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Floristic checklist and distribution of *Trollius* species (Ranunculaceae) in Kazakhstan

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Abstract. *Karabalayeva D, Kurmanbayeva M, Kusmangazinov A, Osmonali B, Zhumagul M. 2025. Floristic checklist and distribution of* Trollius *species (Ranunculaceae) in Kazakhstan. Biodiversitas 26: 4103-4123.* The genus *Trollius*, belonging to the family Ranunculaceae and order Ranunculales, includes species known for their ornamental and medicinal value. However, the current state of *Trollius* species in Kazakhstan remains insufficiently studied. This study provides a comprehensive floristic update on five species: *T. altaicus*, *T. asiaticus*, *T. dschungaricus*, *T. lilacinus*, and *T. komarovii*, the latter formerly assigned to *Hegemone* and recently transferred to *Trollius*. We analyzed a total of 391 herbarium specimens (including 8 newly collected specimens in 2023): *T. altaicus* (177), *T. dschungaricus* (129), *T. lilacinus* (75), *T. asiaticus* (7), and *T. komarovii* (3), from field studies and 12 domestic and international herbarium collections. Additionally, we utilized online biodiversity databases such as GBIF and iNaturalist. During recent fieldwork, four new localities were confirmed for *T. altaicus* and *T. dschungaricus*, with precise georeferencing, notably in the Western Altai (Ivanov Ridge), Zailiyskiy Alatau (Talgar District), Zailiyskiy-Kungei Alatau (Maloe Almatinskoe Gorge), and the Ketpen Ridge (Uygur and Raiymbek Districts). Using QGIS 3.28 and Google Earth, we produced updated distribution maps based on materials dated from 1826 to 2024. The confirmed range of *Trollius* species includes Southern, Southeastern, and Eastern Kazakhstan, covering the Altai, Saur, Tarbagatai, Dzungarian Alatau, the northern and western Tian Shan, and Kyrgyz Alatau regions. This study refines the known distribution of *Trollius* in Kazakhstan and fills important floristic gaps, particularly in high-mountain and border areas. Our results highlight the need for further monitoring and conservation of these species, especially those with restricted distribution such as *T. komarovii*. This updated dataset lays the groundwork for future taxonomic, ecological, and conservation research on Central Asian flora.

Keywords: Distribution, GBIF, herbarium, iNaturalist, Ranunculaceae, *Trollius*

INTRODUCTION

The genus *Trollius* includes 40 recognized species of globular-flowered and is the largest genus within the family Ranunculaceae, as well as in the entire order Ranunculales (POWO 2025). In Russia, 20 species are recognized, with the highest diversity (12 species) recorded in Siberia (Luferov et al. 2018). In China, about 16 species have been described, eight of which are endemic (Li and Tamura 2001). Despite being valuable ornamental and medicinal plants (Saltan and Sviatkovskaya 2023), species of the genus *Trollius* remain poorly studied, and their taxonomic status has been debated. According to the Flora of Kazakhstan (Flora of Kazakhstan 1960), three species of the genus *Trollius* are distributed in Kazakhstan. However, a recent study (Abdulina 1999) recognized five species, as two species previously assigned to the genus *Hegemone* were reassigned to the genus *Trollius*.

Many *Trollius* species are specialists in montane to subalpine wet habitats: moist meadows, stream banks, forest understories and alpine slopes. *Trollius* occurs at elevations of 2,900-4,100 m alpine meadows (Zhao and Wang 2015), sedge bogs and subalpine forests up to 2,500 m (Luferov et al. 2018). High habitat specificity leads to fragmentation and restricted distributions typical of endemic taxa. Additionally, climate change, habitat alteration from agriculture, tourism, grazing, and theme effects on pollination networks threaten edge populations (Fan and Luo 2024; Tastanbekova et al. 2025). Climate modeling also predicts shifts in niche centers and contraction under higher-emission scenarios.

The genus *Trollius* represents a key biogeographic element of the temperate mountain flora of Eurasia. Its range extends from Eastern Europe to East Asia, with the center of species diversity located in the Altai, Tien Shan, and eastern Himalayan regions (Shipchinsky 1937; Kadota 2001). These mountains serve as refugia and centers of speciation, especially for cold-adapted taxa, and are characterized by a high degree of endemism. Kazakhstan, situated at the intersection of major floristic provinces-Siberian, Central Asian, and Dzungarian-plays a critical role as a transitional and contact zone for *Trollius* species distribution. This positioning makes Kazakhstan biogeographically important for understanding east-west and north-south migration pathways, hybrid zones, and ecological gradients affecting alpine flora (Takhtajan 1986; Kamelin 1990; Noroozi et al. 2016). The country's diverse mountain systems (Altai, Saur-Tarbagatai, Dzungarian

Alatau, northern and western Tian Shan) provide a mosaic of habitats across elevation belts, which are essential for the persistence of *Trollius* species sensitive to hydrology and microclimate changes.

Two of the species studied, *T. altaicus* and *T. asiaticus*, are valuable medicinal plants, while the remaining species (*T. dschungaricus*, *T. micranthus*, and *T. lilacinus*) are important ornamental flowering plants (Kubentayev et al. 2019). The species *T. altaicus* was first described by a Russian botanist KA Meyer in 1831 (GBIF Backbone Taxonomy 2025). This species has a vast distribution range (Flora of Kazakhstan 1960). It prefers humid and semi-humid habitats and is often found in meadows and on the lake and river banks (Flora of Kazakhstan 1960).

Earlier, *T. asiaticus* was not distinguished from *T. kytmanovii* (Witkowska-Banaszczak 2015). Despite morphological similarity between *T. asiaticus* and *T. altaicus*, the petal length differs significantly in the two species. Some authors suggest that *T. altaicus* originated from *T. asiaticus* through a mutation, which resulted in the development of dark-colored stylodia, petal reduction, and a shift in the orange coloration of the inner sepals toward the yellow spectrum (Buglova and Zhirova 2019). Despite spontaneous hybridization between *T. altaicus* and *T. asiaticus*, they belong to different taxonomic groups at the subgeneric rank. *Trollius altaicus* belongs to the "true *Trollius* flowers" (*Trollius* section, Doroszewska), which are characterized by narrow petals with almost imperceptible venation, shorter than or equal to the stamens. The petals fall before the stamens at the end of flowering. *Trollius altaicus* differs not only from all species in its section but also from the entire genus by dark red to black-purple carpels. *Trollius dschungaricus* also belongs to this section (Kovalevskaya 2024).

Trollius altaicus and *T. dschungaricus* belong to the same taxonomic group. However, they exhibit several morphological differences. Basal leaves of *T. altaicus* are five-segmented, whereas those of *T. dschungaricus* have three to five lobes. The leaf blade of *T. altaicus* is thin and non-fleshy, while in *T. dschungaricus*, it is thickened and slightly fleshy (Sulborska-Różycka and Weryszko-Chmielewska 2022).

Trollius dschungaricus was first published by EL Regel in 1880 (GBIF Secretariat 2023). It grows in coniferous and deciduous forests and alpine meadows at elevations up to 3,800 m asl, in moist meadows, and on the banks of water bodies (Mitrenina et al. 2020).

Trollius lilacinus is an Altai-Tian Shan species that grows in alpine meadows above 3,000 meters above sea level. It was first published in 1835 (Nartshuk et al. 2020). This species is listed as endangered in the Red Book of Buryatia, but remains unstudied in Kazakhstan.

The species *T. komarovii* was first published in 1974 (POWO 2025). *Trollius komarovii* was initially described as a variety of *T. lilacinus* (Chang et al. 2025). However, this species characterized by five rhomboid sepals clearly differs from *T. lilacinus* which has up to 20 obovate or spatulate sepals (Xu et al. 2023).

An updated checklist drawing on new herbarium collections, expedition data, and recent phylogenetic/morphological insights is essential to clarify species boundaries in a taxonomically challenging genus, fill geographical and ecological gaps in distributional knowledge and inform conservation strategies in light of climate vulnerability and anthropogenic threats. This will provide a robust baseline for monitoring, protection, and ecological research focused on vulnerable *Trollius* lineages. The aim of our research was to identify the distribution range of the genus *Trollius* in Kazakhstan based on the results of our own field trips, analysis of herbarium specimens from national and international collections, and data from various electronic platforms, to facilitate further systematic studies.

MATERIALS AND METHODS

Study area and methods

This study focuses on five species of the genus *Trollius*-*T. asiaticus, T. altaicus, T. dschungaricus, T. lilacinus*, and *T. komarovii*-distributed across several floristic regions of Kazakhstan.

Field surveys

Fieldwork was conducted in June 2023 during the flowering peak to maximize accurate identification and sampling. The route reconnaissance method (Bykov 1983) was applied across eight localities spanning the Western Altai, Zailiyskiy-Kungei, and Dzungarian Alatau regions (Table 1). Collection localities were georeferenced in the field and cross-validated using Google Earth.

Herbarium data

Herbarium records were examined from 14 institutional collections and supplemented with data from global databases (GBIF, iNaturalist). Verified specimens of the five target species were sourced from the following herbaria: AA, ABG, ALTB, AFAKNU, KKSNNP (Kazakhstan); MW, LE (Russia); US, MBG (USA); E (UK); BRNU (Czech Republic); BR (Belgium); NL (Netherlands); S (Sweden). Key collectors included VP Goloskokova and VV Fisyun, who made significant contributions prior to 1988. All label data-including collector name, date, and locality-were transcribed verbatim to maintain historical integrity.

Taxonomic verification and data validation

Species names were verified against Plants of the World Online (POWO 2025) and the International Plant Names Index (IPNI 2025). Coordinates and images from GBIF and iNaturalist were used to validate field identifications and confirm species presence across under-sampled regions.

Mapping and GIS

Spatial analysis was conducted using QGIS 3.28. Collection site coordinates were plotted, and habitat context was assessed using high-resolution satellite imagery via Google Earth. GIS layers were used to

compare historical and current records to detect distribution shifts and under-documented areas.

Systematic and floristic framework

Taxonomic and geographic interpretations were based on the Flora of Kazakhstan (1960), Illustrated Plant Identifier of Kazakhstan, and Plant Reference Guide of Central Asia (Kamelin and Kovalevskaya 1993), integrating legacy and recent data to build a regionally relevant checklist.

RESULTS AND DISCUSSION

All *Trollius* species are mesophytes, typically found in wet meadows, forest habitats, and alpine tundra (Trulevich 2001). According to literature sources, species of this genus are distributed in the mountainous regions of Southern, Southeastern, and Eastern Kazakhstan, specifically in the following floristic regions: Altai, Saur-Tarbagatai, Dzungarian Alatau, Zailiyskiy-Kungei Alatau, Ketpen-Terskey Alatau, Kyrgyz Alatau, and Western Tian Shan. Additionally, mentions were found of *T. altaicus* occurring in the Ulytau, Chu-Ili Mountains, and the Semipalatinsk forest-steppe (Figure 1).

Data presented in the herbarium collections of AA, AFAKNU, MW, LE, US, ABG, MBG, BR, BRNU, KKSNNP, E, ALTB, S, and NL.

Table 1. *Trollius* sample collection localities visited during the field surveys in 2023

Floristic region and species	Label data	Coordinates	Collectors	Collection date
Western Altai- *T. altaicus*	East Kazakhstan region, Ridder city, Ivanov Ridge, surroundings of the "Berezovka" center, mixed-herbaceous riparian meadow. 1,033 m asl	N50°33'20.17", E83°65'46.75"	Karabalayeva DE	13 VI 2023
	East Kazakhstan region, Ridder city, Ivanov Ridge, "Sery Lug" base, meadow. 1,150 m asl	N50°36'01.55", E83°89'63.42"	Karabalayeva DE	15 VI 2023
	Almaty Region, Talgar District, Kotyrbulak Gorge, Pioneer Mountain Resort	N43°18'91.26", E77°13'30.16"	Karabalayeva DE	16 VI 2023
Zailiyskiy Alatau- *T.altaicus*	Almaty Region, Talgar District, Kotyrbulak Gorge, Pioneer Mountain Resort	N43°18′91.26″, E77°13′30.16″	Karabalayeva DE	16 VI 2023
Zailiyskiy-Kungei Alatau- *T. dschungaricus*	Almaty Region, Maloe Almatinskoe Gorge, above the Vorota Tuyukaz base, 2,710 m asl	N43°10′46.96″ E77°06′98.43″	Karabalayeva DE	17 VI 2023
	Almaty Region, Uygur District, Ketpen Gorge, Ketpentau Ridge, 2,604 m asl	N43°33′88.04″ E80°33′48.85″	Karabalayeva DE	19 VI 2023
	Almaty Region, Raiymbek District, territory of the "Kolsai Lakes National Park, surroundings of Saty village, 1,907 m asl	N42°99′47.68″ E78°31′98.12″	Karabalayeva DE	18 VI 2023
	Almaty Region, Uygur District, Ketpen Gorge, Ketpentau Ridge, 2,630 m asl	N43°33′76.17″ E80°33′52.05″	Karabalayeva DE	19 VI 2023

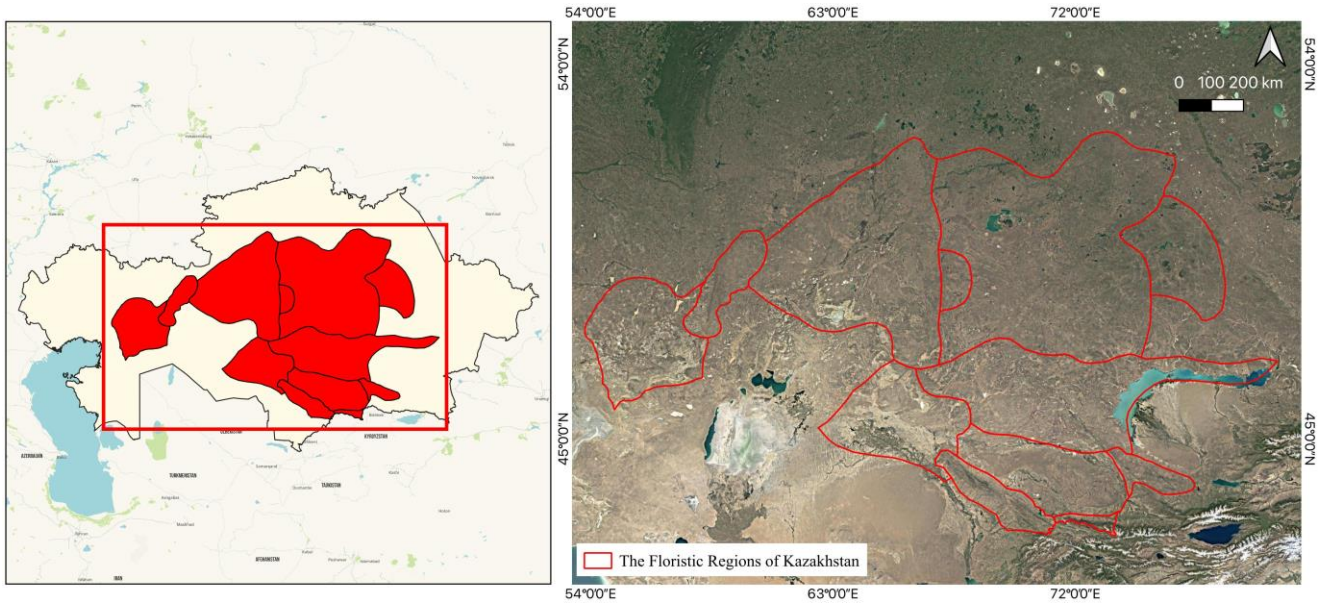

Figure 1. Distribution of the genus *Trollius* in Kazakhstan according to the available literature

Analyzing the obtained herbarium and literature data, we concluded that in the current distribution of the genus *Trollius* (specifically the species *T. altaicus*), floristic regions such as Ulytau and the Chu-Ili Mountains are not considered, while the Semipalatinsk Bor remains questionable due to a lack of sufficient information (Figure 2, Table 2).

