

## Geographical Characteristics of the Allium Flora in Xinjiang (Postprint)

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### Abstract

Allium Linnaeus plants represent valuable plant resources. The Xinjiang region of China, located in the hinterland of the Eurasian continent and situated in central Asia, possesses rich Allium plant diversity. By examining Allium-related monographs, literature, and specimen records, this study investigates Xinjiang Allium plant resources and their floristic geographical characteristics, providing references for systematic classification, biodiversity conservation, and rational development and utilization of resources for this genus. Based on existing Allium records and data, Xinjiang harbors 58 species, 1 subspecies, 2 varieties, and 6 cultivated species of Allium. The floristic geographical characteristics of Allium distributed in Xinjiang are as follows: (1) The distribution areas of Xinjiang Allium plants are mainly concentrated in the Tianshan Mountains, Ili-Tacheng, Altay, and Kashgar regions; Xinjiang Allium plants predominantly grow in desert, grassland, arid slopes, gravelly areas, mountainous regions, alpine zones, and under-forest (forest) habitats; (2) Among the geographical distribution area types, Xinjiang Allium plants are primarily distributed in the II C5b Junggar subregion, whose flora is characterized by temperate desert nature; the I A2 Altai region, II C5a Tacheng-Ili subregion, I A3 Tianshan region, and II C6c Kashgar subregion also contain relatively abundant species; (3) Within the systematic unit types of Xinjiang vegetation regionalization, Allium plants are more species-rich in vegetation provinces including I B1 (Altay Mountains-Beita Mountains Grassland Province), II A2 (North Slope of Eastern Tianshan Grassland, Spruce Forest and Alpine Meadow Vegetation Province), II A1 (Junggar Basin Semi-shrub Desert Vegetation Province), and II B3 (South Slope of Tianshan Desert and Mountain Grassland Vegetation Province), followed by II B1 (Eastern Xinjiang Gravel Gobi Shrub Desert Vegetation Province), I A1 (Western Junggar Basin Mountain Grassland Province), and II B2 (Tarim Basin Shrub Desert Vegetation Province), while relatively fewer species are distributed in II B4 (Pamir-Kunlun-Altun Mountains Desert and Alpine Grassland Vegetation Province) and I C1 (Southern Xinjiang Alpine

Grassland Province); (4) Both horizontal and vertical distributions of Xinjiang *Allium* plants exhibit differentiation; (5) Xinjiang *Allium* plants share numerous species with Kazakhstan and Russia, with no significant difference in the number of shared *Allium* species between Xinjiang region of China and Kazakhstan or Russia, and high similarity among these shared species. Future research should integrate molecular phylogeny (phylogenetic floristic geography), evolutionary history (historical phytogeography), molecular biogeography, and other aspects for in-depth investigation.

## Full Text

### Floristic Characteristics of the Genus *Allium* Linnaeus in Xinjiang, China

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## Abstract

The genus *Allium* Linnaeus represents an important plant resource of significant value. Xinjiang, located in the hinterland of the Eurasian continent and central Asia, harbors rich *Allium* diversity. By examining relevant monographs, literature, and specimen records, this study investigates *Allium* resources and their floristic geographical characteristics in Xinjiang, providing references for systematic classification, biodiversity conservation, and rational resource utilization. Based on existing records and data, Xinjiang hosts approximately 58 *Allium* species, 1 subspecies, 2 varieties, and 6 cultivated species. The floristic characteristics are as follows: (1) *Allium* distribution concentrates primarily in the Tianshan Mountains, Ili, Tacheng, Altay, and Kashgar regions, with habitats spanning deserts, grasslands, arid slopes, gravel lands, mountains, alpine zones, and forest understories. (2) Among geographical element distribution types, Xinjiang *Allium* plants predominantly occur in the Junggar subregion (II C5b), accounting for 84.48% of the total species, followed by the Tianshan region (I A3) at 63.79%, the Tacheng-Ili subregion (II C5a) at 58.62%, the Altay region (I A2) at 56.90%, the Kashgar subregion (II C6c) at 32.76%, and the Kunlun subregion (III F17c) at 31.03%. (3) Within Xinjiang's vegetation regionalization system, species are most abundant in the North Tianshan Grassland Province (I A1), East Tianshan North Slope Grassland-Spruce Forest and Alpine Meadow Province (II A2), Junggar Basin Semi-shrub Desert Province

(II A1), and South Tianshan Desert and Mountain Grassland Province (I I B3). (4) Both horizontal and vertical distribution patterns show differentiation. (5) Xinjiang shares numerous *Allium* species with Kazakhstan and Russia, with high similarity coefficients and minimal differences in shared species numbers. Future research should integrate molecular phylogeny (phylofloristics), evolutionary history (historical phytogeography), and molecular biogeography for deeper investigation.

