



BOTANIC-GEOGRAPHICAL AND ECOREGIONAL INSIGHTS INTO THE DISTRIBUTION OF *RHEUM* L. IN UZBEKISTAN AND CENTRAL ASIA

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Abstract. In this study, the geographical distribution of the genus *Rheum* across Central Asia and Uzbekistan was analyzed in relation to ecoregions, the botanical-geographical regions of Uzbekistan, and altitudinal zones. The results demonstrated that the distribution of *Rheum* species is closely associated with ecoregional and altitudinal factors. The analyses identified the Gissaro–Alai Open Woodlands, Pamir Alpine Desert and Tundra, Alai–Western Tian Shan Steppe, and Tian Shan Foothills Arid Steppe ecoregions as the principal centers of biodiversity for *Rheum* species. Within the flora of Uzbekistan, *Rheum maximowiczii* Losinsk., *Rheum macrocarpum* Losinsk., *Rheum turkestanicum* Janisch., and *Rheum cordatum* Losinsk. were identified as the most widely distributed species. Furthermore, unresolved issues were identified within the systematics of the genus, indicating the need for additional taxonomic studies at the species level. The findings provide an important scientific basis for the conservation of *Rheum* diversity, improving the understanding of their distribution patterns and supporting future taxonomic, biogeographical and conservation research.

Keywords: ecoregions, botanical-geographical regions, *Rheum* L., distribution.

Introduction. Central Asia is one of the regions distinguished by its vast geographical extent and complex natural conditions. The region comprises Kazakhstan, Uzbekistan, Turkmenistan, Kyrgyzstan, and Tajikistan (Tojibaev et al., 2017; Li et al., 2020). Distinctive climatic and ecological conditions of the region have led to the evolution of numerous plant species adapted to harsh environmental conditions, contributing to its high biological diversity. At the same time, increasing anthropogenic pressures, degradation of natural

ecosystems, reduction of vegetation cover, overgrazing, and global climate change have posed serious threats to the biological resources of the region in recent years. As a result, Central Asia is regarded as one of the ecologically vulnerable regions with respect to the conservation of its natural resources, particularly plant diversity (Asatulloev et al., 2023). Central Asia possesses a species-rich flora with high biodiversity. Approximately 10,000 plant species are distributed throughout the region, a considerable proportion of which consists of endemic species restricted to this area (Khassanov, 2015). Increasing human activities are affecting the structure and functional integrity of natural ecosystems, leading to changes in environmental conditions. Excessive exploitation of land resources, habitat degradation and changes in climatic factors have intensified their negative impacts on the distribution of plant species, the stability of their populations and the conservation of biological diversity (Ellis et al., 2012; Gao et al., 2020). Consequently, the natural populations of many plant species have been declining due to changes in natural landscapes, increasing anthropogenic activities, and the unsustainable exploitation of plant resources, particularly medicinal species. This situation has made the conservation and sustainable use of the region's unique floristic resources one of the major environmental challenges (Volis & Beshko, 2023; Rakhmataliev et al., 2025, 2026; Wang et al., 2026).

The genus *Rheum* L., which includes numerous medicinal plant species, represents a notable example. Members of the genus *Rheum* L. (Polygonaceae) are distributed primarily in China, Central Asia, East Asia, the Tibetan Plateau, the Himalayan Mountains, and adjacent mountain systems. The genus comprises approximately 60 species occurring at elevations ranging from 50 to 5,300 m above sea level. Although the greatest species diversity of the genus is concentrated in the mountainous regions of China, numerous species of pharmaceutical and economic importance also occur in Central Asia, as well as in Turkey and Iran (Tabin et al., 2016; Zhao et al., 2017; Bao & Grabovskaya-Borodina, 2003; Kunwar et al., 2021; Rana et al., 2022; Khapilina et al., 2025). According to various sources, the genus is divided into the following sections: *Acuminata*, *Palmata*, *Rhapontica*, *Globulosa*, *Nobilia*, *Orbicularia*, *Spiciformia*, *Rheum*, *Ribesiformia*, and *Diserticola* (Lozina-Lozinskaya, 1936; Kao & Cheng, 1975; Li, 1998; He et al., 2024). The distribution of the genus and related studies have been extensively investigated by Tabin et al. (2016), He et al. (2024), and Aitzhan et al. (2024). Ecoregions and botanical-geographical regions are recognized as the principal biogeographical units for analyzing the geographical distribution patterns of plant species (Olson et al., 2001; Tojibaev et al., 2016). In this framework, the terrestrial surface of the Earth was classified into 14 biomes, 8 biogeographic realms, and a total of 867 ecoregions (Olson et al., 2001). For Uzbekistan, maps of botanical-geographical units were developed based on the natural boundaries of botanical-geographical regions, species distribution, landscapes, and vegetation characteristics. The mountainous part of the country was divided into one province comprising eight botanical-geographical regions and 23 botanical-geographical districts, whereas the lowland part was divided into one province comprising eight botanical-geographical regions and 15 botanical-geographical districts (Tojibaev et al., 2016). Ecoregions represent ecologically homogeneous areas characterized

by climatic conditions, geographical features (topographic factors), and vegetation cover. Such areas play an important role in the evolution and distribution of plant species adapted to specific ecological conditions. In particular, ecoregions characterized by arid climates, high temperatures, or other extreme environmental conditions promote the evolution of species adapted to these environments, thereby contributing to increased levels of endemism (Tojibaev et al., 2016; Asatulloev et al., 2023). The ecoregion approach is widely used to identify areas of high biological diversity. Such assessments are primarily based on species richness and distribution patterns within a given area, providing a basis for establishing priorities for biodiversity conservation. In addition, altitudinal zones and ecological gradients within ecoregions exert significant influences on species composition and their spatial distribution (Körner, 2007). These gradients serve as natural models for investigating the adaptive mechanisms and evolutionary responses of organisms to temperature and other ecological factors. Therefore, ecoregions and their associated ecological gradients are of considerable scientific importance for understanding the formation of biological diversity and the distribution patterns of species (Pandey et al., 2021).

