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Integral Assessment of Species of the Genus *Allium* L. (Amaryllidaceae) in Western Part of the Kyrgyz Alatau

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Abstract

This paper presents the results of the modern species composition of the genus *Allium* L. (Amaryllidaceae) of the western part of the Kyrgyz Alatau. The data on phylogeny, ploidy, chorological data are presented and a modern prospectus of species of the genus *Allium* in the study area is compiled. Large subgenera of *Allium* and *Melanocrommyum* are revealed, which proves the general regularity for mountainous regions of Central Asia. Ploidy of some species (*A. artrosanguineum* and *A. turkestanicum*) of the genus *Allium* growing in the western part of the Kyrgyz Alatau were studied for the first time using flow cytometry methods. The nrITS sequencing was used to construct a phylogenetic tree including sequences from the NCBI database. The phylogenetic tree of species of the genus *Allium* of the Kyrgyz Alatau was compiled taking into account previously published data. In the course of field studies and literature data, the list of studied *Allium* species in the Kyrgyz Alatau is represented by 25 species, which include 7 subgenera and 17 sections. Also, the nomenclature of onion species is brought to the modern understanding of some species names. Based on specimens of the genus *Allium* collected in the western part of the Kyrgyz Alatau, an integral assessment of the current species composition using molecular-genetic, cytometric and traditional botanical methods was carried out.

Keywords: genus *Allius*; ITS data; flow cytometry; Kyrgyz Alatau

1. Introduction

The genus *Allium* L. (Amaryllidaceae J. St.-Hil.), which is a complex systematic group, includes more than 1000 species [1,2]. The ecological range of *Allium* representatives extends from the alpine and subalpine belts to deserts. Almost one third of them grow in the mountains of Central Asia - the world's largest centre of diversity of *Allium* species. Only in the Tien Shan mountains, which are characterised by a high degree of endemism, there are 13 major subgenera of the genus *Allium*, including 56 species endemics to this mountain system [3,4]. According to literature data, there are from 9 to 21 endemic species of this genus and 14 subendemic taxa in the flora of Kazakhstan [5–7]. The object of the present study were species of the genus *Allium* L. of the Kazakhstani (western) part of the Kyrgyz Alatau Range, located at the junction of the Northern and Western Tien Shan and characterised by a correspondingly transitional composition of the flora. According to the botanical and geographical zoning of Kazakhstan, the Kyrgyz Alatau belongs to the Saharan-Gobi desert region, Iran-Turan subregion, Dzungar-North Tien Shan province, Kyrgyz mountain subprovince [8] (Figure 1).

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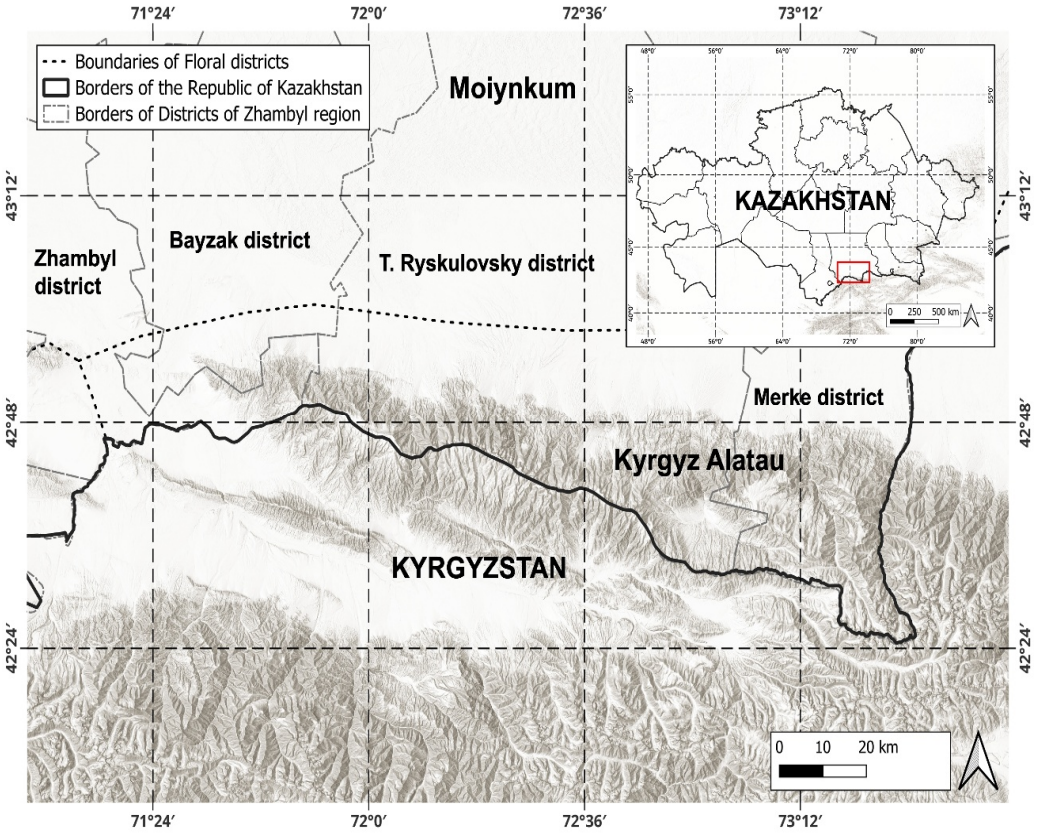

Figure 1. The study area is the Kazakh part of the Kyrgyz Alatau range.

The aim of the study was phylogenetic and taxonomic evaluation of species of the genus *Allium* L. growing in the Kyrgyz Alatau using ITS data to clarify their relationships and identify the systematic position of individual species in the context of existing classifications.

The fundamental treatment of the genus *Allium* is the analysis of onions carried out by Vvedensky A.I. for the 'Flora of the USSR' [5]. In this summary, Vvedensky A.I. [5] divided the genus into 9 sections. In 'Flora of Kazakhstan' [6] by Pavlov N.V. and Polyakov P.P. for the territory of the republic as a whole 108 species of onions are indicated, 29 of which are given as endemic. According to the data of Baytenov M.S. [9] the genus *Allium* in the flora of Kazakhstan is represented by 140 species.

Published by Epiktetov V.G. [10] the list of representatives of the genus *Allium* in the flora of Kazakhstan includes 127 species. At that, 25 species from 7 subgenera and 17 sections are represented in the Kazakh part of the Kyrgyz Alatau Range. Since the Kyrgyz Alatau is a transboundary ridge, it is possible to expand the list by onion species growing in the territories bordering Kyrgyzstan.

2. Results

2.1. Distribution Analyses

As a result of the analysis of literature data, herbarium materials and our own field research, an annotated prospectus of 25 species of the genus *Allium* growing in the Kyrgyz Alatau was compiled. Among the identified species, 1 endemic (*A. oreoprasoides*), 2 subendemics (*A. margaritae*, *A. trachyscordum*), which are also distributed in Kyrgyzstan, and 1 rare species listed in the Red Book of the Republic (*A. suworowii*) [12,13].

Three species of onion, which according to literature data [14] were cited for the Kazakhstan part of the Kyrgyz Alatau (*Allium altissimum*, *Allium schoenoprasum*, *A. kokanicum*) were excluded from the list. One of the largest subgenera of the studied genus includes two main groups: *Allium*, consisting

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of 6 sections, also subgenera *Melanocrommyum* and *Reticulatobulbosa*, including 3sections. Some of the *Allium* species from Kyrgyz Alatau see in Figure 2.

