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Study of *Trollius dschungaricus* Regel (Ranunculaceae Juss.) in the flora of the Saty Gorge

Abstract: The article presents the results of an analysis of herbarium and contemporary data on the distribution of *Trollius dschungaricus* within the Saty Gorge, located in the eastern part of the Kungey Alatau range. The study is primarily based on herbarium specimen collections, supplemented by data from the online platforms GBIF and iNaturalist, as well as materials gathered during field expeditions to natural populations.

A floristic list has been compiled, including 157 species of higher vascular plants belonging to 113 genera and 37 families. The greatest species diversity is concentrated in the following families: Poaceae, Asteraceae, Fabaceae, Lamiaceae, Amaranthaceae, and Rosaceae. Twelve species dominate the plant cover. Out of the total number of species, 152 (95.0%) have forage value, with 18 of them also possessing medicinal properties. Eight species are classified as poisonous. The life forms of the flora are predominantly represented by perennial plants – 136 species, including 100 with prolonged vegetative growth, 18 shrubs, 5 subshrubs and semishrubs each, 2 dwarf subshrubs, as well as 6 tree species.

Perennials play an edificatory role in the plant communities of the surveyed area, whereas annuals (14 species) mainly form modification-type herbaceous layers. Biennial plants are represented by 8 species.

An ecological analysis of the flora indicates a predominance of xerophytic species in the conditions of the mid-mountain belt, as well as the presence of mesophytes and halophytes associated with river valleys and temporary watercourses.

Key words: *Trollius dschungaricus*, Saty Gorge, eastern part of the Kungey Alatau Range, population, floristic composition.

Introduction

The conservation of the gene pool of natural flora is one of the most pressing issues today. The Kungey Alatau Range is a unique and remarkable region of the Northern Tien Shan, located at the junction of three botanical-geographical provinces that differ in their natural characteristics: the Central Tien Shan–Zaalai, the Kashgar–Eastern Tien Shan transitional, and the Jungarian transitional provinces. The study area is of particular interest as a transboundary region with the Republic of Kyrgyzstan, characterized by a high degree of botanical diversity. Due to its borderland physical and geographical position, the formation of its flora has been influenced by several major botanical-geographical centers [1].

The study of *T. dschungaricus* in the Saty Gorge, eastern part of the Kungey Alatau Range, is based on the fact that the species composition has remained in its natural state due to its inaccessibility, and it serves as a reference in floristic terms for the entire Northern Tien Shan. To create a comprehensive conservation picture that can protect and restore endangered species, including *T. dschungaricus* in the studied area, it is necessary to characterize the condition of the populations of this species and determine how they respond to various natural and anthropogenic factors.

The genus *Trollius* L. (family Ranunculaceae Juss.) consists of approximately 40 species, primarily distributed in the extratropical regions of the Northern Hemisphere. In Russia, around 19–20

species are known, with the greatest species diversity observed in Siberia, where 12 species occur [2]. The flora of China includes about 16 species, 8 of which are endemics [3]. Within the flora of Kazakhstan, five species of this genus have been recorded: *T. dschungaricus* Regel, *T. altaicus* C.A. Mey., *T. asiaticus* L., *T. lilacinus* Bunge, and *T. micranthus* (Winkl. et Kom.) Pachom [4–5].

Plants of the genus *Trollius* are characterized by large, brightly colored flowers-primarily orange or yellow-with petals of a narrowed shape and nectaries at the base, as well as trilobed or deeply three-lobed leaves [6]. The range of *T. dschungaricus* covers the eastern mountainous regions of Central Asia and Western China [7].

T. dschungaricus is a perennial herbaceous plant, 15-70 cm tall, with a short rhizome. The stem is erect, slightly raised at the base, usually bearing 1-3 flowers, smooth, with remnants of last year's leaves at the lower part. The basal leaves are long-petioled, palmately five-lobed; their lobes are broad, with 3-5 segments along the edge, having wide, blunt teeth. Stem leaves vary in shape: the lower ones are petiolate, while the upper ones are sessile, with a blade similar to the basal leaves or slightly more deeply divided. The apical leaves gradually decrease in size [8-9].

The peduncle is 2-15 cm long and significantly elongates during fruiting. The flowers are large, up to 6 cm in diameter, with bright golden-yellow sepals, slightly reddish on the outside, ranging from 4 to 15 (sometimes up to 20) in number. The petals-nectaries are about 8 mm long, orange, almost equal in length to the stamens, linear in shape, with a rounded tip, slightly widened and thickened at the end, almost equal in length to the stamens. The nectary pit is located about 1 mm high, with the petal slightly narrowing below it. The stigmas are yellow, and the ovaries are brownish, noticeably wrinkled at the base of the style during blooming. The fruits consist of numerous leaflets up to 10 mm long, gathered in a spherical head; the leaflet tip is straight, slightly bent, about 2 mm long. The seeds are brown-black, shiny, rounded, and slightly angular. Blooming occurs in June [10-11].

T. dschungaricus grows in the coniferous and deciduous forest belt, as well as in alpine meadows, occurring at elevations up to 3800 meters above sea level. The species' range covers the Jungarian, Zailiyskiy and Kungey Alatau, Ketpen, Terskey, Kyrgyz Alatau, and the Western Tien Shan [12].

The climatic conditions characteristic of this species' habitat can be described as sharply continental. This is reflected in significant annual and daily temperature fluctuations, as well as in the abrupt transition from winter to summer.

