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# A SPECIMEN-BASED CHECKLIST AND GEOREFERENCED OCCURRENCE SYNTHESIS OF EREMURUS M.BIEB. (ASPHODELACEAE) IN TAJIKISTAN

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***Annotatsiya:*** *Tojikiston Markaziy Osiyodagi Eremurus M.Bieb. turkumining muhim xilma-xillik markazlaridan biridir. Ushbu tadqiqotda turkumning mamlakat hududida tarqalishi gerbariy namunalari, Plantarium.ru hamda Global Biodiversity Information Facility (GBIF) ma’ lumotlari asosida qayta ko‘ rib chiqildi. Turlar ro‘ yxatini tuzishda gerbariy namunalari asosiy tekshiriladigan ilmiy dalil sifatida qabul qilindi. Asosiy ishchi ma’ lumotlar bazasidagi koordinatalarni Tojikiston davlat chegarasi bilan fazoviy solishtirish natijasida dastlab 1 510 ta yozuv ajratildi; aynan takrorlangan yozuvlar chiqarilgach, 1 286 ta noyob yozuv qoldi. GBIFning faqat tabiiy sharoitdagi qaydlarni o‘ z ichiga olgan bazasidan Tojikistonga tegishli 113 ta yozuv aniqlandi, ulardan 35 tasi asosiy bazadagi yozuvlar bilan barqaror identifikatorlar orqali o‘ zaro mos keldi. Ma’ lumotlarni ehtiyotkorlik bilan birlashtirish natijasida jami 1 364 ta tarqalish qaydi shakllantirildi. Taksonomik sifat nazoratidan so‘ ng 1 345 ta yozuv 25 ta qabul qilingan tur hamda E. stenophyllus subsp. ambigens kenja turiga biriktirildi. Biroq ushbu ko‘ rsatkich Tojikiston florasidagi Eremurus turlarining umumiy boyligini to‘ liq ifodalamaydi. Shu sababli 2025-yilda chop etilgan global monografiyada har bir turning umumiy tarqalishi haqidagi ma’ lumotlar, klassik Flora Tadzhikskoi SSR, zamonaviy ilmiy adabiyotlar hamda POWO/WCVP 2026 taksonomik ma’ lumotlar bazasi bilan qiyosiy tahlil qilindi. Natijada Tojikiston florasi uchun 33 turdan iborat zamonaviy ishchi ro‘ yxat taklif etildi; E. cristatusning mamlakat hududida tarqalishi esa qo‘ shimcha gerbariy namunalarini tekshirishni talab qiladigan muvaqqat holat sifatida baholandi. GBIFda tayyor koordinatalar bilan keltirilgan yozuvlardan tashqari, o‘ rganilgan barcha gerbariy namunalari yorliq ma’ lumotlari asosida Google Earth dasturi yordamida alohida georeferensiyalandi. Olingan natijalar Tojikistondagi Eremurus turlarining taksonomik qayta ko‘ rib chiqilishi, muhofaza holatini baholash va maqsadli dala tadqiqotlarini rejalashtirish uchun ishonchli daliliy asos yaratadi.*

***Kalit so‘ zlar:*** *Eremurus; Asphodelaceae; Tojikiston; gerbariy specimenlari; checklist; georeferensiyalash; GBIF; Plantarium; POWO.*

# ЧЕК-ЛИСТ И ГЕОРЕФЕРЕНЦИРОВАННЫЙ АНАЛИЗ РАСПРОСТРАНЕНИЯ ВИДОВ EREMURUS M.BIEB. (ASPHODELACEAE) В ТАДЖИКИСТАНЕ НА ОСНОВЕ ГЕРБАРНЫХ ОБРАЗЦОВ

***Аннотация:*** *Таджикистан является одним из ключевых центров разнообразия рода Eremurus M.Bieb. в Центральной Азии. В настоящей работе распространение видов рода пересмотрено на основе гербарных образцов, данных Plantarium.ru и Global Biodiversity Information Facility (GBIF). Гербарные образцы рассматривались как основной проверяемый источник для формирования чек-листа. Пространственная проверка координат основной базы относительно государственной границы Таджикистана выявила 1 510 исходных записей; после удаления точных дублей осталось 1 286 уникальных записей. В очищенном наборе GBIF natural-only выявлено 113 записей из Таджикистана, 35 из*