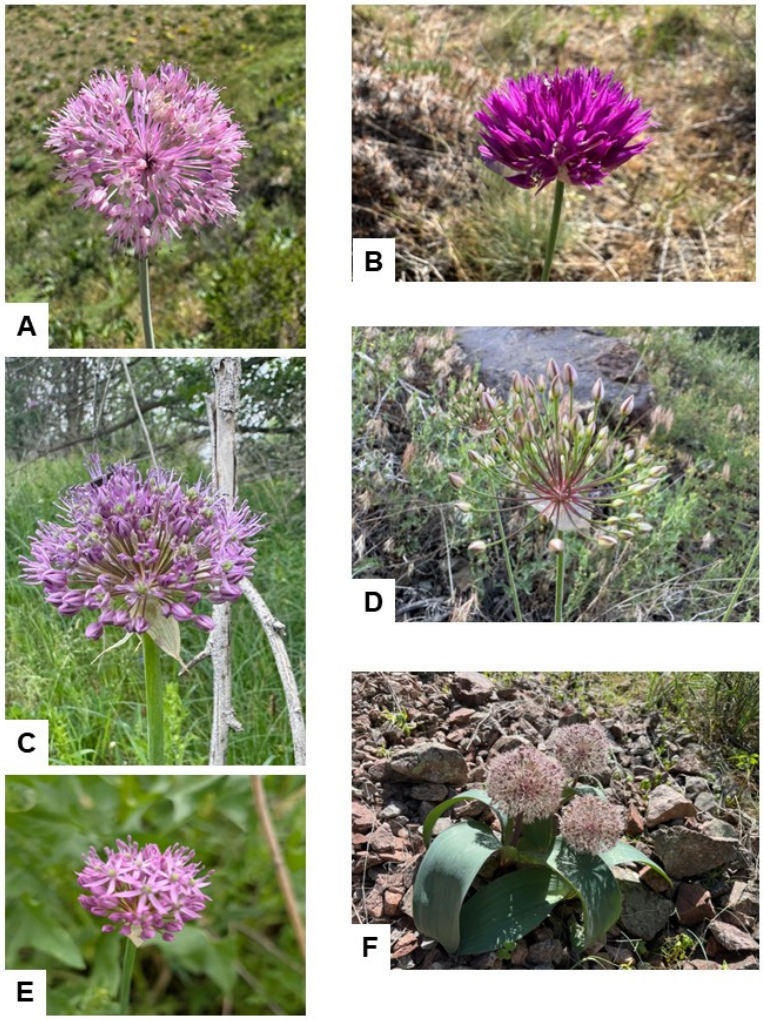

Figure 2. – Photos of some species of the genus *Allium* in the Kyrgyz Alatau (A – *A. caricifolium* (Zhambyl region, Turar Ryskulov district, Makpal gorge, 03.V.2025), B – *Allium barsczewskii* (Zhambyl region, Turar Ryskulov district, Makpal gorge, 03.V.2025), C–*Allium trachyscordum* (Zhambyl region, Zhambyl district, Kara-Arsha gorge 05.V.2025), D – *Allium suworowii* (Zhambyl region, Turar Ryskulov district, Syugaty gorge 03.V.2025), E– *Allium karataviense* (Zhambyl region, Turar Ryskulov district, Syugaty gorge 03.V.2025), F – *Allium fetisowii* (Zhambyl region, Turar Ryskulov district, Syugaty gorge 03.V.2025)).

Meanwhile, in other subgenera, several large sections are also distinguished, each with an equal number of species: *Acmopetala* and *Falcatifolia*.

An annotated outline of the current species composition of the genus *Allium* of the Kyrgyz Alatau is presented below.

Annotated prospectus of species of the genus *Allium* L. of the Kyrgyz Alatau

Subgenus *Allium*

Section *Allium*

***Allium sativum* L. (**1753 in Sp. Pl. 1: 296) - syn. *A. longicuspis* Regel (1875 in Trudy Imp. S.-Peterburgsk. Bot. Sada 3.2: 45.

The wild plants described as *A. longicuspis* Regel are feral cultivated garlic [15].

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Perennial. Grows in shrubs and along the banks of streams at the bottom of gorges in the lower belt of mountains. Blooms VI-VIII.

Viewed herbarium specimens from the Kyrgyz Alatau: **AA** (The southwestern extremity of the Kirghiz ridge, the foothills to the north-west. from Almaly-sai, along the meadow slopes, 03.VI.1963, Goloskokov V. P.).

Distribution in Kazakhstan: 25. Zailiyskiy-Kungei Alatau, 25a. Ketmen-Terskey Alatau, 26. Chu-Ili mountains, 27. Kyrgyz Alatau, 28. Karatau, 29. Western Tien-Shan.

General distribution: Iranian-mountain-Middle Asian cultivated species (cultivated worldwide).

Section *Brevispatha* Valsecchi (1974 in Giorn. Bot. Ital. 108(1-2): 92).

Typus species *Allium parciflorum* Viv.

***Allium margaritae* B. Fedtsch**. (1918 in Izv. Glavn. Bot. Sada R.S.F.S.R. 18: 14.)

Perennial. Grows on rubbly outcrops of variegated rocks. Blooms V-VI.

Viewed herbarium specimens from the Kyrgyz Alatau: **AA** (Kyrgyz Alatau, Zhambyl region, Ulken Almalysay gorge, southern slope. N 42°53'56" E71°42'43" h-1200m, 26.08.2024, Vesselova P.V., Bilibayeva B.K., Abdildanov D.Sh., Ussen S., Akhmetzhanova R.K.)

Distribution in Kazakhstan: 16. Betpakdala, 26. Chu-Ili Mountains, 27. Kyrgyz Alatau.

General distribution: Betpakdala-North Tyanshan (endemic).

Section *Caerulea* (Omelcz.) F. O. Khass. (1996 in Öztürk, Seqmen & Gork (eds.) Plant Life in South-West and Central Asia: 150).

Typus species *Allium caeruleum* Pall.

***Allium caesium* Schrenk (1844** in Bull. Cl. Phys.-Math. Acad. Imp. Sci. Saint-Pétersbourg 2: 113)

Perennial. Grows in steppes and deserts, on plumes and mountain slopes up to the middle belt. Blooms IV-VII.

Viewed herbarium specimens from the Kyrgyz Alatau: **MW** (foothills of the Kirghiz Range, feather grass steppe, 08. VI. 1958, collector Gubanov I.; north-western extremity of the Kirghiz ridge, Syugaty gorge in the lower tichi of the river, along the southern rocky slopes, 05. VI. 1963, collector: Goloskokov V.P.); **AA** (Western tip of the Kyrgyz Alatau, valley of the Merke River, left-bank slope among Bushes. 29.V.1985, Chubarova T.U. North-Western Tip of the Kirghiz Ridge. Syugata Gorge in the lower reaches of the river. Along the southern rocky slopes. 05.VI.1963. Goloskokov V. P. Kirghiz Alatau. Kyzylsu river gorge, foothills, north-eastern slopes. 1500 m above sea level. 16.VII.1948. Rubtsov N. I. Kirghiz ridge. Almalyk-sai gorge, a gap west of the beginning of the gorge, feather grass steppe with spirea bushes and groups of St. John's wort. 25.V.1961. Fisyun V.V. Chibindy Gorge, ridge crest, near the rocks. 04.VI.1960. Gamayunova A.P. Zhambyl region, Turar, Ryskulovsky district, Makpal gorge N 42. 8651568 E 71. 9170940 03.V.2025. Vesselova P.V., Kudabayeva G.M., Friesen N.V., Abdildanov D.Sh., Kenesbay A.Kh., Akhmetzhanova R.K.).

Distribution in Kazakhstan: 3. Irtysh, 9. Turgai, 10. Western Shallow Soil, 11. Eastern Cretaceous-Popochon, 16. Betpakdala, 17. Moyinkum, 18. Balkhash-Alakol, 21. Turkestan, 24. Dzungarian Alatau, 25. Zailiyskiy-Kungei Alatau, 25a. Ketmen-Terskey Alatau, 26. Chu-Ili Mountains, 27. Kyrgyz Alatau, 28. Karatau, 29. Western Tien Shan.

General distribution: North-Turanian-Mountain-Middle Asian (Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan, Xinjiang).

***Allium caeruleum* Pall.** (1773 Reise Russ. Reich 2: 737)

Perennial. Grows on high dry steppes, in foothills and mountains, in wet meadows and shrubs. Blooms V-VI.

Viewed herbarium specimens from the Kyrgyz Alatau: **MW** (Akyrtobe, Taldybulak gorge 11.VII. 1924, collectors: Popov M.G., Makieva E.M.); **AA** (Kara-Bulak gorge, the bottom of the gorge, among the high mint. 07.VI.1961 Gamayunova A. P. Ushch. Syugates. A damp meadow along the bottom of the gorge in the upper reaches. 03.VI.1961, Gamayunova A.P. South-Western Extremity of the Kirghiz Range. Almaly-Sai gorge. Along the southern rocky slopes. 03.VI.1963. Goloskokov V. P. Right side of the sh.r. Merke. South-western rocky slope. 03.VII.1947, Rubtsov N.I., Stepanova E.F.).

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Distribution in Kazakhstan: 2. Tobyl-Ishim, 4. Semipalatinsk hog, 9. Turgai, 10. Western Shallow Soil, 11. Eastern Shallow Soil, 12. Zaisan, 16. Betpakdala, 18. Balkhash-Alakol, 24. Dzungarian Alatau, 25. Zailiyskiy-Kungei Alatau, 25a. Ketmen-Terskey Alatau, 26. Chu-Ili Mountains, 27. Kyrgyz Alatau.

General distribution: Central Palaearctic (Russia: Altai, Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan, China: Xinjiang).

Section *Pallasia* (Tzag.) F.O.Khass., R.M.Fritsch & N.Friesen (2017 in Flora Uzbekistana 1: 87). Typus *A. pallasii* Murrai

***Allium caricifolium* Kar et Kir. (1841 in** Bull. Soc. Imp. Naturalistes Moscou 14: 854) - *Allium pallasii* Murrai pro parte [16].

Perennial. Grows on rubbly and stony slopes, outcrops of variegated rocks, less often in the upper belts of mountains. Blooms V-VI.