Figure 1 – Appearance of *T. dschungaricus* in the flora of the Saty Gorge

In particular, the climate of the Saty Gorge is marked by cold and arid conditions with a short growing season. The hydrothermal coefficient exceeds a value of 1, indicating that precipitation surpasses evaporation [13]. Climatic parameters vary depending on the altitudinal zone: with increasing elevation, air temperature and atmospheric pressure decrease, while humidity, solar radiation, and the amount of precipitation increase. Based on the combination of natural and climatic characteristics, the studied area is classified as a mid-mountain zone. According to long-term observations, the average annual air temperature in the region is +2.0 °C. The warmest month is July, with an average monthly temperature of +14.8 °C, while the coldest is January (–13.7 °C). The annual precipitation amounts to 378 mm, with about 40% (191 mm) falling during the summer period [14]. The growing season lasts less than 170 days. The sum of active temperatures during this period does not exceed 2000 °C, with total precipitation ranging from 150 to 200 mm. The first frosts occur in early September, and the last ones-in the third decade of May. The frost-free period lasts approximately 107 days [9].

The wind regime is characterized by the predominance of southwesterly winds during the summer months and northerly winds in the winter period. The surveyed area is dominated by plant communities typical of the mid-mountain zone,

reflecting the adaptation of *T. dschungaricus* to a cold and relatively dry climate with a short growing season.

The study of the range and ecological-floristic characteristics of rare and narrowly endemic plant species, such as *T. dschungaricus*, represents an important task of modern botany and biodiversity conservation. The eastern part of the Kungey Alatau range, including the Saty Gorge, remains poorly studied in terms of floristic composition and the structure of plant communities, which makes this research especially relevant. The relevance of this work lies in the need to clarify the distribution boundaries of *T. dschungaricus*, assess the condition of its natural populations, and identify the floristic diversity in the area of its occurrence.

The novelty of this study lies in the comprehensive analysis of herbarium materials, modern digital data (GBIF and iNaturalist), as well as results from field expeditions conducted in natural habitats. This approach makes it possible to gain a more complete understanding of the ecological preferences of the species and its habitat conditions, as well as to expand knowledge of the floristic composition of the studied area.

The aim of this study is to analyze the distribution range of *T. dschungaricus* within the Saty Gorge and to characterize the floristic composition of the associated plant communities. The study also examines the biological and ecological features of the identified species, including their life forms, forage and medicinal value, as well as their adaptation to local environmental conditions.

Materials and methods

Field research was conducted from 2022 to 2024 in natural phytocoenoses of the Saty Gorge, located in the eastern part of the Kungey Alatau Range, within the territory of the Kolsai Lakes National Park (Raiymbek District, Almaty Region). The geographical coordinates of the surveyed site are 43°01′29.6″ N, 78°23′20.5″ E, with an elevation of 2733 meters above sea level.

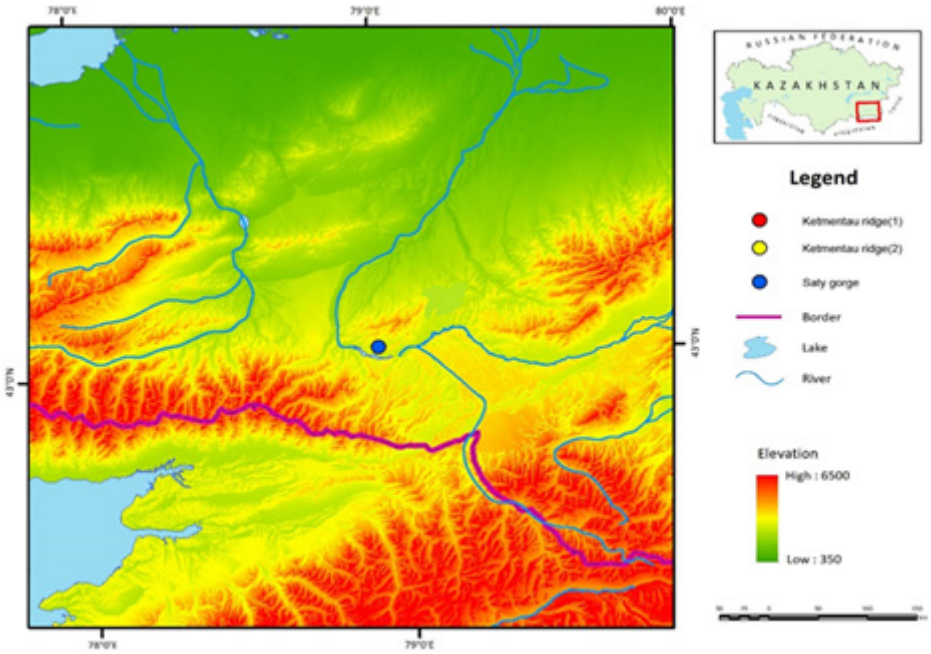

Figure 2 – Study sites of *T. dschungaricus* in the eastern part of the Kungey Alatau Range

The floristic composition of plant communities associated with *T. dschungaricus* was studied within the protected area of the Kolsai Lakes National Park, in the Saty Gorge of the Satinsky rural district (Almaty Region). The study site is bordered as follows: to the north by the lands of the Algabas rural district, to the east by the Karabalyk rural district, to the south by forest fund lands, and to the west and northwest by the lands of the Talgar District.

Classical methods of floristic, ecological-geographical, and geobotanical analysis were used to study the species composition and structure of plant communities. Herbarium material was collected following the standard field geobotanical techniques [15-17]. To clarify the range of *T. dschungaricus*, route reconnaissance methods.

As part of monitoring studies aimed at identifying plant species found in the community, sample plots of various sizes: 5×10 m in rocky areas, 10×20 m in meadow communities, and 50×100 m in forest communities. Species density and the area occupied by the population, followed by quantitative accounting.

During field studies, GPS navigation devices (Garmin, Etrex 2010), habitat maps, and a digital camera for photo documentation (Nikon D3200 18-55 VR II Kit, 2015) were used to reference descriptive points.