This study analyzed the distribution patterns of species of the genus *Rheum* L. across the ecoregions of Central Asia and the botanical-geographical regions of Uzbekistan. The geographical distribution of the genus across ecoregions and botanical-geographical districts was examined, and the influence of altitude on its distribution in Central Asia was evaluated. In addition, species richness across different ecoregions and botanical-geographical districts was assessed, and its significance for the conservation and protection of biological diversity was highlighted.

Materials and Methods

Field surveys were conducted throughout Uzbekistan from March to September during 2024–2026 at elevations ranging from 50 to 3,000 m above sea level. The occurrence localities of the genus *Rheum* were recorded during these surveys. During the study, species were identified using the taxonomic keys provided in *Conspectus Florae Asiae Mediae* (Vvedensky, 1971), *Flora of the U.S.S.R.* (Komarov, 1970), *Flora of Cultivated Plants* (Girenko et al., 1988), *Flora of Uzbekistan* (Korovin & Vvedensky, 1953), *Flora of the Kirghiz SSR: Key to Plants* (Vvedensky, 1953), *Flora of Kazakhstan* (Pavlov, 1960), *Flora of Tajikistan SSR* (Ovchinnikov, 1968), and *Flora of Turkmenistan* (Fedchenko, 1937). The identifications were subsequently verified using the *Plants of the World Online* (POWO) database. The scientific names of all species were recorded in accordance with the nomenclature accepted by *Plants of the World Online* (POWO, 2026). The study followed the accepted taxonomy of the *Plants of the World Online* (POWO) database. Accordingly, taxa treated as synonyms in the database were not considered as separate species, and all analyses were conducted exclusively on the basis of accepted species.

In this study, the geographical coordinates of collection localities recorded on herbarium specimens from Central Asia deposited in the TASH (National Herbarium of Uzbekistan), LE (Herbarium of Vascular Plants, Komarov Botanical Institute), and MW (Moscow University Herbarium) collections were determined using Retromap.ru (1985). In

addition, occurrence coordinates were obtained from the Global Biodiversity Information Facility (GBIF), iNaturalist, and Plantarium databases. The analyses were based on the distribution of *Rheum* species across the ecoregions of Central Asia (14) and the botanical-geographical regions of Uzbekistan (6) (Olson et al., 2001; Tojibaev et al., 2016; Dinerstein et al., 2017). The terrestrial ecoregions of Central Asia were extracted from the global terrestrial ecoregions map using ArcGIS v10.8. (Dinerstein et al., 2017). Distribution maps of the species in Central Asia and Uzbekistan were also prepared using ArcGIS v10.8. Subsequently, graphs and charts illustrating species richness across the ecoregions and the botanical-geographical regions of Uzbekistan were generated using OriginPro Software. Elevation ranges were determined from the geographical coordinates using GPS Visualizer. After calculating the elevation range for each species, the number of species occurring within each elevation interval was determined. Subsequently, the relationship between species richness and elevation was evaluated based on all 14 *Rheum* species and presented graphically.

Results and Discussion

Analysis of the Ecoregions of Central Asia

In this study, a map of the ecoregions of Central Asia, including Afghanistan, was developed (Fig. 1). Based on the occurrence of *Rheum* species in 21 of the 37 ecoregions (Fig. 2A), a species richness map of the genus across the ecoregions of Central Asia was developed. Our results showed that the Pamir–Alai Mountain System and the northwestern part of the Tian Shan Mountain System represent the principal centers of *Rheum* diversity in Central Asia. Among the ecoregions, the Gissaro–Alai Open Woodlands (GAOW) was identified as the primary center of diversity, harboring 11 species (Fig. 1). In addition, the Pamir Alpine Desert and Tundra (PADT), Alai–Western Tian Shan Steppe (AWTSS), and Tian Shan Foothill Arid Steppe (TSFAS) ecoregions were identified as secondary centers of *Rheum* diversity after the Gissaro–Alai Open Woodlands (GAOW), including 7, 5, and 5 species, respectively. Furthermore, four *Rheum* species were recorded in the Tian Shan Montane Conifer Forests (TSMCF), Central Asian Northern Desert (CAND), Rock and Ice (RI), and Tian Shan Montane Steppe and Meadows (TSMMS) ecoregions. Three *Rheum* species were recorded in each of the Badkhyz and Karabil Semi-desert (BKSD) and Emin