**Keywords:** *Allium* Linnaeus; species diversity; flora; floristic characteristics; floristic affinity; Xinjiang

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## Introduction

The genus *Allium* was first described by Linnaeus in 1753 in *Species Plantarum*, with *Allium sativum* (garlic) designated as the lectotype. Currently comprising approximately 660–700 species, *Allium* is predominantly distributed across the Holarctic region and seasonally arid areas of the Northern Hemisphere, with a few species in the Southern Hemisphere (e.g., South Africa and Central/South America). Traditionally placed in the broad Liliaceae (*Liliaceae* s.l.) due to its superior ovary, the genus was also assigned to the narrow Amaryllidaceae (*Amaryllidaceae* s.s.) based on umbel inflorescence and involucre structures. Molecular systematics has since established *Allium* within the Amaryllidaceae subfamily Alliioideae, a classification widely accepted today.

In China, *Flora of China* records 138 *Allium* taxa (including varieties and introduced species), while *Flora Xinjiangensis* documents 50 species (including 6 cultivated). The genus exhibits extensive distribution across northwestern, southwestern, northern, and northeastern China. Valued for its bioactive compounds (flavonoids, steroidal saponins, organosulfur compounds), morphological diversity, clonal growth, and fibrous root systems, *Allium* species serve as important resources for vegetables, condiments, medicine, ornamentals, and ecological protection. Their drought tolerance and ecosystem regulation functions are particularly significant in arid regions for sand fixation and grassland degradation prevention. Given these values, understanding Xinjiang's *Allium* species composition and geographical distribution is essential for research and development.

Central Asia and western China, including the Pamir Plateau, represent a primary origin center for cultivated *Allium* species. This study synthesizes literature, herbarium specimens, and online databases to analyze *Allium* diversity, species composition, geographical distribution, and floristic characteristics in Xinjiang, aiming to provide foundational data for taxonomy, conservation, and resource utilization.

## 1. Study Area Overview

Xinjiang lies in central Eurasia and northwestern China, spanning 34°15' - 49°10' N and 73°20' - 96°25' E, covering  $1.66 \times 10^6$  km<sup>2</sup> (approximately one-sixth of China's land area). It borders India, Pakistan, Afghanistan, Tajikistan, Kyrgyzstan, Kazakhstan, Russia, and Mongolia, and adjoins Gansu, Qinghai, and Tibet within China.

The region's topography follows a "three mountains embracing two basins" pattern, with complex geomorphology, substantial elevation differences, and intricate geological conditions. The climate is 典型的温带大陆性干旱荒漠气候 [typical temperate continental arid desert climate], transitioning from temperate in northern Xinjiang to warm temperate in southern Xinjiang, characterized by large temperature variations, long sunshine hours, low precipitation, strong winds, and dry air. Major soil types include desert soils, meadow soils, swamp soils, grassland soils, forest soils, saline soils, and aeolian sands. Vegetation coverage is generally low, with sensitive and fragile ecosystems dominated by deserts, grasslands, forests, scrublands, mountain meadows, and alpine meadows. This complex landscape, variable climate, and unique germplasm resources have fostered distinctive regional flora with high biological diversity.

## 2. Methods

We consulted *Flora Xinjiangensis*, *Flora Xinjiangensis* (Brief Edition), *Flora of China*, *Flora Desertiensis Reipublicae Populorum Sinarum*, *Higher Plants of China*, and other relevant literature. Specimen data were obtained from the National Specimen Information Infrastructure (NSII) and Chinese Virtual Herbarium (CVH). Species information, altitudinal ranges, habitats, and distribution localities (counties/cities) were compiled and statistically analyzed using Microsoft Excel. Wu Zhengyi's Chinese floristic regionalization system and Zhang Dianmin's vegetation regionalization scheme were applied to determine distribution types and vegetation regionalization units. Floristic relationships with neighboring regions were assessed using Sorenson's similarity coefficient:  $S = [2c/(A+B)] \times 100\%$ , where A and B represent total species numbers for two regions (excluding cultivated, cosmopolitan, and introduced species), and c is the number of non-cosmopolitan shared species. Nomenclature was verified against *Flora of China* and The Plant List; species lacking voucher specimens were excluded.