*которых были непосредственно сопоставлены с основной базой по устойчивым идентификаторам. Консервативное объединение сформировало 1 364 записи. После таксономического контроля 1 345 записей были отнесены к 25 принятым видам и E. stenophyllus subsp. ambigens. Эта цифра отражает полноту георефернцированной базы, а не полное видовое богатство флоры страны. Сопоставление видовых очерков монографии 2025 г., Flora Tadzhikskoi SSR, современной литературы и POWO/WCVP 2026 позволило предложить рабочий современный список из 33 видов для Таджикистана; присутствие E. cristatus оставлено предварительным до повторной проверки ваучерных образцов. За исключением записей GBIF с уже имеющимися координатами, исследованные гербарные образцы были индивидуально георефернцированы в Google Earth по данным этикеток. Полученный синтез создаёт воспроизводимую основу для дальнейшей таксономической ревизии, охраны и полевых исследований Eremurus в Таджикистане.*

***Ключевые слова:*** *Eremurus; Asphodelaceae; Таджикистан; гербарные образцы; чек-лист; георефернцирование; GBIF; Plantarium; POWO.*

## A SPECIMEN-BASED CHECKLIST AND GEOREFERENCED OCCURRENCE SYNTHESIS OF EREMURUS M.BIEB. (ASPHODELACEAE) IN TAJIKISTAN

***Abstract:*** *Tajikistan is one of the principal centres of diversity of Eremurus M.Bieb. in Central Asia. This study reassesses the distribution of the genus in the country using an integrated evidence base assembled from herbarium specimens, Plantarium.ru and the Global Biodiversity Information Facility (GBIF). Herbarium vouchers were treated as the primary verifiable evidence for checklist construction because their identifications, labels and geographic interpretations can be re-examined. Spatial screening of the principal working database identified 1,510 coordinate records within Tajikistan; exact duplicate removal reduced this to 1,286 unique records. The quality-controlled GBIF natural-only dataset contained 113 Tajikistan records, 35 of which matched records in the principal database through stable identifiers. Conservative integration therefore produced 1,364 occurrence records. After taxonomic quality control, 1,345 records were assignable to 25 accepted species and E. stenophyllus subsp. ambigens. This number represents direct coverage of the georeferenced occurrence dataset rather than total national richness. Examination of the "General distribution" statement for every species in the 2025 global monograph, together with Flora Tadzhikskoi SSR, recent literature and the current POWO/WCVP 2026 backbone, supports a working modern checklist of 33 species for Tajikistan; E. cristatus is retained provisionally pending renewed voucher-based confirmation. Except for GBIF records already supplied with geographic coordinates, examined herbarium specimens were individually georeferenced in Google Earth from specimen-label locality data. The resulting synthesis provides an auditable baseline for taxonomic revision, conservation assessment, historical biogeography and targeted field surveys of Eremurus in Tajikistan.*

***Keywords:*** *Eremurus; Asphodelaceae; Tajikistan; herbarium specimens; checklist; georeferencing; GBIF; Plantarium; POWO.*

### Introduction

Herbarium collections are long-term scientific archives that document the occurrence of plants in a defined place and time. A herbarium voucher can be re-examined when species concepts change, when identifications are questioned, or when historical locality information needs reinterpretation. Digitization has extended this classical taxonomic role by transforming collections into spatial and temporal biodiversity datasets that can be used for systematics, biogeography, phenology, conservation and global-change research [1–6].

For floristic checklist construction, this verifiability is particularly important. A country-level checklist should not be treated merely as a compilation of names reported in literature; ideally, the presence of each taxon should be traceable to voucher material or another critically evaluated source. Observation data are useful for extending geographic coverage, but they do not always permit the same level of taxonomic reassessment as preserved specimens.

Tajikistan is almost entirely mountainous and lies within the Pamir-Alai and adjacent Central Asian mountain systems. Its strong elevational gradients, geological heterogeneity and historical climatic dynamics have generated exceptional floristic richness and endemism. Recent analyses place the country among the major centres of plant endemism in the Mountains of Central Asia biodiversity hotspot [10, 11]. The genus *Eremurus* is one of the characteristic geophytic components of this flora.

*Eremurus* is distributed principally from the eastern Mediterranean and Southwest Asia through Central Asia to western China and the Himalaya. Central Asia is one of the principal centres of diversity and evolutionary history of the genus [12, 13]. The 2025 global monograph recognizes at least 61 non-hybrid species and 14 hybrid taxa worldwide and reports 52 species for Central Asia, 31 of them endemic to the region [13].

The number of *Eremurus* taxa reported for Tajikistan has varied through time because of changes in taxonomic concepts and data availability. Flora Tadzhikskoi SSR listed 28 species [8, 13]. Later biodiversity syntheses commonly referred to approximately 29 taxa, and recent work characterizes Tajikistan as a core distributional area for 29 *Eremurus*

taxa, about half of them endemic or subendemic [10]. The current study revisits this question using a combined specimen, occurrence and modern taxonomic framework.