For taxonomic research, the following sources were used for plant species identification: Flora of Kazakhstan [5], Key to the Plants of Central Asia [18] , and the compiled works of M.S. Baytenov [19], Flora of Kazakhstan [20]. Publications dedicated to the flora and vegetation of the Kungey Alatau Range [21] were also consulted.

Resources from the Herbarium Fund of the Institute of Botany and Phytointroduction (Almaty, Kazakhstan) (acronym AA) were used for the clarification of herbarium materials,. Plant names are given according to the databases Plants of the World Online (POWO) (URL: https://powo.science.kew.org/) [7] and the website Plantarium (URL: https://www.plantarium.ru/) [22].

Results and discussion

To establish the studied locations of *T. dschungaricus* in the eastern part of the Kungey Alatau Range, an inventory of the Herbarium Funds of Almaty (AA) and Al-Farabi Kazakh National University (AFAKNU) was conducted, along with a review of the GBIF and iNaturalist platforms [21-22]. As a result, key distribution sites of the species in this region were identified (see Figure 3).

A total of 95 specimens of *T. dschungaricus* were studied from the herbarium collection, collected in the floristic region of the Zailiyskiy – Kungey Alatau. Of these, 16 specimens are stored in the Herbarium Fund of Almaty (AA), and 2 in (AFAKNU), with 6 specimens registered in GBIF and 7 in iNaturalist.

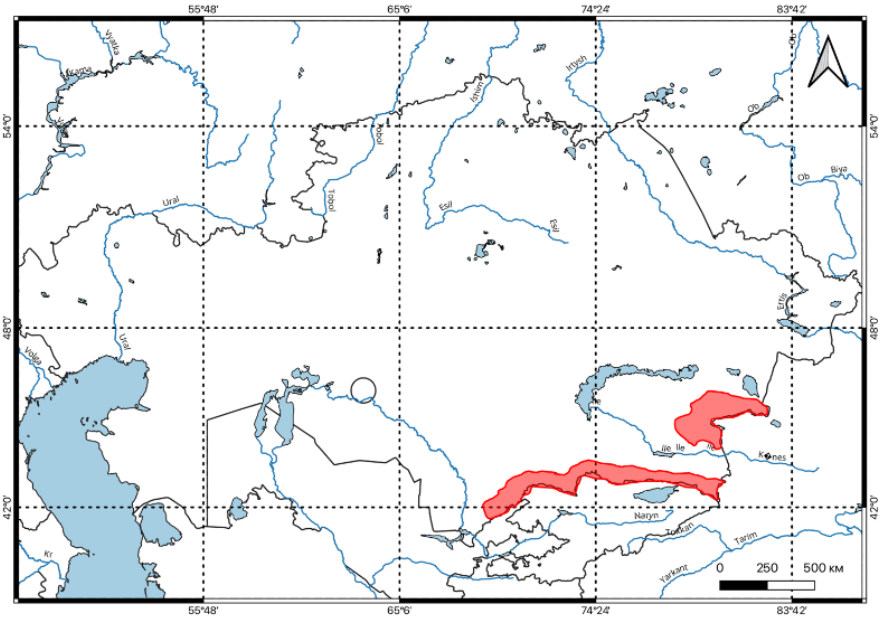

Figure 3 – Distribution map of *T. dschungaricus* in the Kungey Alatau

The herbarium specimens span the period from 1936 to 2023. The earliest specimen was collected by B.A. Bykov and is stored in (AFAKNU) herbarium collection.

In addition, the herbarium collection of the Institute of Botany and Phytointroduction (Almaty, Kazakhstan) was supplemented with *T. dschungaricus* specimens collected on June 16, 2023, by D.Ye. Karabalayeva. The specimens were gathered in the Almaty Region, Raiymbek District, within the territory of the Kolsai Kolderi National Park, near the village of Saty, at an elevation of 1709 m (coordinates: N42°99'47.60", E78°38'98.12").

Based on the inventory of herbarium materials and label data, an expedition route was established through the Saty Gorge, which represents the most typical habitat of *T. dschungaricus* in the eastern part of the Kungey Alatau Range. The floristic list compiled from field survey data includes 160 plant species belonging to 113 genera and 37 families. The highest number of species occurs in the families Poaceae, Asteraceae, Fabaceae, Lamiaceae, Amaranthaceae, and Rosaceae. The floristic composition involving *T. dschungaricus* in the Saty Gorge, Raiymbek District, Almaty Region, is presented in Table 1.

Table – Floristic composition involving T. dschungaricus in the Saty Gorge within the eastern part of the Kungey Alatau Range

