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Ecological and biological features of some rare and endemic plant species of south-east Kazakhstan

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Abstract. The article presents the results of ecological and biological analysis of species composition of five rare and endangered endemic plant species of southeastern Kazakhstan listed in the Red Book of the Republic of Kazakhstan. The importance of this research topic is determined by the need for a comprehensive and in-depth understanding of the ecological and biological characteristics of rare plant species growing in the southeast of Kazakhstan. The studies were conducted in the southeast of Kazakhstan (Zailiysky Alatau, Ketpen), where the objects of the study were representatives of rare and endangered endemic plant species: *Astragalus rubtzovii* Boriss, *Taraxacum kok-saghyz* L.E. Rodin., *Schmalhausenia nidulans* (Regel) Petr. *Betula Jarmolenkoana* Golosk., *Rheum wittrockii* Lundstr., from natural populations. The study of the state of the coenopopulation of rare and endemic plant species was carried out by route and semi-stationary methods. The novelty of the work is that for the first time the most complete ecological and biological characteristics of rare and endangered endemic plant species of the southeast of Kazakhstan are given, their biological features and habitat characteristics are studied. In the study area, 5 identified rare and endangered endemic plant species are represented by 2 types of life forms, where the predominant group among rare and endemic species is hemiocryptophytes (perennial plants) and one species is represented by a phanerophyte - a woody plant (Betula jarmolenkoana).

Keywords: rare and endangered endemic plant species, population, environmental factors, biodiversity.

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Introduction

Currently, the problem of preserving biodiversity has become the most pressing due to the increasing anthropogenic impact on the environment (Concept for the development and placement of specially protected natural areas until 2030 in the Republic of Kazakhstan; "Concept for the transition of the Republic of Kazakhstan to sustainable development for 2007-2024"; Law of the Republic of Kazakhstan dated 17.06.2008 N 43-IV "On ratification of the Cartagena Protocol on Biosafety to the Convention on Biological Diversity") [1]. The study of these species helps to learn their ecological and biological characteristics, distribution, and the reasons for their disappearance. This allows us to develop effective measures for the conservation and restoration of endangered plant species and their habitats. Nowadays, there is a significant depletion of the gene pool of plants of the natural flora, and especially relict species, some of which are rare and are on the verge of extinction. Relict plant species have great scientific value as a reliable source of information about the vegetation of past geological eras. Over 90% of recent human-caused extinctions are wild species known from only one nation. These nationally endemic species represent one of the greatest global conservation responsibilities for any country. To meet this responsibility, we must first identify nationally endemic species [2]. Rare and endangered plant species play an important role in maintaining the ecological balance, providing food, shelter, and medicinal resources for many animals, as well as humans. Studying these species helps to learn their ecological and biological characteristics, distribution, and the reasons for their extinction. This allows us to develop effective measures to preserve and restore endangered plant species and their habitats. Nowadays, there is a significant depletion of the gene pool of plants of the natural flora, and especially relict species, some of which are rare and are on the verge of extinction. Relict plant species have great scientific value as a reliable source of information about the vegetation of past geological eras.

The need to study the rare, endemic, and relict mountain flora of southeastern Kazakhstan in general and its constituent elements in particular is constantly increasing due to excessive and long-term exploitation of mountain pastures, leading in some cases to irreversible changes in biocenoses, reduction of habitats, and the disappearance of rare and endangered endemics and subendemics. The limited distribution characteristic of endemic species makes them very vulnerable to adverse natural and anthropogenic impacts. Intensive economic activity, which remains at a high level in the vicinity of populated areas even now, leads to the destruction of the natural habitat. As a result, there is a threat of destruction of individual species, especially rare ones and those with limited distribution. Solving practical problems of protecting scientifically and practically valuable plant species is impossible without studying biology, including an ecological assessment of the state of their populations.

Recently, there has been increased interest in the study of rare and endemic plant species among foreign researchers all over the world. [3-11]. Conservation of endemic species is becoming an important task for preserving the uniqueness and value of regional flora, such as the southeast of Kazakhstan.

The aim of this work was to study the bioecological features of rare and endangered endemic plant species of the southeast of Kazakhstan for further development of a strategy for their protection.

The main tasks were to study and research the ecology of species, the structure of their populations, the features of phenological development and the viability of individuals in a natural environment, and to develop recommendations for the protection of unique species of the southeast of Kazakhstan.

Materials and methods

The material for this work was field research on the study of rare, endemic and endangered species of flora of the south-east of Kazakhstan. The object of the study was rare, endemic and endangered species of natural flora of the south-east of Kazakhstan. The main research method was route-reconnaissance. Collection and processing of herbarium material was carried out according to the generally accepted method of A.K. Skvortsov [12]. In the process of defining the herbarium, the following multi-volume summaries were used as sources: "Flora of Kazakhstan" [13], “Trees and shrubs of Kazakhstan” [14], " Key to plants of Middle Asia" [15], "Illustrated Identifier of Plants of Kazakhstan" [16]. The arrangement of species and supraspecific categories in the summary, disappearing rare, endemic and subendemic species was carried out according to the system of A.L. Takhtadzhyan [17,18]. To clarify the species and generic names, the latest summaries of S.K. Cherepanov, S.A. Abdulina [19, 20] were used. The types of life forms were carried out according to the classifications of K. Raunkier and I.G. Serebryakov [21]. When analyzing rare, endemic and subendemic species, the schemes developed by B.A. Bykov, A.I. Tolmachev and R.V. Kamelin were used [22, 23, 24].

Results and discussion

The territory occupying the southeastern part of Kazakhstan is called Zhetysu, it includes the large mountain system of the Northern Tien Shan, which is of great interest to researchers. The Northern Tien Shan system includes the following ranges: Zailiysky Alatau, Kungei Alatau, Ketpen, Kyrgyz Alatau, Chu-Ili Mountains. The Northern Tien Shan is a relatively young mountainous country created by block uplifts and folding on the site of an old, previously existing, but strongly leveled one (Figure 1).