The aims were to: (1) identify all georeferenced records attributable to Tajikistan in the supplied *Eremurus* databases; (2) remove traceable duplicate records and document data provenance; (3) evaluate taxonomic names against current accepted nomenclature; (4) compare direct occurrence evidence with the country distribution stated in the 2025 monograph and other floristic sources; (5) estimate the current working species richness of *Eremurus* in Tajikistan; and (6) provide a reproducible evidence base for future taxonomic, conservation and field studies.

Literature review

The botanical exploration of Tajikistan and the broader former Soviet Central Asian region produced extensive herbarium collections from the late nineteenth century onward. Flora Tadzhikskoi SSR remains a fundamental historical source for the flora of the country [8]. Its treatment of *Eremurus* formed the basis for many later floristic and conservation publications.

More recently, Illustrated Flora of Tajikistan and adjacent areas has provided an updated regional synthesis [9], while Plants of the World Online (POWO), using the World Checklist of Vascular Plants (WCVP), supplies a continuously updated taxonomic and country-distribution backbone [16]. These modern sources are especially valuable for reconciling historical synonyms and changing species concepts.

Tajikistan-wide biodiversity studies emphasize the country's high endemism and vulnerability to biodiversity loss [10, 11]. Raduła et al. [10] explicitly identified Tajikistan as a core distributional area for 29 *Eremurus* taxa. The Red Book of the Republic of Tajikistan (2017) lists nine *Eremurus* species of conservation concern: *E. aitchisonii*, *E. candidus*, *E. lachnostegius*, *E. micranthus*, *E. tadshikorum*, *E. hilariae*, *E. korowinii*, *E. pubescens* and *E. roseolus* [20].

Tajik research has also addressed economically and biologically important species. *Eremurus hissaricus*, for example, has been studied for root polysaccharides and traditional medicinal use, and that literature likewise notes approximately 29 *Eremurus* species in Tajikistan [15]. Such studies demonstrate that the genus is important not only for systematics and floristics but also for conservation and applied plant research.

Phylogenomic work has further reinforced the importance of Central Asia for *Eremurus* evolution. Plastome and nuclear data suggest that the traditional infrageneric classification is not fully congruent with molecular relationships and identify Central Asia as a key region in the origin and diversification of the genus [12]. This makes careful linkage between historical specimens and modern accepted names essential.

Materials and methods

Data sources

Two principal electronic datasets supplied for this study were analysed. The first, is a working compilation of historical and contemporary *Eremurus* specimen and observation records from multiple herbarium repositories and Plantarium.ru. The second, is a previously quality-controlled GBIF dataset restricted to records interpreted as belonging to natural distributions.

The principal database contains records representing LE, TAD, TASH, MW, AA and FRU, together with Plantarium.ru. These sources were integrated because a national checklist cannot be reliably reconstructed from any single herbarium alone. Importantly, the term "all herbarium data" in this paper refers to the herbarium records assembled in the supplied working database; it should not be interpreted as a claim that every physical *Eremurus* sheet preserved in every herbarium worldwide has been digitized or examined.

The GBIF quality-control workbook contains 6,420 original GBIF rows, 2,896 records with coordinates and 2,277 records retained in the global natural-only final dataset after exclusion of cultivated, botanic-garden, severe coordinate-quality and range-inconsistent records. The Tajikistan subset comprised 113 records.

Geographic screening and georeferencing

Except for GBIF occurrence records already supplied with geographic coordinates, all examined herbarium specimens represented in the working herbarium database were individually georeferenced using Google Earth. Localities were reconstructed from specimen-label information, including country, administrative unit, mountain range, river, valley, gorge, settlement, pass, road and other topographic features. Historical and variant toponyms were compared with modern geographic objects wherever possible.

Coordinates were standardized as decimal latitude and longitude in WGS84. Reconstructed historical coordinates should therefore be interpreted as georeferenced locality estimates rather than direct GPS measurements collected in the field. Border records and geographically anomalous points were checked against the locality text.

A systematic orientation problem was identified in the principal workbook: in most historical rows, the numeric values placed under the written "Longitude" and "Latitude" headers were geographically reversed. Coordinate orientation was therefore normalized from plausible Central Asian geographic ranges before spatial screening.

Duplicate control and database integration

Geographic screening of the principal database identified 1,510 raw coordinate records falling inside Tajikistan. Exact duplicate comparison across the populated record fields removed 224 repeated rows, leaving 1,286 unique records.