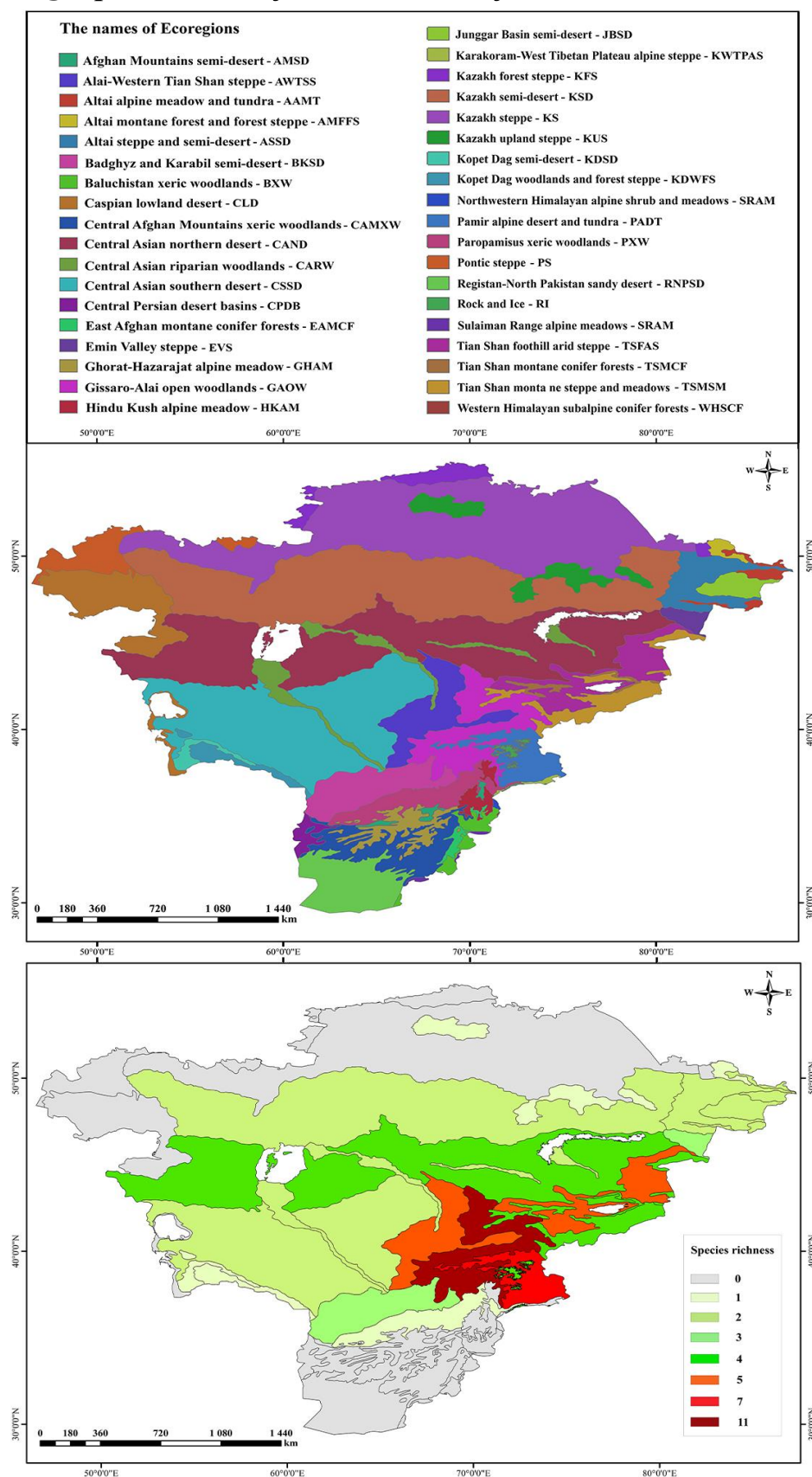


Figure 1. Ecoregions of Central Asia (Dinerstein et al., 2017) shown above and the species richness map of *Rheum* species distributed across these ecoregions shown below.