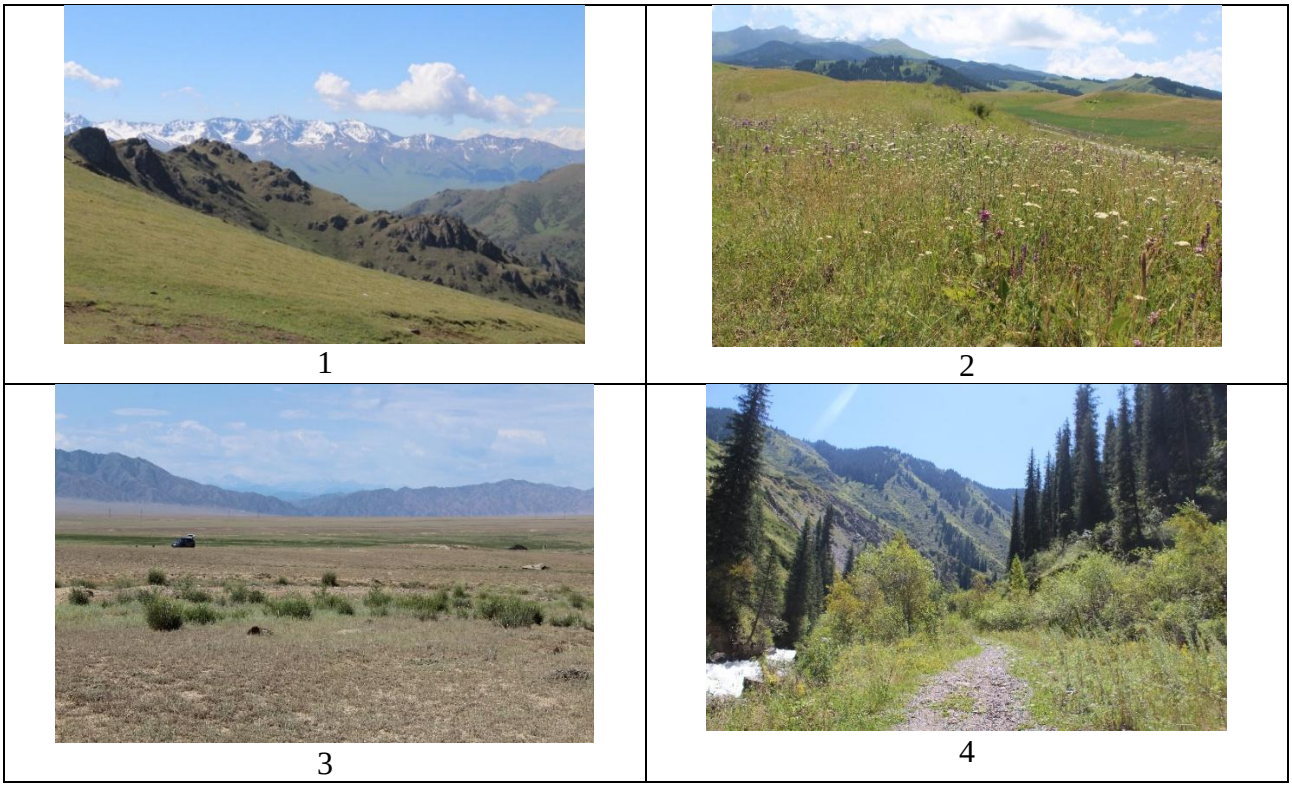

Figure 1. Ridges of the Northern Tien Shan 1. Ketpen ridge. 2. Kungey Alatau ridge. 3. Sugatinskaya Valley. 4. Zailiysky Alatau, Turgen gorge

Later, the uplifts and folds were subjected to various relief changes, especially river erosion. In addition, an important role in the formation of the high-mountain relief of the Northern Tien Shan was played by ancient glaciation, which left trough valleys and glacial cirques. The Northern Tien Shan has a very complex mountainous relief. Along with the main high ridges of the Zailiysky Alatau and Kungey-Alatau, there are intramountain depressions, valleys, foothill sloping plains and other relief forms. Thus, the Zailiysky Alatau in the eastern part behind the Talgar massif breaks up into a number of spurs (Sarytau, Karash, etc.), separated by intramountain depressions and plateaus. All three main groups of mountain relief types are represented in the Northern Tien Shan mountains: mountain complex, foothill complex and complex of relief types of intramountain depressions. The main difference of the first relief type is that it has a high position (over 3000 m) and occupies the watershed-central parts of the main ridges. A characteristic element of the second type are deep troughs - valleys, once occupied by a glacier, cutting through the mountain slopes [25]. Troughs are found on the northern and southern slopes of the Zailiysky Alatau and Kungey-Alatau. The intramountain depressions are plains raised to various absolute heights. These include the Ili and Kegen depressions. The crests of the watershed ranges are dissected relatively shallowly for the most part. Only the Talgar massif in the Zailiysky Alatau, the Choktal massif and the area of the Kant-Bas-Tau peak in the Kungey-Alatau and some lateral spurs are characterized by steep-sloping high-mountain relief. The climate features of the study area are determined by the fact that the territory of the Northern Tien Shan belongs to the desert zone [25].

Figure 2. Map-scheme of Almaty region

According to the diversity of natural and climatic conditions, conditions of heat and moisture supply, vegetation period, the territory of the Northern Tien Shan is divided into the following agroclimatic regions: 1. Very arid foothill-plain region, occupying a strip of foothill (submontane) plains. 2. Arid foothill region, is a foothill or "counters". 3. Mountainous region, starting from an altitude of 1200 - 1600 m. Changes in climatic conditions of the study area are subject to the law of vertical zonality (Figure 2) [26].