According to the analysis of the obtained data, *T. altaicus* is distributed in the mountainous areas of Southern, Southeastern, and Eastern Kazakhstan. In terms of mountain systems, it is found in the Altai, Saur Ridge, Tarbagatai Ridge, Dzungarian Alatau, Northern Tian Shan (Zailiyskiy-Kungei Alatau, Ketpen- Terskey Alatau), Kyrgyz Alatau, and Western Tian Shan (Figures 3 and 4).

The most common habitats of *T. altaicus* are subalpine meadows, moss-lichen tundra, and stream banks. In terms of moisture requirements, *T. altaicus* is a mesophytocryophyte; it will thrive in well-drained substrates overly saturated with cold flowing or subterranean waters from high-altitude streams where a stable high soil moisture promotes its growth, flowering, and reproduction. Thus, the presence of wetlands and the maintenance of their hydrological regime are crucial for the preservation and development of *T. altaicus* populations.

Further analysis of herbarium collections provided the following data on *T. asiaticus*. This species was first described by K Ledebour in 1826. Below, are the coordinates of *T. asiaticus* that were correctly attributed. Information from herbarium specimens AA, MW, ALTB, KKSNNP, GBIF, and iNaturalist on the floristic regions of *T. asiaticus* (Table 3).

The typical habitats of *T. asiaticus* are high-altitude meadows, sparse forests, subalpine woodlands, and tundra. The earliest specimen of this species is dated to 1891. It was collected by IE Shavrov in the Western Altai, Biy district, near NA Shavrov's beekeeping station on the Black Uba River, 20 versts from the village of Strezhnoe. Only a few specimens and observations of this species are available; therefore, it is difficult to identify the species distribution range within Kazakhstan. However, we consider Eastern Kazakhstan (the Kazakh part of Altai) as the main distribution area of the species, while its presence in the Dzungarian Alatau remains uncertain (Figures 5 and 6).

Herbarium specimens play a key role in scientific research, serving as an essential part of floristic collections. They allow botanists and researchers to not only accurately identify a species but also study its distribution and assess changes in its range over time. Such data, collected in herbariums, assist not only in classification but also in monitoring changes in ecosystems that affect floral diversity in these mountainous regions.

Herbarium specimens of the species *T. dshungaricus* in the collections of AA, AFAKNU, BR, MW, US, BRNU, NL, GBIF, and iNaturalist by floristic regions. The least amount of data has been recorded for *T. asiaticus* and *T. komarovii*. In 1891, IE Shavrov collected herbarium specimens of *T. asiaticus*, which is found in Eastern Kazakhstan (Altai) and the Dzungarian Alatau. Information from herbarium specimens AA, AFAKNU, BR, MW, US, BRNU, NL, GBIF, iNaturalist on the floristic regions of the species *T. dshungaricus* (Table 4).

According to the analysis of the obtained data, *T. dschungaricus* is distributed in mountainous areas of South and South-East Kazakhstan. Relative to mountain systems-Dzungarian Alatau, Northern Tian-Shan (Zailiyskiy-Kungei Alatau, Ketpen-Terskey Alatau), Kyrgyz Alatau, Western Tian-Shan (Figures 7 and 8).

According to GBIF data, three records of *T. lilacinus* have been documented without a specified date. One of them belongs to JJ Halda and is stored in the herbarium of the Royal Botanic Garden Edinburgh Living Plant Collections (E). Another, associated with Mojmir Pavelka, is also held at the Royal Botanic Garden Edinburgh Living Plant Collections (E) and Moscow University Herbarium (MW), and was described by Schrenk. Specimens of *T. lilacinus* are represented in the herbariums AA, MW, E, AFAKNU, US, BRNU, S, GBIF, and iNaturalist, as shown in Table 5. *Trollius lilacinus* was first recorded by AG Schrenk in 1840. Information from herbarium specimens on the floristic regions of *T. lilacinus* (Table 5).

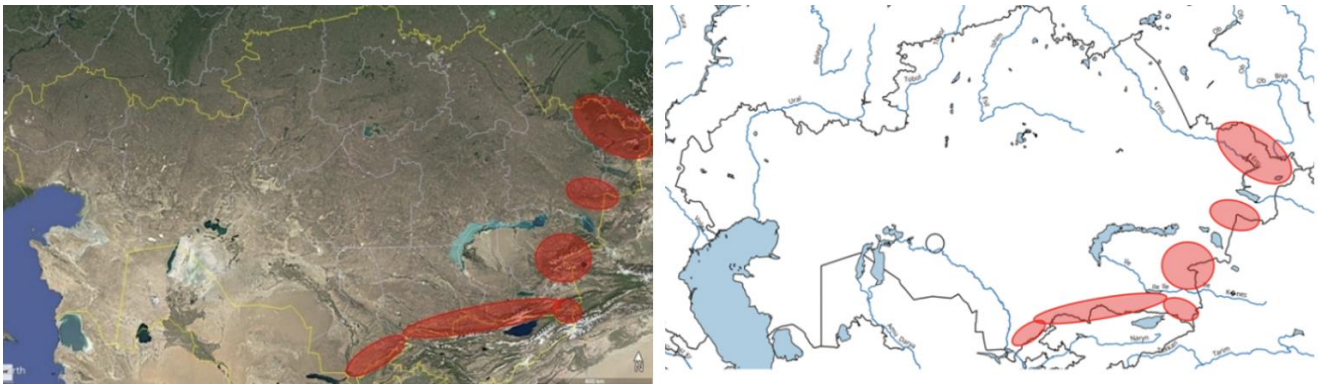

Figure 2. Distribution of the genus *Trollius* in Kazakhstan according to herbarium data

Table 2. Information from herbarium specimens AA, MW, US, ABG, ALTB, MBG, BRNU, E, NL, GBIF, iNaturalist on the floristic regions of the species *Trollius altaicus*

Floristic area	Collection location (label data)	Collectors	Date of collection and herbarium specimens
Dzungarian Alatau	Dzungarian Alatau	Schrenk AG	1840, (AA)
	Dzungarian Alatau	Karelin, Kiriloff	1841, (MW, GBIF)
	The vicinity of Lepsinsk, rocky banks of a mountain river in the gorge of the Dzungarian Alatau range, N45°52´34.28", E80°61´94.89"	Lipshits S	20 VI 1928, (MW, GBIF)
	Dzungarian Alatau, Lepsi gorge, meadow area below the summit of Jatybay-Tykcha, opposite the village of Gerasimovka	Lipshits S	28 VI 1928, (AA)
	Lepsinsky ridge, Lugovoe gorge, area below the summit of Jabat-Takchi, opposite the village of Gerasimovka, N45°78´27.28", E80°87´10.47"	Lipshits S	28 VI 1928, (MW, GBIF)
	Northern part of the Dzungarian Alatau, Lepsi Gorge, southern slope of Mount Kyzasu near the village of Kolpakovskoye, near a snow patch	Lipshits S	02 VII 1928, (AA)
	Lepsinsk gorge, slope on the summit of Mount Kyzasu near the village of Kolpakovskoye, near a snow patch, N45°81´65.97", E81°08´11.62"	Lipshits S	2 VII 1928, (MW, GBIF)
	Dzungarian Alatau, Lepsi gorge, alpine meadow near a snow patch on the summit of Mount Abyl-Tau, in the vicinity of the village of Glinovskoye	Pavlov NV	07 VII 1928, (AA)
	Dzungarian Alatau, N45°74´52.78", E81°36´18.57"	Pavlov NV	7 VII 1928, (MW, GBIF)
	Dzungarian Alatau, upper reaches of the Karatal river, mountains at the source of the Karatal, Soldatskaya Gorge south of the Chizhi River, western slope, 1,750 m asl	Shipchinsky NV	31 VII 1930, (AA)
	Dzungarian Alatau	Grigoriev YS	14 VII 1931, (AA)
	Dzungarian Alatau	Lipschitz YS	14 VII 1931, (AA)
	Dzungarian Alatau ridge, northern slopes of the gorge	Kornilova VS	19 VI 1934, (AA)
	Dzungarian Alatau, area near village Lepsinsk	-	26 VIII 1934, (US, GBIF);
	Southern slope of the Dzungarian Alatau, middle course of the Malyi Usek River, Djilandy Mountains, northern slope	Linchevsky OA	17 VI 1937, (AA)
	Southwestern spurs of the Dzungarian Alatau, Altyn-Emel Ridge, Matai Mountains, northern meadow slope in the upper reaches of the Matai River	Goloskokov VP	20 VI 1956, (AA)
	Southwestern spurs of the Dzungarian Alatau, Altyn-Emel Ridge, Mount Matay, Itmurin River Gorge, on the northern meadow slopes near the summit, N44°40´52.73", E78°94´84.35"	Goloskokov VP	26 VI 1956, (MW, GBIF)
	Southwestern spurs of the Dzungarian Alatau, Altyn-Emel ridge, Matay Mountains, eastern Itmurin Gorge, on the northern meadow slopes	Goloskokov VP	26 VI 1956, (AA)
	Dzungarian Alatau, Zhelanash gorge, 80 km east of Sarkand village, Taldykorgan Region, meadows and shrub thickets in the forest belt	Gubanov IA	5 VI 1957, (MW, GBIF)
	Dzungarian Alatau, N42°71´54.57", E79°27´21.93"	Gubanov IA	19 VII 1958, (MW, GBIF)
	Chingiz-Tau, birch-willow groves in the valley of the Kalgutta river, near the right tributaries of Syroy Lug, close to the trees	Gamayunova AP	20 VI 1958, (AA)
	Western spurs of the Dzungarian Alatau, Koturkain Mountains, upper reaches of the Karagayly River, along a spring	Goloskokov VP	27 V 1959, (AA)
	Northern spurs of the Dzungarian Alatau, Bebokan Mountains, near the village of Dzerzhinsky, among deciduous forest	Goloskokov VP	20 VI 1959, (AA)
	Northern slope of the Dzungarian Alatau, upper reaches of the Baskhan river, in the gorge, at avalanche sites	Goloskokov VP	29 VI 1959, (MW, GBIF)
	Dzungarian Alatau, N45°23´87.55", E80°31´65.81"	Goloskokov VP	29 VI 1959, (MW, GBIF)
	Southern Altai, Sarymsakty ridge, upper reaches of the Sarymsakty River, forest boundary, in wet areas	Roldugin II	21 VII 1960, (AA)
	Kazakh SSR, Kyrgyz ridge, Chibindy gorge, northeastern slope, among subalpine tall grass	Fisyun VV	05 V 1961, (AA)
	Northern spurs of the Dzungarian Alatau ridge, in the zone of subalpine meadows, near the village of Konstantinovka	Lushpa OU	01.VI.1963, (AA)
	Dzungarian Alatau, Koktal River gorge, southwestern slope	Vasilieva AN	17 VII 1966, (AA)
	Dzungarian Alatau, Koktal River gorge, southwestern slope	Yanchenko LM	10 VII 1966, (AA)
	Dzungarian Alatau, slope of the Lepsy river gorge	Stepanova EF	14 VI 1970, (AA)
	Southwestern spurs of the Dzungarian Alatau, ravine southwest of the Yangi-Altyn-Emel pass, northern slopes	Fisyun VV	13 VI 1971, (AA)
	Southwestern spurs of the Dzungarian Alatau, ravine southwest of the Yangi-Altyn-Emel pass, on the northern slopes near a spring	Goloskokov VP	14 VI 1971, (AA)
	Upper reaches of Borokhudzira in the Dzungarian Alatau, Suattau Mountains, near the Koishi Pass, subalpine meadows	Goloskokov VP	02 VII 1971, (AA)
	Southern spurs of the Dzungarian Alatau, Suattau Mountains near the Yugentas Pass, on mixed-grass slopes	Goloskokov VP	03 VII 1971, (AA)
	Taldykorgan region, Northern Dzungarian Alatau, Kora River Valley, base of the left slope, in the middle part, near the former bridge	Oleg Kosterin	20 VI 1993, (iNaturalist)