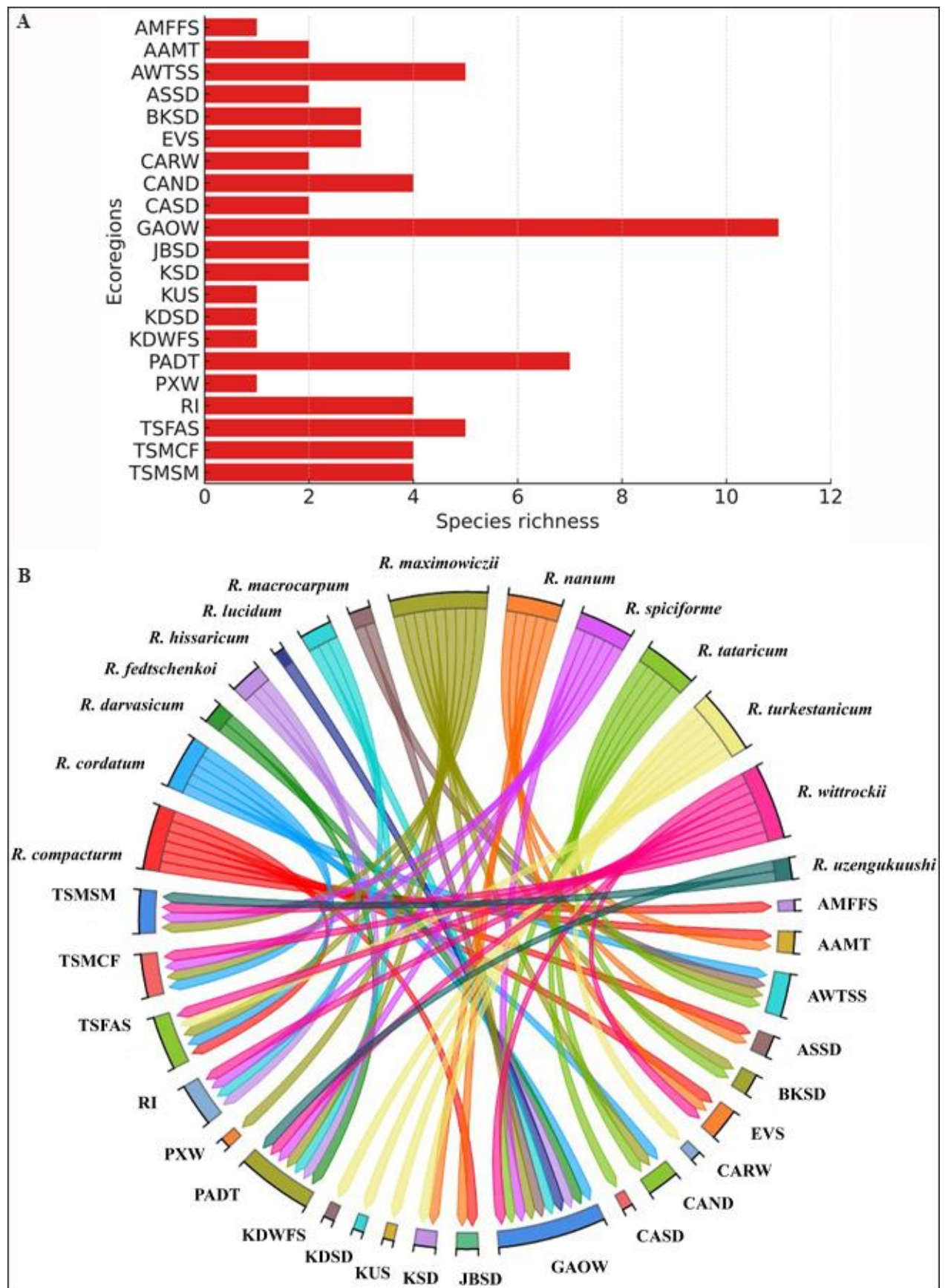


Figure 2. A and B – Species richness of *Rheum* species and the ecoregions in which they are distributed.

Table 1. Grouping of *Rheum* species based on the number of ecoregions.

Groups	Species	Number of Ecoregions

1	<i>Rheum maximowiczii</i> Losinsk., <i>Rheum tataricum</i> L.f.	9
2	<i>Rheum turkestanicum</i> Janisch.	8
3	<i>Rheum wittrockii</i> C.E.Lundstr.	7
4	<i>Rheum compactum</i> L.	6
5	<i>Rheum cordatum</i> Losinsk., <i>Rheum nanum</i> Siev., <i>Rheum spiciforme</i> Royle	5
6	<i>Rheum fedtschenkoi</i> Maxim. ex Regel, <i>Rheum lucidum</i> Losinsk.	3
7	<i>Rheum darvasicum</i> V.S.Titov ex Losinsk., <i>Rheum macrocarpum</i> Losinsk., <i>Rheum uzengukuushi</i> Lazkov & H.J.Choi	2
8	<i>Rheum hissaricum</i> Losinsk.	1

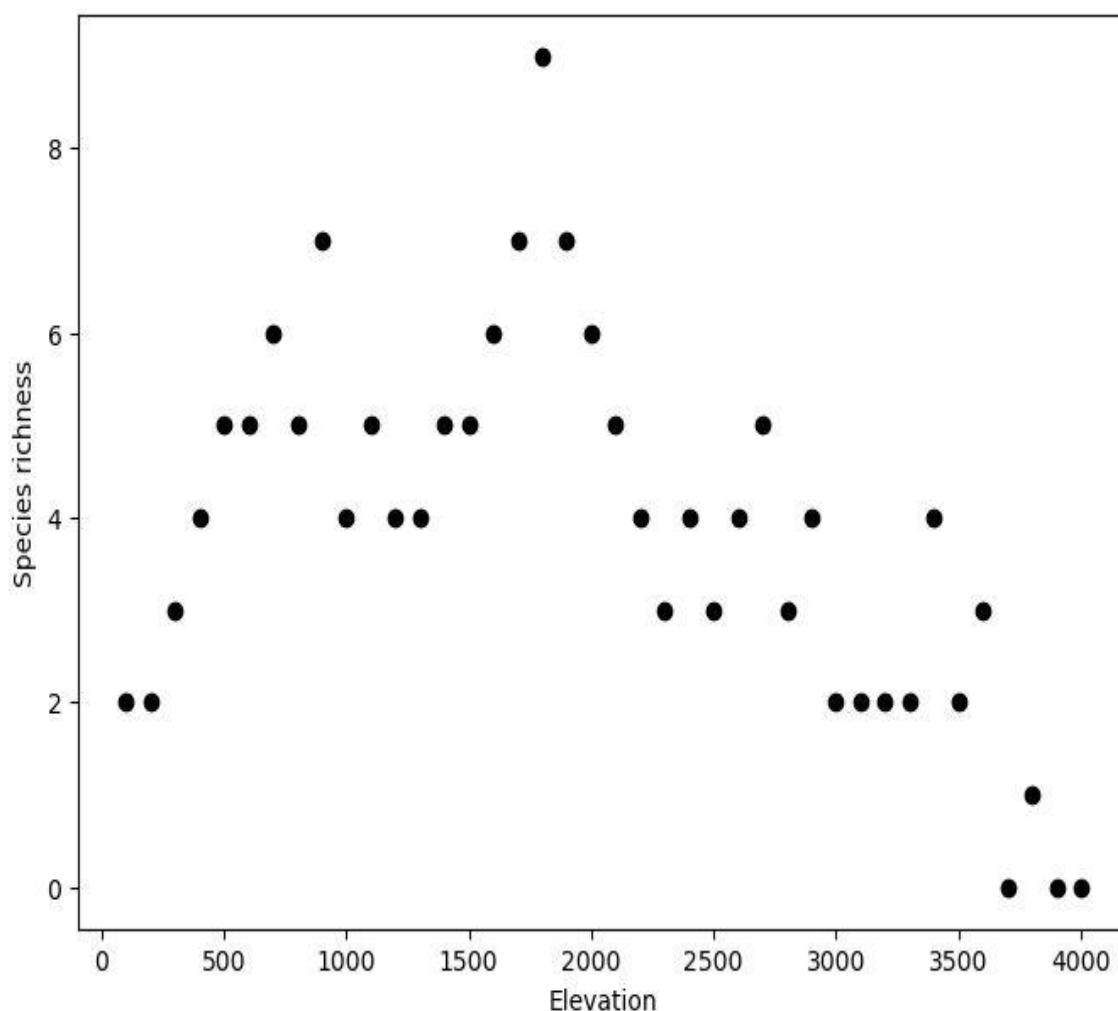


Figure 3. Relationship between species richness and elevation in *Rheum* species.