Names of species	Family	Life forms [25]	Ecological groups
Juniperus turkestanica Kom.	Cupressaceae Gray	Shrub	Xerophyte
J. sabina L.	Cupressaceae Gray	Shrub	Xerophyte
Picea schrenkiana Fisch. & C.A.Mey.	Pinaceae Spreng. ex F.Rudolphi	Tree	Mesophyte
Ephedra intermedia Schrenk & C.A.Mey.	Ephedraceae Dumort.	Subshrub	Xerophyte
E. distachya L.	Ephedraceae Dumort.	Subshrub	Xerophyte
Botriochloa ischaemum (L.) Keng.	Poaceae Barnhart	Perennial	Xerophyte
Lasiagrostis splendens (Trin.) Kunth.	Poaceae Barnhart	Perennial	Xerophyte
Stipa caucasica Schmalh.	Poaceae Barnhart	Perennial	Xerophyte
S. kirghisorum P.A.Smirn.	Poaceae Barnhart	Perennial	Xerophyte
S. capillata L.	Poaceae Barnhart	Perennial	Xerophyte
S. sareptana A.K.Becker	Poaceae Barnhart	Perennial	Xerophyte
Phleum phleoides (L.) H.Karst.	Poaceae Barnhart	Perennial	Mesophyte
Alopecurus pratensis L.	Poaceae Barnhart	Perennial	Mesophyte
A. soongoricus Fisch. & C.A.Mey.	Poaceae Barnhart	Perennial	Xerophyte
Agrostis gigantea Roth.	Poaceae Barnhart	Perennial	Mesophyte
Calamagrostis epigejos (L.) Roth	Poaceae Barnhart	Perennial	Mesophyte
Helictotrichon pubescens (Huds.) Pilg.	Poaceae Barnhart	Rhizomatous perennial	Mesophyte
H. asiaticum (Roshev.) Grossh.	Poaceae Barnhart	Rhizomatous perennial	Mesophyte
Phragmites communis Trin.	Poaceae Barnhart	Rhizomatous perennial	Hydrophyte
Koeleria gracilis Pers.	Poaceae Barnhart	Perennial	Xeromesophyte
Dactylis glomerata L.	Poaceae Barnhart	Perennial	Mesophyte
Poa bulbosa Steud.	Poaceae Barnhart	Perennial	Xeromesophyte
P. stepposa (Krylov) Roshev.	Poaceae Barnhart	Perennial	Xeromesophyte
P. pratensis L.	Poaceae Barnhart	Perennial	Mesophyte
P. angustifolia L.	Poaceae Barnhart	Perennial	Xeromesophyte
P. alpina L.	Poaceae Barnhart	Perennial	Psychrophyte

Continuation of the table

Names of species	Family	Life forms [25]	Ecological groups
Puccinellia distans (Jacq.) Parl.	Poaceae Barnhart	Perennial	Mesoxerophyte
Festuca sulcata Hack.	Poaceae Barnhart	Perennial	Xeromesophyte
F. kryloviana Reverd.	Poaceae Barnhart	Perennial	Xeromesophyte
Bromus inermis Leyss.	Poaceae Barnhart	Perennial	Mesophyte
B. tectorum L.	Poaceae Barnhart	Annual	Xerophyte
Agropyron repens (L). Beauv.	Poaceae Barnhart	Perennial	Mesophyte
A. pectiniforme Roem. & Schult.	Poaceae Barnhart	Perennial	Xerophyte
Eremopyrum orientale (L.) Jaub. & Spach	Poaceae Barnhart	Annual	Xerophyte
Hordeum bogdanii Wilensky	Poaceae Barnhart	Perennial	Xerophyte
Leymus angustus (Trin.) Pilg.	Poaceae Barnhart	Perennial	Xerophyte
Kobresia capilliformis N.A.Ivanova	Cyperaceae Juss.	Perennial	Hydrophyte
Carex humilis Willd. ex Kunth.	Cyperaceae Juss.	Perennial	Hydrophyte
C. pachystylis J. Gay.	Cyperaceae Juss.	Perennial	Hydrophyte
C. aneurocarpa V. Krecz.	Cyperaceae Juss.	Perennial	Hydrophyte
C. karoi Freyn.	Cyperaceae Juss.	Perennial	Hydrophyte
C. songorica Kar. & Kir.	Cyperaceae Juss.	Perennial	Hydrophyte
Eremurus tianschanicus Pazij & Vved. ex Pavlov	Asphodelaceae Juss.	Perennial	Mesophyte
Allium oreoprasum Schrenk.	Amaryllidaceae J.St.-Hil.	Perennial	Mesophyte
A. fetisowii Regel	Amaryllidaceae J.St.-Hil.	Perennial	Mesophyte
Tulipa kolpakowskiana Regel	Liliaceae Juss.	Perennial	Mesophyte
Iris tenuifolia Pall.	Iridaceae Juss.	Perennial	Xerophyte
I. brevituba (	Iridaceae Juss.	Perennial	Xerophyte
Salix triandra L.	Salicaceae Mirb.	Tree	Hydrophyte
S. caprea L.	Salicaceae Mirb.	Shrub	Hydrophyte
Urtica cannabina L.	Urticaceae Juss.	Perennial	Mesophyte
U. urens L.	Urticaceae Juss.	Annual	Mesophyte
Rumex confertus Willd.	Polygonaceae Juss.	Perennial	Hydrophyte
Atraphaxis virgata ((Regel) Krasn.	Polygonaceae Juss.	Shrub	Xerophyte
A. frutescens (L.) K.Koch	Polygonaceae Juss.	Shrub	Xerophyte
Polygonum aviculare L.	Polygonaceae Juss.	Annual	Hydrophyte
P. patulum M.Bieb.	Polygonaceae Juss.	Annual	Mesophyte
Chenopodium album L.	Amaranthaceae Juss.	Annual	Hygrophyte
Atriplex tatarica L.	Amaranthaceae Juss.	Annual	Halophyte
Eurotia ceratoides (L.) C.A.Mey.	Amaranthaceae Juss.	Shrublet	Halophyte
Kochia prostrata (L.) Schrad.	Amaranthaceae Juss.	Half-shrub	Halophyte
Salsola arbuscula Pall.	Amaranthaceae Juss.	Shrub	Halophyte
Climacoptera brachiata (Pall.) Botsch.	Amaranthaceae Juss.	Annual	Halophyte
Anabasis salsa (Ledeb.) Benth. ex Volkens	Amaranthaceae Juss.	Half-shrub	Halophyte
Nanophyton erinaceum (Pall.) Bunge	Amaranthaceae Juss.	Bushlet	Halophyte
Aconitum leucostomum Vorosch.	Ranunculaceae Juss.	Perennial	Hydrophyte
A. soongaricum (Regel) Stapf	Ranunculaceae Juss.	Perennial	Hydrophyte
Ceratocephala orthoceras DC.	Ranunculaceae Juss.	Annual	Hydrophyte