	Almaty Region, Sarkand district, Kok-Zhota tract, at the foot of Mount Aktas	Danilov MP, Shormanova AA, Kurmantaeva AA, Bilibaeva BK	18 VI 2014, (AA)
Altai	Ridder	Ledebour C	26 IV 1826, (LE)
	Ridder	Schemonaicha, Vydricha, Ledebour C	01 V 1826, (LE)
	Ridder	Ledebour C	18 V 1826, (LE)
	Shilgan Floodplain	Ledebour C	12 VI 1826, (LE)
	Semipalatinsk region, the area around Katon-Karagay	Shigitsyn AS	1913, (MW, GBIF)
	Western (Kazakhstan) Altai Mountains, N49°06´13.82", E85°43.93"	Shumkova AG	7 VII 1923, (MW, GBIF)
	Semipalatinsk Governorate, Bukhtarma district, surroundings of Katon-Karagay, Narym range, headwaters of the Solonechny stream (N49°10′, E55°06′), alpine meadow near the snow	Krylov PN, Sergievskaya L	29 VII 1928, (BRNU, GBIF)
	Western (Kazakhstan) Altai Mountains, N49°07´24.33", E85°64´99.34"	Smirnow P	19 VII 1930, (MW, GBIF)
	Western (Kazakhstan) Altai Mountains, N49°07´24.33", E85°64´99.34"	Smirnow P	19 VII 1930, (MW, GBIF)
	Altai, Katon-Karagay village	Smirnow P	19 VII 1930, (AA)
	Western Altai, Ridder Forest	Yevseenko V	17 VII 1933, (AA)
	Western (Kazakhstan) Altai Mountains, N49°07´24.33", E85°64´99.34"	Smirnow P	19 VII 1930, (MW, GBIF)
	Altai, Kalbin range, Mynbulak village, summer herd, Kazan-Gazar locality, Kochkarnik	Andreev IG	23 VI 1936, (AA)
	Southern Altai, at the foot of the northern slope of the Narym range, opposite Katon-Karagay, 1,400 m	Elenevskiy R	26 VI 1936, (MW, GBIF)
	Altai, Ridder, ravine along the Khorizovka river	Kubanskaya ZV	29 VI 1936, (AA)
	Western (Kazakhstan) Altai Mountains	Elenevskiy R	2 VII 1936, (MW, GBIF)
	Altai, Ridder district, pass from the Khorizovka River	Kuznetsov NM	01 VI 1937, (AA)
	East Kazakhstan region, Ridder district, northern slope of Mount Krestovaya	Kuznetsov NM	26 VI 1937, (AA)
	Altai, Ivanovskie Belki, scree on damp soil near a snow patch	Gamayunova AP	15 VII 1944, (AA)
	Western Altai, northwest of Ridder, Mount Golukha, among the subalpine meadow	Polyakov PP	27 VII 1947, (AA)
	East Kazakhstan region, Samarsky district, Kaindinsky forest, floodplain of the Kainy River, among the pine forest, 3 km from the central border	Elizaryeva OA	12 VI 1948, (AA)
	East Kazakhstan region, Samarsky district, Kaindinsky forest, floodplain meadow in the headwaters of the Kainy River	Snegirev VA	04.VI.1970, (AA)
	Altai, Ulbin range, 10 km east of Leninogorsk, moist meadow	Yanchenko LM	28 VI 1973, (AA)
	East Kazakhstan region, Altai, Narym range, Koksor Mountains	Stepanova EF, Mikheeva NN	17 VII 1973, (AA)
	East Kazakhstan region, surroundings of Lake Markakol, northwest of the village of Urunkhayka, marshy meadow	Grudzinskaya LM	01 VI 1976, (AA)
	East Kazakhstan region, surroundings of the city of Leninogorsk	Grudzinskaya LM	01 VI 1976, (AA)
	East Kazakhstan region, Sarymsakty range, Akbulak River, 12 km from Katon-Karagay	Utegenov K, Shormanova AA	22 VI 1981, (AA)
	East Kazakhstan region, Sarymsakty range, southeastern foothills, forest	Bialieva RA	04 VIII 1985, (AA)
	East Kazakhstan region, Altai, Narym range, surroundings of the village of Cherdoyak, aspen-birch forest, floodplain meadows	Bidullayeva AM	14 VII 1986, (AA)
	East Kazakhstan region, Altai, Southern Altai range, Sorvenok Pass, meadows among larch-fir forest	Ivashchenko AA, Isayev EB	28 VI 1987, (AA);
	East Kazakhstan region, Altai, Southern Altai range, northern slope, Karu-Kaba basin, 2030 m.	Ivashchenko AA, Isayev EB	03 VII 1987, (AA)
	East Kazakhstan region, Sarymsakty range, Burkhat Pass, northern rocky slope, wormwood tundra	Ivashchenko AA, Isayev EB	19 VII 1987, (AA)
	East Kazakhstan region, Sarymsakty ridge, Burkhat Pass, opposite the village of Chingistai, slope of flat stones, northern slope, alpine belt	Ivashchenko AA, Isayev EB	20 VII 1987, (AA)
	Altai, Kalba ridge, 4 km south of the village of Pargyl, the first gorge, 700 m, along the floodplain	Utebekov KI	16 VIII 1987, (AA)
	East Kazakhstan region, Altai, Narym Ridge, north of the village of Sergeevka, intermountain valley among the forests, grassland and herbaceous vegetation	Bidullayeva AM	10 VI 1988, (AA)
	East Kazakhstan region, Altai, Narym ridge, Mount Ak-Choku, northern exposure, shrub and herbaceous vegetation	Bidullayeva AM	13 VI 1988, (AA)
	Altai, Kurchum ridge, 20 km north of the village of Gornoye, summit of the southern slope, rocky and stony substrate	Myrzakulov PM	24 VI 1988, (AA)
	South Altai, Kurchum ridge, Mount Sarytau, 2-4 km to the south, 2,645 m	Isayev EB	01 VII 1988, (AA)
	East Kazakhstan region, Altai, Narym ridge, Mount Zhesulu, 2,410 m above sea level, rocky summit	Bidullayeva AM	05 VII 1988, (AA)

	East Kazakhstan region, Altai, Narym ridge, Mount Saralka, southern exposure, 2,350 m asl	Bidullayeva AM	06 VII 1988, (AA)
	East Kazakhstan region, Altai, Narym ridge, Bolgyn gorge, 7-8 km southeast of the village of Bolgyn, 1,650-2,100 m asl, among the Siberian juniper thickets	Bidullayeva AM	14 VII 1988, (AA)
	East Kazakhstan region, Sarymsakty ridge, upper reaches of Kumshibai gorge, coniferous forest	Isayev EB	17 VII 1988, (AA)
	East Kazakhstan region, Altai, Southern Altai ridge, upper reaches of the Kurti River	Isayev EB	25 VII 1988, (AA)
	South Altai, Kurchum ridge, 20 km north of the village of Gornoye, rocky-gravelly-clayey southern slope, steppe areas	Myrzakulov PM, Isayev EB	08 VIII 1988, (AA)
	Katon-Karagay district, pass between the Sarymsakty and Tarbagatai ridges, 14 km south of the main road to Katon-Karagay. Alpine meadows with patches of snow, N49°11′6.66", E86°02′3.61"	Solomon JC	2 VIII 1995, (MBG, GBIF)
	Altai, right bank of the Bukhtarma river, foxtail meadow at the edge of a larch forest near Mount Kainar	Kudabayeva GM	04 VI 1999, (AA)
	Altai, grazed meadow at the edge of a spruce forest on the left bank of the Bukhtarma River	Kudabayeva GM	30 VI 1999, (AA)
	East Kazakhstan region, Zyryanovsk District, vicinity of the Osinovsky Pass, meadow in willow thickets by a stream	An'kova TV, Grebenyuk A	22 V 2004, (AA)
	East Kazakhstan region, Katon-Karagay District, eastern slope of Mount Karashongal, base of the rocky belt, N49°26′03.8, E86°94′04.3	Kosterin O	30 VII, 2010, (iNaturalist)
	East Kazakhstan region, Katon-Karagay District, 15 km east-southeast of the village of Ust-Chindagatuy, southern foothills of the Ukok Plateau, right bank of the Muzdy-Bulak stream.	Kosterin O	30 VI 2012, (iNaturalist, GBIF)
	East Kazakhstan region, Glubokoye District, N49°93′09.23", E82°70′77.52"	Kolesnikov V	5 VII 2013, (iNaturalist, GBIF)
	East Kazakhstan region, Leninogorsk, N50°36′21.0, E83°93′93.2	Ralph Martin	31 V 2014, (iNaturalist)
	East Kazakhstan region, Ridder, N50°34′18.33", E83°87′37.73"	Kubentayev SA	10 VII 2014, (iNaturalist, GBIF)
	East Kazakhstan, Ridder, N50°36′71.64", E83°87′13.17"	Kubentayev SA	8 VIII 2014, (iNaturalist, GBIF)
	East Kazakhstan region, Kurchum District, N48°.83′82.4, E85°99′99.2	Kubentayev SA	8 VI 2016, (iNaturalist)
	East Kazakhstan region, Kurchum District, N48°60′98.9, E85°94′21.4	Kubentayev SA	8 VI 2016, (iNaturalist)
	East Kazakhstan region, Cherymoshka river, alpine and subalpine meadows near the snowfields, riverbanks	Bolbotov GA, Kechaikin AA, Shmakov AI	25 VI 2020 (iNaturalist,)
	East Kazakhstan region, Alpine and subalpine meadows near the snowfields, riverbanks, Cherymoshka river, N49°4′14, E85°2′12"	Bolbotov GA	25 VI 2020, (ALTB, GBIF)
	East Kazakhstan region, Cherymoshka River	Bolbotov GA	25 VI 2020, (ALTB, GBIF)
	East Kazakhstan region, Ridder, N50°36′25.76", E83°87′4.66"	Blazhko O	18 VI 2020, (iNaturalist, GBIF)
	East Kazakhstan region, Ridder, N50°31′08.0, E83°79′69.5"	Kubentayev SA	27 VI 2021, (iNaturalist)
	East Kazakhstan region, Kurchum district, Ushkurmynger ridge, Kopyrtas River, N48°56′06, E86°25′62"	Bolbotov GA	6 VII 2021, (ABG, GBIF)
	East Kazakhstan region, Kurchum district, Ushkurmynger ridge, Kopyrtas River, alpine and subalpine meadows, riverbanks	Bolbotov GA	6 VII 2021, (ABG, GBIF)
	East Kazakhstan region, Glubokovsk district, N50°26′98.32, E82°81′28.62"	Kubentayev SA	14 VI 2022 (iNaturalist, GBIF)
	East Kazakhstan region, Katon-Karagay district, N49°15′34.62", E86°04′93.68"	Kubentayev SA	30 V 2023, (iNaturalist, GBIF)
	East Kazakhstan region, Katon-Karagay district, N49°15′34.6, E86°04′93.6	Gypaetus	30 V 2023, (iNaturalist)
	East Kazakhstan region, Altai, N50°26′6.11", E83°22′8.89"	Issakova E, Lagus O	30 мая 2023, (ABG, GBIF)
	East Kazakhstan region, Leninogorsk district, N50°35′35.2, E83°89′33.1	Gypaetus	1 VI 2023, (iNaturalist)
	East Kazakhstan region, Ridder, Polevaya street, N50°32′46.38", E83°54′77.83"	Mahabbat	5 VI 2023, (iNaturalist, GBIF)
	East Kazakhstan region, N50°33′99.4, E83°74′90.8	Zholdas D	7 VI 2023, (iNaturalist)
	East Kazakhstan region, N50°34′23.8, E83°74′99.9	Turash Z	7 VI 2023, (iNaturalist)
Saur-Tarbagatai	In pratensibus and radicem montium Aktschauly, in montibus Tarbagatai locis demissioribus	Karelin GS, Kiriloff IP	1840, (BR, GBIF)
	Tarbagatai	Karelin GS	1840, (MW, GBIF)
	Tarbagatai	Karelin GS	1840, (MW, GBIF)
	Tarbagatai	Karelin GS	1840, (MW, GBIF)
	Saur-Tarbagatai, Saur ridge, Yandyktas	Schrenk AG	1841, (AA)