Valley Steppe (EVS) ecoregions. Two *Rheum* species were recorded in each of the Altai Alpine Meadow and Tundra (AAMT), Altai Steppe and Semi-desert (ASSD), Central Asian Riparian Woodlands (CARW), Central Asian Southern Desert (CASD), Junggar Basin Semi-desert (JBSD), and Kazakh Semi-desert (KSD) ecoregions. In the Altai Montane Forest

and Forest Steppe (AMFFS), Kazakh Upland Steppe (KUS), Paropamisus Xeric Woodlands (PXW), Kopet Dag Woodlands and Forest Steppe (KDWFS), and Kopet Dag Semi-desert (KDSD) ecoregions, one *Rheum* species was recorded in each ecoregion. The species were divided into eight groups based on the number of ecoregions in which they occur (Table 1). The relationships between species and ecoregions are presented in Figure 2. The results showed that the two species included in Groups 1 and 6 occurred in nine and three identical or different ecoregions, respectively. In Groups 2, 3, 4, and 8, one species in each group occurred in eight, seven, six, and one identical or different ecoregions, respectively. The three species included in Groups 5 and 7 occurred in five and two identical or different ecoregions, respectively (Table 1).

In this study, the relationship between elevation and species richness was also determined. In *Rheum* species, a distinct pattern of species diversity was observed at elevations ranging from approximately 500 to 3,400 m above sea level (Figure 3). The highest species richness was recorded at elevations between approximately 1,500 and 2,000 m, where nine species were observed. The elevation-based analysis revealed a strong relationship between elevation and species richness within the study area.

Analysis of the Botanical-Geographical Regions of Uzbekistan

For the territory of Uzbekistan, which has an important geographical position in Central Asia, a distribution map of *Rheum* species was developed based on the botanical-geographical regionalization map of Uzbekistan developed by Tojibaev et al. (2016) (Fig. 4). In this regionalization, the flora of Uzbekistan was divided into one mountainous province comprising eight botanical-geographical regions and 23 botanical-geographical districts: I. Central Asian Mountain Province: I-1 Western Tien Shan (districts: I-1-a Ugam-Pskem, I-1-b Western Chatkal (Chimgan), I-1-c Arashan, I-1-d Kurama (Akhangaran), I-1-e Chorkesar, I-1-f near-Tashkent), I-2 Fergana (I-2-a Southern Chatkal district), I-3 Fergana-Alay (districts: I-3-a Western Alay, I-3-b Eastern Alay), I-4 Nuratau (districts: I-4-a Nuratau, I-4-b Aktau, I-4-c near-Nuratau outlier mountains), I-5 Kuhistan (districts: I-5-a Northern Turkestan, I-5-b Malguzar, I-5-c Urgut, I-5-d Ziadin-Zirabulak), I-6 Western Hissar (districts: I-6-a Kashkadarya, I-6-b Tarkapchigay, I-6-c Baysun, I-6-d Kuhitang, I-6-e Surkhan-Sherabad), I-7 Hissar-Darvaz (I-7-a Sangardak-Tupalang district), I-8 Panj (I-8-a Babatag district).

The lowland part was divided into one province comprising eight botanical-geographical regions and 15 botanical-geographical districts: II. Turan Province: II-1 Central Fergana (districts: II-1-a Kayrakum–Yazyavan, II-1-b Eastern Fergana), II-2 Middle Syrdarya (districts: II-2-a Chinaz, II-2-b Mirzachul), II-3 Kyzylkum (districts: II-3-a Kyzylkum, II-3-b Kyzylkum outlier mountains), II-4 Bukhara (districts: II-4-a Middle Zeravschan, II-4-b Lower Zeravschan, II-4-c Karshi–Karnabchul), II-5 Karakum (II-5-a North-Eastern Karakum district), II-6 Southern Aral (districts: II-6-a Khorezm, II-6-b Amudarya delta), II-7 Aral (II-7-a Aral sea bottom district), II-8 Ustyurt (districts: II-8-a Northern Ustyurt, II-8-b Southern Ustyurt) and maps were developed based on the

boundaries of botanical-geographical regions, species distribution, landscapes and vegetation cover characteristics (Tojibaev et al., 2016).