As a result of expeditionary surveys, locations of 5 rare and endangered endemic species of southeastern Kazakhstan were identified in different ecological and phytocenotic conditions (Figure 3).

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Figure 3. Rare, endemic and endangered plant species of the southeast of Kazakhstan 1. *Astragalus rubtzovii* Boriss. 2. Relict sands of Kumtekey. 3. Kegen valley. 4. *Taraxacum kok-saghyz* L.E. Rodin. 5. *Schmalhausenia nidulans* (Regel.) Petr. 6. Big Almaty lake. 7. Bayankol River. Narynkol. 8. *Betula Jarmolenkoana* Golosk. 9. *Rheum wittrockii* Lundstr. 10. Big Almaty gorge

Typical habitats of rare species - *Schmalhausenia nidulans* (Regel) Petr., *Rheum wittrockii* Lundstr., *Taraxacum kok-saghyz* L.E. Rodin., *Betula Jarmolenkoana* Golosk. are meadow and sandy soils of the upper alpine and middle forest belts. It is necessary to note the unusual habitat of the endemic species *Astragalus rubtzovii* Boriss., which grows on relict sands of the middle belt at an altitude of 1911 m above sea level.

Table 1. Rare and endangered endemic species of the south-east of Kazakhstan *Astragalus rubtzovii* Boriss, *Taraxacum kok-saghyz* L.E. Rodin., *Schmalhausenia nidulans* (Regel) Petr. *Betula Jarmolenkoana* Golosk., *Rheum wittrockii* Lundstr., discovered during field research

Species name	Geographical location	Location coordinates
Astragalus rubtzovii Boriss,	Almaty region, Ketpen ridge, relict sands "Kumtekey", mid-mountain.	42°56'031", 079°19'266", 1911 м above sea level.
Taraxacum kok-saghyz L.E. Rodin.	Almaty region, Ketpen ridge, in the Kegen valley, mid-mountain.	N43°03'495", E079°13'328" 1834 м above sea level.
Schmalhausenia nidulans (Regel) Petr.	Almaty region, Medeu district, Big Almaty lake, space station, north-eastern slope. Alpine belt.	43°02′430′′, 76°56′ 570′′, 3260 м above sea level.
Betula Jarmolenkoana Golosk.	Almaty region, Ketpen ridge, Narynkol, Bayankol tugai, middle mountains.	43°09'402", 080°20'369", 2248 м above sea level.
Rheum wittrockii Lundstr.	Almaty region, Medeu district, Big Almaty gorge, south-eastern slope.	43°04'504", 76°59'462", 2281 м above sea level.

Five rare and endangered endemic species of southeastern Kazakhstan identified during field studies: *Astragalus rubtzovii* Boriss, *Taraxacum kok-saghyz* L.E. Rodin., *Schmalhausenia nidulans* (Regel) Petr. *Betula Jarmolenkoana* Golosk., *Rheum wittrockii* Lundstr., are included in the Red Book of Kazakhstan (Table 1). They belong to 5 genera and 4 families (Table 2).

Table 2. Species composition of rare and endangered endemic plant species of south-east Kazakhstan

№	Family	Genus	Species
1.	Fabaceae	Astragalus	*Astragalus rubtzovii* Boriss.
2.	Asteraceae	Taraxacum Schmalhausenia	1.*Taraxacum kok-saghyz* L.E. Rodin. 2.*Schmalhausenia nidulans* (Regel) Petr.
3.	Betulaceae	Betula	*Betula Jarmolenkoana* Golosk.
4	Polygonaceae	Rheum	*Rheum wittrockii* Lundstr.

The study of rare and endangered endemic species of southeastern Kazakhstan cannot be complete without an analysis of life forms, since its ecobiomorphological structure reflects the nature of plant adaptation to a set of environmental conditions that have developed in certain ecotopes and therefore its analysis serves as a reliable tool for understanding the ecology of a habitat. The basis for the analysis of life forms in our studies was the life form systems of I.G. Serebryakov [21]. The life form system of K. Raunkier is based on the adaptation of plants to enduring unfavorable conditions of low autumn-winter temperatures in regions with a cold climate and summer drought in arid regions. The main classification feature is: the location of renewal buds, and the degree of their protection, as well as their position in relation to the soil surface. The 5 rare and endangered endemic species we identified are represented by 2 types of life forms, these are perennial herbaceous plants with dying above-ground parts and one species - a tree. In relation to humidity, all rare and endangered endemic species of southeastern Kazakhstan that we discovered are divided into the following ecological groups: 1. in relation to plants' relation to humidity – mesophytes, which include plants of fairly humid habitats with a predominance of taproot species (*Taraxacum kok-saghyz* L.E. Rodin., *Schmalhausenia nidulans* (Regel) Petr., *Rheum wittrockii* Lundstr., *Betula Jarmolenkoana* Golosk.). 2. mesoxerophytes plants that are adapted to conditions that are lower than average for soil moisture reserves, i.e. they are intermediate between xeromesophytes and euxerophytes (*Astragalus rubtzovii* Boriss). *Astragalus rubtzovii* Boriss. is a typical psammophyte. Taproot perennials dominate in meadow cenoses and one woody plant grows in tugai. Psammophytic groups developing on desert sands within the study area of south-east Kazakhstan have a limited distribution in the Kegen and Saryzhaz valleys and represent a local type of vegetation. The study area of the Kum-Tekey sand massifs, where the rare endemic species *Astragalus rubtzovii* Boriss was found, is located in the Kegen valley near the Kegen river. This is a small island sand massif, with an area of 15 km^2, located 12 km southeast of the village of Kegen, near the foot of the Chol-Adyr mountains at an altitude of 1911 m above sea level. Its vegetation is dominated by *Elymus giganteus*, which occupies the tops and slopes of sandy hillocks, and *Medicago falcata*, which occupies the depressions between the hillocks. Xerophilous shrubs and subshrubs, characteristic of the desert type of vegetation, are practically absent, except for rare and isolated specimens of *Kochia prostrata* and *Krascheninnikovia ceratoides*. The central part of the sand massif is noticeably higher than its periphery. Sand ridges, sometimes up to 10 m high, stretch from east to west, their slopes are steep. The regular arrangement of the ridges is disrupted by deflation of the sands, which occurs under the influence of intensive grazing of cattle from nearby villages. As a result of deflation, the sand ridges overgrown with vegetation are deformed into bare or almost bare sand mounds of various sizes and outlines [27]. According to M.S. Baitenov [28], the Kum-Tekey sand massif was formed during the interglacial period during the widespread melting of ice, which increased the living force of the Charyn River waters. The coenoecological confinement of *Astragalus rubtzovii* to dynamic sandy habitats gives grounds to consider the species a local neoendemic with a Quaternary age. It should be noted that due to excessive grazing pressure