	Saur Tarbagatai, N47°30´78.74", E84°95´51.65"	Goncharov NF	18 VII 1930, (MW, GBIF)
	Saur-Tarbagatai, Saur ridge, Terakty river gorge, along the bottoms of ravines, in areas of moisture	Yashchenko MII	31 V 1954, (AA)
	Saur-Tarbagatai, Monrak ridge, Mount Cherbas, 1,800 m.	Stepanova EF	10 VII 1972, (AA)
	Saur-Tarbagatai, Saur ridge, Terekty gorge	Stepanova EF	31 VII 1972, (AA)
	Saur-Tarbagatai, Tarbagatai ridge, Say-Asu Pass, among the grassland and herbaceous meadow, at an altitude of 2,100 m asl	Stepanova EF	20 VI 1978, (AA)
	Saur-Tarbagatai, Monrak ridge, northwestern spurs, Tuyuk Gorge	Rakityanskaya TM	26 V 1981, (AA)
	Saur-Tarbagatai, Monrak ridge, Kotal-Chilik area, 1,800 m, along the moist meadows of the northwestern exposure	Rakityanskaya TM	14 VII 1985, (AA)
Zailiyskiy-	North and Central Tian Shan	Pryanishnikov AV	1931, (MW, GBIF)
Kungei-	Talas Alatau range, upper reaches of the Kshi-Kaindy River, subalpine zone, 2,500 m asl	Linchevsky OA	27 VI 1933, (AA)
Alataui	Zailiyskiy Alatau, Kastek district, Kastek river gorge, Baytamanak-Say	Linchevsky OA	25 V 1936, (AA)
	Zailiyskiy Alatau ridge, Mount Suok-Tau, Chien River Gorge, grassy slope	Dmitrieva AA	07 VI 1936, (AA)
	Zailiyskiy Alatau, surroundings of Karakastek, grassy slope in the Chien river gorge, near Mount Suok-Tau	Seregin AP	9 VI 1936, (MW, GBIF)
	Kshi-Kaindy Pass, northern slope	Seregin AP	13 VII 1949, (MW, GBIF)
	Zailiyskiy Alatau, Komissarovka gorge, northern slope, 6 km east of Medeo, clearing in a spruce forest	Gamayunova AP	28 V 1956, (AA)
	East Kazakhstan region, northern slopes of the Kalbin Ridge, floodplain of the Tulsky spring	Eremeeva RV	18 VI 1956, (AA)
	Western spurs of the Talas Alatau, Aksu River canyon, surroundings of the Burkut-Uya area near the stream	Zaitseva LI	13 VI 1961, (AA)
	Western spurs of the Talas Alatau, Aksu-Jabagly Nature Reserve, upper reaches of the Kshi-Kaindy River valley, clay soils at an altitude of 2700 m asl	Karmysheva NH	24 VII 1961, (AA)
	Zailiyskiy Alatau, Utas River Gorge	Baitenov MS	20 VII 1968, (AA)
	Zailiyskiy Alatau, Assy area, northern slope of the mountain	Kurochkina LYa	21 VI 1982, (AA)
	Almaty Region, Aksu district, N45°07´84.05", E 79°63´32.46"	Gorbunov P	1 VI 2016, (iNaturalist, GBIF)
	Almaty Region, Aksu district, N 45°07´83.75", E 79°63´32.03"	Gorbunov P.	1 VI 2016, (iNaturalist, GBIF)
	Almaty Region, Kerbulak district, N44°74´2.48, E79.41´2.06"	Kryzhatyuk BV	17 VIII 2016 (iNaturalist, GBIF)
	Almaty Region, Talgar district, N43°19´52.59", E77°12´26.39"	-	31 V 2018, (GBIF)
	Almaty Region, Bostandyk district, N43°08´05.92", E76°98´56.23"	Braiter S	20 V 2023, (iNaturalist, GBIF)
	Almaty Region, N43°16,78.3, E77°08´60.2	Markieva A	20 V 2023, (iNaturalist)
	Almaty Region, Medeu district, N43°17´54.76", E77°10´03.73"	Epiktetov V	25 V 2023, (iNaturalist, GBIF)
	Almaty Region, N43°17´46.98", E77°10´90.27"	Satekov I	25 V 2023, (iNaturalist, GBIF)
	Almaty Region, Talgar district, N43°15´79.45", E77°10´04.11"	Mialik A	16 VI 2023, (iNaturalist, GBIF)
	Zailiyskiy Alatau, N43°17´80.13", E77°09´45.06"	Selkinto	31 V 2024, (iNaturalist, GBIF)
	Almaty Region, N43°17´79.1, E77°09´44.9	Roman U	31 V 2024, (iNaturalist)
	Almaty Region, Karasai district, N43°05´61.6", E76°97´64.8"	Tim Cowley	5 VI 2024, (iNaturalist)
	Almaty Region, Karasai district, N42°95´54.0", E76°58´87.6"	Elana	16 VI 2024, (iNaturalist)
	Almaty Region, N43°15´99.0", E77°09´57.3"	Shomina M	20 VI 2024, (iNaturalist)
	Almaty Region, N43°25´34.3", E79°55´14.6"	Davidson SJ	29 VI 2024, (iNaturalist)
	Almaty Region, Talgar district, N43°11´76.8", E77°11´50.5"	Cybernetic	8 VII 2024, (iNaturalist)
	Almaty Region, N43°15´99.03", E77°09´57.33"	Maria	20 VI 2024, (iNaturalist, GBIF)
	Almaty Region, Karasai district, N43°07´40.3, E76°91´27.9"	Dina J	8 VII 2024, (iNaturalist)
	Almaty Region, Rayimbek district, N42°45´10.38", E80°12´88.38"	Epiktetov V	20 VII 2024, (iNaturalist, GBIF)
Western	Aulie-Ata gorge, Talas Alatau, Aksai River	Popov MG	07 VII 1922, (MW, GBIF)
Tian Shan	Talas Alatau, Jambul gorge	-	5 VIII 1930, (MW, GBIF)
	Western Tian Shan and Karatau, N42°44´38.86", E70°76´95.48"	Pavlov NV	22 VII 1931, (MW, GBIF)
	Western Tian Shan, near Kyz-Ulken-Kul Lake, in mass quantities in low places	Masalsky AP	08 VI 1936, (AA);
	Zailiyskiy Alatau ridge, Kastek River Gorge, grassy slope	Dmitrieva AA	26 VI 1936, (AA)
	Western Tian Shan, Talas Alatau, Aksu-Jabagly Nature Reserve, Tobshak-saz, near a stream	Yanushko N	16 VII 1941, (AA)

	South Kazakhstan region, Tulkibas District, Western Tian Shan, Talas Alatau, Aksu-Jabagly Nature Reserve, northern slope of the Kshi-Kaindy River	Daeva OV	5 VIII 1949, (MW, GBIF)
	South Kazakhstan, Aksu-Jabagly Nature Reserve, upper reaches of the Kshi-Kaindy River, alpine meadow, closer to the snow, N42°43´75.42", E70°47´57.95"	Golubev	9 VII 1951, (MW, GBIF)
	Kyrgyz Djugum, in the gorges of the Tshibindy River, on the northeastern slopes	Fisjun V	5 VI 1961, (US, GBIF)
	South Kazakhstan, Talas Alatau, Aksu-Jabagly Nature Reserve, Ayna Kul Lake	Barabanov E	21 VI 1961, (MW, GBIF)
	Western Tian Shan, Talas Alatau, Aksu-Jabagly Nature Reserve, alpine meadows in the upper reaches of the M. Kaindy River gorge, 2,400 m asl	Gubanov IA	11 VIII 1966, (MW, GBIF)
	Western Tian Shan, Talas Alatau, Aksu-Jabagly Nature Reserve, Kishi-Kaindy Gorge, closer to the snowfields in the subalpine zone, 2,400 m	Pavlov NV	11 VIII 1966, (MW, GBIF)
	The northern slope of the Ulken-Kaindy pass, approximately 14 km southeast of the village of Jabagly, formerly known as Novo-Nikolaevka, and 85 km southwest of the city of Zhambyl	Harper, Geoffrey H	6 VIII 1996, (E, GBIF)
	South Kazakhstan, Aksu-Zhabagly Nature Reserve, N42°24´71.16", E70°66´92.65"	Stefano Doglio	15 VI 2006, (iNaturalist, GBIF)
	South Kazakhstan, Tulkubas District, N42°37´96.21", E70°64´14.03"	Epiktetov V	19 VI 2016, (iNaturalist, GBIF)
	Zhambyl region, Koksay Gorge, Aksu-Jabagly Nature Reserve, N42°41´74.9, E70°92´22.7	Elena	15 VI 2024 (iNaturalist)
Kyrgyz Alatau	Ketpen Ridge, upper reaches of the Kyrgyz Alatau, subalpine meadow, N43°26´57.68", E79°51´68.11"	Rodin L	15 VIII 1931, (MW, GBIF)
	Kyrgyz Alatau, Kyrgyz Ridge, northern gorges of Kaindy, wet slopes in the shade of birches	Gamayunova AP	31 V 1961, (AA)
	Kyrgyz Ridge, northern gorges of Kaindy, saddle above the birch forest, tall-grass meadows	Fisjun V	31 V 1961, (AA)
	Kyrgyz Ridge, Chibyndy Gorge, upper reaches, wet meadow	Gamayunova AP	05 VI 1961, (AA)
	Kazakh SSR, Kyrgyz Ridge, Chibyndy River Gorge, northeastern slope, among subalpine tall grass, N42°77´6.94", E72°19´9.44	Fisjun V	5 VI 1961, (BRNU, GBIF)
	Kyrgyz Djugum, in the narrow valleys of the Tshibindy River, on the northeastern slopes, in subalpine tall grass meadows	Fisjun V	5 VI 1961, (NL, GBIF)
	Kyrgyz Djugum, in the gorges of the Tshibindy River, on the northeastern slopes, in subalpine tall grass meadows	Fisjun V	5 VI 1961, (NL, GBIF)
	Kyrgyz Ridge, Chibindy River Gorge, northeastern slope, among subalpine tall grass	Fisjun V	5 VI 1961, (MW, GBIF)
	Northwestern end of the Kyrgyz Ridge, upper reaches of the Syugaty River, along the northern grassy slopes near the spring	Goloskokov VP	07 VI 1963, (AA)
	Western end of the Kyrgyz Alatau, Chelsu River valley, Ush-Sala locality	Nelina NV	11 VII 1983, (AA)
	Southern macroslope of the Kyrgyz Alatau, Kumbel Pass (ascent), northern juniper slope	Nelina NV	05 VI 1984, (AA)

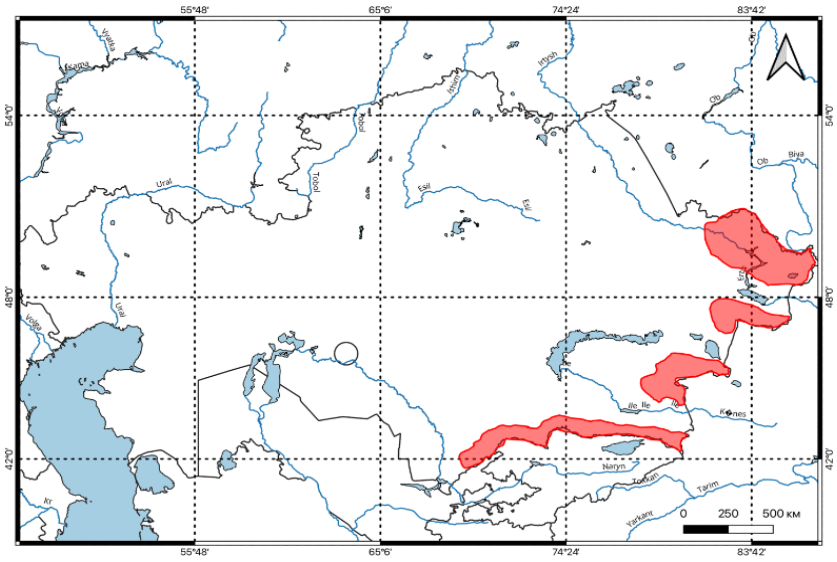

Figure 3. Distribution map of *Trollis altaicus* in Kazakhstan based on the herbarium and field data

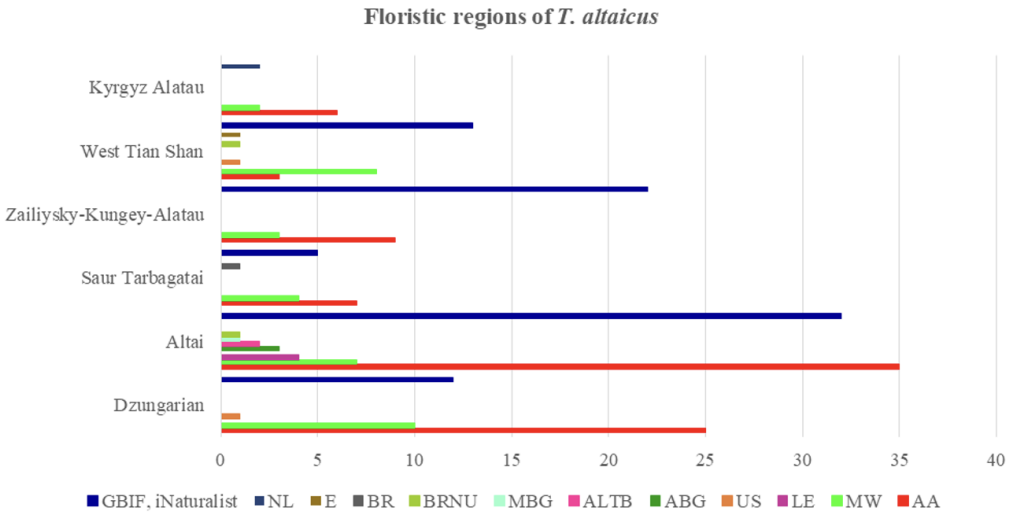

Figure 4. Number of findings of *Trollius altaicus* species according to herbarium collections and main observations in electronic databases

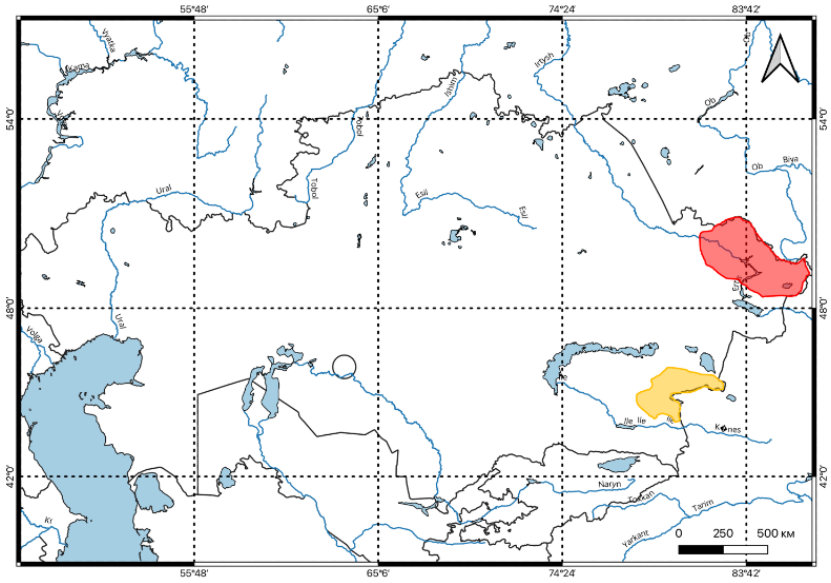

Figure 5. Distribution map of *Trollius asiaticus* within Kazakhstan (the main range in Kazakhstan is highlighted red, and the Dzungarian Alatau is highlighted yellow)

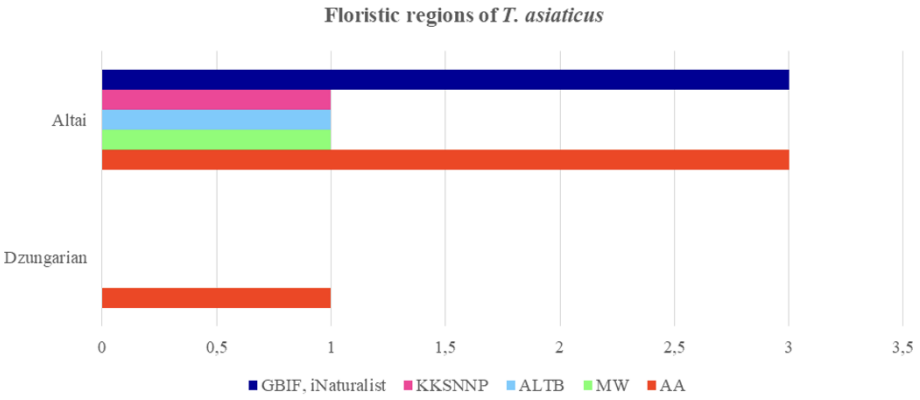

Figure 6. Number of finds of *Trollius asiaticus* species according to herbarium collections and main observations on electronic databases