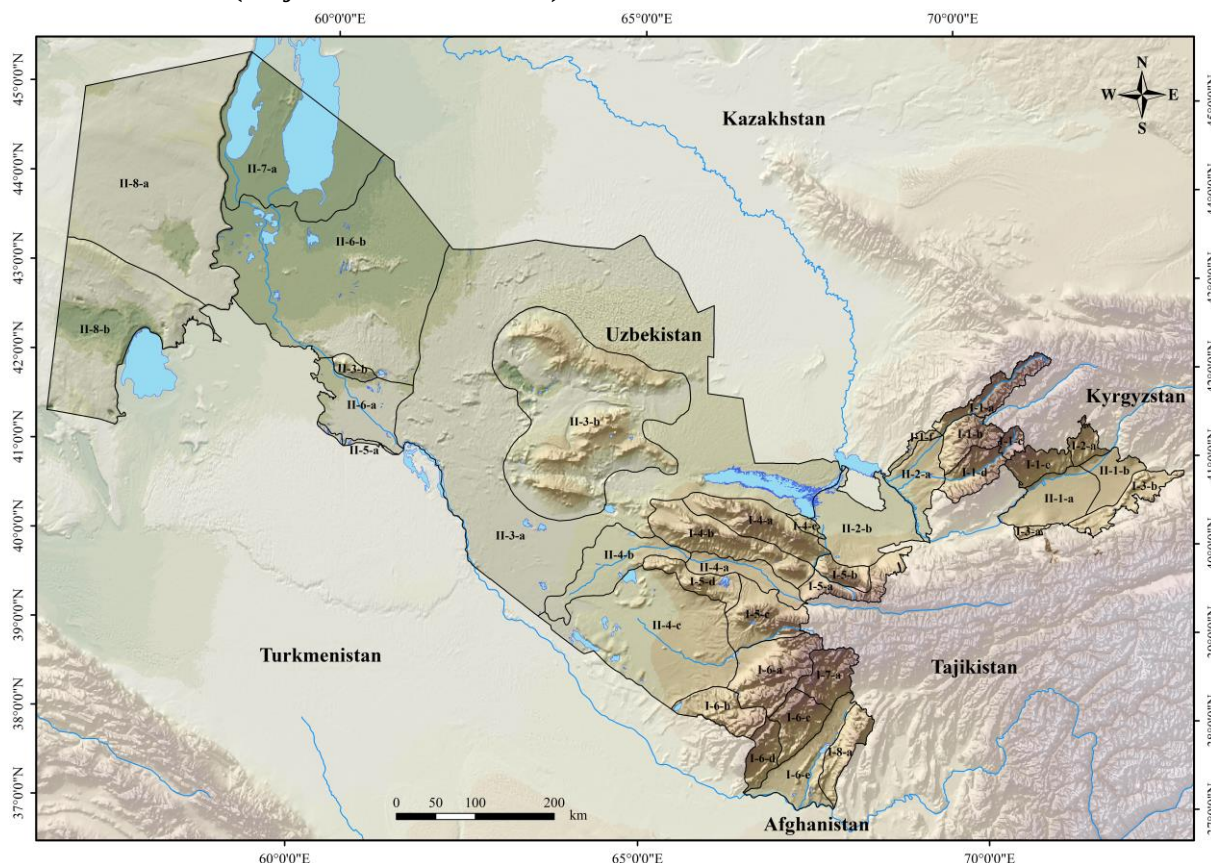


Figure 4. Botanical-geographical regionalization map of Uzbekistan developed by Tojibaev et al. (2016).

During our study, a distribution map of *Rheum macrocarpum*, *Rheum fedtschenkoi*, *Rheum cordatum*, *Rheum maximowiczii*, *Rheum tataricum*, and *Rheum turkestanicum* species across the botanical-geographical regions of the flora of Uzbekistan was developed (Fig. 5). According to the results, *Rheum macrocarpum* is distributed in the botanical-geographical districts I-4-a Nuratau, I-4-b Aktau, I-4-c near-Nuratau outlier mountains, I-5-a Northern Turkestan, I-5-b Molguzar, I-6-c Baysun, and I-8-a Babatag, which belong to the Nuratau, Kuhistan, Western Hissar, and Panj regions of the mountain and foothill areas. *Rheum fedtschenkoi* is distributed in the districts I-5-c Urgut, I-6-a Kashkadarya, I-6-c Baysun, and I-7-a Sangardak–Tupalang, which belong to the Kuhistan, Western Hissar, and Hissar–Darvaz regions. *Rheum cordatum* is distributed in the districts I-4-a Nuratau, I-4-b Oqtog‘, I-6-d Kuhitang, I-8-a Babatag, I-1-a Ugam–Pskem, and I-1-b Western Chatkal (Chimgan), which belong to the Nuratau, Western Hissar, Panj, and Western Tian Shan regions. *Rheum maximowiczii* is distributed in the districts I-1-a Ugam–Pskem, I-1-b Western Chatkal (Chimgan), I-1-c Arashan, I-1-d Kurama (Akhangaran), I-1-e Chorkesar, I-4-a Nuratau, I-5-c Urgut, I-6-a Kashkadarya, I-6-c Baysun, I-6-d Kuhitang, and I-7-a Sangardak–Topalang, which belong to the Western Tian Shan, Nuratau, Kohiston, Western Hissar, and Hissar–Darvaz regions.

In the lowland desert-steppe areas of Uzbekistan, *Rheum tataricum* is distributed in the districts II-8-a Northern Ustyurt and II-8-b Southern Ustyurt, which belong to the Ustyurt

region. In addition, *Rheum turkestanicum* is distributed in the districts II-3-a Kyzylkum, II-3-b Kyzylkum Residual Mountains, II-4-c Karshi–Karnabchul, I-6-d Kuhitang, and I-6-e Surkhan–Sherabad, which belong to the Kyzylkum, Bukhara, and Western Hissar regions (Fig. 6).