on the relict sand massifs of Kum-Tekey, the species *Astragalus rubtzovii* is on the verge of extinction.

Below is a geobotanical description of plant communities with the participation of rare and endangered endemic species *Astragalus rubtzovii* Boriss, *Taraxacum kok-saghyz* L.E. Rodin., *Schmalhausenia nidulans* (Regel) Petr., *Betula Jarmolenkoana* Golosk., *Rheum wittrockii* Lundstr., identified in the southeast of Kazakhstan (Tables 3, 4).

Table 3. Geobotanical characteristics of plant communities with the participation of rare endangered species *Schmalhausenia nidulans* (Regel) Petr. and *Rheum wittrockii* Lundstr. - Zailiysky Alatau, Big Almaty gorge of the Kumbel river

Description number				1	
Date				02.08.2024	
Population area size, m^2				25x25	
Woody plants					
Forest type				Spruce forests	
Tree-shrub community				Spruce forests	
Grassy community				Shrub-herb	
Herbaceous and subshrub layer					
Total projective cover, %				100	
Projective cover of trees, %				25	
Projective cover of shrubs, %				5-10	
Projective cover of grass cover, %				60-70	
Phenophase by species, according to B.A. Bykov				vegetation, fruiting	
Surface condition				Outcrops of parent rocks, rock outcrops, dead wood	
Degree of anthropogenic transformation				Average	
Degree of soil moisture				атмосферные осадки	
Geomorphology, location					
JPS coordinates of the terrain				N 43°15'267" E 77°45'676"	
Height above sea level m.,				3256	
Slope, degrees				45	
Exposition				North-Eastern	
Microrelief				Rolling, undulating, uneven elevations, lower part of the slope	
Macrorelief, м				Big Almaty gorge of the Kumbel river	
Floristic diversity					
Species name Latin name	Family	Abundance by Drude	Placement by B.A. Bykov	Height, m/cm	Phenophase
Tree layer					
Picea schrenkiana Fisch. & C.A. Mey.	*Pinaceae*	cop1 (30-40%)	uneven	12-20	vegetat, fruiting
Populus tremula L.	*Salicaceae*	sol (1-5%)	singular, uneven	5-7	vegetat, fruiting
Betula tianschanica Rupr.	*Betulaceae*	sol (1-3%)	singular, uneven	3	vegetat, fruiting
Sorbus tianschanica Rupr.	*Rosaceae*	sp (1-3%)	singular, uneven	3-5	vegetat, fruiting
Salix alatavica Kar. ex Stschegl.	*Salicaceae*	sol (1-5%)	singular, uneven	5-7	vegetat, fruiting
Shrubs (projective coverage 10–20%)					