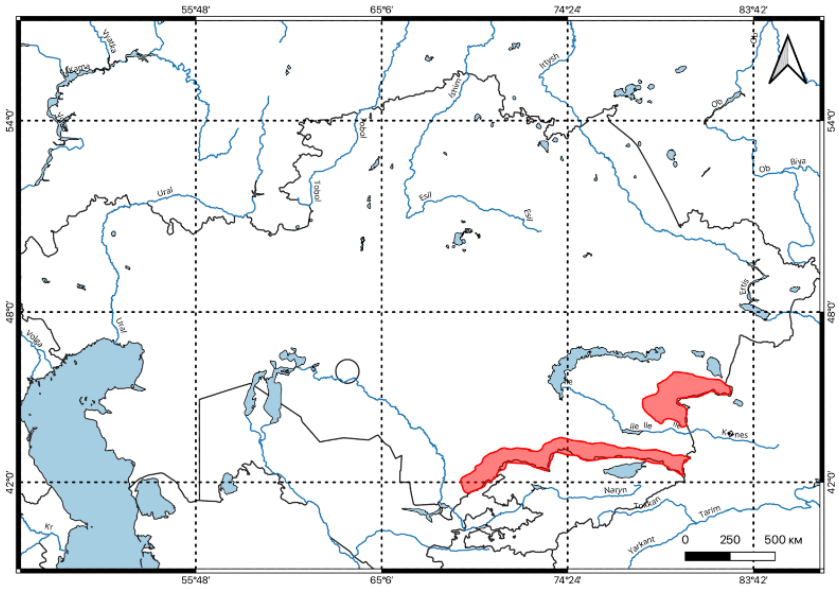

Figure 7. Distribution map of *Trollius dschungaricus* within Kazakhstan

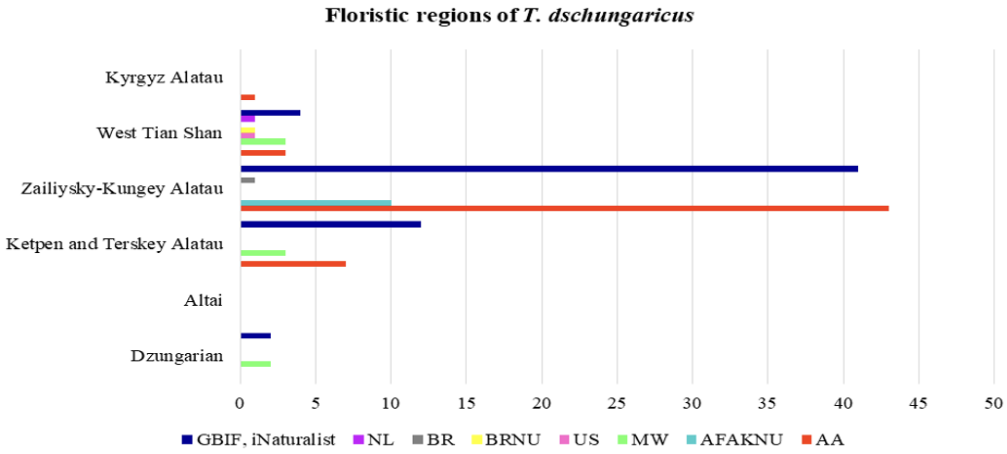

Figure 8. Number of *Trollius dschungaricus* occurrences in herbarium collections and key observations from electronic databases

Table 3. Information from herbarium specimens AA, MW, ALTB, KKSNNP, GBIF, and iNaturalist on the floristic regions of *Trollius asiaticus*

Floristic region	Collection location (label data)	Collectors	Date of collection and herbarium specimens
Dzungarian Alatau	Dzungarian Alatau, Jelanash Gorge, 80 km north of Sarkand in the Taldykorgan region, meadows and shrub thickets in the forest belt	Chubanov IA	05 VI 1957, (AA)
Altai	Western Altai, Biysky district, NA Shavrov's apiary on the Black Uba River, 20 versts from the village of Strezhnoe	Shavrov IE	7 VII 1891, (MW, GBIF)
	Western Altai, northwest of Ridder, Mount Golukha, amidst subalpine meadows	Polyakov P	27 VII 1947, (AA)
	Kolbinskiy Ridge, the floodplain of the Kainy River	Polyakov P	12 VI 1948, (AA)
	Southern Altai, Narym Ridge, Koksor Mountains	Stepanova EF	17 VII 1973 (AA)
	East Kazakhstan Region, Katon-Karagay District, Karagai State National Nature Park, N49°55′84, E86°30′42	Bolbotov GA	02 VI 2021, (ALTB, GBIF)
	East Kazakhstan Region, Katon-Karagay District, Karagai State National Nature Park, N49°55′84. E° 86°30′42,	Bolbotov GA, Kechaikin AA, Shmakov AI	2 VI 2021, (KKSNNP, GBIF)

According to the analysis of the obtained data, *T. lilacinus* is distributed in the mountainous areas of Southern, Southeastern, and Eastern Kazakhstan. Considering the mountain systems, it is found in the Altai, Saur Range, Tarbagatai Range (under question), Dzungarian Alatau, Northern Tian Shan (Zailiyskiy-Kungei Alatau, Ketpen-Terskey Alatau), and Western Tian Shan (Figures 9 and 10).

It should be noted that the first herbarium specimens of *T. lilacinus* were dated to 1840 by AG Schrenk, with numerous discoveries recorded in 1936. However, herbarium collections have not been replenished with new specimens from 2006 to 2016. The specified electronic databases, such as GBIF and iNaturalist, provide precise coordinates and photographs of *T. lilacinus*, which allows for the search and collection of new populations for subsequent systematic analysis.

Herbarium specimens of *T. komarovii* were also found, which is a virtually understudied species. All reviewed specimens are mainly dated from 1932 to 1943, with very few modern collections. Therefore, research is needed to determine the current state of biodiversity of the species and their points of natural occurrence. Information from herbarium specimens AA, iNaturalist, and GBIF on the floristic regions of the species *T. komarovii* (Table 6).

According to the data available for *T. komarovii*, the main distribution area of the species in Kazakhstan is the western Tian Shan (Figures 11 and 12). The first recorded herbarium specimen of *T. komarovii* was collected in 1937 in Kazakhstan. In 1937, AP Masalsky collected the first herbarium specimen of *T. komarovii*, whose main range in Kazakhstan is the Western Tian Shan. This specimen serves as an important historical record of the species' presence in the country. The second specimen was collected in 1992, 55 years later. This specimen confirms that the species continued to exist in the same areas and remained a characteristic component of the flora during that period. It serves as evidence of the population's stability and its resilience to changes in the climate and ecology of the region. The most recent specimen was collected in 2018 using online platforms for tracking natural observations, such as iNaturalist and GBIF. This specimen confirms the current status of the species and its persistence in modern ecosystems.

The largest number of *T. altaicus* specimens is represented in the herbarium collection of the Institute of Botany, while the other collections contain a minimal number of specimens of this species. The analysis of the species' habitats indicates that it is most prevalent in the East Kazakhstan region. However, individual specimens have been noted in the Almaty Region, along the Charyn River, and generally in the Zailiyskiy Alatau. The species is associated with mountainous elevations, rocky and humid habitats, as well as near snow patches in moist alpine meadows. This distribution pattern confirms the species' preference for elevations ranging from approximately 1,800 to 2,800 meters, where stable snowmelt and moisture regimes provide suitable microhabitats. Its occurrence near snow patches and on rocky, humid slopes is consistent with other mesophilic Ranunculaceae adapted to short growing seasons and cold soils.

Among the analyzed specimens, *T. dschungaricus* is represented by 54 specimens, and *T. lilacinus* by 24 specimens in the collection of the Institute of Botany and Phyto-introduction. These species are found in the Dzungarian Alatau, in the rivers Big Almaty Lake and Malaya Almatinka, and in the Kaiyndy area. The species grows in moist soils along spruce trees, by riverbanks, in mountainous areas, and on rocky slopes. Both species show clear ecological preferences for montane and subalpine spruce forest belts, moist ravines, and talus habitats. Their occurrence in areas with fluctuating hydrological regimes suggests potential vulnerability to climate-induced changes in snowmelt timing, runoff volume, and seasonal desiccation.

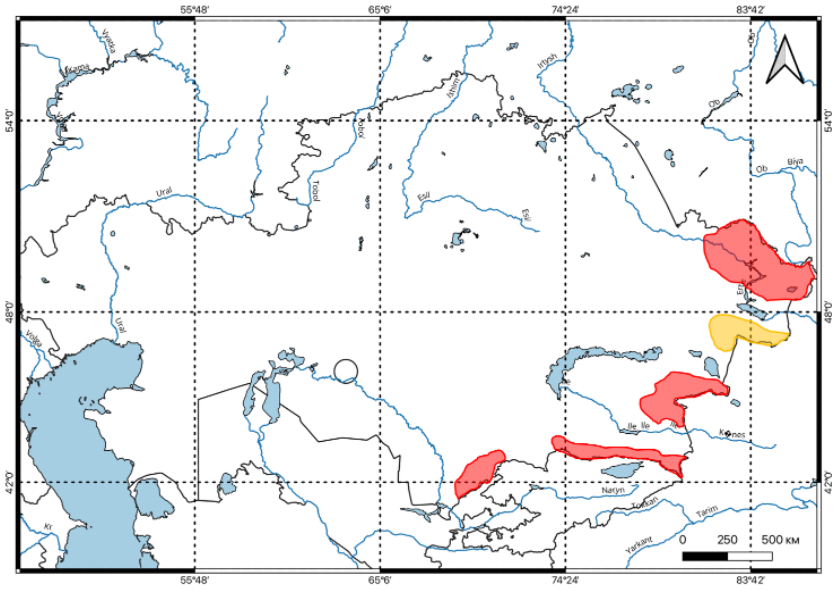

Figure 9. Distribution map of *Trollius lilacinus* within Kazakhstan

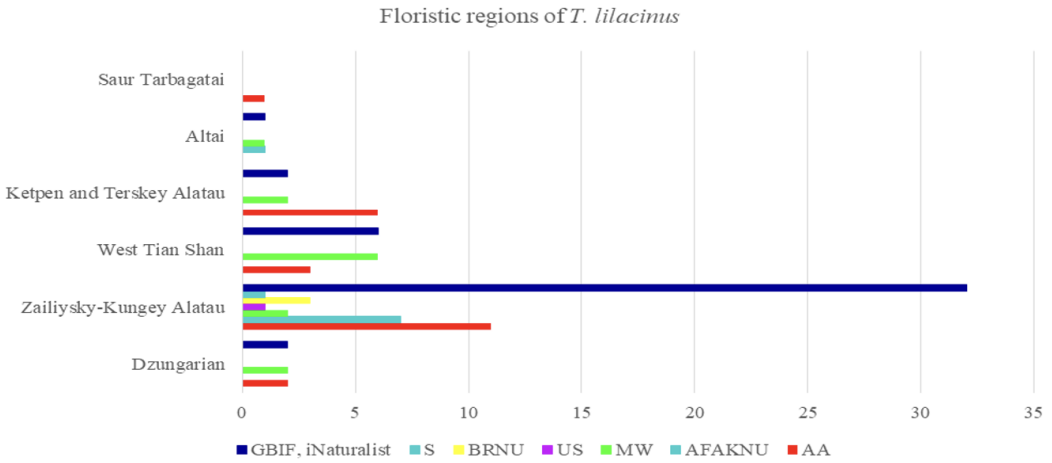

Figure 10. Number of findings of *Trollius lilacinus* species from herbarium collections and main observations from electronic databases

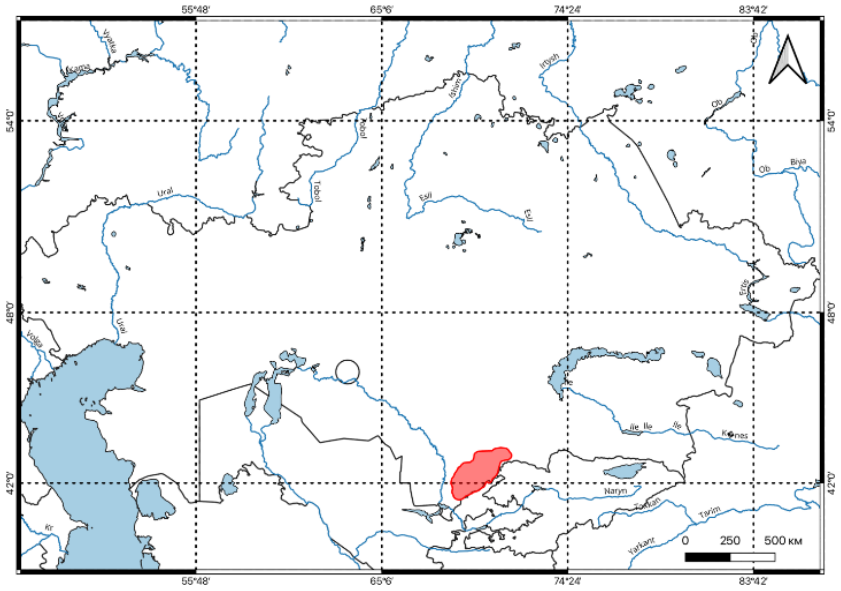

Figure 11. Distribution map of *Trollius komarovii* within Kazakhstan

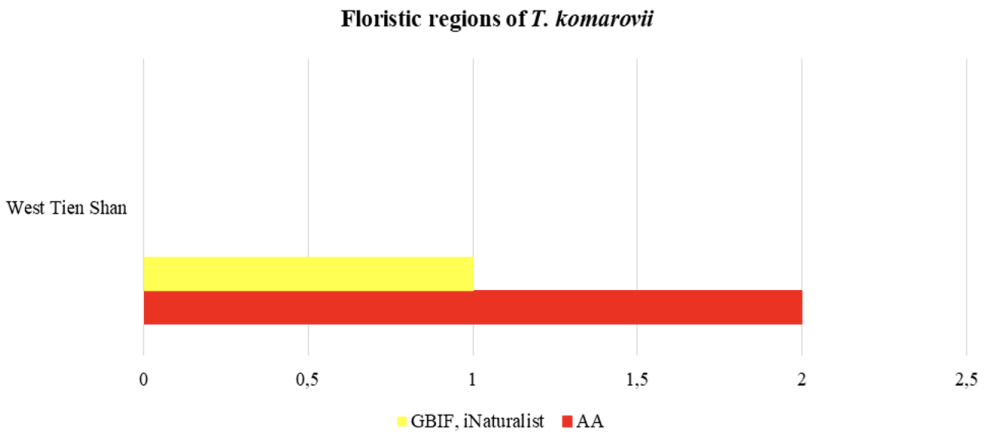

Figure 12. Number of records of *Trollius komarovii* species in herbarium collections and main observations from electronic databases