Viewed herbarium specimens from the Kyrgyz Alatau: **AA** (Zhambyl region, Merken district, Molaly gorge. N42°45′35″ E73°1′29″ h-1230 m 24.V.2023. Vesselova P.V., Kudabayeva G.M., Shormanova A.A., Osmonali B.B., Abdildanov D.Sh., Ussen S.; Zhambyl region, Turar Ryskulov district, Makpal gorge N 42. 8651568 E 71. 9170940 03.V.2025. Vesselova P.V., Kudabayeva G.M., Friesen N.V., Abdildanov D.Sh., Kenesbay A.Kh., Akhmetzhanova R.K.).

Distribution in Kazakhstan: 24. Dzungarian Alatau, 25. Zailiyskiy-Kungei Alatau, 25a. Ketmen-Terskey Alatau, 26. Chu-Ili Mountains, 27. Kyrgyz Alatau.

General distribution: mountain-central Asian (Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan, China: Xinjiang).

Section *Mediasia* F. O. Khass., Yengal. & N. Friesen (2006 in Aliso 22: 386).

Typus A. turkestanicum Regel

***Allium turkestanicum* Regel** (1875 in Trudy Imp. S.-Peterburgsk. Bot. Sada 3.2: 197).

Perennial. Grows in clay, sandy and rubbly desert steppes. Blooms VI-VII.

Viewed herbarium specimens from the Kyrgyz Alatau: **AA** (Kirghiz Range, northern gorges, Katudzhan gorge, dry slopes of the left bank; on shallow earth in groups. 16.VI.1961 Gamayunova A.P.).

Distribution in Kazakhstan: 15. Kyzylorda, 16. Betpakdala, 18. Balkhash-Alakol, 21. Turkestan, 25. Zailiyskiy-Kungei Alatau, 26. Chu-Ili Mountains, 27. Kyrgyz Alatau, 28. Karatau.

General distribution: North Turanian-mountain-Middle Asian (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan).

Section *Minuta* F. O. Khass. (1996 In Öztürk, Seqmen & Gork (eds.) Plant Life in South-West and Central Asia: 150.)

Typus *A. minutum* Vved.

***Allium parvulum* Vved.** (1934 in Byull. Sredne-Aziatsk. Gosud. Univ. xix. 124).

Perennial. Grows on rubbly variegated plumes of mountains. Blooms V-VI.

Viewed herbarium specimens from the Kyrgyz Alatau: **AA** (Dzhambi region, steppe hillock between Chu and Lugovaya stations. 25.V.1948. Pavlov N.V. South-Kazakh region. Department of Land Management, Aulie-Ata district. Plain from Ak-Chulak. Bluegrass-sedge steppe with coarse forbs.14.V.1933. Kornilova V. S.).

Distribution in Kazakhstan: 25. Zailiyskiy-Kungai Alatau, 27. Kyrgyz Alatau, 28. Karatau.

General distribution: Prityanshansky (Kazakhstan, Kyrgyzstan).

Subgenus Butomissa (Salish.) N. Friesen (2006 in Aliso 22: 387) – Genus Butomissa Salisb. 1866 in Gen. Pl. fragm. Cont. part. Liriogamae: 90.

Section *Austromontana* N. Friesen (2006 in Aliso 22: 387)

Typus species *Allium oreoprasum* Schrenk

***Allium oreoprasum* Schrenk** (1842 in Bull. Acad. Imp. Sci. Saint-Pétersbourg 10.23: 354).

Perennial. Inhabits rocks and rocky slopes of mountains. Blooms V-VII.

Viewed herbarium specimens from the Kyrgyz Alatau: **AA** (Kyrgyz Alatau, valley of the Merke River, right side of the Taldysu tract, southern slope. 26.VI.1985. Chubarova T.U. Western Extremity of the Kyrgyz Alatau, Kaindy River Valley, Dry Eastern Rocky Slope in the Lower Cordon Area.

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20.V.1984. Nelina N.V. Zap. extremity of the Kirghiz Alatau, southern. macroslope. the valley of the Nelda River. Rocky slope of the south-eastern exposure, thickets. 21.VI.1984. Nelina N.V.).

Distribution in Kazakhstan: 24. Dzungarian Alatau, 25. Zailiyskiy-Kungei Alatau, 25a. Ketmen-Terskey Alatau, 27. Kyrgyz Alatau, 29. Western Tien Shan.

General distribution: Mountain-central Asian (Afghanistan, Kazakhstan, Kyrgyzstan, Pakistan, Tajikistan, Tibet, Uzbekistan, Western Himalayas, Xinjiang).

Subgenus *Cepa* (Mill.) Prokh. (1990 in Razp. Slov. Akad. Znanosti Umetn., Razr. Nar. Vede (SAZU) 31: 250, 251). — *Cepa* Mill. 1754 in Gard. Dict. Abr., ed. 4.

Typus species *Allium cepa* L.

Section *Annuloprason* T.V. Egorova (1977 in Rast. Tsent. Azii, Mater. Bot. Inst. Komarova 7: 57).

Typus Allium atrosanguineum Schrenk

***Allium atrosanguineum* Schrenk** (1842 in Bull. Acad. Imp. Sci. Saint-Pétersbourg 10.23: 355).

Perennial. Grows on stony and fine-grained places in alpine and subalpine belts of mountains, often in huge thickets. Blooms VI-VIII.

Viewed herbarium specimens from the Kyrgyz Alatau: **AA** (Western tip of the Kyrgyz Alatau, Southern macroslope, Kenkol Valley. 04.VI.1984. Karmysheva N.Kh. Western extremity of the Kyrgyz Alatau, the valley of the Aspara River, the Kumbel Pass, a wet meadow and a south-eastern stony-rubble slope. 12.VII.1984. Zaripov R.G. Kirghiz ridge, upper reaches of the gorge. Solver. Alpine lawn on compacted soil. 17.VI.1961. Fisyun V.V. Ridge of the Kyrgyz Alatau, Zhambyl region, Turar, Ryskulov district, Karakystak pass. N42°40'7" E72°50'26" h-2530m 19.07.2023. Vesselova P.V., Kudabayeva G.M., Friesen N.V., Osmonali B.B., Abdildanov D.Sh., Ussen S.).

Distribution in Kazakhstan: 23. Tarbagatai, 24. Dzungarian Alatau, 25. Zailiyskiy-Kungei Alatau, 25a. Ketmen-Terskey Alatau, 27. Kyrgyz Alatau, 29. Western Tien Shan.

General distribution: mountain-central Asian (Afghanistan, China, Kazakhstan, Kyrgyzstan, Pakistan, Tajikistan, Uzbekistan).

***Allium semenovii* Regel** (1986 in Bull. Soc. Imp. Naturalistes Moscou 41.1: 449).

Perennial. Grows in alpine meadows. Blooms VI-VII.

Viewed herbarium specimens from the Kyrgyz Alatau: **AA** (Kirghiz Range, Chungur Gorge, upper reaches of the Solyusher River. 17.VI.1961. Fisyun V.V.).

Distribution in Kazakhstan: 24. Dzungarian Alatau, 25. Zailiyskiy-Kungei Alatau,, 25a. Ketmen-Terskey Alatau, 27. Kyrgyz Alatau.

General distribution: Mountain-Middle Asian-Himalayan (Kazakhstan, Kyrgyzstan, Tajikistan, Western China, India: Himalayas).

Subgenus *Melanocrommyum* (Webb & Berth.) Rouy (1910 in Fl. France 12: 378 — *Allium* sect. *Melanocrommyum* Webb et Berth (1846 in Phytogr. Canar. 3: 347).

Typus Allium nigrum L.

Section *Acmopetala* R.M. Fritsch (1992 in Hanelt et al. (eds.), The genus *Allium*: taxonomical problems and genetic resources: 74).

Typus Allium backhousianum Regel.

***Allium dasyphyllum* Vved.** (1925 in Byull. Sredne-Aziatsk. Gosud. Univ. ix. Suppl. 6).

Perennial. Grows on stony slopes in the upper belt of mountains. Blooms VII.

Distribution in Kazakhstan: 27. Kyrgyz Alatau [17].

General distribution: Kyrgyz-Alatau (endemic to the Kyrgyz Alatau (Kyrgyzstan, Kazakhstan - sub-endemic).

***Allium taschkenticum* F.O. Khass. et R.M. Fritsch** (1994 in Linz. Biol. Beitr. 26: 971).

Typus *Allium taschkenticum* F.O. Khass. et R.M. Fritsch

Perennial. Grows on shrubby and herbaceous slopes in the lower belt of mountains. Blooms V-VI.

Distribution in Kazakhstan: 26. Chu-Ili Mountains, 27. Kyrgyz Alatau, 29. Western Tien Shan.

General distribution: Western Tien Shan (Kazakhstan - subendem, Kyrgyzstan, Uzbekistan).

***Allium suworowii* Regel (**1881 in Gartenflora 30: 356.)

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Perennial. Grows on shrubby and herbaceous slopes and plumes of mountains. Blooms V-VI.