Cotoneaster melanocarpus Fisch. ex Blytt	*Rosaceae*	sol (1-3%)	singular, uneven	1,5-2	vegetat, fruiting
Cotoneaster oliganthus Pojark.	*Rosaceae*	sol (1-3%)	singular, uneven	1,5-2	vegetat, fruiting
Rosa alberti Regel	*Rosaceae*	sol (1-3%)	in groups, unevenly	1,5	vegetat, fruiting
Rosa beggeriana Schrenk	*Rosaceae*	sol (1-3%)	in groups, unevenly	1,5	vegetat, fruiting
Lonicera hispida Pall. ex Schult.	*Caprifoliaceae*	sol (1-2%)	in groups	1,5-2	vegetat, fruiting
Lonicera karelinii Bunge ex P. Kir.	*Caprifoliaceae*	sol (1-2%)	in groups	1,5-2	vegetat, fruiting
Lonicera stenantha Pojark.	*Caprifoliaceae*	sol (1-2%)	in groups	1,5-2	vegetat, fruiting
Lonicera microphylla Willd. ex Schult.	*Caprifoliaceae*	sol (1-2%)	in groups	1,5-2	vegetat, fruiting
Rubus idaeus L.	*Rosaceae*	sol (1-3%)	in groups	1,5-2	vegetat, fruiting
Ribes meyeri Maxim.	*Grossulariaceae*	sol (1-3%)	singular, uneven	1,5-2	vegetat, fruiting
Herbaceous-shrub layer (projective coverage: 15–20%)					
Euonymus semenovii Regel & Herder	*Celastraceae*	sp- sol (5-15%)	diffusely	0,5-1,5	vegetat, fruiting
Phedimus hybridus (L.) 't Hart. (Sedum hybridum L.)	*Crassulaceae*	sp-cop (10-25%)	in groups, unevenly	5-10	vegetat, fruiting
Hylotelephium ewersii (Ledeb.) H.Ohba(Sedum ewersii Ledeb.)	*Crassulaceae*	sp-cop (15-30%)	in groups, unevenly	7-15	vegetat, fruiting
Pyrola rotundifolia L.	*Ericaceae*	sol (2-5%)	singular, uneven	10	vegetat, fruiting
Goodyera repens (L.) R. Br.	*Orchidaceae*	sol (1-5%)	singular	-	vegetat, fruiting
Poa nemoralis L.	*Poaceae*	sp (10-15%)	in groups, unevenly	30-40	vegetat, fruiting
Phragmites australis (Cav.) Trin. ex Steud.	Poaceae	sol (1-3%)	singular, uneven	70	vegetat, fruiting
Fragaria vesca L.	*Rosaceae*	sol (1-5%)	in groups, unevenly	35	vegetat, fruiting
Mentha asiatica Boriss.	*Fabaceae*	sol (1-5%)	in groups, unevenly	70	vegetat, fruiting
Alchemilla vulgaris L.	*Asteraceae*	sol (1-5%)	in groups, unevenly	35	vegetat, fruiting
Poa pratensis L.	*Poaceae*	sol (1-5%)	in groups, unevenly	70	vegetat, fruiting
Dracocephalum origanoides Stephan.	*Lamiaceae*	sol (1-5%)	in groups, unevenly	35	vegetat, fruiting
Artemisia absinthium L.	*Asteraceae*	sol (1-5%)	in groups, unevenly	70	vegetat, fruiting
Plantago major L.	*Plantaginaceae*	sol (1-5%)	in groups, unevenly	35	veget, flowering, fruiting
Prunella vulgaris L.	*Lamiaceae*	sol (1-5%)	in groups, unevenly	70	veget, flowering, fruiting
Artemisia annua L.	*Asteraceae*	sol (1-5%)	in groups, unevenly	35	veget, flowering, fruiting
Geranium albiflorum L.	*Geraniaceae*	sol (1-5%)	in groups, unevenly	70	veget, flowering, fruiting
Geranium pratense L.	*Geraniaceae*	sol (1-5%)	in groups, unevenly	35	veget, flowering, fruiting
Iris sogdiana Bunge	*Iridaceae*	sol (1-5%)	in groups, unevenly	65	vegetat, fruiting
Dracocephalum nutans L.	*Lamiaceae*	sol (1-5%)	in groups, unevenly	45	vegetat, fruiting
Dracocephalum origanoides Stephan.	*Lamiaceae*	sol (1-5%)	in groups, unevenly	40	vegetat, fruiting

*Eremurus fuscus (*O. Fedtsch.) Vved.	*Asphodelaceae*	sol (1-5%)	in groups, unevenly	90	veget, flowering, fruiting
*Phleum phleoides (*L.) H. Karst.	*Poaceae*	sol (1-5%)	in groups, unevenly	100	veget, flowering, fruiting
Elytrigia repens (L.) Nevski	*Poaceae*	sol (1-5%)	in groups, unevenly	70	veget, flowering, fruiting
Agropyron pectiniforme Roemer & Schultes	*Poaceae*	sol (1-5%)	in groups, unevenly	80	veget, flowering, fruiting
Dactylis glomerata L.	*Poaceae*	sol (1-5%)	in groups, unevenly	90	veget, flowering, fruiting
Rheum wittrockii Lundstr.	*Polygonaceae*	sol (1-5%)	in groups, unevenly	100	veget, flowering, fruiting
*Schmalhausenia nidulans (*Regel) Petr.	*Asteraceae*	sol (1-5%)	in groups, unevenly	65	veget, flowering, fruiting
Alfredia acantholepis Kar. & Kir.	*Asteraceae*	sol (1-5%)	in groups, unevenly	100	veget, flowering, fruiting
Helictotrichon tianschanicum (Roshev.) Henrard.	*Poaceae*	sol (1-5%)	in groups, unevenly	100	veget, flowering, fruiting
Erigeron acris L.	*Asteraceae*	sol (1-5%)	in groups, unevenly	55	veget, flowering, fruiting
Galium aparine L.	*Cyperaceae*	sol (1-5%)	in groups, unevenly	70	veget, flowering, fruiting
Carex polyphylla Kar. & Kir.	*Cyperaceae*	sol (1-5%)	in groups, unevenly	30	vegetat, fruiting
Senecio nemorensis L.	*Asteraceae*	sol (1-5%)	in groups, unevenly	65	veget, flowering, fruiting
Senecio jacobaea L.	*Asteraceae*	sol (1-5%)	in groups, unevenly.	75	veget, flowering, fruiting
Semenovia transiliensis Regel & Herd.	*Apiaceae*	sol (1-5%)	in groups, unevenly	90	veget, flowering, fruiting
Daucus carota L.	*Apiaceae*	sol (1-5%)	in groups, unevenly	95	veget, flowering, fruiting
Myosotis suaveolens Waldst. & Kit. ex Willd.	*Boraginaceae*	sol (1-5%)	in groups, unevenly	85	veget, flowering, fruiting
Thalictrum petaloideum L.	*Ranunculaceae*	sol (1-5%)	singular, uneven	65	vegetat, fruiting
Ligularia macrophylla (L.) DC.	*Asteraceae*	sol (1-5%)	in groups, unevenly	85	veget, flowering, fruiting
Melilotus officinalis (L.) Lam.,	*Fabaceae*	sol (1-5%)	in groups, unevenly	75	veget, flowering, fruiting
Melilotus albus Medikus.	*Fabaceae*	sol (1-5%)	in groups, unevenly	85	veget, flowering, fruiting
Berteroa incana (L.) DC.	*Brassicaceae*	sol (1-5%)	in groups, unevenly	85	veget, flowering, fruiting

Table 4. Geobotanical characteristics of plant communities with the participation of rare endangered species *Astragalus rubtzovii* Boriss, *Taraxacum kok-saghyz* L.E. Rodin., and *Betula Jarmolenkoana* Golosk., – Ketpen ridge, Kegen valley, Kum-Tekey sands, Narynkol, Bayankol tugai