Continuation of the table

Names of species	Family	Life forms [25]	Ecological groups
Thalictrum collinum Wallr.	Ranunculaceae Juss.	Perennial	Mesophyte
Th. simplex L.	Ranunculaceae Juss.	Perennial	Mesophyte
Papaver croceum Ledeb.	Papaveraceae Juss.	Perennial	Xerophyte
Sedum alberti Regel	Crassulaceae J.St.-Hil.	Perennial	Xerophyte
Descurainia sophia (L.) Webb ex Prantl	Brassicaceae Burnett	Annual	Hydrophyte
Erysimum diffusum Ehrh.	Brassicaceae Burnett	Biennial	Mesophyte
Alyssum desertorum Stapf	Brassicaceae Burnett	Annual	Xerophyte
Spiraea hypericifolia L.	Rosaceae Juss.	Shrub	Mesophyte
Cotoneaster oliganthus Pojark.	Rosaceae Juss.	Shrub	Mesophyte
C. multiflorus Bunge	Rosaceae Juss.	Shrub	Mesophyte
Sorbus tianschanica Rupr.	Rosaceae Juss.	Tree	Mesophyte
Potentilla erecta (L.) Raeusch.	Rosaceae Juss.	Perennial	Mesophyte
P. asiatica (Th.Wolf) Juz.	Rosaceae Juss.	Perennial	Mesophyte
Sanguisorba officinalis L.	Rosaceae Juss.	Perennial	Mesophyte
Rosa platyacantha Schrenk.	Rosaceae Juss.	Shrub	Xerophyte
Cerasus tianschanica Pojark.	Rosaceae Juss.	Shrub	Mesophyte
Orostachys thyrsiflora Fisch.	Crassulaceae J.St.-Hil.	Biennial	Xerophyte
Rosularia platyphylla (Schrenk) A.Berger	Crassulaceae J.St.-Hil.	Perennial	Xerophyte
Medicago falcata L.	Fabaceae Lindl.	Perennial	Mesophyte
Halimodendron halodendron (Pall.) Voss	Fabaceae Lindl.	Shrub	Xerophyte
Trifolium repens L.	Fabaceae Lindl.	Perennial	Mesophyte
T. pratense L.	Fabaceae Lindl.	Perennial	Mesophyte
Caragana aurantiaca Koehne	Fabaceae Lindl.	Shrub	Xerophyte
C. balchaschensis (Kasn. ex Kom.) Pojark.	Fabaceae Lindl.	Shrub	Xeromesophyte
C. pleiophylla (	Fabaceae Lindl.	Shrub	Xeromesophyte
Astragalus sulcatus L.	Fabaceae Lindl.	Perennial	Xeromesophyte
Oxytropis merkensis Bunge	Fabaceae Lindl.	Perennial	Xerophyte
Vicia cracca L.	Fabaceae Lindl.	Perennial	Mesophyte
Hedysarum Semenovii Regel et Herd.	Fabaceae Lindl.	Perennial	Mesoxerophyte
Geranium pratense L.	Geraniaceae Juss.	Perennial	Mesophyte
G. collinum Stephan ex Willd.	Geraniaceae Juss.	Perennial	Mesoxerophyte
Peganum harmala L.	Nitrariaceae Lindl.	Perennial	Xerophyte
Nitraria schoberi L.	Nitrariaceae Lindl.	Shrub	Xerophyte
Hypericum perforatum L.	Hypericaceae Juss.	Perennial	Мезофит
Tamarix ramosissima Ledeb.	Tamaricaceae Link.	Shrub	Xerophyte
Helianthemum songaricum Schrenk ex Fisch. & C.A.Mey.	Cistaceae Juss.	Shrub	Xerophyte
Hippophae rhamnoides L.	Elaeagnaceae Juss.	Shrub	Xerophyte
Elaeagnus argentea Pursh	Elaeagnaceae Juss.	Tree	Xerophyte
Scaligeria setacea (Schrenk) Korov.	Apiaceae Lindl.	Perennial	Xerophyte
Daucus carota L.	Apiaceae Lindl.	Biennial	Mesophyte
Goniolimon sewerzowii Herder	Plumbaginaceae Juss.	Perennial	Xerophyte
Limonium michelsonii Lincz.	Plumbaginaceae Juss.	Perennial	Xerophyte