The GBIF natural-only subset contained 113 Tajikistan records. Catalogue numbers, occurrence identifiers, specimen/record numbers and other stable identifiers were cross-compared to reduce double counting of institutional specimens that were also exposed through GBIF. Thirty-five GBIF records matched records already represented in the principal database. The resulting conservative integrated count was therefore 1,286 + 113 − 35 = 1,364 occurrence records.

Because some duplicate digital representations may lack a shared persistent identifier, 1,364 is treated as a conservative evidence-record estimate rather than an absolute count of physically distinct herbarium sheets.

Taxonomic standardization and species-richness reconciliation

Historical names and spelling variants were standardized against POWO/WCVP 2026 and the modern *Eremurus* literature [13, 16]. Examples include *E. angustifolius* as a synonym of *E. olgae* and *E. pectiniformis* as a synonym of *E. hissaricus*. Original identifications were retained conceptually for auditability even when an accepted name was applied analytically.

The "General distribution" statement of every non-hybrid species account in The genus *Eremurus* of the world [13] was screened for Tajikistan. This produced 34 nominal species names mentioning Tajikistan when *E. alberti* is included. These names were then reconciled with the current POWO/WCVP backbone. *Eremurus ambigens* is currently treated as *E. stenophyllus subsp. ambigens* and was therefore not counted as an additional species. *Eremurus himalaicus* is accepted but its current native range in POWO is Afghanistan to the western Himalaya and does not include Tajikistan, so it was excluded pending convincing voucher evidence. Conversely, *E. zenaidae* is currently recognized by POWO as native to Kyrgyzstan, Tajikistan and Uzbekistan and was added to the national working checklist. *Eremurus cristatus* was retained provisionally because the 2025 monograph reports Tajikistan whereas the current POWO country backbone does not; voucher reassessment is required.

Accordingly, the present paper uses 33 species as the working modern checklist for Tajikistan, one of them (*E. cristatus*) distributionally provisional. A strict POWO-only interpretation would contain 32 species. *Eremurus stenophyllus subsp. ambigens* is additionally recognized at infraspecific rank.

Temporal analysis

Collection dates were standardized when interpretable. Obvious chronological anomalies and uninterpretable date fields were excluded from decade-level summaries rather than silently corrected. Approximately 1,200 reliable dated records spanning 1869–2025 were retained for temporal analysis.

Results and discussion

Structure of the integrated evidence base

The combined analysis demonstrates that the majority of the Tajikistan evidence is specimen-based and historically distributed among several major herbaria. The principal database yielded 1,286 unique Tajikistan records after exact deduplication, whereas the GBIF natural-only subset contributed 113 records. After removal of 35 directly identifiable cross-dataset overlaps, the conservative integrated dataset contained 1,364 records.

Table 1

**Principal stages in constructing the Tajikistan Eremurus evidence database**

| Dataset / QC stage | Records |
|---|---|
| Raw principal-database coordinates inside Tajikistan | 1,510 |
| Principal database after exact duplicate removal | 1,286 |
| Exact duplicate rows removed | 224 |
| GBIF natural-only records from Tajikistan | 113 |
| GBIF records directly matched to principal database | 35 |
| Conservative integrated occurrence dataset | 1,364 |
| Records assignable to accepted taxa after taxonomic QC | 1,345 |
| Unidentified or taxonomically/geographically flagged records | 19 |
| Reliable dated records used for temporal analysis | ca. 1,200 |

The 1,286 unique records in the principal database were distributed among LE (664), TAD (265), TASH (249), MW (74), Plantarium.ru (29), AA (3) and FRU (2). LE therefore contributed more than half of the principal evidence base, while TAD and TASH together contributed another 514 records. This pattern shows the importance of integrating collections across national and institutional boundaries.

Table 2

**Sources represented in the principal Tajikistan working database**

| Source | Records | Share, % |
|---|---|---|
| LE | 664 | 51.6 |
| TAD | 265 | 20.6 |
| TASH | 249 | 19.4 |
| MW | 74 | 5.8 |
| Plantarium.ru | 29 | 2.3 |
| AA | 3 | 0.2 |
| FRU | 2 | 0.2 |
| Total | 1,286 | 100.0* |