Viewed herbarium specimens from the Kyrgyz Alatau: **AA (**A saline damp meadow in the steppe between Chu and Lugovaya stations. 24.V.1948. Pavlov N.V. Kirghiz Alatau, the valley of the Kaindy River, near the road in the vicinity of the lower cordon. 20.V.1984. Nelina N.V. Kirghiz Alatau, uroch. Chungur (Slutorsky). Gorge. Kara-Archa. 28.V.1984. Nelina N. V. Zhambyl Region, Turar Ryskulovsky District, Makpal Gorge. N 42. 8651568 E 71. 9170940 H-1182 m. 03.05.2025. Vesselova P.V., Kudabayeva G.M., Friesen N.V., Abdildanov D.Sh., Kenesbay A.Kh., Akhmetzhanova R.K.).

Distribution in Kazakhstan: 18. Balkhash-Alakol, 21. Turkestan, 27. Kyrgyz Alatau, 28. Karatau, 29. Western Tien Shan.

General distribution: Near-North Tien Shan (Afghanistan, Kazakhstan, Kyrgyzstan, Tadzhikistan, Turkmenistan, Uzbekistan).

Section *Longibidentata* (R.M. Fritsch) R.M. Fritsch (2009 in Bot. Jahrb. Syst. 127.4: 465) – 1994 in in Khassanov & Fritsch, Linzer Biol. Beiträge 26: 974..

Typus Allium fetisowi Regel

***Allium fetisowi* Regel** (1877 in Trudy Imp. S.-Peterburgsk. Bot. Sada 5: 631).

Perennial. Grows on shrubby and herbaceous slopes in the lower belt of mountains. Blooms V-VI.

Viewed herbarium specimens from the Kyrgyz Alatau: **MW** (Akyrtobe, Taldybulak gorge, subalpine and alpine cereals, 12. VII. 1924, collector: Popov M.G.); **AA** (Western tip of the Kyrgyz Alatau, Chungur gorge, right bank of the river, south-eastern slope and top of the mountain. 28.VI.1985. Chubarova T.U. North-Western Tip of the Kirghiz Ridge. Syugata Gorge in the upper reaches of the river. Along the steep northern slope.07.VI.1963. Goloskokov V.P. Kirghiz ridge, northern gorges. Almalyk-sai gorge, steppe slopes with shrubs, at the top of the spurs, height 1500 m. 23.V.1963. Gamayunova A.P. Kirghiz ridge, Almalyk-sai gorge. Steppe meadows in the middle part of the ridge along the wide saddle of the Kaindy. 01.VI.1961 Gamayunova A.P. Kirghiz ridge, Almalyk-sai gorge 3rd gap to the west of the main gorge. Steppe slopes of the southern exposure, stony places. 26.V.1961. Fisyun V. V.)

Distribution in Kazakhstan: 25. Zailiyskiy-Kungei Alatau, 26. Chu-Ili Mountains, 27. Kyrgyz Alatau, 29. Western Tien Shan.

General distribution: Tien Shan (Kazakhstan, Kyrgyzstan, China).

Section *Miniprason* R.M. Fritsch (1992 in Hanelt et al. (eds.), The genus *Allium*: taxonomical problems and genetic resources: 74).

Typus Allium karataviense Regel.

***Allium karataviense* Regel** (1875 in Acta Horti Petropolit. 3.2: 243.

Perennial. Grows on rubbly mobile placers in the lower and middle belts of mountains.

Blooms IV-VI.

Viewed herbarium specimens from the Kyrgyz Alatau: **AA** (Kyrgyz Range. 03.VII.1947. Rubtsov N. I., Stepanova E. F. Kirghiz Ridge. The vicinity of the city of Dzhambul, foothills, the beginning of the Butumainak gorge, scree. 18.V.1961. Fisyun V. V. Western tip of the Kyrgyz Alatau, valley of the Syugatti River, rocky canyon, thalweg. 24.V.1984. Nelina N. V.).

Distribution in Kazakhstan: 26. Chu-Ili Mountains, 27. Kyrgyz Alatau, 28. Karatau, 29. Western Tien-Shan.

General distribution: Iranian-mountain-Middle Asian (Afghanistan, Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan).

Subgenus *Polyprason* Radic (1990 in Razp. Slov. Akad. Znan. Umet. 31: 253).

Typus Allium moschatum L.

Section *Falcatifolia* N. Friesen (2006 in Aliso 22: 390)

Typus Allium carolinianum DC.

***Allium platyspathum* Schrenk** (1841 in Enum. Pl. Nov.: 7).

Perennial. Grows in subalpine and alpine meadows. BloomsVI-VII.

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Viewed herbarium specimens from the Kyrgyz Alatau: **AA** (Kyrgyz Alatau. Kaindy tract, grass-sedge bog with birch and spruce, 2200 m above sea level. 18.VII.1948. Rubtsov N. I. Aspara Forest, Kumbel pass, south-eastern slope. Alt. 3000–3500 m above sea level. 12.VIII.1980. Zaripov R. G. Kyrgyz Alatau, Karabalty gorge, near the Tyuzashu pass. Along the wet sais, 2750 m. 16.VII.1970. Roldugin I. I.).

Distribution in Kazakhstan: 22. Altai, 23. Tarbagatai, 24. Dzungarian Alatau, 25. Zailiyskiy-Kungei Alatau, 25a. Ketmen-Terskey Alatau, 27. Kyrgyz Alatau, 29. Western Tien Shan.

General distribution: mountain-central Asian (Afghanistan, Altai, Kazakhstan, Kyrgyzstan, Mongolia, Mongolia, Pakistan, Tajikistan, Uzbekistan, Western China).

***Allium polyhyllum* Kar. et Kir.** (1842 in Bull. Soc. Imp. Naturalistes Moscou 15: 509) - syn. *A. carolinianum* Redoute pro parte [18].

Perennial. Occurs on rubbly slopes, in alpine and subalpine belts of mountains. Blooms VII-VIII.

Viewed herbarium specimens from the Kyrgyz Alatau: **MW** (upper reaches of the Kishi Kaindy, rocky slope, 19.VII. 1951, collector Golubev V.); **AA** (Kirghiz Range, 4-5 km west of the Merke River Gorge. 18.VII.1947. Rubtsov N.I., Stepanova E.F. Northern macroslope, shch. Nelds. Rocky slopes. 15.VI.1984. Nelina N.V. Kirghiz Ridge. Gorge. Sulyusher. Alpine lawns near snowfields. 17.VI.1961. Fisyun V.V. Kyrgyz Alatau, shch. Shaldy in the rocks. 27.VIII.1951. Baitenov M.S.).

Distribution in Kazakhstan: 24. Dzungarian Alatau, 25. Zailiyskiy-Kungei Alatau, 25a. Ketmen-Terskey Alatau, 27. Kyrgyz Alatau, 29. Western Tien Shan.

General distribution: mountain-central Asian (Afghanistan, Kazakhstan, Kyrgyzstan, Mongolia, Nepal, Pakistan, Tajikistan, Tibet, Uzbekistan, China).

***Allium hymenorhizum* Ledeb.** (1830 in Fl. Altaica 2:12).

Perennial. Inhabits damp saline meadows, in mountains on grassy marshes and meadows.

Blooms VI-VII.

Viewed herbarium specimens from the Kyrgyz Alatau: **AA** (Western tip of the Kyrgyz Alatau, valley of the Aspara River, Archaly tract. 15.07.1984. Zaripov R.G. Zap. the extremity of the Kirghiz Alatau, the valley of the Aspara River, the Kumbel Pass, a wet meadow. 16.08.1984. Zaripov R.G.

Kyrgyz Range. The Aral-Tyube river gorge, a gravelly slope among fescue vegetation. 05.08.1947. Rubtsov N.I., Stepanova E.F. Ridge of the Kyrgyz Alatau, Zhambyl region, Turar Ryskulov district, serpentine. N42°40'26" E72°50'31" h-2290m. 19.07.2023. Vesselova P.V., Kudabayeva G.M., Friesen N.V., Osmonali B.B., Abdildanov D.Sh., Ussen S.).

Distribution in Kazakhstan: 18. Balkhash-Alakol, 22. Altai, 23. Tarbagatai, 24. Dzungarian Alatau, 25. Zailiyskiy-Kungei Alatau, 25a. Ketmen-Terskey Alatau, 26. Chu-Ili Mountains, 27. Kyrgyz Alatau, 28. Karatau, 29. Western Tien-Shan.

General distribution: Iranian-mountain-central Asian (Afghanistan, Russia, Iran, Kazakhstan, Kyrgyzstan, Mongolia, Tajikistan, Turkey, Uzbekistan, China).

Section *Oreiprason* F. Herm. (1939 in Feddes Repert. 46: 57).

Typus Allium saxatile M.Bieb.

***Allium leptomorphum* Vved. (1952 in** Bot. Mater. Gerb. Inst. Bot. Akad. Nauk Uzbeksk. S.S.R. xiii. 29).

Perennial. Grows on rocks and placers of mountains. Blooms VII-VIII.