## 3. Results

### 3.1 Species Composition and Distribution of *Allium* L. in Xinjiang

Xinjiang hosts 58 *Allium* species, 1 subspecies, 2 varieties, and 6 cultivated species. Newly documented taxa include *Allium amphibolum*, *A. blandum*, *A. clathratum*, *A. decipiens*, *A. eduardi*, *A. kaschianum*, *A. kurssanovii*, *A. ledebourianum*, *A. megalobulbon*, *A. oreophilum*, *A. pevtzovii*, *A. rubens*, *A. sairamense*, *A. tekesicola*, *A. tenuissimum*, and the subspecies *Allium platyspathum*

subsp. *amblyophyllum*.

Distribution concentrates in the Tianshan Mountains, Ili-Tacheng, Altay, and Kashgar regions, aligning with Xinjiang' s major mountain systems. Habitats are diverse, including deserts, grasslands, arid slopes, gravel lands, mountains, alpine zones, and forest understories, spanning elevations of 0–5400 m.

## 3.2 Floristic Regionalization Types

**3.2.1 Floristic Subregions (Geographical Elements)** The Junggar subregion (II C5b) contains the richest *Allium* flora with 49 species (84.48% of Xinjiang' s total), followed by the Tianshan region (I A3) with 37 species (63.79%), Tacheng-Ili subregion (II C5a) with 34 species (58.62%), Altay region (I A2) with 33 species (56.90%), Kashgar subregion (II C6c) with 19 species (32.76%), and Kunlun subregion (III F17c) with 18 species (31.03%).

**3.2.2 Vegetation Regionalization Units** *Allium* species are most abundant in the North Tianshan Grassland Province (I A1), East Tianshan North Slope Grassland-Spruce Forest and Alpine Meadow Province (II A2), Junggar Basin Semi-shrub Desert Province (II A1), and South Tianshan Desert and Mountain Grassland Province (I I B3). Moderate representation occurs in East Xinjiang Gravel Gobi Shrub Desert Province (I I B1), Junggar Basin Western Mountain Grassland Province (I A1), and Tarim Basin Shrub Desert Province (I I B2). Fewer species inhabit the Altun Mountain Desert and Alpine Grassland Province (II B4) and South Xinjiang Alpine Steppe Province (I C1).

## 3.3 Shared Species and Floristic Affinity

**3.3.1 Comparison with Adjacent Chinese Provinces** Xinjiang shares 28 *Allium* species with Gansu (similarity coefficient 34.86%), 24 with Qinghai (28.86%), and 21 with Tibet (24.14%). Eight species are common to all four provinces, including *Allium atosanguineum*, *A. carolinianum*, *A. mongolicum*, *A. polyrhizum*, *A. przewalskianum*, and *A. ramosum*.

**3.3.2 Comparison with Adjacent Countries** Xinjiang exhibits stronger floristic affinities with Central Asian countries than with Chinese provinces: 45 shared species with Kazakhstan (59.60% similarity) and Russia (48.08% similarity), 33 with Mongolia (38.40% similarity), 25 with Kyrgyzstan (19.72% similarity), and 14 with Tajikistan (13.79% similarity). Most shared species possess nectaries at the ovary base, suggesting potential coevolution with pollinators. The high similarity with Kazakhstan and Russia supports treating these three regions as an integrated floristic unit.

## 4. Discussion

### 4.1 Species Inventory and Distribution

**4.1.1 Species Richness** Previous studies report varying species counts: *Flora Xinjiangensis* (1996) recorded 50 species (including 6 cultivated), while Lin et al. documented 34 wild species. Our updated inventory of 58 species reflects improved survey efforts and specimen verification. *Allium* represents a large genus in China's seed plant flora, with approximately 138 species nationwide, of which Xinjiang accounts for 44.27%—a remarkable proportion given the region's arid climate.

**4.1.2 Habitat Characteristics** Most *Allium* species inhabit open, sunny, dry locations with moderate humidity, ranging from various forest types and European subalpine meadows to Himalayan moist subalpine/high-altitude grasslands and Central Asian alpine zones. Some taxa tolerate saline-alkali environments, while others thrive in moist soils, organic substrates, swamps, wetlands, or even aquatic habitats. In Xinjiang, species predominantly occur in grassland and desert habitats (“dry-warm” environments), with fewer in “wet-cold” or “dry-hot” conditions, indicating that moderate temperature and moisture regimes are critical for survival.