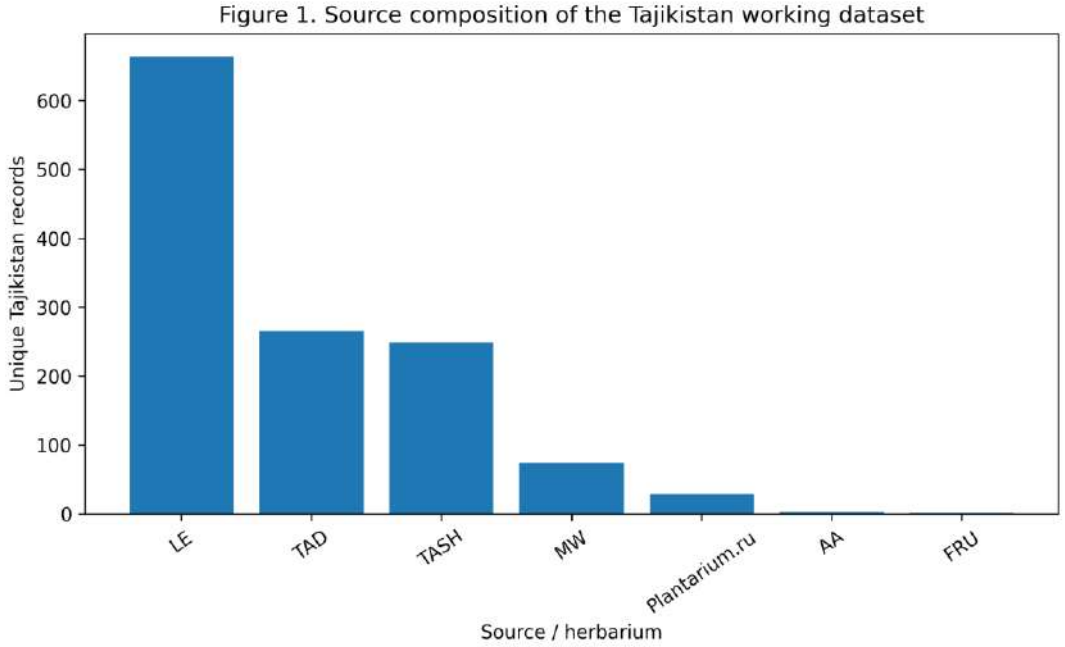



**Figure 1. Source composition of the Tajikistan working dataset. Herbarium codes and Plantarium.ru refer to the sources represented in the supplied principal database.**

Within the 113 Tajikistan GBIF records, 82 were PRESERVED_SPECIMEN, 27 HUMAN_OBSERVATION and four LIVING_SPECIMEN records linked to wild-source locality information. Thus, even within the GBIF layer, preserved specimens comprised the dominant evidence category.

Species richness: from occurrence coverage to a national checklist

After synonymization and quality control, 1,345 records were assignable to 25 accepted species plus *E. stenophyllus subsp. ambigens*. Nineteen records were retained outside the accepted occurrence total because they were unidentified to species or represented taxonomically/geographically questionable determinations requiring renewed examination. The occurrence-dataset richness must not be interpreted as the full flora of Tajikistan.

Table 3

**Historical and current estimates of Eremurus richness in Tajikistan**

| Source / interpretation | Richness | Comment |
|---|---|---|
| Flora Tadzhikskoi SSR (1963) | 28 species | Classical national flora [8, 13] |
| Recent biodiversity synthesis (2021) | 29 taxa | Tajikistan described as a core distributional area [10] |
| 2025 monograph species accounts | 34 nominal species | Reconstructed from all “General distribution” statements mentioning Tajikistan |
| Current QC georeferenced database | 25 species + 1 subspecies | Direct specimen/occurrence representation in the analysed databases |
| Present taxonomically reconciled checklist | 33 species + 1 subspecies | Recommended working total; E. cristatus provisional |

| | | |
|---|---|---|
| Strict current POWO country interpretation | 32 species + 1 subspecies | Excludes provisional E. cristatus |