Description number	2
Date	19.08.2024
Population area size, m^2	25x25
Woody plants	
Forest type	Spruce forests
Woody-shrubby community	Spruce forests
Grassy community	Shrub-forb
Herbaceous and subshrub layer	
Total projective cover, %	100

Projective cover of trees, %	20
Projective cover of shrubs, %	5-10
Projective cover of grass cover, %	80-90
Phenophase by species, according to B.A. Bykov	vegetation, beginning of fruiting
Surface condition	Outcrops of parent rocks, rock outcrops, grass
Degree of anthropogenic transformation	Average
Degree of soil moisture	atmospheric precipitation
Geomorphology, location	
JPS coordinates of the area	N 43°03'495" E 79°13'328"
Height above sea level m., m	1834
Slope, degrees	20
Exposition	North-Eastern
Microrelief, m	Rolling, undulating, uneven elevations, lower part of the slope
Macrorelief, m	Ketpen ridge, Kegen valley, Kum-Tekey sands, Narynkol, Bayanakol tugai.

Floristic diversity					
Species name Latin name	Family	Abundance by Drude	Placement by B.A. Bykov	Height, m/cm	Phenophase
Tree layer					
Betula jarmolenkoana Golosk.	*Betulaceae*	cop1 (30-40%)	in groups. unevenly	20-30	veget. fruiting
Salix alatavica Kar. ex Stschegl.	*Salicaceae*	sol (1-5%)	singular, uneven	5-7	veget. fruiting
Salix argyracea E. Wolf.	*Salicaceae*	sol (1-5%)	singular, uneven	5-7	veget. fruiting
Hippophae rhamnoides L.	*Elaeagnaceae*	sol (1-5%)	singular, uneven	3-7	veget. fruiting
Shrubs (projective covering: 10–20%)					
Cotoneaster oliganthus Pojark.	*Rosaceae*	sol (1-3%)	singular, uneven	1,5-2	veget. fruiting
Rosa alberti Regel	*Rosaceae*	sol (1-3%)	in groups. unevenly	1,5	veget. fruiting
Berberis sphaerocarpa Kar. & Kir.	*Berberidaceae*	sol (1-2%)	singular, uneven	1,5-2	veget. fruiting
Caragana kirghisorum Pojark.	*Fabaceae*	sol (1-2%)	singular, uneven	1,5-2	veget. flowering, fruiting
Cerasus tianschanica Pojark.	*Rosaceae*	sol (1-2%)	singular, uneven	1,5-2	veget. flowering, fruiting
Clematis songarica Bunge.	*Ranunculaceae*	sol (1-2%)	singular, uneven	1,5-2	veget. flowering, fruiting
Juniperus sabina L.	*Cupressaceae*	sol (1-2%)	singular, uneven	1,5-2	veget. flowering, fruiting
Krascheninnikovia ceratoides (L.) Gueldenst.	Chenopodiaceae	sol (1-2%)	singular, uneven	1,5-2	veget. flowering, fruiting
Herbaceous-shrub layer (projective covering): 15–20%					

Elytrigia repens L.	*Poaceae*	sol (1-3%)	in groups. unevenly	45	veget. flowering, fruiting
Achillea millefolium L.	*Rosaceae*	sol (1-3%)	in groups. unevenly	70	veget. flowering, fruiting
Geranium pratense L.,	*Geraniaceae*	sol (1-3%)	in groups. unevenly	35	veget. flowering, fruiting
Aster canescens (Nees) Fisjun.	*Asteraceae*	sol (1-3%)	in groups. unevenly	50	veget. flowering, fruiting
Inula rhizocephala Schrenk.	Asteraceae	sol (1-3%)	singular, uneven	10	veget. fruiting
Polygonum aviculare L.	Poaceae	sol (1-5%)	in groups. unevenly	35	veget. fruiting
Leymus racemosus (Lam.) Tzvelev.	Poaceae	sol (1-3%)	in groups. unevenly	85	veget. flowering, fruiting
Onopordum acanthium L.	Asteraceae	sol (1-3%)	in groups. unevenly	95	veget. flowering, fruiting
Astragalus rubtzovii Boriss.	Fabaceae	sol (1-3%)	in groups. unevenly	25	veget. flowering, fruiting
Lappula consanguinea (Fisch. et Mey.) Gurke.	Boraginaceae	sol (1-3%)	in groups. unevenly	20	veget. flowering, fruiting
Artemisia annua L.	Asteraceae	sol (1-3%)	in groups. unevenly	75	veget. flowering, fruiting
Erysimum diffusum Ehrh.	Brassicaceae	sol (1-3%)	in groups. unevenly	65	veget. flowering, fruiting
Astragalus borodinii Krasn.	Fabaceae	sol (1-3%)	in groups. unevenly	40	veget. flowering, fruiting
Kochia prostrata (L.) Schrad.	Chenopodiaceae	sol (1-3%)	in groups. unevenly	60	veget. flowering, fruiting
Scutellaria paulsenii V. Brig.	Lamiaceae	sol (1-3%)	in groups. unevenly	25	veget. flowering, fruiting
Astragalus karkarensis M. Pop.	Fabaceae	sol (1-3%)	in groups. unevenly	25	veget. flowering, fruiting
Lepidium apetalum Willd.	Brassicaceae	sol (1-3%)	in groups. unevenly	35	veget. flowering, fruiting
Ziziphora clinopodioides Lam.	Lamiaceae	sol (1-3%)	in groups. unevenly	30	veget. flowering, fruiting
Carex turkestanica Regel.	Cyperaceae	sol (1-3%)	in groups. unevenly	20	veget. flowering, fruiting
Medicago falcata L.	Fabaceae	sol (1-3%)	in groups. unevenly	15	veget. flowering, fruiting
Artemisia sieversiana Willd.	Asteraceae	sol (1-3%)	in groups. unevenly	45	veget. flowering, fruiting