Table 4. Information from herbarium specimens AA, AFAKNU, BR, MW, US, BRNU, NL, GBIF, iNaturalist on the floristic regions of the species *Trollius dshungaricus*

Floristic region	Collection location (label data)	Collectors	Date of collection and herbarium specimens
Zailiyskiy-Kungei Alatau	Zailiyskiy Alatau, Semirechye Region, Vernensky District, and Vernyi	Sokalsky ND	17 VI 1907, (AA)
	Zailiyskiy Alatau, surroundings of Almaty, Baterayna Gorge	Popov MG	21 VII 1926, (AA)
	Zailiyskiy Alatau, vicinity of Almaty, Baterayna Gorge	Geld AI	21 VI 1926, (AA)
	Zailiyskiy Alatau, Malaya Almatinka, Ak-Zhailau, vicinity of the city of Almaty	Popov MG	23 VI 1926, (AA)
	Alma-Ata, Ak- Zhailau	Popov MG	23 VI 1926, (AA)
	Zailiyskiy Alatau, alpine meadow in the upper reaches of the Batareyka River, at an altitude of 2,200 meters	Peterson G	05 VI 1935, (AA)
	Zailiyskiy Alatau, a slightly marshy meadow in the valley of the Big Almatinka River	Kubanskaya ZB	06 VI 1935, (AA)
	Zailiyskiy Alatau, Jinishke Gorge	Bykov B	20 VII 1935, (AFAKNU)
	Zailiyskiy Alatau Ridge, Mount Suok-Tau, Chien River Gorge, grassy slope	Dmitriyeva AA	07.VI.1936, (AA)
	Zailiyskiy Alatau, Chien River Gorge near Mount Suok-Tau, subalpine zone	Mikhailova VP	08 VI 1936, (AA)
	Zailiyskiy Alatau, Chien River Gorge near Mount Suok-Tau, subalpine zone	Mukhlya AV	10 VI 1936, (AA)
	Zailiyskiy Alatau, Malaya Almatinka River Gorge, 2,650 m asl, northeast slope	Goloskokov VP	10 VI 1936, (AA)
	Zailiyskiy Alatau, Malaya Almatinka River Gorge, Aman-Zhailau, slopes	Goloskokov VP	15 VI 1936, (AA)
	Zailiyskiy Alatau, Malaya Almatinka River Gorge, Aman- Zhailau, slopes	Bykov B	20 VI 1936, (AAFAKNU)
	Zailiyskiy Alatau, Big Almatinka River Gorge	Bykov B	20 VI 1936, (AAFAKNU)
	Zailiyskiy Alatau, Turgen, Teskensu Creek, alpine belt	Rachmanina S	21 VI 1936, (AA)
	Northern slope of the Kungei Alatau Range, Kurmekty, northern slope among the grassland	Mikhailova VP	27 VI 1937, (AA)
	Zailiyskiy Alatau, Big Jenishke, Muyun-Saz (Taban-Karagai locality)	Bykov BA, Lubenets E	05 VII 1936, (AA)
	Kungei Alatau, Dzelanash, Merke River Gorge	Bykov BA	12 VII 1936, (AAFAKNU)
	Kungei Alatau, Big Dzelanash Gorge, grassy slopes	Gorbunova EP	21 VI 1937, (AA)
	Kungei Alatau, Big Dzelanash Gorge	Goloskokov VP	10 VII 1937, (AA)
	North slope of Kungei Alatau, Kurmekty Pass, at an altitude of 2800 m, juniper zone	Mikhailova VP	30 VI 1937, (AA)
	Almaty District, Alma-Arasan Gorge, mountains around the Almaty Lake	Ageeva	16 VII 1938, (AAFAKNU)
	Zailiyskiy Alatau, in the Assy valley, among the meadow with mixed grasses	Polyakov PP	24 VII 1941, (AA)
	Zailiyskiy Alatau, Malyi Almatinsky Gorge, subalpine belt	Solomchenko AZ	VI 1946, (AAFAKNU)
	Kain-Say Gorge, eastern slope	Federenko	27 VI 1948, (AAFAKNU)
	Northern slopes of the Kungei Alatau, sources of the right tributaries of the Kulsay River near the pass to Kyrgyzstan, 2,890 m, in shrublands	Roldugin II	14 VII 1952, (AA)
	Zailiyskiy Alatau, western part of the northern slope of Tur-Aygyr, east of Mount Karagayly, among sparse spruce forest	Goloskokov VP	03 VI 1953, (AA)
	Northern slope of the Kungei Alatau, Kurmekty River Gorge, a clearing in a spruce forest	Roldugin II	05 VII 1953, (AA)
	Kungei Alatau, floodplain of the Ulken Taldybulak River	Arystangaliyev SA	20 VII 1953, (AA)
	Almaty Region, Narynkol District, Murtaly locality, left bank of the upper reaches of the Murtaly River	Sapozhnikova	01 V 1954, (AAFAKNU)
	Northern slope of the Kungei Alatau, Karabulak Gorge (west), in the floodplain among the spruce forest	Roldugin II, Fisyun VB	07 VIII 1955, (AA)
	Northern Tian Shan, Zailiyskiy Alatau massif, valley of the Malaya Almatinka. Meadows in the forest zone	Lisowski S	27 VI 1959, (BR, GBIF)
	Eastern foothills of the Kungei Alatau, Dzhalanash Gorge, near the trail leading to the pass into Kyrgyzstan, at the upper limit of the spruce forests	Goloskokov VP	29 VII 1959, (AA)
	Malaya Almatinka Gorge, Medeo area	Tarasova	26 VI 1960, (AAFAKNU)
	Zailiyskiy Alatau, Kensai Gorge, on alpine meadows	Lushpa OY	02 VII 1960, (AA)

Zailiyskiy Alatau, Malaya Almatinka River Gorge, on herbaceous meadows at the upper forest boundary	Roldugin II	12 VI 1963, (AA)
Zailiyskiy Alatau, upper reaches of the Kaskelen River, along the northern grassy slopes in the spruce belt at an altitude of 2,450 m	Goloskokov VP	24 VI 1963, (AA)
Northern slope of the Kungei Alatau, Kaindy Gorge, in a meadow at 2,250 m asl	Roldugin I	08 VIII 1964, (AA)
Northern slope of the Kungei Alatau, Kurmekty River Gorge, watershed meadow, among grass and herbaceous associations	Roldugin I	09 VIII 1964, (AA)
Northern slope of the Kungei Alatau mountain range, Big Djalanash Gorge, in the meadows, at 2,350 m	Roldugin I	21 VIII 1964, (AA)
Zailiyskiy Alatau, Talgar Gorge, in juniper-spruce forests at an altitude of 2,600 m.	Roldugin I	07 VI 1967, (AA)
Zailiyskiy Alatau, Dala-Ashik Mountains, Sulu-say Gorge	Lushpa OY	28 VI 1968, (AA)
Zailiyskiy Alatau, Kasambek Gorge, glade in a spruce forest	Roldugin I	01 VIII 1968, (AA)
Almaty Region, Kegen District, southern slope of Mount Shol´adyr	Arystangaliyev SA	08 VII 1974, (AA)
Almaty Region, Narynkol District, the ridges of Mount Laily	Mikheeva NN	11 VII 1974, (AA)
Zailiyskiy Alatau, Urochishche Dzhenishke, western slope	Vasilieva AN	17 VI 1976, (AA)
Zailiyskiy Alatau, Oi-Zhailau Gorge, cliffs	Vasilieva AN	21 VI 1976, (AA)
Zailiyskiy Alatau, Turgen River Gorge, subalpine meadows	Grudzinskaya LM	1980, (AA)
Kungei Alatau Range, Kara-Bulak River Gorge, grassy clearing in a spruce forest	Fisyun VB	08 VIII 1982, (AA)
Western end of the Kyrgyz Alatau, Chelsu River valley, Ush-Sala tract	Nelina NV	11.VII.1983, (AA)
Zailiyskiy Alatau, Kiik-bay gorge, meadows	Esirkenova AA	20 VII 1992, (AFAKNU)
Kungei Alatau, Charyn, 2,200 m asl, on the plateau surface, Kensu Gorge	Mukhtubayeva SK	13 VII 1998, (AA)
Almaty, Medeu district, N43°13´07.36", E77°01´64.76"	Ebel A	28 V 2006, (iNaturalist, GBIF)
Almaty southeastern environs, northern edge of the Kok-Zhailau Plateau, in the valley of the brook. N43°13´99.29", E77°00´68.96"	Kosterin O	5 VII 2009, (iNaturalist, GBIF)
Almaty southeastern environs, upper valley of the Gorel'nik River, N43°11´26.84", E77°04´18.75	Kosterin O	8 VII 2009, (iNaturalist, GBIF)
Southeastern Almaty environs, Zailiyskiy Alatau Mountains, left bank of the Mynzhylky Reservoir, N43°08´25.07", E77°07´68.72"	Kosterin O	10 VII 2009, (iNaturalist, GBIF)
Southeastern Almaty environs, Zailiyskiy Alatau Mountains, lower part of the Mynzhylky Valley, N43°08´34.32", E77°07´50.38"	Kosterin O	10 VII 2009, (iNaturalist, GBIF)
Almaty, Medeu District, N43°06´26.22", E 76°98´52.67"	Smith PC	26 V 2013, (iNaturalist, GBIF)
Almaty, Bostandyk District, N43°06´01.45", E76°98´62.97	Smith PC	26 V 2013, (iNaturalist, GBIF)
Almaty, Bostandyk District, N43°04´85.6", E76°95´35.6	Ebel A	9 VI 2013, (iNaturalist, GBIF)
Almaty Region, Raiymbek District, N42°72´97.55", E79°45´71.96"	Gorbunov P	5 VII 2017, (iNaturalist, GBIF)
Almaty Region, Zailiyskiy Alatau, the serpentine road to the Big Almaty Observatory, 2,348 м н.у.м	Danilov MP, Akhatayeva DA, Bilibayeva BK	07 VI 2018, (AA)
Almaty Region, Karasai District, N43°05´61.11", E76°97´83.33"	Calame T	19 VI 2018, (iNaturalist, GBIF)
Almaty, Medeu District, N43°13´48.0", E77°05´25.5"	Yenikeyev M	18 V 2019, (iNaturalist)
Almaty Region, Karasai District, N43°04´31.21", E76°94´06.07"	Gorbunov P	11 VII 2019, (iNaturalist, GBIF)
Almaty Region, Talgar District, N43°15´30.2", E76°98´96.6"	Alex	23 V 2020, (iNaturalist)
Almaty Region, Karasai District, N43°05´29.0", E76°71´00.3"	Strenada V	14 VI 2021, (iNaturalist)
Almaty, N43°13´90.22", E77°06´51.25"	Naumenko A	26 VI 2021, (iNaturalist, GBIF)
Almaty, N43°13´16.08", E77°05´73.28"	Naumenko A	26 VI 2021, (iNaturalist, GBIF)
Almaty, Medeu District, N43°17´45.42", E77°10´26.97"	Ruslan	12 V 2022, (iNaturalist, GBIF)
Almaty, Bostandyk District, N43°06´76.61", E76°98´91"	Ruslan	29 V 2022, (iNaturalist, GBIF)
Almaty Region, Raiymbek District, N42°91´31.6", E78°34´56.5"	Alex	20 VI 2022 г. (iNaturalist, GBIF)
Almaty Region, Raiymbek District, N42°94´13.57", E78°28´23.87"	Alex	22 VI 2022 г. (iNaturalist, GBIF)
Almaty Region, Raiymbek District, N43°04´15.09", E78°57´13.73"	Alex	24 VI 2022, (iNaturalist, GBIF)
Almaty Region, Raiymbek District, N42°94´18.03", E78°32´23.76"	Alex	17 VI 2022, (iNaturalist, GBIF)
Almaty Region, Raiymbek District, N43°04´15.09", E78°57´13.73"	Alex	24 VI 2022, (iNaturalist, GBIF)
Almaty Region, Uygur District, N43°27´50.6", E79°52´24.9"	Davidson SJ	6 VII 2022, (iNaturalist)
Almaty, Medeu District, N43°12´47.22", E77°08´92.96"	Ebel A	26 V 2023, (iNaturalist, GBIF)
Almaty Region, Raiymbek District, N42°98´71.9", E78°32´66.6"	Boldyrev D	30 V 2023, (iNaturalist)
Almaty Region, Kegen District, N42°93´18.83", E78°23´47.04"	Satekov I	3 VI 2023, (iNaturalist, GBIF)
Almaty, N43°06´02.08", E76°98´05.36"	Epiktetov V	10 VI 2023, (iNaturalist, GBIF)
Almaty Region, Karasai District, N43°07´82.3", E76°90´57.8"	Semenov V	16 VI 2023, (iNaturalist, GBIF)