Table 4

**Working modern checklist of Eremurus species in Tajikistan**

| No. | Accepted species | Evidence status in this study | Notes |
|---|---|---|---|
| 1 | *Eremurus aitchisonii* | Database-supported | Red Book: VU |
| 2 | *Eremurus alberti* | Database-supported | Pamir-Alai; type locality near Kulob region |
| 3 | *Eremurus altaicus* | Database-supported | Widespread Central Asian mountain species |
| 4 | *Eremurus brachystemon* | Database-supported | Tajikistan endemic in 2025 monograph |
| 5 | *Eremurus buchаricus* | Database-supported | Tajikistan–N Afghanistan regional endemic |
| 6 | *Eremurus candidus* | Database-supported | Tajikistan endemic; Red Book: VU |
| 7 | *Eremurus comosus* | Database-supported | Pamir-Alai / Alay |
| 8 | *Eremurus cristatus* | Literature-supported; provisional | Voucher and country-distribution reassessment required |
| 9 | *Eremurus fuscus* | Database-supported | Pamir-Alai and Tian Shan |
| 10 | *Eremurus hilariae* | Database-supported | Red Book: CR |
| 11 | *Eremurus hissaricus* | Database-supported | Gissar–Zarafshan; E. pectiniformis synonymized |
| 12 | *Eremurus iae* | Literature-supported | Pamir-Alai; Chulbair region |
| 13 | *Eremurus inderiensis* | Literature-supported | Current POWO also includes Tajikistan |
| 14 | *Eremurus kaufmannii* | Database-supported | Pamir-Alai |
| 15 | *Eremurus korowinii* | Literature-supported | Red Book: EW |
| 16 | *Eremurus korshinskyi* | Database-supported | Afghanistan–Pakistan–Tajikistan |
| 17 | *Eremurus lachnostegius* | Literature-supported | Red Book: VU |
| 18 | *Eremurus luteus* | Literature-supported | Afghanistan–Iran–Central Asia |
| 19 | *Eremurus micranthus* | Literature-supported | Tajikistan endemic; Red Book: VU |
| 20 | *Eremurus olgae* | Database-supported | Includes historical E. angustifolius |
| 21 | *Eremurus parviflorus* | Database-supported | Pamir-Alai regional endemic |
| 22 | *Eremurus pubescens* | Database-supported | Red Book: EW |
| 23 | *Eremurus regelii* | Database-supported | Pamir-Alai / Tian Shan |
| 24 | *Eremurus robustus* | Database-supported | Mountain meadows |
| 25 | *Eremurus roseolus* | Database-supported | Red Book: CR |
| 26 | *Eremurus saprjagajevii* | Database-supported | Tajikistan endemic in 2025 monograph |
| 27 | *Eremurus soogdianus* | Database-supported | Pamir-Alai / Tian Shan |
| 28 | *Eremurus stenophyllus* | Database-supported | Accepted species; widespread in SW/Central Asia |
| 29 | *Eremurus suworowii* | Database-supported | Pamir-Alai |
| 30 | *Eremurus tadshikorum* | Database-supported | Tajikistan endemic; Red Book: VU |
| 31 | *Eremurus tianschanicus* | Database-supported | Tian Shan / Pamir-Alai |

| | | | |
|---|---|---|---|
| 32 | *Eremurus turkestanicus* | Database-supported | Central Asian mountain endemic |
| 33 | *Eremurus zenaidae* | POWO-supported | Current POWO includes Tajikistan; absent from 2025 monograph Tajik distribution |

The reconciliation highlights why checklist richness and occurrence-database richness answer different questions. The national checklist summarizes critically evaluated taxonomic knowledge, whereas the occurrence database documents the individual georeferenced records presently available for analysis. Eight checklist species are currently absent from, or not reliably represented in, the accepted georeferenced occurrence subset: *E. inderiensis*, *E. micranthus*, *E. cristatus*, *E. iae*, *E. korowinii*, *E. lachnostegius*, *E. luteus* and *E. zenaidae*. Their absence from the final coordinate dataset should therefore be interpreted as a digitization, georeferencing or verification gap rather than proof of biological absence.

Table 5

**Accepted taxa represented in the conservative integrated georeferenced dataset**

| Accepted taxon | Merged records |
|---|---|
| *Eremurus stenophyllus* | 309 |
| *Eremurus robustus* | 153 |
| *Eremurus parviflorus* | 148 |
| *Eremurus soogdianus* | 148 |
| *Eremurus olgae* | 143 |
| *Eremurus suworowii* | 72 |
| *Eremurus comosus* | 51 |
| *Eremurus hissaricus* | 48 |
| *Eremurus altaicus* | 46 |
| *Eremurus alberti* | 39 |
| *Eremurus fuscus* | 35 |
| *Eremurus kaufmannii* | 31 |
| *Eremurus turkestanicus* | 27 |
| *Eremurus korshinskyi* | 16 |
| *Eremurus regelii* | 14 |
| *Eremurus aitchisonii* | 13 |
| *Eremurus stenophyllus subsp. ambigens* | 12 |
| *Eremurus brachystemon* | 10 |
| *Eremurus tianschanicus* | 10 |
| *Eremurus roseolus* | 6 |
| *Eremurus bucharicus* | 5 |
| *Eremurus hilariae* | 3 |
| *Eremurus saprjagajevii* | 2 |
| *Eremurus tadshikorum* | 2 |
| *Eremurus candidus* | 1 |
| *Eremurus pubescens* | 1 |