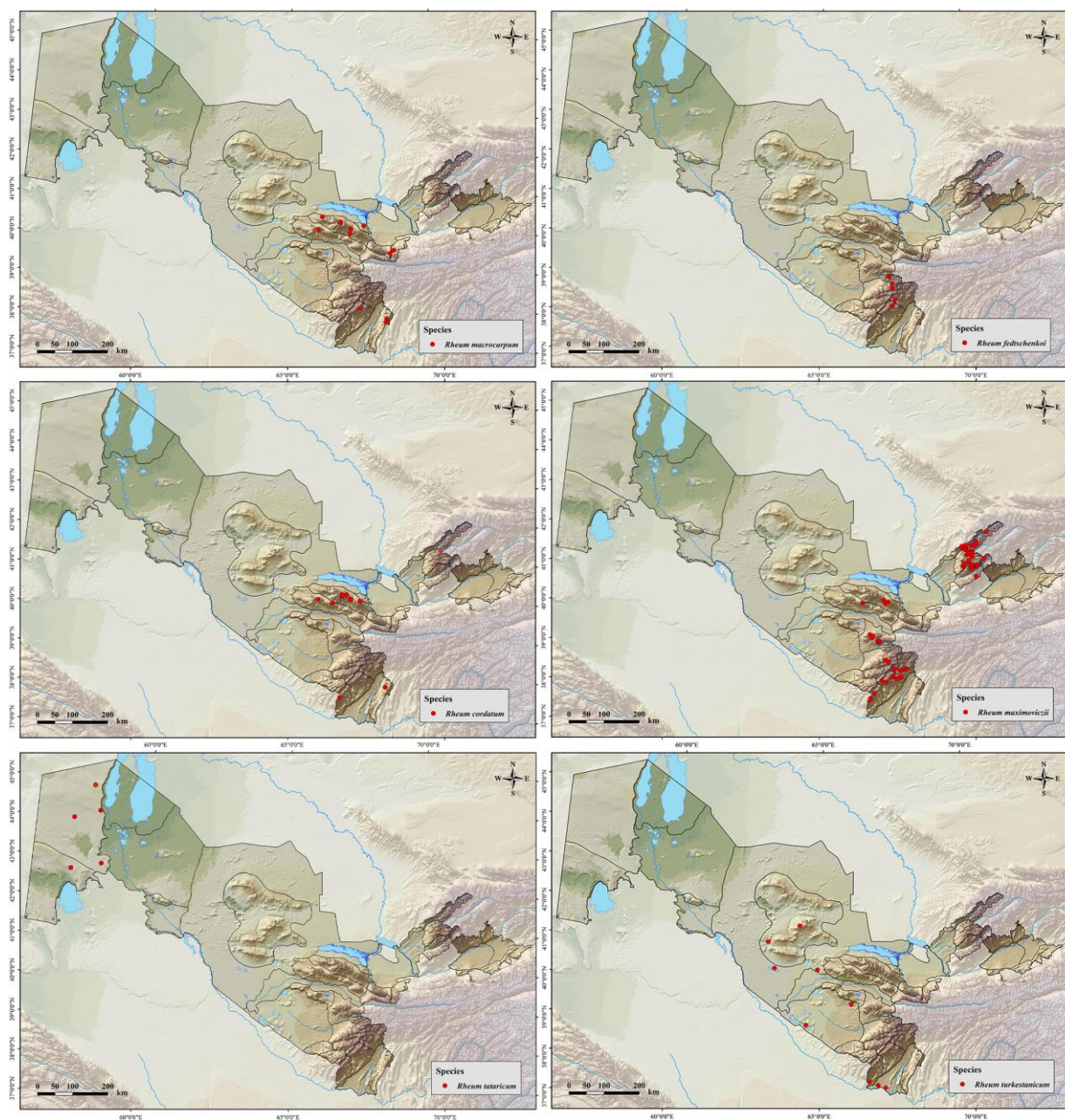


Figure 5. Distribution of *Rheum* species across botanical-geographical districts.

Taxonomic Issues in the Genus Rheum L.

During the study, information on some species, particularly *Rheum wittrockii*, *Rheum darvasicum* and *Rheum hissaricum*, was insufficient or limited; therefore, these species were not included in our analyses of the botanical-geographical regions of Uzbekistan, although they have been reported in some sources (Vvedensky, 1971; Korovin & Vvedensky, 1953; Komarov, 1970; He et al., 2024; Li & Tojibaev, 2024). These three species are also distributed in the flora of Tajikistan. *Rheum wittrockii* also occurs in the floras of Kazakhstan and Kyrgyzstan. Future field studies in the mountainous regions of the southern and northern

parts of Uzbekistan will provide clear evidence regarding the current occurrence of these species in the flora of Uzbekistan (Vvedensky, 1953; Pavlov, 1960; Ovchinnikov, 1968; Nowak et al., 2020). These species are reported from the Tian Shan, Pamir–Alai, and Hissar mountain ranges in major available sources dedicated to the flora of Central Asia and Uzbekistan, or are represented by herbarium records preserved in the TASH collection, which mainly date back to the 20th century. Only widely distributed species, such as *Rheum maximowiczii*, have herbarium records in the TASH collection based on specimens collected