Continuation of the table

Names of species	Family	Life forms [25]	Ecological groups
Gentianella turkestanorum (Gand.) Holub	Gentianaceae Juss.	Perennial	Mesophyte
Convolvulus tragacanthoides Turcz.	Convolvulaceae Juss.	Shrublet	Xerophyte
C. arvensis L.	Convolvulaceae Juss.	Perennial	Hydrophyte
Echium vulgare L.	Boraginaceae Juss.	Biennial	Mesophyte
Scutellaria transeliensis Juz.	Lamiaceae Martinov	Perennial	Xerophyte
Nepeta pannonica L.	Lamiaceae Martinov	Perennial	Mesophyte
Dracocephalum integrifolium Bunge	Lamiaceae Martinov	Perennial	Xerophyte
Eremostachys speciosa Rupr.	Lamiaceae Martinov	Perennial	Xerophyte
Phlomis oreophila Kar.et Kir	Lamiaceae Martinov	Perennial	Xerophyte
Eriophyton oblongatum (Schrenk) Bendiksby	Lamiaceae Martinov	Perennial	Xerophyte
Lagochilus diacanthophyllus Bong. & C.A.Mey.	Lamiaceae Martinov	Perennial	Xerophyte
Salvia deserta Schangin	Lamiaceae Martinov	Perennial	Xerophyte
Ziziphora clinopodioides Lam	Lamiaceae Martinov	Perennial	Xerophyte
Origanum vulgare L.	Lamiaceae Martinov	Perennial	Mesophyte
Thymus marschallianus Willd.	Lamiaceae Martinov	Half-shrub	Xerophyte
Patrinia intermedia (Hornem.) Roem. & Schult.	Caprifoliaceae Juss.	Perennial	Mesophyte
Scabiosa ochroleuca L.	Caprifoliaceae Juss.	Perennial	Mesophyte
Verbascum songoricum Schrenk ex Fisch. & C.A.Mey.	Scrophulariaceae Juss.	Biennial	Xerophyte
Plantago media L.	Plantaginaceae Juss.	Perennial	Mesophyte
Galium verum L.	Rubiaceae Juss.	Perennial	Mesophyte
Lonicera tatarica L.	Caprifoliaceae Juss.	Shrub	Mesophyte
Galatella fastigiiformis Novopokr.	Asteraceae Bercht. & J.Presl	Perennial	Xerophyte
G. punctata (Waldst. & Kit.) Nees	Asteraceae Bercht. & J.Presl	Perennial	Mesophyte
Leontopodium fedtschenkoanum Beauverd	Asteraceae Bercht. & J.Presl	Perennial	Xerophyte
Ambrosia artemisiifolia L.	Asteraceae Bercht. & J.Presl	Annual	Xerophyte
Achillea millefolium L.	Asteraceae Bercht. & J.Presl	Perennial	Mesophyte
Ajania fastigiata (C.Winkl.) Poljakov	Asteraceae Bercht. & J.Presl	Perennial	Mesophyte
Artemisia rutifolia Stephan ex Spreng.	Asteraceae Bercht. & J.Presl	Half-shrub	Xerophyte
A. santolinifolia (Pamp.) Turcz. ex Krasch.	Asteraceae Bercht. & J.Presl	Half-shrub	Xerophyte
A. absinthium L.	Asteraceae Bercht. & J.Presl	Perennial	Xerophyte
A. scoparia Waldst. & Kit.	Asteraceae Bercht. & J.Presl	Annual, Perennial	Xerophyte
A. dracunculus L.	Asteraceae Bercht. & J.Presl	Perennial	Mesophyte
A. scopaeformis Ledeb.	Asteraceae Bercht. & J.Presl	Perennial	Xerophyte
A. transiliensis Poljakov	Asteraceae Bercht. & J.Presl	Half-shrub	Xerophyte
A. tianschanica Krasch. ex Poljakov	Asteraceae Bercht. & J.Presl	Half-shrub	Xerophyte
A. heptapotamica Poljakov	Asteraceae Bercht. & J.Presl	Perennial	Xerophyte
A. sublessingiana (B.Keller) Krasch. ex Poljakov	Asteraceae Bercht. & J.Presl	Perennial	Xerophyte
Arctium tomentosum Mill.	Asteraceae Bercht. & J.Presl	Biennial	Hygrophyte
Alfredia acantholepis Kar. & Kir.	Asteraceae Bercht. & J.Presl	Perennial	Xerophyte
Cirsium vulgare (Savi) Ten.	Asteraceae Bercht. & J.Presl	Biennial	Hygrophyte

Continuation of the table

Names of species	Family	Life forms [25]	Ecological groups
C. esculentum (Siev.) C.A.Mey.	Asteraceae Bercht. & J.Presl	Perennial	Mesophyte
Centaurea iberica Trevir. ex Spreng.	Asteraceae Bercht. & J.Presl	Perennial	Mesophyte
C. squarrosa Willd.	Asteraceae Bercht. & J.Presl	Biennial	Xerophyte
Cichorium intybus L.	Asteraceae Bercht. & J.Presl	Perennial	Mesophyte
Tragopogon dubius Scop.	Asteraceae Bercht. & J.Presl	Biennial	Mesophyte
Taraxacum officinale F.H.Wigg.	Asteraceae Bercht. & J.Presl	Perennial	Mesophyte
Chondrilla ambigua Fisch. ex Kar. & Kir.	Asteraceae Bercht. & J.Presl	Perennial	Mesophyte

The highest number of species in plant communities with *T. dschungaricus* are represented by the following families: Poaceae (20%), Asteraceae (17%), Lamiaceae (7%), Fabaceae (7%), Rosaceae (6%), Ranunculaceae (3%), Amaranthaceae (5%), Cyperaceae (4%), and Polygonaceae (3%) of the total number of species, as shown in the diagram (Figure 4).

In terms of life forms, herbaceous perennials predominate (65%), followed by shrubs (12%), herbaceous annuals (9%), biennial plants (5%), trees (4%), shrubs and shrublets (3%), and subshrubs (1%) (Figure 5).