Distribution in Kazakhstan: 25. Zailiyskiy-Kungei Alatau, 26. Chu-Ili Mountains, 27. Kyrgyz Alatau.

General distribution: North Tianshanian (Kazakhstan, Kyrgyzstan).

***Allium obliquum* L.** (1753 in Sp. Pl. 1: 296).

Perennial. Grows on rocks and stony slopes in foothills and lower belt of mountains. Blooms VI-VII.

Viewed herbarium specimens from the Kyrgyz Alatau: **AA** (Kyrgyz Alatau, Kultakhr gorge, scree. 19.08.1948. Rubtsov N. I.).

Distribution in Kazakhstan: 23. Tarbagatai, 24. Dzungarian Alatau, 25. Zailiyskiy Kungei, Alatau, 25a. Ketmen-Terskey Alatau, 26. Chu-Ili Mountains, 27. Kyrgyz Alatau, 28. Karatau.

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General distribution: Central Palaearctic (Romania, Ukraine, Russia (Southern Urals, Siberia), Kazakhstan, Kyrgyzstan, Mongolia, China (western).

Subgenus *Porphyroprason* (Ekberg) R.M.Fritsch (2006 in Aliso 22: 386 - *Allium* sect. *Porphyroprason* Ekberg 1969in Bot. Not. 122: 65.

Typus Allium oreophilum C.A:Mey.

Section *Porphyroprason* Ekberg (1969in Bot. Not. 122: 65.

Typus *A. oreophilum* C. A. Mey

***Allium platystemon* Kar. & Kir.** (1842 in Bull. Soc. Imp. Naturalistes Moscou 15(2): 514). - Syn. *A. oreophillum* C.A.Mey. pro parte [19].

Perennial. Grows on rubbly slopes in the upper belt of mountains. Blooms VI-VIII.

Viewed herbarium specimens from the Kyrgyz Alatau: **MW** (Kishi Kaindy, the top of the mountain range, 19.VII. 1951, collector Golubev V.); **AA** (Kirghiz ridge, 4–5 km west of the Merke river gorge, northern gravelly slope, about 2700 m above sea level. 14.VII.1947. Rubtsov N.I., Stepanova E.F. Kirghiz Alatau. Upper reaches of the Shamsi River, alpine meadow, on crushed stone. 31.VII.1948. Rubtsov N.I.).

Distribution in Kazakhstan: 23. Tarbagatai, 24. Dzungarian Alatau, 25. Zailiyskiy-Kungei Alatau, 25a. Ketmen-Terskey Alatau, 27. Kyrgyz Alatau, 29. Western Tien Shan.

General distribution: mountain-central Asian (Afghanistan, Kazakhstan, Kyrgyzstan, Pakistan, Tajikistan, Uzbekistan, China).

Subgenus *Reticulatobulbosa* (Kamelin) N. Friesen (2005 in Aliso 22: 389).

Typus Allium lineare L.

Section *Campanulata* Kamelin (1980 in Bot. Journ. 65.10: 1461).

Typus *Allium xiphopetalum* Aitch. & Baker

***Allium barsczewskii* Lipsky** (1900 in Acta Horti Petropolit. 18: 114)

Perennial. Occurs on fine-grained or rubbly steppes, slopes of foothills and mountains.

Flowering V-VII, flowering VI-VIII.

Viewed herbarium specimens from the Kyrgyz Alatau: **AA** (Aulie-Ata district. Trails of the Kyrgyz ridge. To the northeast of the Ak-Chulak base of the Konesovkhoz No 49. 13.V.1933. Kornilova V. S. Kirghizskii hr. Suyundyk-sai river. The northern slope is about 2500 m above sea level. 22.VII.1947. Rubtsov N. I., Stepanova E. F. Kirghiz Ridge. Sundyk-sai river gorge, northern slope. Height about 2500 m. 28.VII.1947. Rubtsov N.I., Stepanova E.F. Dzhamb.region, steppe trail of the mountain between the village of Chulak-Tau and Kok-Tal. 30.V.1948. Pavlov N.V. Kirghiz ridge, western extremity. Butumainak gorge. Limestone cliffs, southern slope. 19.V.1961. Fisyun V.V. Kirghiz ridge, northern gorges. Almalyk-sai gorge, southern steppe slopes. 22.V.1961. Fisyun V.V. Kirghiz Ridge. The central part of Almalyk-say. Southern steppe slope among *Carex pachystilis*. 22.V.1961. Gamayunova A.P. Kirghiz Range, Northern Gorges. Almaly-Sai Gorge. Meadow-Steppe Slopes. 24.V.1961. Fisyun V.V. Kirghiz ridge, Almalyk-sai gorge, eastern slit. 24.V.1961 Gamayunova A.P. Kyrgyz ridge, northern gorges. Uzunbulak gorge, ridges of spurs. 28.V.1961. Fisyun V.V. Kirghiz Range, the upper reaches of the Kaindy river, near the top of Mount Tegres, at an altitude of 1500 m. 01.VI.1961. Gamayunova A. P. Kirghiz ridge, northern gorges. Slopes of the Dzhaksalyk-Sai Ridge. 01.VI.1961. Gamayunova A. P. Foothill loess plain of the Kirghiz ridge between Lugovoy and Dzhambul. Among the ephemerae. 15.V.1963. Goloskokov V.P. Foothill loess plain of the Kirghiz ridge between Merke and Meadow. Among the ephemeral meadow. 15.05.1963. Goloskokov V.P. South-western tip of the Kirghiz ridge. Almaly-sai gorge. Along the southern rocky slopes. 02.VI.1963 Goloskokov V.P. Western tip of the Kyrgyz Alatau, valley of the Syugatti River, stony red ridge of low mountains. 24.V.1984 Nelina N.V. Kirg. Alat. river Aspara, tract. Char, watershed. 22.VI.1985. Chubarova T. U. Zhambyl region, Kyrgyz Alatau. Merke Gorge, near the outpost 12.V.2018 Vesselova P.V., Mukhtubayeva S.K., Danilov M.P. Zhambyl region, Kyrgyz Alatau. Merke Gorge, near the outpost 12.V.2018 Vesselova P.V., Mukhtubayeva S.K., Danilov M.P.).

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Distribution in Kazakhstan: 21. Turkestan, 25. Zailiyskiy-Kungei Alatau, 26. Chu-Ili Mountains, 27. Kyrgyz Alatau, 28. Karatau, 29. Western Tien-Shan.

General distribution: Iranian-Mountain-Middle Asian-Western Himalayan (Afghanistan, Iran, Kazakhstan, Kirgizstan, Pakistan, Tadzhikistan, Uzbekistan, West Himalaya)

***Allium longiradiatum* (Regel) Vved.** (1923 in Vved. & al., Key Fl. Tashkent Pt. 1 — *Allium tataricum* var. *longiradiatum* Regel 1875 in Acta Horti Petropolit. 3.2: 180).

Viewed herbarium specimens from the Kyrgyz Alatau: **AA** (Kyrgyz Alatau ridge, foothills. 25.V.1986. Kamenetskaya I. I.).

Perennial. Inhabits loess plains and foothills. Blooms IV-V.

Distribution in Kazakhstan: 27. Kyrgyz Alatau, 29. Western Tien Shan.

General distribution: Western Tien Shan (Kazakhstan, Uzbekistan).

Section Scabriscapa (Tscholok.)N.Friesen (2006 in Aliso 22: 389).

Typus Allium scabriscapum Boiss.

***Allium trachyscordum* Vved.** (1925 in Byull. Sredne-Aziatsk. Gosud. Univ. ix. Suppl. 11).

Perennial. Occurs on rubbly mountain slopes. Blooms VI-VII.

Viewed herbarium specimens from the Kyrgyz Alatau: **AA** (South-western tip of the Kirghiz ridge, foothills to the north-west of Almaly-Say. 03.VI.1963. Goloskokov V.P. Zap. tip of the Kyrgyz Alatau. Dale Sugats, left-bank lowlands from the cordon 2-3 km up. 15.VI.1985 Karmysheva N.Kh. Western tip of the Kyrgyz Alatau, northern macroslope, valley of the Syugata River, red hills adjacent to the mouth of the river. 05.VIII.1988. Karmysheva N.Kh.).

Distribution in Kazakhstan: 16. Betpakdala, 26. Chu-Ili Mountains, 27. Kyrgyz Alatau, 28. Karatau.

General distribution: Betpakdala-Severoturan-Tianshanian (Kazakhstan, Kyrgyzstan).

Section *Nigrimontana* N. Friesen (2006 in Aliso 22:390).

Typus Allium drobovii Vved.

***Allium oreoprasoides* Vved.** (1925 in Trudy Turkestansk. Nauchn. Obshch. 2: 29).

Perennial. Inhabits rubbly mountain slopes. Blooms V-VI.