**4.1.3 Endemism** According to *Endemic Species of Xinjiang* and *Flora Xinjiangensis*, only two *Allium* species are endemic to Xinjiang: *Allium grisellum* and *Allium roborowskianum*. This low endemism suggests relatively recent diversification or active gene flow with neighboring regions.

## 4.2 Floristic Patterns

**4.2.1 Diversity and Distribution Centers** The Tianshan Mountains constitute a major diversity and distribution center for wild *Allium* in China, harboring 37 species. This aligns with the region's role as a biodiversity hotspot and reflects the “three mountains” topography of Xinjiang.

**4.2.2 Geographical Elements** *Allium* is a holarctic, north temperate, and south temperate disjunct genus, conferring a pronounced temperate character to Xinjiang's flora. The predominance of desert and grassland habitats reflects Mediterranean and Central Asian phytogeographic elements, with many species serving as constructive or dominant components of desert and steppe vegetation (e.g., *Allium polyrhizum* in desert communities). Water and thermal conditions emerge as primary determinants of *Allium* distribution, with temperate elements showing strong ecological adaptability to high altitudes.

**4.2.3 Vegetation Regionalization** *Allium* distribution closely matches Xinjiang's major mountain systems, with highest richness in provinces associated with the “three mountains.” This pattern parallels findings for *Pedicularis* and *Salsola* in Xinjiang, reinforcing the influence of topography and climate on floristic composition.

**4.3 Floristic Affinity and Connections** Xinjiang's *Allium* flora shows closer ties to Central Asia than to adjacent Chinese provinces, with shared species numbers exceeding those with Gansu, Qinghai, or Tibet. The high similarity with Kazakhstan and Russia (45 shared species each) suggests these regions share common evolutionary histories and dispersal pathways. Many shared species possess basal nectaries, potentially facilitating pollination-mediated gene flow across regions. We propose that Xinjiang, Kazakhstan, and Russia be considered as an integrated unit in *Allium* floristic studies.

#### 4.4 Origin, Evolution, and Dispersal

**4.4.1 Global *Allium* Evolution** Molecular phylogenetic studies indicate *Allium* originated anciently and evolved along three independent lineages. The first and oldest lineage includes subgenera *Microscordum*, *Nectaroscordum*, and *Amerallium* (the latter being the largest, with Old and New World branches). The second lineage comprises *Caloscordum*, *Anguinum*, *Porphyroprason*, and *Melanocrommyum*. The third and most complex lineage includes *Rhizirideum*, *Allium*, *Reticulatobulbosa*, *Polyprason*, and *Butomissa*. Some subgenera are non-monophyletic, and phylogenetic positions of certain species remain debated.

**4.4.2 Xinjiang *Allium* Evolution** Xinjiang's *Allium* flora likely originated from East Asian and Central Asian ancestors, with species undergoing diversification and dispersal events that expanded their ranges. The region may represent a transition zone or secondary center of diversification. Subgenera *Porphyroprason* and *Melanocrommyum* show connections to Mediterranean and Central Asian lineages, while *Rhizirideum* and *Reticulatobulbosa* suggest broader Eurasian affinities. Xinjiang's flora exhibits two main evolutionary lineages (second and third phylogenetic lines) and significant morphological polymorphism.

#### 5. Conclusions

1. This study documents 58 *Allium* species, 1 subspecies, 2 varieties, and 6 cultivated species in Xinjiang through comprehensive literature and specimen review.
2. Distribution shows both horizontal and vertical differentiation, with highest richness in the North Tianshan Grassland Province (I A1), East Tianshan North Slope Grassland-Spruce Forest and Alpine Meadow Province (II A2), Junggar Basin Semi-shrub Desert Province (II A1), and South Tianshan Desert and Mountain Grassland Province (I I B3).
3. Xinjiang's *Allium* flora maintains affinities with adjacent Chinese provinces (Gansu, Qinghai, Tibet) and neighboring countries (Mongolia, Russia, Kazakhstan, Kyrgyzstan, Tajikistan), but shows particularly strong connections with Central Asian regions, especially Kazakhstan and Russia. The high similarity and minimal differences in shared species support treating Xinjiang, Kazakhstan, and Russia as an integrated floristic unit.

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