	Almaty Region, Karasai District, N43°05´92.42", E76°98´66.44"	Epiktetov V	17 VI 2023, (iNaturalist, GBIF)
	Almaty Region, Karasai District, N43°05´35.01", E76°96´36.48"	Epiktetov V	18 VI 2023, (iNaturalist, GBIF)
	Almaty Region, Mountaineers' Memorial, N43°10´63.89", E77°07´38.89"	Svetlanasp	5 VI 2024, (iNaturalist, GBIF)
	Almaty, Medeu District, N43°12´67.4, E77°05´44.73"	Epiktetov V	8 VI 2024, (iNaturalist, GBIF)
	Almaty, Medeu District, N43°10´89.17", E77°03´58.73"	Epiktetov V	8 VI 2024, (iNaturalist, GBIF)
	Almaty Region, N43°16´07.28", E77°10´29.66"	Daisan	8 VI 2024, (iNaturalist, GBIF)
	Almaty Region, Black Waterfall, N43°11´97.6", E77°07´20.6"	Елена	8 VI 2024, (iNaturalist)
	Almaty Region, Karasai District, N43°06´41.74, E76°83´54.25"	Елана	30 VI 2024, (iNaturalist, GBIF)
	Almaty, Medeu District, N43°12´02.74", E77°05´18.72"	Yevdokimov I	20 VI 2024, (iNaturalist, GBIF)
	Almaty, Medeu District, N43°10´19.36", E77°07´64.15"	Yevdokimov I	21 VI 2024, (iNaturalist, GBIF)
	Almaty Region, Karasai District, N43°06´87.73", E76°91´45.15"	Julayeva D	8 VII 2024, (iNaturalist, GBIF)
	Almaty Region, Kegen District, N42°94´21.15", E78°32´51.93"	Alex	23 VII 2024, (iNaturalist, GBIF)
Ketpen - Terskey Alatau	Kungei Alatau, near the settlement of Chektal, alpine meadow on the northern slope of the Utash Gorge, around 3,000 m	Smirnov PA	28 VI 1931, (MW)
	Almaty Region, Raiymbek District	Lipschitz S	16 VI 1932, (MW, GBIF)
	Almaty Region, Raiymbek District	Lipschitz S	16 VI 1932, (MW, GBIF)
	Terskey Alatau, the upper reaches of the Big Kokpak River.	Koshechkina G	1940, (AA)
	The upper reaches of the Battery River, on the slopes among the meadows in the subalpine zone	Serebryakov I	24 VI 1940, (MW, GBIF)
	Eastern part of the Terskey Alatau (Narynkol District, Almaty Region), in the valley of the Big Kokpak River, on the meadow	Polyakov PP	16 VI 1948, (AA)
	Ketmen Mountains, Bolshoy Ketmen Gorge	Godvinsky MI	19 VI 1958, (AA)
	Northern slope of the Ketpen-Tau Range, Arkalykholsai Gorge, the peak of the northern slope near the spruce forest	Roldugin II, Fisyun VB	21 VI 1964, (AA)
	Kazakh SSR, Northern Tian Shan, northern slope of the Ketpen Range, Big Achenakho River Gorge, on forest-meadow clearings at an elevation of 2,200 m asl	Roldugin II, Fisyun VB	26 VI 1964, (AA)
	Ketpen Range, Supatsay Gorge, northern slope	Vasilieva AN	26 VI 1964, (AA)
	North slope of the Ketpen-Tau range, Big Ketpen Gorge, near the upper forest boundary, 2,260 m asl	Roldugin II, Orazova AO	28 VI 1964, (AA)
	Almaty Region, Talgar District, N43°15´20.86", E77°01´70.07"	Mialik A	12 VI 2023, (iNaturalist, GBIF)
	Almaty Region, Talgar District, N43°10´88.79", E77°03´34.41"	Mialik A	13 VI 2023, (iNaturalist, GBIF)
	Almaty Region, Talgar District, N43°11´74.7", E77°13´14.9"	Mialik A	15 VI 2023, (iNaturalist)
	Almaty Region, Talgar District, N43°11´58.6", E77°12´23.5"	Mialik A	15 VI 2023, (iNaturalist)
	Almaty Region, Talgar District, N43°15´41.3", E 77°12´70.8"	Mialik A	16 VI 2023, (iNaturalist, GBIF)
	Almaty Region, Talgar District, N43°15´18.47", E77°12´19.99"	Mialik A	16 VI 2023, (iNaturalist, GBIF)
	Almaty Region, Raiymbek District, N42°93´97.3", E78°32´51.5"	Ufimov R	28 V 2024, (iNaturalist)
	Almaty Region, Talgar District, N43°18´08.7", E77°11´33.6"	Kanunnikov	1 VI 2024, (iNaturalist)
	Almaty Region, Talgar Pass-Left Talgar, N43°12´09.68", E77°13´82.17"	Epiktetov V	16 VI 2024, (iNaturalist, GBIF)
	Almaty Region, Raiymbek District, N42°64´10.2", E79°91´88.8"	Kisology	27 VI 2024, (iNaturalist)
	Almaty Region, Raiymbek District, N42°99´30.6", 78°45´90.0"	Strobl D	4 VII 2024, (iNaturalist)
	Almaty Region, Raiymbek District, N42°58´27.56", E80°02´07.24"	Elana	26 VII 2024, (iNaturalist, GBIF)
Western Tian Shan	Tian Shan, Ketpen Range, Mount Karatau, upper reaches of the Sumbe River, subalpine meadows	Arystangaliyev SA	19 VII 1962, (AA)
	Tian Shan, Ketpen Range, Mount Aygaitas, alpine meadows	Arystangaliyev SA	04 VIII 1963, (AA)
	Tian Shan, Ketpen Range, upper reaches of the Kyrgyzsay River, subalpine meadows	Arystangaliyev SA	10 VIII 1963, (AA)
	Northern Tian Shan, northern slope of the Ketpen Range, gorge of the Big Achenakho River, on forest-meadow clearings, 2,200 m asl	Roldugin I	26 VI 1964, (US, GBIF)
	Kazakh SSR, Northern Tian Shan, northern slope of the Ketpen Range, gorge of the Big Achenaho River, Ulyken Dihan, on forest-meadow clearings, 2,200 m asl	Roldugin I, Fissjun V	26 VI 1964, (BRNU, GBIF)
	Tian Shan Borealis, northern slope of the Ketpen Range, in the gorge of the Big Achenakho River, in forest-meadow clearings	Roldugin I, Fissjun V	26 VI 1964, (NL, GBIF)
	Northern Tian Shan, northern slope of the Ketpen Range, Big Achenakho River gorge, in forest-meadow clearings, at 2,200 m asl	Roldugin I	26 VI 1964, (MW, GBIF)
Kyrgyz-Alatau	Southern macroslope of the Kyrgyz Alatau, beginning of the Kumbel pass, northern juniper grass slope	Nelina NV	05 VI 1984, (AA)
Dzungarian-Alatau	Dzungarian Alatau, Taldykorgan Region, Andreyevsky District, 4 km from Lepsinsk, grassland with mixed grasses	Vinogradov VA	20 VI 1990, (MW, GBIF)
	Southern slope of the Dzungarian Alatau mountain range, Tishkan River valley	Pimenov MG	09 VII 1974, (MW, GBIF)

Table 5. Information from herbarium specimens on the floristic regions of *Trollus lilacinus*

Floristic region	Collection location (label data)	Collectors	Date of collection and herbarium specimens
Dzungarian-Alatau	Dzungarian Alatau	Schrenk AG	1840, (AA)
	Southern slope of the Dzungarian Alatau, upper reaches of the Malaya Usek River, among the steppes	Rubtsov NI	20 VI 1937, (AA)
	Dzungarian Alatau	Karelin	1841, (MW, GBIF)
	Kazakhstan, Taldykorgan Province, the northern Dzungarian Alatau Mountains, the northern main slope of the Mynzhylky Range, the headwaters of the Kyzylagash River, a soaking meadow near the Semenov-Tian-Shanskiy Pass	Oleg K	21 VI 1993, (iNaturalist, GBIF)
Zailiyskiy-Kungei Alatau	Semirechye Region, Vernensky District, city of Vernyi, Mynzhylky. Above the second scree. Near the city of Vernyi	Sokalski N, Genina V	31 V 1907, (BRNU, GBIF)
	Verniy. Mittel-Asien.	Sokalskiy N	17 VI 1907, (US, GBIF)
	Semirechye Region, Vernensky District	Nasarowi MI	17 VI 1907, (MW, GBIF)
	Semirechye Region, Vernensky District, city of Vernyi	Sokalskij ND	17 VI 1907, (BRNU, GBIF)
	Semirechye Region, Vernensky Uyezd, Kaskelen Pass, alpine rocky scree, N42°91′38.9", E76°54′44.4"	Shishkin B, Genina V	23 VI 1913, (BRNU, GBIF)
	Almaty, Bolshoye Almatinskoye Gorge, Almaty Pass, under the glacier, near the snow	Shishkin BK	24 VI 1928, (AA)
	Lepsinsky Gorge, meadows and banks of the Kolyuchikov River, under the summit of Mount Saltur, N45°26′57.54", E81°98′43.78"	Pavlov NB	22 VII 1928, (MW, GBIF)
	Kazakh SSR, surroundings of Alma-Ata, Talgar Pass, 3,300 m, on rocky soil	Rachmanina S	12 VII 1935, (AA)
	Zailiyskiy Alatau, Dzhenyshke Taban-Karagai, alpine meadow near snow patches	Bykov B	27 V 1936, (AFAKNU)
	Kazakh ASSR, surroundings of the city of Alma-Ata, Zailiyskiy Alatau, subalpine zone near the "Gates"	Rubtsov NI	08 VI 1936, (AA)
	Zailiyskiy Alatau, Malaya Almatinka	Bykov B	10 VI 1936,(AFAKNU)
	Zailiyskiy Alatau, gorge of the Malaya Almatinka River, altitude 2,650 m.	Goloskokov VP	10 VI 1936, (AA)
	Zailiyskiy Alatau, gorge of the Malaya Almatinka River, gates, wet areas	Goloskokov VP	10 VI 1936, (AA)
	Headwaters of the Malaya Almatinka River, rocks near the moraine of the Chertovo Gorge	Linchevsky OA	27 VI 1936, (AA)
	Zailiyskiy Alatau, Malyi Almatinka, Mynzhylky Gorge	Bykov B	05 VII 1936, (AFAKNU)
	Zailiyskiy Alatau, Turgene River, headwaters of the Tesken-su stream, Kok-Paktak mountains, stony slopes, around 3,000 m	Popov MG	22 VII 1936, (AA)
	Kungei Alatau, pass from Merke to Kyrgyzstan, southern rocky slopes, above sea level 3,500 m	Gorbunova ЕП	03 VII 1937, (AA)
	North slope of the Kungei Alatau mountain range, Kurmekty Pass, near the snow	Mikhailova VP	09 VII 1937, (AA)
	Kungei Alatau	Bykov B	01 VII 1937, (AFAKNU)
	Zailiyskiy Alatau, the pass gap	Bykov B	28 VI 1938,(AFAKNU)
	North slopes of the Kungei Alatau, right tributaries of the Kulsay River near the pass to Kyrgyzstan, 3,200 m, near snow patches	Goloskokov VP	14 VII 1952, (AA)
	North slopes of the Kungei Alatau, Tau-Chilik Basin, upper reaches of the Saty River, near the snow patch	Arystangaliyev SA	15 VII 1952, (AA)
	Small Almaty Gorge, alpine meadows, western slope	Kenesarina	02 VI 1953,(AFAKNU)
	Zailiyskiy Alatau, Big Almaty Gorge, alpine meadows	Kornenko	09 IX 1958,(AFAKNU)
	Zailiyskiy Alatau, alpine meadows on the northern slope of Mount Bolgov	Ismailov, Amanzholov	21 VI 1998, (AAFAKNU)
	Almaty, Tian Shan, Ile-Alatau National Nature Park, wet meadow near the upper observatory, N43°02'26,7", E76°56'41,4"	Stenberg L	4 VI 2008, (S, GBIF)
	Southeast of Almaty, in the upper valley of the Gorel'nik River, N43°10′00.81", E77°04′51.79"	Kosterin O	8 VII 2009, (iNaturalist, GBIF)
	Southeast of Almaty, at the headwaters of the Gorel'nik River, near Lake Titova, N43°08′83.21", E77°05′02.1"	Kosterin O	9 VII 2009, (iNaturalist, GBIF)
	Southeast of Almaty, the headwaters of the Gorel'nik River, at the base of a reddish-stone scree near Lake Titova, N43°08.95", E77°05.28"	Kosterin O	9 VII 2009, (iNaturalist, GBIF)
	Almaty Region, Karasai District, N43°04′82.67", E76°94′73.5"	Epiktetov V	14 VI 2016, (iNaturalist, GBIF)
	Almaty Region, Karasai District, N43°04′07.83", E76°94′50.11"	User 57956	23 V 2018, (GBIF)
	Almaty Region, Karasai District, N43°04′07.13", E76°94′50.81"	User 57956	23 V 2018, (GBIF)
	Kazakhstan, N43°28′72.92", E76°94′12.37"	-	21 VII 2019, (GBIF)