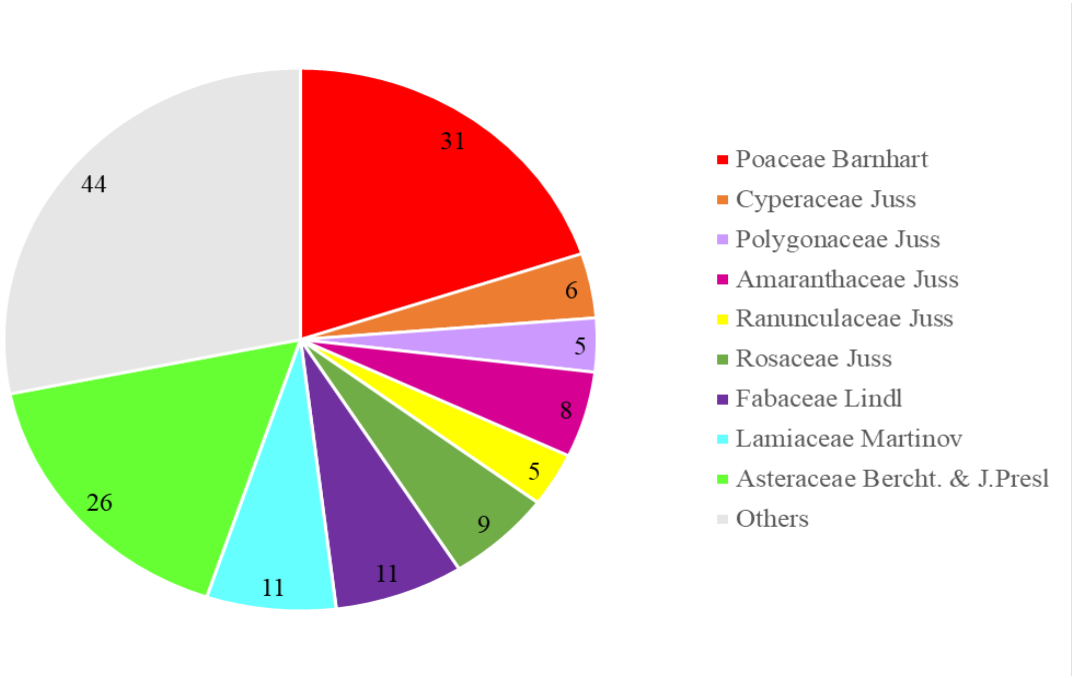

Figure 4 – Spectrum of leading plant families in the territory of Kolsai Lakes National Park

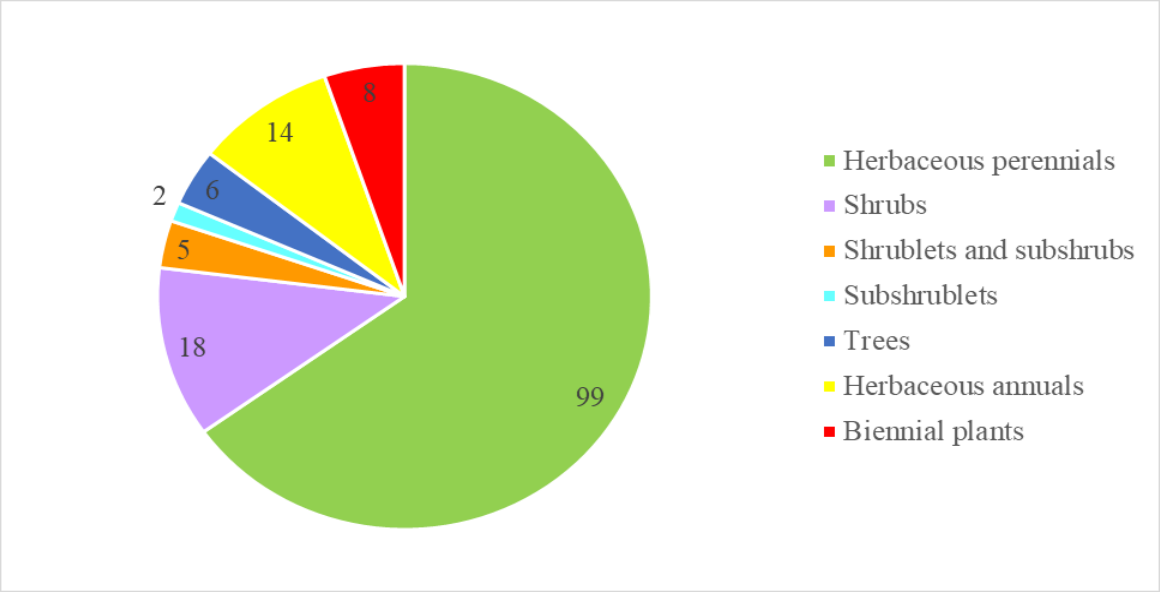

Figure 5 – Life forms according to Serebryakov (1962) [26] in the territory of Kolsai Lakes National Park

The predominant life form in the studied area is perennial plants (137 species), among which are: long-living herbaceous perennials (99 species), shrubs (18 species), subshrubs and semi-shrubs (5 species each), semi-shrubs (2 species), and trees (6 species). Perennials play an edifying role in the studied area, forming the main structure of the vegetation cover. Annuals, represented by 14 species, mainly form modifications of the grassland. Biennial plants make up 8 species (Figure 5).

As for the composition of life forms depending on temperature, humidity, and substrate structure, it is determined by the predominance of ecological plant groups: xerophytes (40%), mesophytes (35%), mesoxerophytes (2%), hygrophytes (5%), hydrophytes (7%), xeromesophytes (6%), halophytes (4%), and psychrophytes (1%) (Figure 6).

