endemic of Kyzylkum. Arid Ecosystems. 2022;12(1):78–84. https://doi.org/10.1134/S2079096122010103
39. Abduraimov OS, Maxmudov AV, Abduraimov AS. Current state of local populations *Tulipa greigii* Regel (Liliaceae) in Uzbekistan. E3S Web of Conferences; 2022. 351:01093. https://doi.org/10.1051/e3sconf/202235101093
40. Abduraimov OS, Li W, Shomurodov HF, Feng Y. The main medicinal plants in arid regions of Uzbekistan and their traditional use in folk medicine. Plants. 2023;12(16):2950. https://doi.org/10.3390/plants12162950
41. Pupikina KA, Xasanova SR, Kudashkina NV, Galiaxmetova EX, Shakirova R. Resource science and standardization of medicinal plant raw materials. Ufa: Russian; 2019. 117 p.
42. Lavrenko EM, Korchagin A. Field geobotany. Moscow: Russian; 1964.
43. Key to plants of Central Asia. Critical summary of flora. Tashkent: Uzbekistan; 1981. 41–43 p.
44. Key to plants of Central Asia. Tashkent: Uzbekistan; 1987. 6–175 p.
45. POWO. Plants of the world online [internet]. Kew:Royal Botanic Gardens. 2024 [cited 24 Oct 2024]. Available from: https://powo.science.kew.org/.
46. The Plant List. Plant list organization [internet]. 2024 [cited 24 Oct 2024]. Available from: http://www.theplantlist.org/
47. IPNI. International Plant Names Index. Published [Internet]. Kew:The Royal Botanic Gardens. 2024 [cited 24 Oct 2024]. Available from: https://www.ipni.org/
48. Cao Q, Wei Y, Li W, Feng Y, Abduraimov OS. The distribution characteristics of vegetation in the Subrange of the Altai mountains, Xinjiang. Plants. 2023;12(22):3915. https://doi.org/10.3390/plants12223915
49. Saribaeva S, Abduraimov O, Allamuratov A. Assessment of the population status of *Allium Oschaninii* O. Fedtsch. in the mountains of Uzbekistan. Ekológia (Bratislava). 2022;41(2):147–54. https://doi.org/10.2478/eko-2022-0015
50. Yang L, Abduraimov O, Tojibaev K, Shomurodov K, Zhang YM, Li WJ. Analysis of complete chloroplast genome sequences and insight into the phylogenetic relationships of *Ferula* L. BMC Genomics. 2022;23(1):643. https://doi.org/10.1186/s12864-022-08868-z