Viewed herbarium specimens from the Kyrgyz Alatau: AA (The western tip of the Kyrgyz Alatau, the valley of the Aspara River, the Archaly tract. 19.VIII.1984. Zaripov R.G. Zap. Kyrgyz Alatau, northern macroslope, mouth of the Syugatta River, red-crushed stone ridges. 24.V.1984. Nelina N.V.).

Distribution in Kazakhstan: 27. Kyrgyz Alatau, 28. Karatau.

General distribution: Western Tianshan (Kazakhstan (Endem).

The chorological analysis of the studied group of species showed that 16 types of ranges were distributed among 7 arealological groups: Central Palearctic (2 species), Mountain-Central Asian (7 species), Mountain-Middle Asian (5 species), North-Turano-Mountain-Middle Asian (2 species), Betpakdalin-Tianshan (2 species), Tianshan (6 species), Prityanshan (2 species). Such distribution of species speaks in favour of the mountain origin of most of the composition of the studied species.

2.2. Flow Cytometry

For 6 species collected during expedition trips (*Allium turkestanicum*, *A. suworiwii*, *A. barzsczewskii*, *A. artrosanguineum*, *A. margaritae*, *A. caeruleum*), flow cytometry analysis was performed. Data on the genome size of these samples were obtained (Table 1; Figure 3).

Table 1. DNA content of the studied *Allium* samples.

Species	Mean 2C ± SD, pg	CV	1C, Gbp	Expected ploidy
A. turkestanicum	22,310 ±0,566	2,54%	21,820	2
A. suworiwii	44,159 ± 0,446	1,01%	43,187	2
A. barzsczewskii	21,948 ± 0,624	2,84%	21,465	2

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A. artrosanguineum	22,740 ± 0,018	0,08%	22,240	2
A. margaritae	13,907 ± 0,047	0,34%	13,601	2
A. caeruleum	20,043 ± 0,796	3,97%	19,602	2

As a result of screening the literature data, a table on genome size was compiled for other species of the genus *Allium* growing in the western part of the Kyrgyz Alatau (Table 2).

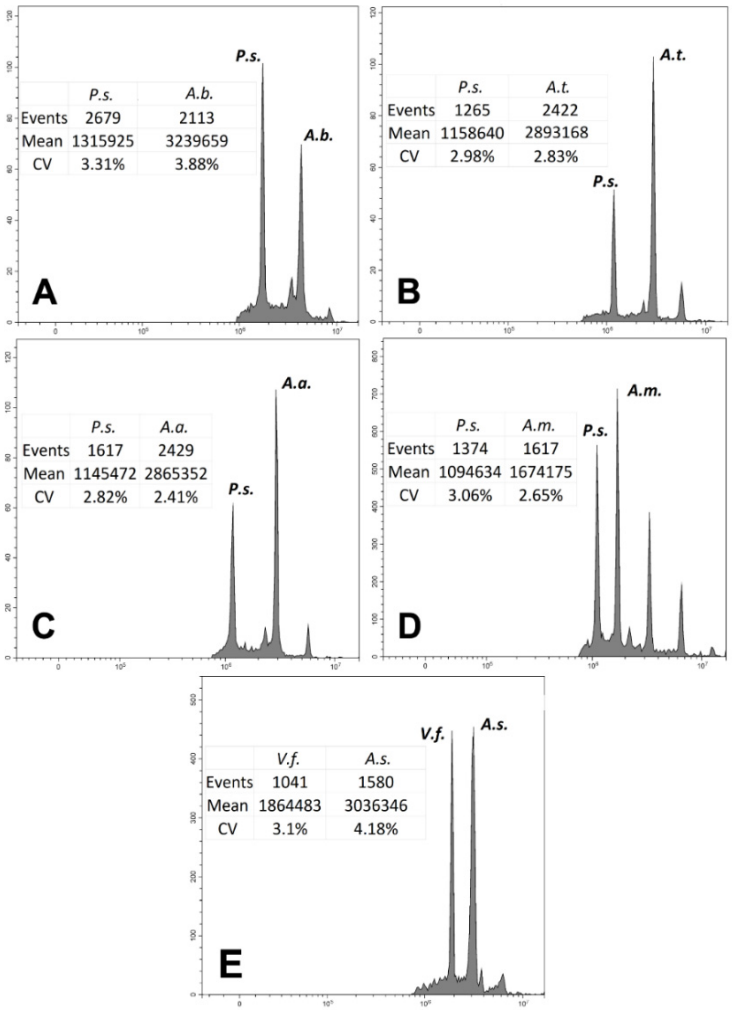

Figure 3. Examples of ungated flow cytometric histograms of the *Allium* samples (log scale). A, *A. barzsczewskii*; B, *A. turkestanicum*; C, *A. atrosanguineum*; D, *A. margaritae;* E, *A. suworowii*. P.s. – *Pisum sativum* internal standard; V.f. – *Vicia faba* internal standard.

Table 2. Genome sizes of the studied species of the genus *Allium* (according to literature sources and databases).

№	Species	DNA Amount 2C (pg)	Original Reference
3	*A. barsczewskii*	31.60	[20]
4	*A. caeruleum*	23.50	[21]
5	*A. caesium*	25.90	[22]
8	*A. fetisowii*	26.26	[23]

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9	*A. hymenorhizum*	25.70	[21]
10	*A. karataviense*	39.68	[26]
13	*A. longicuspis*	35.10	[27]
15	*A. margaritae*	31.50	[22]
16	*A. oreophilum*	38.80	[22]
19	*A. obliquum*	26.30	[21]
23	*A. schoenoprasum*	16.90	[25]
25	*A. suworowii*	37.62	[24]

2.3. Phylogenetic Analysis

Due to the fact that out of 25 species noted for the Kazakhstan part of the flora of the Kyrgyz Alatau ridge, we had actual genetic material at our disposal for only 6 species (Figure 4), we were able to obtain ITS sequences only for these 6 species (8 specimens) (Table 3), the remaining ITS sequences were taken from the NCBI database [11]. It should be noted that most of the sequences used in this paper (for the missing species from the NCBI database), were sequenced earlier also by the authors of this paper.

Table 3. Collection points of genetic material of species of the genus *Allium* and accessions number of ITS sequences.

№	Sample number	Species	Location of material collection	**Voucher number**	**ITS**
1	Al16	*Allium turkestanicum*	Betpakdala floristic region, Zhambyl region, southern part of BetpakdalaN 45.839444 E 73.413889	AA0003680	PV915722
2	Al17	*A. suworowii*	Moyinkum floristic area, Zhambyl region, Chui district, close to the road, Moyinkum-Chu highway, sands. Saxaulnik. N 44.257222 E 73.190556	AA0003681	PV915724
3	Al18	*A. barsczewskii*	Moyinkum floristic area, Zhambyl region, Chui district, close to the road on the left side of the road in the town of Chu. N 43.3925 E 74.026111	AA0003682	PV915721
4	Al19	*A. barsczewskii*	Kyrgyz Alatau, Zhambyl region, T. Ryskulov district, Karakystak village. N 42.792222 E 72.9	AA0003683	PV915720
5	Al21	*A. caeruleum*	Kyrgyz Alatau, Zhambyl region, T. Ryskulov district,	AA0003684	PV915723

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			Karakystak. N 42.792222 E 72.9		
6	Al22	*A. turkestanicum*	Kyrgyz Alatau, Zhambyl region N 42.889830 E 71.801594	AA0003685	PV915719
7	Al23	*A. atrosanguineum*	Kyrgyz Alatau, Zhambyl Oblast, Kaskasu Gorge. N 42.543611 E 73.203333	AA0003686	PV915718
8	Al24	*A. margaritae*	Kyrgyz Alatau, Zhambyl region, Zhambyl district, ul. Ulken Almalysay, southern slope. N 42.898889 E 71.711944	AA0003687	PV915717