Achnatherum splendens (Trin.) Nevski.	Poaceae	sol (1-3%)	in groups. unevenly	75	veget. flowering, fruiting
Elytrigia repens L.	Poaceae	sol (1-3%)	in groups. unevenly	55	veget. flowering, fruiting
Leymus racemosus (Lam.) Tzvelev.	Poaceae	sol (1-3%)	in groups. unevenly	85	veget. flowering, fruiting
Astragalus rubtzovii,	Fabaceae	sol (1-3%)	in groups. unevenly	25	veget. flowering, fruiting
Elymus giganteus Vahl.	Poaceae	sol (1-3%)	in groups. unevenly	70	veget. flowering, fruiting
Bromopsis inermis (Leyss.) Holub	Poaceae	sol (1-3%)	in groups. unevenly	35	veget. flowering, fruiting
Capsella-bursa-pastoris (L.) Medik.	Brassicaceae	sol (1-3%)	in groups. unevenly	15	veget. flowering, fruiting
Secale silvestre Host.	Poaceae	sol (1-3%)	in groups. unevenly	20	veget. flowering, fruiting
Thymus marschallianus Willd.	Lamiaceae	sol (1-3%)	in groups. unevenly	15	veget. flowering, fruiting
Thymus stepposus Klokov & Des. Shost.	Lamiaceae	sol (1-3%)	in groups. unevenly	15	veget. flowering, fruiting
Lappula microcarpa (Ledeb.) Gürke	Boraginaceae	sol (1-3%)	in groups. unevenly	20	veget. flowering, fruiting
Allium pallasii Murray	Alliaceae	sol (1-3%)	in groups. unevenly	30	veget. flowering, fruiting
Lappula macrocarpa (Ledeb.) Gürke	Boraginaceae	sol (1-3%)	in groups. unevenly	15	veget. flowering, fruiting
Festuca ganeschini Drob.	Poaceae	sol (1-3%)	in groups. unevenly	20	veget. flowering, fruiting
Stipa capillata L.	Poaceae	sol (1-3%)	in groups. unevenly	15	veget. flowering, fruiting
Carex turkestanica Regel.	Cyperaceae	sol (1-3%)	in groups. unevenly	10	veget. flowering, fruiting
Corispermum hyssopifolium L.	Chenopodiaceae	sol (1-3%)	in groups. unevenly	25	veget. flowering, fruiting
Melandrium viscosum (L.) Pers.	Caryophyllaceae	sol (1-3%)	in groups. unevenly	30	veget. flowering, fruiting
Arenaria serpyllifolia L.	Caryophyllaceae	sol (1-3%)	in groups. unevenly	10	veget. flowering, fruiting

Delphinium iliense Huth	Ranunculaceae	sol (1-3%)	in groups. unevenly	45	veget. flowering, fruiting
Meniocus linifolius (Stephan ex Willd.) DC.	Brassicaceae	sol (1-3%)	in groups. unevenly	20	veget. flowering, fruiting
Astragalus scabrisetus Bong.	Fabaceae	sol (1-3%)	in groups. unevenly	25	veget. flowering, fruiting
Astragalus karkarensis Popov	Fabaceae	sol (1-3%)	in groups. unevenly	25	veget. flowering, fruiting
Potentilla orientalis Juz.	Rosaceae	sol (1-3%)	in groups. unevenly	35	veget. flowering, fruiting
Cynoglossum officinale L.	Boraginaceae	sol (1-3%)	in groups. unevenly	45	veget. flowering, fruiting
Salsola collina Pall.	Chenopodiaceae	sol (1-3%)	in groups. unevenly	30	veget. flowering, fruiting
Scutellaria sieversii Bunge	Lamiaceae	sol (1-3%)	in groups. unevenly	45	veget. flowering, fruiting
Linaria bungei Kuprian.	Scrophulariaceae	sol (1-3%)	in groups. unevenly	40	veget. flowering, fruiting
Orobanche caesia Rchb.	Scrophulariaceae	sol (1-3%)	in groups. unevenly	20	veget. flowering, fruiting
Scorzonera inconspicua Lipsch. ex-Pavlov.	Asteraceae	sol (1-3%)	in groups. unevenly	60	veget. flowering, fruiting
Heteropappus canescens (Nees) Novopokr.	Asteraceae	sol (1-3%)	in groups. unevenly	40	veget. flowering, fruiting
Scabiosa ochroleuca L.	Dipsacaceae	sol (1-3%)	in groups. unevenly	70	veget. flowering, fruiting
Festuca valesiaca Gaudin.	Poaceae	sol (1-3%)	in groups. unevenly	45	veget. flowering, fruiting
Poa pratensis L.	Poaceae	sol (1-3%)	in groups. unevenly	45	veget. flowering, fruiting

The flora of the studied populations of rare and endangered endemic species *Astragalus rubtzovii* Boriss, *Taraxacum kok-saghyz* L.E. Rodin., *Schmalhausenia nidulans* (Regel) Petr., *Betula Jarmolenkoana* Golosk., *Rheum wittrockii* Lundstr., in the southeast of Kazakhstan includes 107 species belonging to 68 genera and 27 families. Characteristic marker species are *Picea schrenkiana* L., *Elytrigia repens* (L.) Nevski L., *Melilotus officinalis* (L.) Lam., *Melilotus albus* Medikus. *Berteroa incana*, *Poa pratensis* L., *Poa annua* L., *Dactylis glomerata* L., *Trifolium repens* L., *Trifolium pratense* L., *Geranium transversale* (Kar. & Kir.) Vved., *Geranium divaricatum* Ehrh., *Artemisia vulgaris* L., *Arctium lappa* L., *Capsella bursa-pastoris* (L.) Medik., *Xanthium strumarium* L. The presence of weed species: *Urtica cannabina* L., *Arctium lappa* L., *Xanthium strumarium* L., confirms the high anthropogenic load on natural phytocenoses.