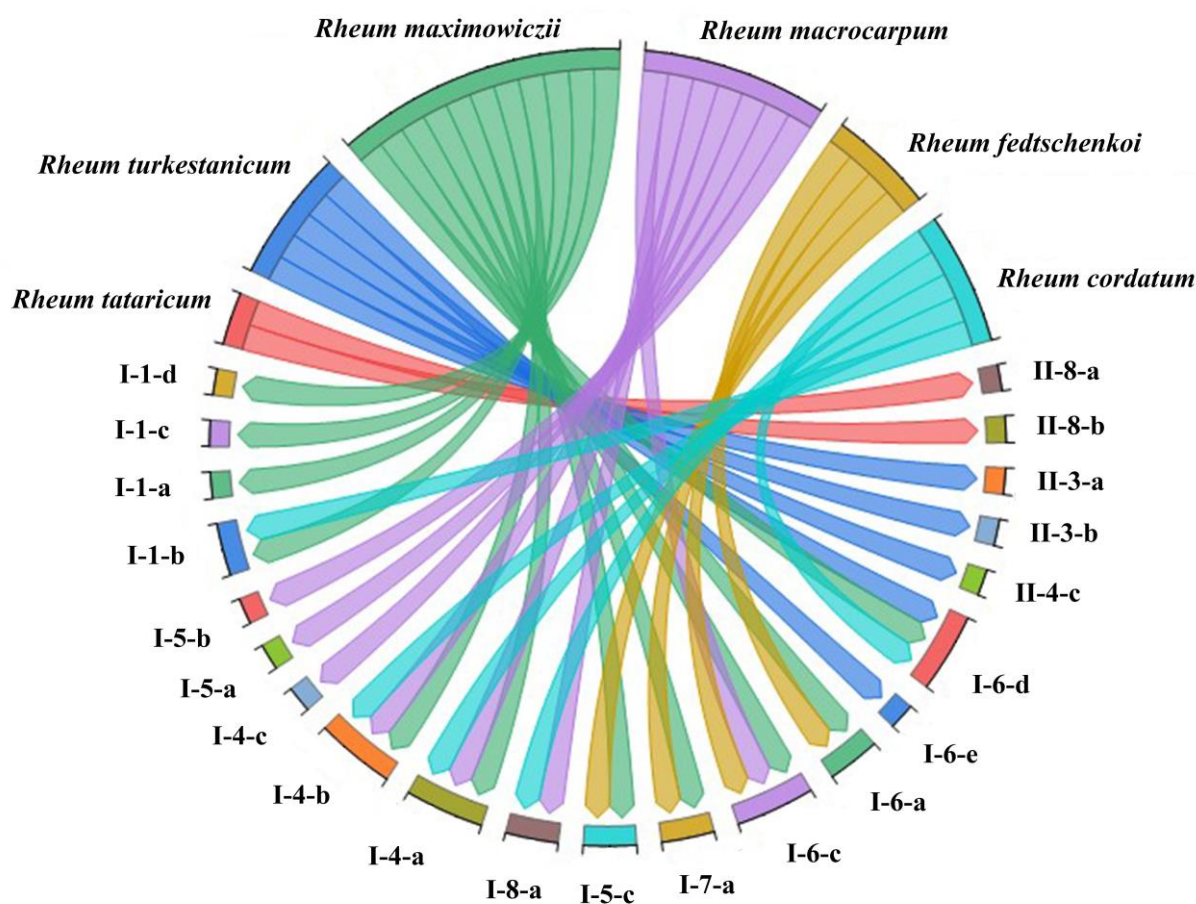


Figure 6. Distribution of *Rheum* species across botanical-geographical districts.

after 2000. In the work by Korovin and Vvedensky (1953), the taxa *Rheum megalophyllum* Sumnev., *Rheum renifolium* Sumnev., and *Rheum rupestre* Litv. ex Losinsk. were reported as separate species; however, according to the currently accepted taxonomy of the Plants of the World Online (POWO) database, these three taxa are recognized as synonyms of *Rheum turkestanicum*. Bunga o‘xshagan holatni *Rheum lobatum* Litv. ex Losinsk., *Rheum plicatum* Losinsk., *Rheum vvedenskyi* Sumnev va *Rheum macrocarpum* turlari o‘rtasida, *Rheum korshinskyi* V.S.Titov ex Losinsk. va *Rheum lucidum* turlari o‘rtasida, *Rheum reticulatum* Losinsk., *Rheum rhizostachyum* Schrenk va *Rheum spiciforme* turlari o‘rtasida, *Rheum altaicum* Losinsk. va *Rheum compactum* turlari o‘rtasida ham ko‘rishgiz mumkin (Vvedensky, 1971; Korovin & Vvedensky 1953; Komarov, 1970; Aitzhan et al., 2024; Li & Tojibaev, 2024; POWO, 2026).

Conclusion

In conclusion, this study provided important information on the distribution of *Rheum* species in Central Asia and Uzbekistan. In particular, the distribution of *Rheum* species across ecoregions and botanical-geographical regions of Uzbekistan, as well as their close relationship with elevation factors, was determined. Among the ecoregions of Central Asia, the GAOW, PADT, AWTSS, and TSFAS ecoregions were identified as centers of biodiversity for *Rheum* species. Therefore, the implementation of biodiversity conservation measures within these ecoregions is considered appropriate. In the flora of Uzbekistan, *Rheum maximowiczii*, *Rheum macrocarpum*, *Rheum turkestanicum*, and *Rheum cordatum* were identified as the most widely distributed species. In addition, taxonomic issues within the genus requiring further detailed scientific investigations at the species level were identified. In future studies, it is necessary to conduct more detailed investigations of the taxonomy of *Rheum* species in these regions and the historical processes that have contributed to the expansion of their distribution ranges.

Authors' contribution: A.R., A.T., G.Z. and Kh.D. conceived the study, collected the data, prepared the distribution maps, performed the analyses, and wrote the original draft of the manuscript. T.A. and L.S. contributed to the development and refinement of the methodology, supervised the research, critically reviewed and edited the manuscript. All authors read and approved the final version of the manuscript.

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Consent for publication: Not applicable, as this study does not include any identifiable personal data or images requiring consent for publication.

Data Availability Statement: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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Conflict of interest: The authors declare that they have no conflict of interest.

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