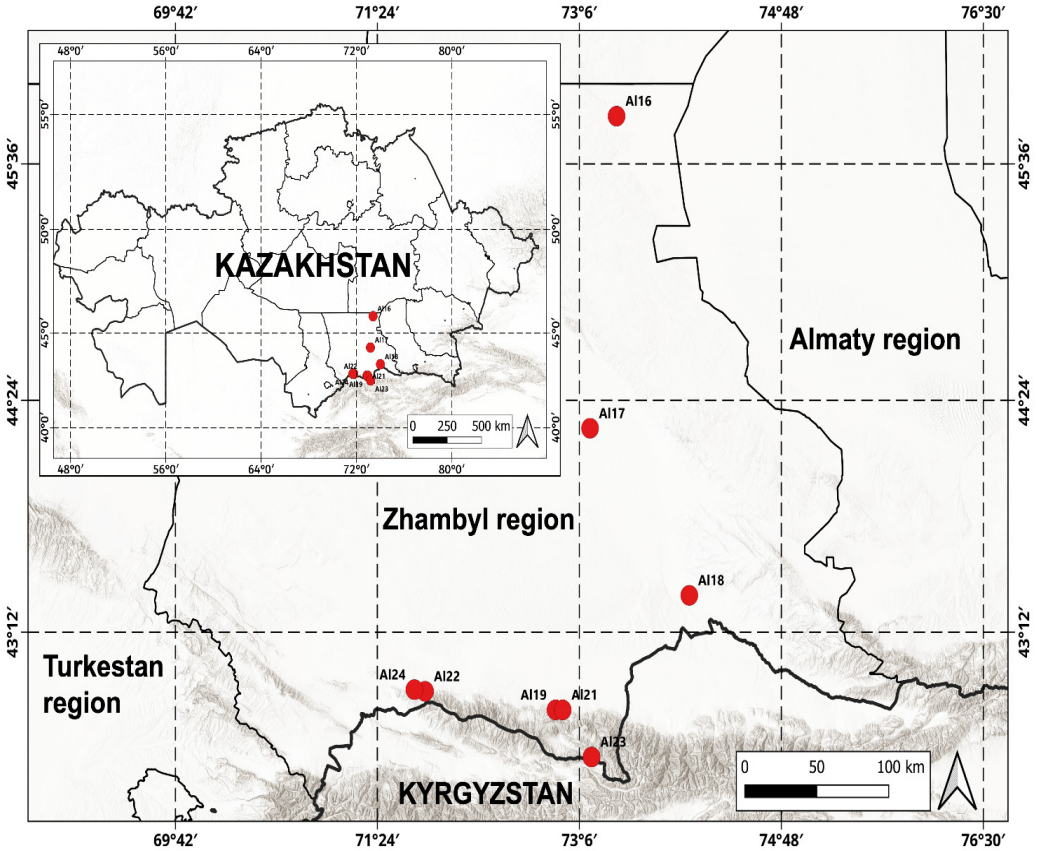

Figure 4. Map of specimen collection points of *Allium* species.

Sequencing of ITS (ITS1-ITS4) fragments was carried out for 6 species (8 specimens) (Appendix A). Of these, 5 species were collected directly from the study area. The rest – the sequences used in this work – were sequenced previously (in other works of the authors of the paper). The ITS tree of sequences is made using the studied specimens and supplemented with specimens from the NCBI database. Samples of own materials are highlighted in bold in the tree. For ease of visual perception, colour highlighting is done.

The tree shows not only species affiliation, but also subgenus and sectional divisions (Figure 5).

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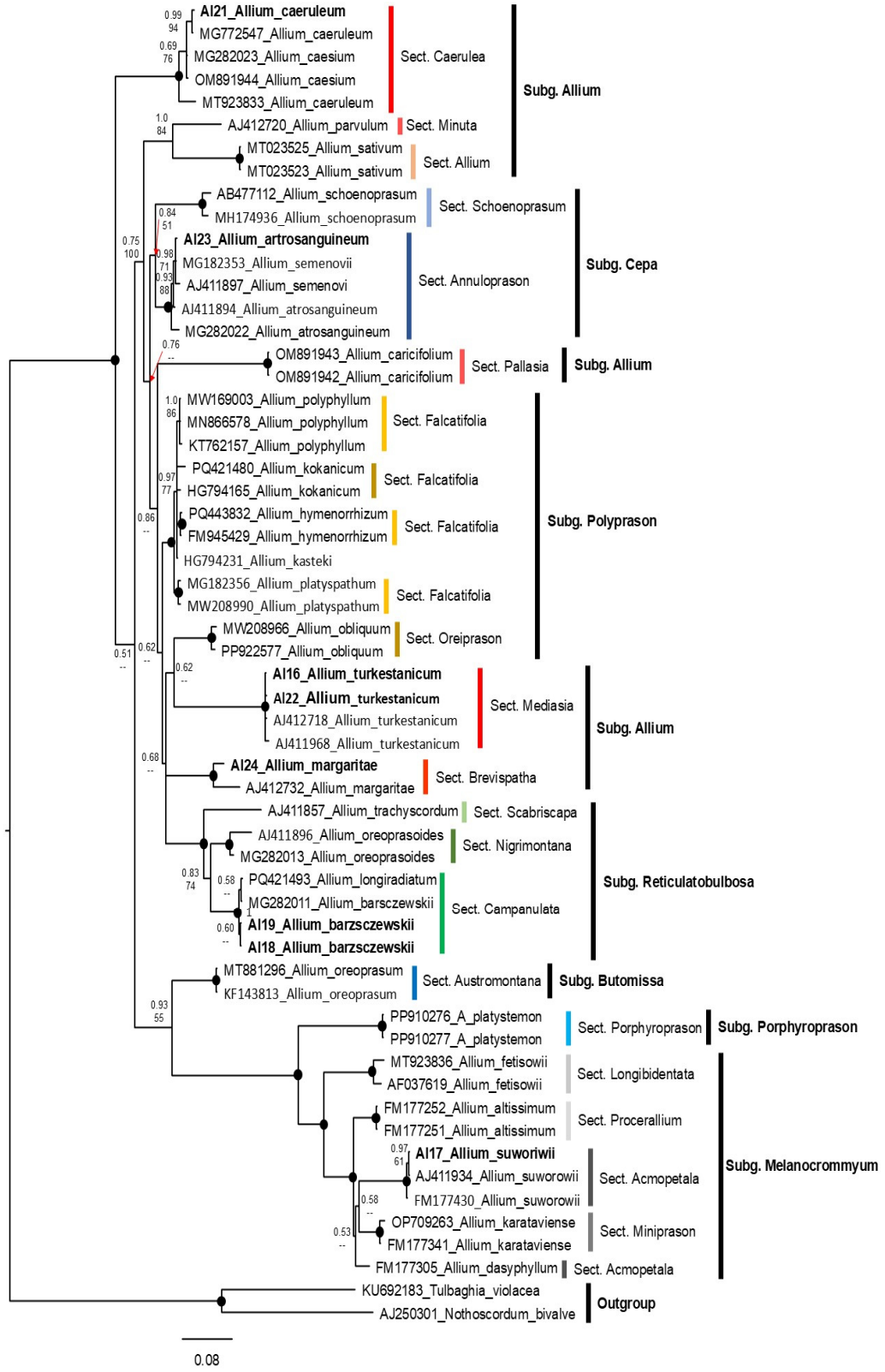

Figure 5. ITS tree of species of the genus *Allium*. The joint presence of Bayesian with a probability greater than 0.98 and bootstrap support greater than 95% is indicated by a black dot. The samples we investigated are highlighted in bold. The following data were obtained by running the data through the JModeltest software: 010234+G+F, -lnL 7923.16582, AIC 16137.894239, weight 0.493067.

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3. Discussion

The analysis of species composition shows that within the Kyrgyz Alatau, representatives of subgenera *Allium* and *Melanocrommyum* are the most widely distributed among 7 subgenera of the studied genus. Such distribution corresponds to the general regularity noted for mountainous regions of Central Asia [1,4].

The subgenus *Allium* includes the largest number of species - 9 (5 sections), belonging mainly to the *Allium* section and characterised by adaptation to growing in the upper belt of mountains (subalpine and alpine belts). Representatives of the subgenus *Allium* are characterised by a wide ecological amplitude and play a key role in the vegetation cover of mountain ecosystems of the Kyrgyz Alatau. Subgenus *Melanocrommyum* is represented by 5 species (3 sections), characterised by characteristic large inflorescences, which underlines their potential ornamental value. Representatives of the subgenus are adapted to arid conditions and are confined to stony places. Phenological plasticity and clear ecological predilection of species testify to high adaptive ability of the genus to different conditions of altitudinal belt of the region.

The richness of species and their specialisation underline the floristic uniqueness of the Kyrgyz Alatau as an important centre of biodiversity of the genus *Allium* in Central Asia. The majority of species are regionally confined to the Tien Shan floristic province. Some species are also found in the neighbouring ranges: Terskey Alatau, Zailiyskiy Alatau, Karatau. *Allium* species in the Kyrgyz Alatau are clearly differentiated by altitudinal and microclimatic conditions, which indicates their high ecological plasticity and adaptation to extreme mountain conditions. Distribution by belts reflects the gradient from xerophytic steppes to mesophytic high-mountain meadows. Species of the genus *Allium* within the Kyrgyz Alatau on the territory of Kazakhstan demonstrate clear confinement to certain altitudinal belts and habitat types. The main mass of species is represented by inhabitants of mountain, subalpine and alpine belts, with a pronounced propensity to specific ecological conditions.

In general, the ecology and ranges of representatives of the genus *Allium* in the Kyrgyz Alatau reflect a high degree of ecological specialisation combined with geographical selectivity. Many species are confined to narrow ecological niches, which makes them vulnerable to anthropogenic impact and climatic changes. At the same time, species with a wider ecological amplitude often become components of secondary habitats, reflecting the processes of adaptation and change of plant communities under increasing pressure.