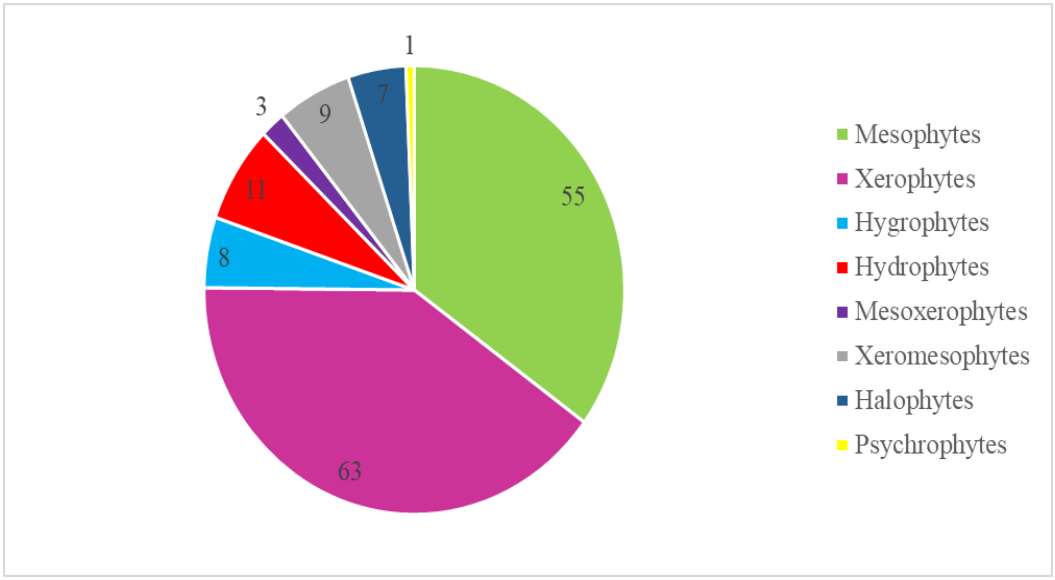

Figure 6 – Ecological plant groups in the territory of Kolsai Lakes National Park

The ecological analysis of the flora of the area showed a wide distribution of xerophytes in the conditions of the mid-mountain zone, as well as the presence of mesophytes and halophytes in river valleys and dry streambeds. The relief plays an important role in the spatial distribution of the vegetation cover. Depending on the habitat conditions and species composition, the natural forage lands are systematized within two main relief forms: the mid-mountain zone and the valleys of mountain rivers.

The predominant vegetation in the surveyed area is that of the mid-mountain zone. The leading types of vegetation in these conditions are relatively homogeneous in terms of background coverage, including steppe communities with species such as *Stipa kirghisorum*, *S. caucasica*, *Festuca valesiaca*, as well as shrub and mixed grassland communities.

On the mountains, hills, and intermountain valleys, sod-forming grasses are widely distributed. The most common species is *Festuca valesiaca* (fine fescue), less frequently *Stipa sareptana* (sarepta feathergrass), and more rarely, the feathergrasses: Kirgiz and Caucasian (*Stipa kirghisorum, S. caucasica*).

In the Saty Gorge area, the dominant plant communities are Festuca, Stipa, and mixed grasslands. In the southern part of the region, on the gently rolling and hilly areas of the terrain, Festuca communities prevail, and these are widespread throughout the district. Stipa communities mainly occupy flat intermountain valleys, and they are less commonly found on the slopes of the hills.

In depressions, on slopes and peaks, the proportion of Festuca and Stipa decreases, and mixed grass forms begin to dominate. On the steep slopes of the gorges, shrubs are often encountered.

On the northern slopes of the ridges, there are communities of sod-forming grass-polygonal grassland and grass-mixed grassland types, with exposures of native rocks.

The conducted study made it possible to refine the current distribution range of *T. dschungaricus* and to characterize the ecological features of its habitats in the eastern part of the Kungey Alatau Range. A multi-level approach that included the analysis of herbarium specimens and field investigations proved effective in identifying natural populations of the species and assessing the accompanying floristic diversity.

The coenofloristic analysis showed that the studied plant communities are characterized by high species richness and a composition typical of the mid-mountain zone. The predominance of mesophytic species and the dominance of the families *Poaceae, Asteraceae, Lamiaceae, Fabaceae*, and *Rosaceae* indicate a stable adaptation of the vegetation cover to moderately humid conditions. The identified species demonstrate significant ecological plasticity, which enables them to thrive under fluctuating temperature and moisture regimes.

Thus, *T. dschungaricus* is part of stable plant communities and can be considered an ecologically significant component of the region's flora. The obtained data expand our understanding of the biodiversity and vegetation structure of the eastern Kungey Alatau and can serve as a foundation for future ecological monitoring and environmental planning.

Conclusion

A comprehensive study of the current state of the ornamental and valuable species *T. dschungaricus* in the eastern part of the Kungey Alatau Range is an important step toward a deeper understanding of its ecology and conservation. Research on this species requires a multi-level approach that includes both the analysis of historical data and field investigations. The initial stage of the work involved the inventory of herbarium materials stored in major herbarium collections, such as those at the Institute of Botany and Phytointroduction (AA) and Al-Farabi Kazakh National University (AFAKNU), as well as data from online platforms like GBIF and iNaturalist. This made it possible to determine the geographic coordinates and locations of the species, which served as the basis for planning field expedition routes and identifying the habitats of *T. dschungaricus* in the study region.

A detailed analysis of the coenoflora of T. dschungaricus was conducted in the Saty Gorge. The investigation of the coenoflora revealed a high similarity in species composition between the flora of this gorge and the general flora of the Kungey Alatau Range, indicating that the studied plant community is typical for this region.

One of the key findings was the predominance of mesophytic species, which in turn influenced the dominance of families such as Poaceae (20%), Asteraceae (17%), Lamiaceae (7%), Fabaceae (7%), and Rosaceae (6%). This reflects the vegetation's adaptation to the moderately humid conditions characteristic of the area. It also confirms that the

plant species associated with *T. dschungaricus* exhibit high ecological plasticity and can thrive under varying levels of moisture and temperature, making them an important component of the region's ecosystems.

Thus, the research not only revealed the distribution patterns, ecological specificity, and phytocoenotic role of *T. dschungaricus* in the eastern part of the Kungey Alatau Range, but also made a significant contribution to the understanding of the region's floristic diversity and plant community structure.

The obtained results form an important foundation for the development of conservation measures aimed at protecting the declining population of this highly ornamental species. Furthermore, the presented data can be used in long-term ecological monitoring programs of the flora in the eastern Kungey Alatau and in planning sustainable natural resource use within protected natural areas.

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Conflict of interest

All authors are aware of the article's content and declare no conflict of interest.

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