Ecological and biological analysis confirmed the mesophytic and meso-xerophytic nature of the mountain flora of meadow habitats of populations of rare and endangered endemic plant species *Astragalus rubtzovii* Boriss, *Taraxacum kok-saghyz* L.E. Rodin., *Schmalhausenia nidulans* (Regel) Petr. *Betula Jarmolenkoana* Golosk., *Rheum wittrockii* Lundstr., south-east of Kazakhstan. The main limiting factors that significantly restrict the dispersal of the species are high competition in phytocenoses, anthropogenic load, strict ecological confinement.

Conclusion

Thus, the studies of natural populations of rare and endemic plant species: *Astragalus rubtzovii* Boriss, *Taraxacum kok-saghyz* L.E. Rodin., *Schmalhausenia nidulans* (Regel) Petr. *Betula Jarmolenkoana* Golosk., *Rheum wittrockii* Lundstr., growing in the territory of southeastern Kazakhstan, showed that they are found in different plant communities. The studied species, with the exception of the woody plant Betula Jarmolenkoana Golosk., mainly belong to perennial polycarpic plants growing in forest and alpine zones, they are characterized by a certain morphological structure that determines their adaptive potential, they exhibit high adaptive abilities, which indicates their significant ecological plasticity and can form the basis for their introduction into culture. In the studied territory of the Ketpen ridge and Zailiyskiy Alatau, endemic, subendemic and rare plant species are represented by 2 types of life forms, where the predominant group among endemic, subendemic and rare species is hemiocryptophytes and one representative of phanerophytes

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Оңтүстік-Шығыс Қазақстандағы сирек және эндемикалық өсімдіктер түрлерінің экологиялық және биологиялық ерекшеліктері

Аңдатпа. Мақалада Қазақстан Республикасының Қызыл кітабына енгізілген оңтүстік-шығыс Қазақстанның сирек кездесетін және жойылып кету қауіпі төнген эндемикалық өсімдіктерінің түр құрамына экологиялық-биологиялық талдау нәтижелері берілген. Бұл зерттеу тақырыбының маңыздылығы Қазақстанның оңтүстік-шығысында өсетін сирек кездесетін өсімдік түрлерінің экологиялық және биологиялық ерекшеліктерін жан-жақты және терең білу қажеттілігімен анықталады. Зерттеу Қазақстанның оңтүстік-шығысында (Іле Алатауы, Кетпен) жүргізілді, мұнда зерттеу объектісі табиғи популяциялардан сирек және жойылып бара жатқан эндемикалық өсімдіктер түрлерінің өкілдері болды: *Astragalus rubtzovii* Boriss, *Taraxacum kok-saghyz* L.E. Rodin., *Schmalhausenia nidulans* (Regel) Petr. *Betula Jarmolenkoana* Golosk., *Rheum wittrockii* Lundstr. Сирек және эндемикалық өсімдік түрлерінің ценопопуляциясының жағдайын зерттеу маршруттық және жартылай стационарлық әдістерді қолдану арқылы жүргізілді. Жұмыстың жаңалығы алғашқы рет Қазақстанның оңтүстік-шығысындағы сирек кездесетін және жойылып бара жатқан эндемикалық өсімдік түрлерінің ең толық экологиялық-биологиялық сипаттамалары беріліп, олардың биологиялық ерекшеліктері мен тіршілік ету ортасының зерттеу болып табылды. Зерттелетін аумақта сирек кездесетін және жойылып кету қауіпі төнген 5 эндемикалық өсімдік түрі, тіршілік формасының 2 түрімен ұсынылған, сонымен қоса мұнда сирек және эндемиялық түрлердің арасында басым топ гемиокриптофиттер (көпжылдық өсімдіктер) және фанерофиттің бір түрі – сүректі өсімдік (Betula Jarmolenkoana) болып табылады.

Түйін сөздер: сирек және жойылып бара жатқан эндемикалық өсімдіктер түрлері, экологиялық факторлар, популяциясы, биологиялық әртүрлілік.

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Эколого-биологические особенности некоторых редких и эндемичных видов растений юго-востока Казахстана

Аннотация. В статье представлены результаты эколого-биологического анализа видового состава пяти редких и находящихся под угрозой исчезновения эндемичных видов растений юго-востока Казахстана, занесенных в Красную книгу Республики Казахстан. Важность данной темы исследования определяется необходимостью всестороннего и глубокого познания эколого-биологических особенностей редких видов растений, произрастающих на юго-востоке Казахстана. Исследования проведены на территории юго-востока Казахстана (Заилийский Алатау, Кетпен), где объектом исследования явились представители редких и исчезающих эндемичных видов растений: *Astragalus rubtzovii* Boriss, *Taraxacum kok-saghyz* L.E. Rodin., *Schmalhausenia nidulans* (Regel) Petr. *Betula Jarmolenkoana* Golosk., *Rheum wittrockii* Lundstr., из

природных популяций. Изучение состояния ценопопуляции редких и эндемичных видов растений проводилось маршрутным и полустационарным методами. Новизна работы заключается в том, что впервые дана наиболее полная эколого-биологическая характеристика редких и исчезающих эндемичных видов растений юго-востока Казахстана, изучены их биологические особенности и характеристика местообитаний. На исследуемой территории 5 выявленных редких и исчезающих эндемичных видов растений представлены 2 типами жизненных форм, где преобладающей группой среди редких и эндемичных видов является гемиокриптофиты (многолетние растения) и один вид представлен фанерофитом - древесным растением (*Betula jarmolenkoana*).

Ключевые слова: редкие и находящиеся под угрозой исчезновения эндемичные виды растений, популяция, экологические факторы, биоразнообразие.

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