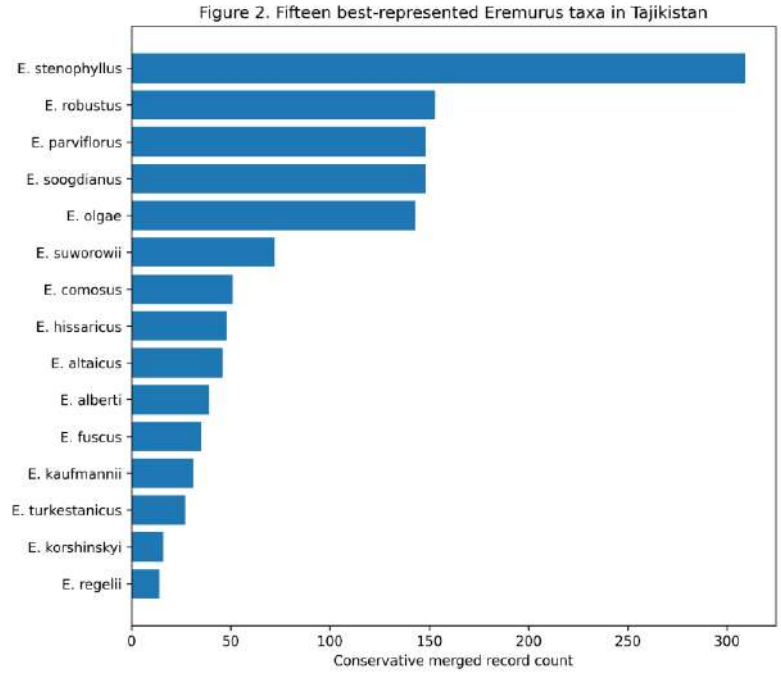



**Figure 2. Fifteen best-represented *Eremurus* taxa in the conservative integrated Tajikistan dataset.**

The best-represented species were *E. stenophyllus* (309 records), *E. robustus* (153), *E. parviflorus* (148), *E. soogdianus* (148) and *E. olgae* (143). These counts quantify documentary representation rather than population abundance. Collection effort, taxonomic history, accessibility and digitization intensity all influence record counts.

Geographic pattern

The 1,286 unique records in the principal herbarium/Plantarium layer form a broad spatial network across Tajikistan, with concentration in historically accessible mountain valleys and collecting routes. The distribution pattern corresponds primarily to the Pamir-Alai and associated ranges, but the point density is strongly affected by collecting history. Consequently, the map should be interpreted as a map of documented botanical evidence, not a census of population density.

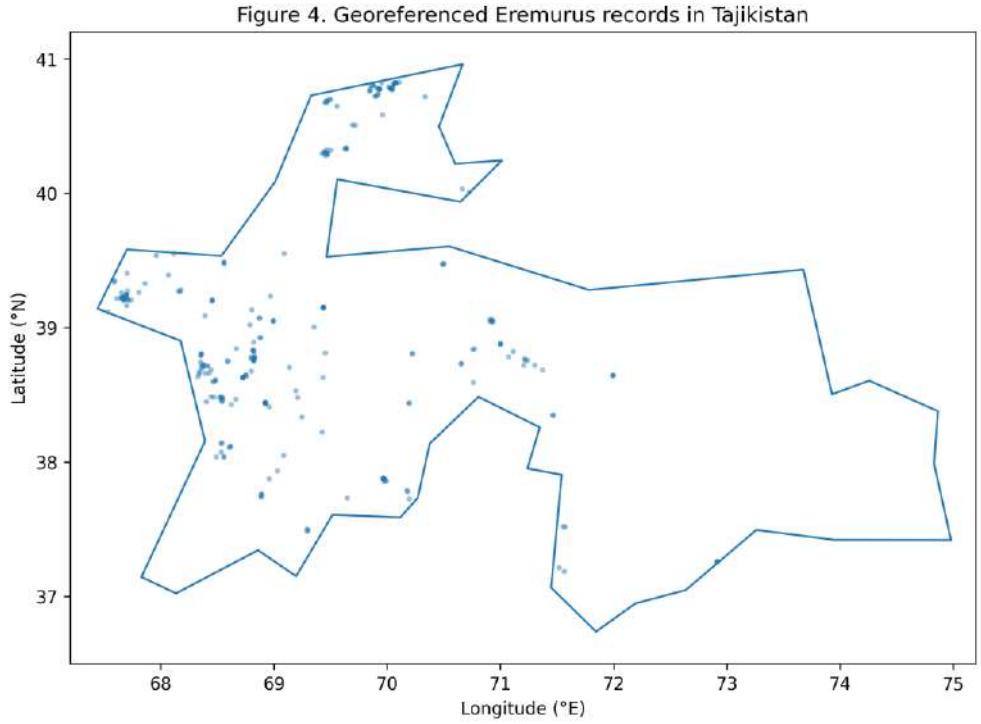



**Figure 4. Georeferenced *Eremurus* records from the principal herbarium/Plantarium database falling within Tajikistan. Historical coordinates were reconstructed from specimen labels and are not equivalent to field-measured GPS points.**