According to the results of the analysis by flow cytometry, data were obtained for six species of the genus *Allium*, represented in four subgenera and belonging to different sections. The following species were identified in the subgenus *Allium*: *A. turkestanicum* from section *Mediasia* with DNA content of 22.310 ± 0.566 pg, *A. margaritae* from section *Brevispatha* with 13.907 ± 0.047 pg and *A. caeruleum* from section *Caerulea* with 20.043 ± 0.796 pg. In subgenus *Melanocrommyum*, *A. suworiwii*, a representative of section Acmopetala, is characterised by a value of 44.159 ± 0.446 pg. Subgenus Reticulatobulbosa is represented by the species *A. barzschzewskii* from section *Campanulata* (21.948 ± 0.624 pg), and subgenus *Cepa* - by the species *A. artrosanguineum* from section *Annuloprason* with DNA content of 22.740 ± 0.018 pg (Table 2).

According to literature data, although the genome size is quite different, ploidy is similar in all and all are diploid (Figure 2).

According to the Plant DNA database [28], for most species characteristic of the Kyrgyz Alatau, the DNA content varies within 20-30 pg (Table 3), with some exceptions showing much higher values. For example, *Allium karataviense* recorded 39.68 pg, *A. platystemon* 38.80 pg, and *A. suworowii* 37.62 pg. According to Jones and Rees [25], the minimum amount of DNA within the genus *Allium* was previously recorded in *A. schoenoprasum* (16.90 pg). It should be noted that for a significant number of species of the genus *Allium*, the size of the nuclear genome has not been determined so far, which opens prospects for further studies.

Within the framework of the present work, for *A. margaritae*, we recorded the minimum value of DNA content in the genus *Allium* equal to 13.907 ± 0.047 pg (Table 1; 3). This is significantly lower

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than the value reported in Vakhtina et al. [22], where 31.50 pg is given for the same species. This discrepancy probably indicates the possible presence of polyploid forms within *A. margaritae*. Considering the low coefficient of variation of our measurements (0.34%), the data obtained seem reliable.

Similar discrepancies between published data and our results were found for *Allium* barzschzewskii and *A. suworowii*. For *A. barzschzewskii*, we determined the DNA content at 21.948 pg with a coefficient of variation of 2.84%, while a number of earlier publications for this species give a value of 31.60 pg [20]. Taking into account outdated methods of analysis and possible methodological differences, a discrepancy of about 10 pg can be considered acceptable.

For *A. suworowii*, we obtained a value of 44.159 pg (CV = 1.01%), whereas the database gives 37.62 pg [24]. Despite some difference, both values are in a close range and probably reflect both intraspecific variability and differences in the methods used. It should be emphasised that modern flow cytometry technologies provide higher accuracy and reproducibility of results, which increases the reliability of our measurements.

The species *A. caeruleum* showed a value of 20.043 pg (CV = 3.97%), which is comparable to the previously published genome size of 23.50 pg [21]. Thus, the data confirm each other within the margin of error.

For the two species studied, *A. artrosanguineum* and *A. turkestanicum*, the results of flow cytometry are presented for the first time. The values obtained are 22.740 ± 0.018 pg (CV = 0.08%) and 22.310 ± 0.566 pg (CV = 2.54%), respectively.

Molecular phylogenetic data are of particular interest: based on the analysis of ITS-sequences, it was found that the studied onion species from the Kyrgyz Alatau occupy the expected phylogenetic positions and correspond to previously published phylogenetic reconstructions [29–34], with no significant deviations detected. However, given that only five of the 25 *Allium* species distributed in the Kyrgyz Alatau were sampled directly from the Kyrgyz Range (see Table 3), further sequencing may reveal new or refined phylogenetic relationships.

4. Material and Methods

4.1. Distribution Analyses

Field studies were conducted during 2024-2025 on the territory of the western part of the Kyrgyz Alatau. The research included route surveys covering various types of habitats. In the course of field work, a targeted collection of herbarium material and samples of representatives of the genus *Allium* L. growing in this territory was carried out [5,6]. Along with this, they were photographed (Figure 2), geographically referenced using a GPS device (Figure 4).

The fundamental works on the genus *Allium* [3,5,6,35] were used to identify the collected materials and all modern publications on the genus *Allium* affecting species growing in the Kyrgyz Alatau [29–36] were considered. The herbarium collections of the Institute of Botany and Phytointroduction (AA, Almaty, Kazakhstan) and the Moscow State University named after M.V. Lomonosov (MW, Moscow, Russia) were studied. The names of taxa are given according to the databases International Plant Names Index (IPNI) [37] and Plants of the World Online (POWO) [2]. Materials from the Plantarium website [17] were also used.

The QGIS 3.34.13 program was used for data mapping (https://qgis.org, accessed on 5 June 2025).

4.2. Flow Cytometry

The DNA content was determined by flow cytometry techniques with propidium iodide (PI) staining. Leaves dried with silica gel were used as samples. Samples were chopped with standard using a sharp razor blade in LB01 buffer containing PI (50 µg/ml), RNase (50 µg/ml) [38] supplemented with 12 mM sodium thiosulfate and 1% polyvinylpyrrolidone [39]. The nuclear suspension was filtered through nylon filter with a pore size 30 µm. Analyses were performed on a Cytoflex (Beckman Coulter, Inc.) cytometer. Peaks with at least 1000 nuclei and a CV of less than 5 %

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were used for analysis. Histograms were visualized and processed using CytExpert software (Beckman Coulter, Inc.). Descriptive statistic was calculated using XLStat (Addinsoft). As an internal standard was used the *Pisum sativum* 'Ctirad', 2C = 9.09 pg and *Vicia faba* 'Inovec', 2C = 26.9 pg [38,40].

4.3. Phylogenetic Analyses

ITS DNA fragments were sequenced for the species studied of the genus *Allium*. The primers ITS1 (5′-TCCGTAGGTGAACCTGCGG-3′) and ITS4 (5′-TCCTCCTCCGCTTATTGATATGC-3′) were used for ITS fragments. Polymerase chain reaction was performed in 50 μl of reaction mixture using Biomaster HS-Taq PCR-Color 2x PCR kit (Biolabmix LLC, Novosibirsk) in the following composition: per sample: 25 μl of ready PCR mixture, 21 μl of H2O, 1 μl of 10 mM respective primers, 2 μl of total DNA. Amplification protocol: 95 °C (3 min); 35 cycles: 95 °C (20 s), 57 °C (30 s), 72 °C (30 s); 72 °C (5 min). Amplification products were purified using microcolumns. Sequencing was performed by the Sanger method using an ABI PRISM 3500 XL sequencer. The obtained nucleotide sequences were aligned using the ClustalW algorithm in the MEGAX software [41] with manual evaluation of the read quality.

Both datasets (nrITS markers) were analyzed separately through Fitch parsimony with the heuristic search option in PAUP version 4.0 b10 [42] with MULTREES, TBR branch swapping, and 100 replicates of random addition sequence. Gaps were treated as missing data. The consistency index (CI) was calculated to estimate the amount of homoplasy in the character set [43]. The most parsimonious trees returned by the analysis were summarized in one consensus tree using the strict consensus method. Bootstrap support (BS)—were performed using 1,000 pseudoreplicates to assess the support of the clades [44]. Bayesian phylogenetic analyses were also performed using MrBayes 3.1.23 [45]. The sequence evolution model was chosen by following the Akaike information criterion (AIC) obtained from jModelTest2 [46]. Two independent analyses with four Markov chains were run for 10 million generations, sampling trees every 100 generations. The first 25% of the trees were discarded as burn-in. The remaining 150,000 trees were combined into a single dataset, and a majority-rule consensus tree was obtained, along with posterior probabilities (PP).

Two species were selected as an outgroup: *Tulbaghia violacea* Harv. and *Nothoscordum bivalve* (L.) Britton [34].

5. Conclusions

Thus, as a result of complex field studies, molecular-genetic analysis and critical review of literature data, it was established that the flora of the genus *Allium* in the Kyrgyz Alatau is represented by 25 species belonging to 7 subgenera and 17 sections. Within the framework of this work the nomenclature of a number of taxa was brought in accordance with modern systematic ideas (e.g., *Allium polyphyllum* as a synonym of *A. carolinianum* and *A. caricifolium* – *A. pallasii*), which is important for unification of regional and global databases.

The analysis of chorological data indicates the predominance of species with mountain genesis, reflecting the specific conditions of formation of the Central Asian flora. The results of flow cytometry showed that at the same level of ploidy (diploids), representatives of *Allium* show significant variation in the size of the nuclear genome. This suggests the presence of adaptive divergence due to the ecological diversity of mountain ecosystems of the Kyrgyz Alatau.

According to the phylogenetic tree, species are arranged in accordance with the expected taxonomic relationships, but further study of representatives of the genus *Allium* growing in the western part of the Kyrgyz Alatau may lead to clarification of the systematic composition, including possible identification of previously unrecorded species or exclusion of erroneously included taxa.

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Data Availability Statement: All data supporting this study's findings are available in the main text or Appendices.

Conflicts of Interest: All authors declare that they have no competing interests and personal relationships and agree on the contents of the paper.

Appendix A

Allium margaritae

Allium barsczewskii

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