	Kazakhstan, N43°15´27.22", E77°11´48.45	-	29 V 2022, (GBIF)
	Almaty Region, Raiymbek District, N42°94´14.95", E78°28´33.27"	Alex	22 VI 2022, (iNaturalist, GBIF)
	Almaty Region, Karasai District, N43°04´32.79", E76°94´49.39"	Braiter S	10 VI 2023, (iNaturalist, GBIF)
	Almaty Region, Talgar District, N43°10´42.07", E77°03´71.47"	Mialik A	13 VI 2023, (iNaturalist, GBIF)
	Almaty Region, Talgar District, N43°10´27.07", E77°04´00.16"	Mialik A	13 VI 2023, (iNaturalist, GBIF)
	Almaty Region, Karasai District, N43°08´13.65", E77°07´27.74"	Mialik A	14 VI 2023, (iNaturalist, GBIF)
	Almaty Region, Karasai District, N43°08´88.4", E77°05´08.0"	Markieva A	18 VI 2023, (iNaturalist)
	Almaty, Medeu District, N43°06´97.22", E77°07´77.78"	Svetlana	21 VI 2023, (iNaturalist, GBIF)
	Almaty Region, Karasai District, N43°07´91.7", E77°09´53.56"	Kanunnikov N	9 VII 2023, (iNaturalist, GBIF)
	Almaty Region, Karasai District, N43°07´70.14", E77°10´01.21"	Kanunnikov N	9 VII 2023, (iNaturalist, GBIF)
	Lakes of the Kensu River Gorge, N42°86´52.71", E78°60´55.5"	Elana	13 VII 2023, (iNaturalist, GBIF)
	Almaty, Medeu District, N43°17´00.16", E77°13´41.23"	Kanunnikov N	1 VI 2024, (iNaturalist, GBIF)
	Almaty, Medeu District, N43°08´11.11", E77°08´11.11"	Svetlana	5 VI 2024, (iNaturalist, GBIF)
	Almaty, Medeu District, N43°08´13.89", E77°07´94.44"	Svetlana	5 VI 2024, (iNaturalist, GBIF)
	Almaty, Medeu District, N43°10´68.08", E77°04´04.52"	Kanunnikov N	8 VI 2024, (iNaturalist, GBIF)
	Almaty, Talgar District, N43°11´97.649", E77°07´20.6"	Elena	8 VI 2024, (iNaturalist)
	Almaty, Medeu District, N43°07´91.67", E77°07´28	Kanunnikov N	16 VI 2024 г. (iNaturalist, GBIF)
	Almaty, Medeu District, N43°09´27.47", E77°04´74.25"	Kanunnikov N	16 VI 2024 г. (iNaturalist, GBIF)
Western Tian Shan	Syr-Darya Region, Aulie-Ata District, Arabika Gorge, Talas Alatau	Minkwitz ZA	1909, (MW, GBIF)
	Syr-Darya Region, Aulie-Ata District, Talas Alatau, Ak-Say Gorge, wet areas by the stream in the alpine zone	Vvedensky AI	6 VIII 1922, (MW, GBIF)
	Syr-Darya Region, Sayram-Su	Simonova O	9 VIII 1923, (MW, GBIF)
	Talas Alatau Mountains, marshy meadows along the springs on the plateau at the upper reaches of the Topchak-Su River, 2,700 m	Pavlov NB	30 VII 1931, (MW, GBIF)
	South Kazakhstan, Western Tian Shan, Upper reaches of the Ugam River, Chakir-Tas area, subalpine meadows near snowfields	Makarchuk VU	10 VII 1940, (AA)
	Talas Alatau	Karmysheva NH	16 VI 1943, (MW, GBIF)
	Djabagly Valley, Choshkaly-say area near the trail on the reed beds, 2,400 m asl	Karmysheva NH	16 VI 1943, (AA)
	Talas Alatau, western Aksu-Jabagly, 3,000 m asl	Zosimovskaya	VIII 1947, (MW, GBIF)
	Western foothills of the Talas Alatau, Aksu-Jabagly Nature Reserve, headwaters of the Jabagly River, sedge near the base of the pass to Aksai through Kurussay	Karmysheva NH	27 VII 1957, (AA)
Ketpen-Terskey Alatau	Ketpen range, Left Big Ketpen Gorge, 25 km. Subalpine belt of the mountains	Gubanov IA	08 VI 1957, (MW, GBIF)
	Northern slopes, Terkey-Alatau, 75 km northeast of the city of Przhevalsky, Alpine belt of the mountains	Gubanov IA	20 VII 1958, (MW, GBIF)
	Ketpen range, Big Ketpen, near the snowfields, 2,500 m	Blokhin VG	22 VI 1960, (AA)
	Ketpen range, Left Big Ketpen Gorge, 25 km from the village of Ketpen, subalpine zone of the mountains	Gubanov IA	23 VI 1960, (AA)
	Ketpen range, the left branch of the Big Ketpen Gorge	Vasilieva AN	28 VI 1964, (AA)
	Tian Shan, Ketpen Range, Ketpensay Gorge, near the snowfields	Arystangaliyev SA	10 VIII 1964, (AA)
	Zailiyskiy Alatau, the gorge of the Malaya Almatinka River, near the snow patch, in the moist alpine meadows	Roldugin II	12 VI 1967, (AA)
	Eastern Ketpen, Kolzhat Gorge, Malyi Tekeli	Kudabayeva GM	24 VII 1977, (AA)
Altai	Altai, Mount Khrustalnaya, 2,300 m asl	Bykov B	02 VII 1930, (AFAKNU)
	Southern Altai, Naryn range, near the village of Katon-Karagay, headwaters of the Akbulak rivers, alpine meadow	Smirnov P	19 VII 1930, (MW, GBIF)
Saur-Tarbagatai	Tarbagatai range, highlands, alpine meadow with elements of gravelly-lichen tundra	Tsyganov AP	03 VII 1987, (AA)

Table 6. Information from herbarium specimens AA, iNaturalist, and GBIF on the floristic regions of the species *Trollius komarovii*

Floristic region	Collection location (label data)	Collectors	Date of collection and herbarium specimens
Western Tian Shan	Western Tian Shan, Talas Alatau, Aksu- Zhabagly Nature Reserve, Baldabrek River basin, Shunkuldeik area, Alpine zone, meadow along the creek and slopes	Masalsky AP	29 VII 1937, (AA)
	Western Tian Shan, Karzhantau range, Upper reaches of the Kasksu River, left bank with reedbeds	Kudabayeva GM	16 VIII 1992, (AA)
	South Kazakhstan region, N42°12´20.06", E70°31´16.46"	Ebel A	29 V 2018, (iNaturalist, GBIF)

Trollius asiaticus is represented by only 4 herbarium specimens in the collection of the Institute of Botany and Phyto-introduction. It has been scarcely collected and studied in the collections of Moscow State University (MW) and Al-Farabi Kazakh National University (AFAKNU), so this species requires thorough research. The limited number of *T. asiaticus* records may reflect historical under-sampling or local rarity. Given the sparse distribution and potential overlap with morphologically similar species, a comprehensive taxonomic and ecological reassessment is necessary to clarify its true range and conservation status.

The results of this study contribute to a better understanding of the current distribution and diversity of the genus *Trollius* in Kazakhstan and complement earlier floristic and taxonomic works (Serebryanyi 2019; Ogureeva and Bocharnikov 2022). The confirmation of five species within the country, primarily based on herbarium specimens and validated database records, aligns with previous accounts of the genus' broad ecological amplitude and its affinity for moist montane habitats (Trulevich 2001; Kadota 2016). Our findings are consistent with earlier studies that noted the prevalence of *T. altaicus* across a wide altitudinal and geographical range, particularly in the Altai and Tien Shan Mountain systems (Putilin et al. 2021). Such altitudinal flexibility reflects the ecological plasticity of *T. altaicus*, yet at the same time, the genus' dependence on cold, moist mountain systems renders it sensitive to rising temperatures and shifting precipitation patterns. Potential upward migration of suitable habitats due to climate warming may compress species distributions into increasingly narrow alpine zones (Figure 13, Table 7).

Table 7. Morphological comparative of *Trollius* species in Kazakhstan

Species	Key traits	Elevation range (m)	Habitats	Confirmed provinces / Region
T. altaicus	Sepals and petals morphologically distinct; long persistent style	Up to 2600	Wet meadows, valleys, moist slopes	Eastern Kazakhstan (Altai)
T. dschungaricus	Serrated small leaves; yellow/purple styles; hood-shaped petals	1500-2600 (subalpine zone)	Moist mountain meadows and river valleys	Northeastern Kazakhstan (Northern Tien Shan)
T. asiaticus	Sepals and petals similar; short style; oblong-elliptical petals	Up to 2600	Moist meadows, forests, forest edges	Widespread, including much of Kazakhstan
T. lilacinus	Lilac multilayered petals; pubescent leaves below flowers	2700 (alpine tundra)	Alpine tundra, high mountain meadows	Altai Mountains
T. komarovii	(Traits poorly documented; needs clarification)	Up to 2600	Presumed saline or riparian habitats (tentative)	Southern Kazakhstan

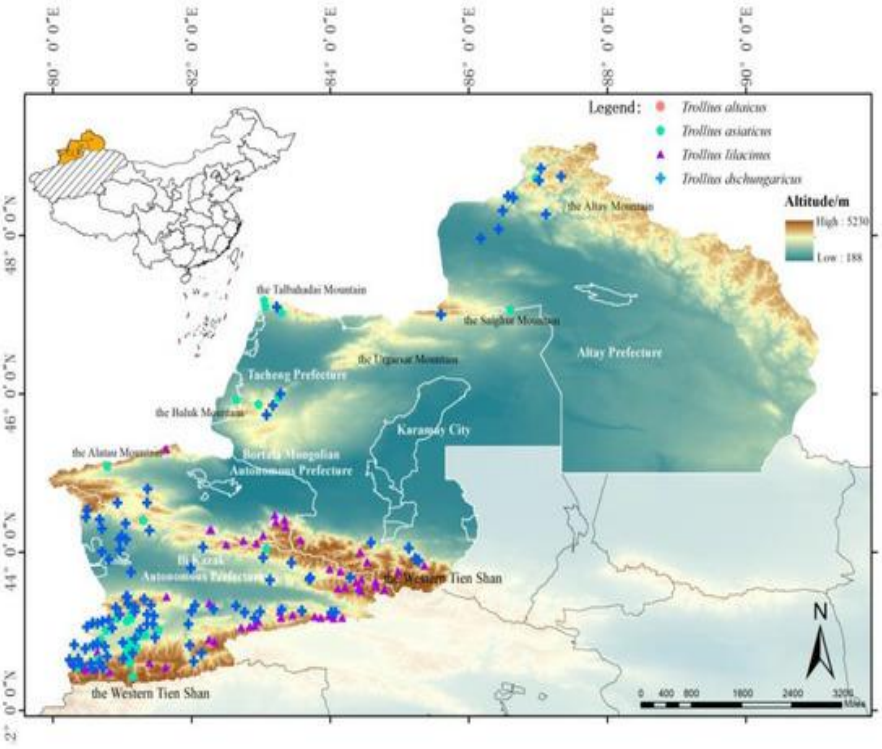

Figure 13. Actual locations and possible ranges near Kazakhstan

The taxonomic ambiguity within *Trollius*, widely discussed in the literature (Wu et al. 2003; Erst et al. 2020a), was evident during our examination of overlapping morphological traits and hybridization zones. This is especially relevant in regions such as the Dzungarian Alatau and the Kyrgyz Alatau, where contact zones between *T. altaicus*, *T. lilacinus*, and *T. dschungaricus* are likely to occur. These findings corroborate earlier assertions by Serebryanyi (2019) regarding the extensive hybridization potential and the unclear species boundaries that complicate genus-level taxonomy. These hybrid zones are not only of taxonomic concern but may also indicate ongoing ecological shifts in response to climate change, where formerly allopatric populations are brought into contact. Similar patterns have been observed in other montane Ranunculaceae, such as Aconitum and Delphinium, where warming trends facilitate hybridization in overlapping elevational zones.

Digital biodiversity databases, particularly GBIF and iNaturalist, played a supplemental role in this study. While GBIF has previously been highlighted as the most comprehensive digital biodiversity aggregator (Zizka et al. 2020), its data are known to contain spatial and taxonomic inaccuracies. Likewise, iNaturalist, while democratizing biodiversity observation, depends heavily on non-expert identifications and machine learning algorithms, making it less reliable for fine-scale taxonomic work. As such, our results highlight the need for cautious interpretation of digital records, in agreement with critiques from recent meta-analyses (Erst et al. 2020b; Buglova and Kozlova 2024). Despite their limitations, these digital platforms remain valuable for detecting potential new populations, especially in under-sampled regions. However, for genera like *Trollius*-with high morphological variability and hybridization potential-digital records should be treated as preliminary, requiring validation through herbarium comparison and field surveys.

Importantly, our study underscores the enduring value of herbarium collections as a foundation for species distribution research. Compared to open-access databases, herbarium specimens offer verifiable, georeferenced records supported by physical voucher specimens. These remain indispensable for validating occurrence data and ensuring taxonomic accuracy-especially in genera like *Trollius*, where morphological plasticity can obscure identification. The integration of historical herbarium data with targeted field surveys and biodiversity databases enabled the confirmation of five *Trollius* species in Kazakhstan, the identification of rare and under-collected taxa such as *T. asiaticus* and *T. komarovii*, and the detection of new occurrence localities-most notably in the previously undocumented Ulytau region and in high-elevation zones of the Dzungarian Alatau and Ketpen Ridge.

The species with the newest records was *T. dschungaricus*, followed by *T. altaicus*, which were frequently encountered during field expeditions and also well represented in herbarium collections. In contrast, *T. asiaticus* and *T. komarovii* remain underrepresented, highlighting the need for intensified exploration in their presumed ranges, particularly in the Central Kazakhstan uplands and parts of the Western Tien Shan.

The checklist also highlights areas of potential hybridization, particularly in the Dzungarian Alatau, and underscores the vulnerability of *Trollius* species to habitat degradation, hydrological changes, and climate-induced range shifts. Their dependence on moist montane ecosystems-often in narrow altitudinal bands-makes them sensitive indicators of ecological stability in high mountain environments.

This updated synthesis directly informs national floristic inventories by refining species occurrence data and updating distribution boundaries for conservation and policy frameworks. It provides an essential baseline for Red List assessments, supports the design of floristic monitoring programs, and contributes to conservation planning in alpine and subalpine habitats.

Furthermore, it contributes to broader Central Asian biodiversity research by filling spatial and taxonomic gaps in open-access biodiversity repositories such as GBIF and iNaturalist, while also emphasizing the need for expert validation of such datasets to ensure data quality.

In conclusion, this analysis confirms that Kazakhstan's mountainous ecosystems-especially in the Altai, Tien Shan, and Dzungarian regions-are critical for maintaining the taxonomic diversity of the genus *Trollius* and for supporting the country's overall floristic richness. The spatial distribution of *Trollius* species in Kazakhstan reveals pronounced east-west gradients, strong association with mountain ranges, and elements of endemism. Most species are concentrated in the eastern part of the country-in the Altai, Dzungarian Alatau, and Northern Tien Shan. Broadly distributed species such as *T. altaicus* and *T. asiaticus* occur across a range of elevations, while *T. lilacinus* and *T. dschungaricus* exhibit narrower ecological amplitudes and are likely local endemics restricted to subalpine and alpine meadows. Ecological niche modeling conducted by Fan and Luo (2024) using MaxEnt indicates a northward and westward shift in species' suitable ranges under climate change scenarios (SSP3-7.0 and SSP5-8.5), posing a particular threat to ecologically specialized alpine taxa. The spatial suitability maps (AUC>0.9) support the stability of core mountain habitats while highlighting peripheral habitat contraction. Some species, such as *T. komarovii*, are known only from fragmentary records and require further confirmation of their distribution. In Kazakhstan, where the endemic flora comprises approximately 8% of the total flora (Kubentayev et al. 2024), accurate delimitation of *Trollius* species ranges and ecological preferences is essential for conservation prioritization. Therefore, spatial analysis supported by herbarium and molecular data is crucial for identifying vulnerable populations, refining distribution boundaries, and preventing biodiversity loss under changing climatic conditions.

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