Historical dynamics of botanical collecting

Table 6

**Dated Eremurus records by decade**

| Decade | Records |
|---|---|
| 1860s | 1 |
| 1870s | 4 |
| 1880s | 29 |
| 1890s | 16 |
| 1900s | 17 |
| 1910s | 98 |
| 1920s | 37 |
| 1930s | 291 |
| 1940s | 167 |
| 1950s | 153 |
| 1960s | 244 |
| 1970s | 27 |
| 1980s | 15 |
| 1990s | 6 |
| 2000s | 4 |
| 2010s | 63 |
| 2020s | 28 |

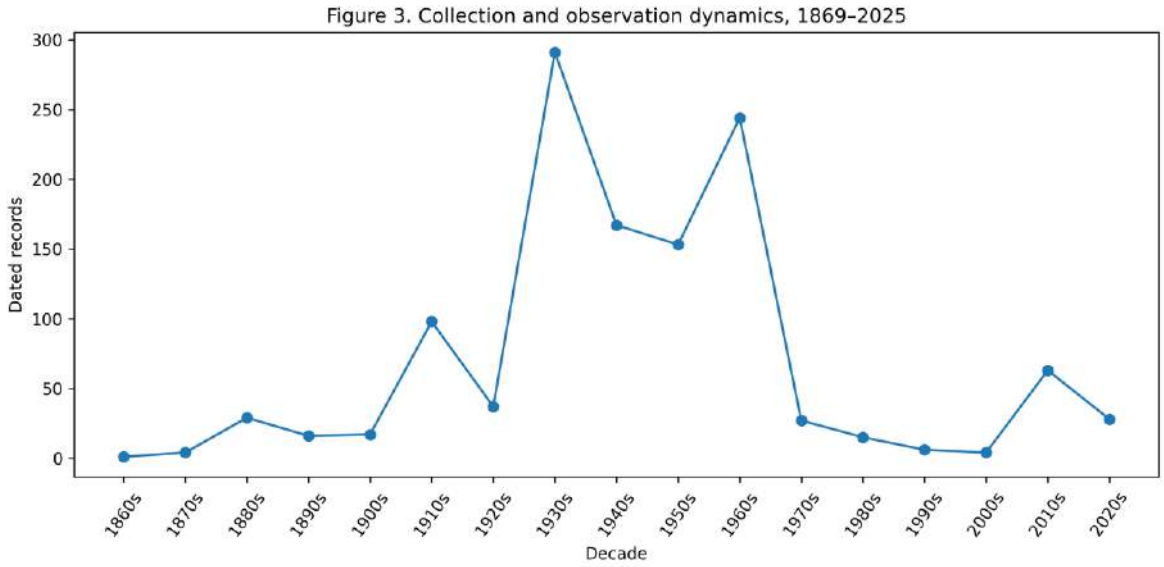



**Figure 3. Collection and observation dynamics of the reliable dated Tajikistan records, 1869–2025.**

The temporal series shows pronounced collecting maxima in the 1930s (291 records) and the 1960s (244 records). These peaks reflect intensified botanical exploration rather than changes in natural abundance. Historical specimens nevertheless provide an important baseline for identifying repeated localities and for future comparison with modern field observations.

Conservation implications

The Red Book of the Republic of Tajikistan (2017) lists nine *Eremurus* species: *E. aitchisonii* (VU), *E. candidus* (VU), *E. lachnostegius* (VU), *E. micranthus* (VU), *E. tadshikorum* (VU), *E. hilariae* (CR), *E. korowinii* (EW), *E. pubescens* (EW) and *E. roseolus* (CR) [20]. Historical herbarium vouchers are especially valuable for these taxa because they may preserve the only verifiable evidence for former populations or localities that have not been recently confirmed.

The occurrence gaps identified in this study provide a practical survey agenda. Literature-supported species missing from the quality-controlled coordinate dataset should be targeted first for herbarium digitization and re-georeferencing, followed by field verification of historical localities. Particular priority should be given to narrow endemics and Red Book taxa.

Scientific novelty and practical significance

The novelty of this study lies in combining several evidence layers within one quality-controlled workflow: historical herbarium records, Plantarium.ru occurrences, GBIF natural-only records, modern taxonomic reconciliation and country-level floristic literature.

The analysis independently screens coordinates against Tajikistan, documents duplicate removal, distinguishes voucher-based evidence from observations, identifies coordinate-orientation errors in the source workbook, standardizes synonyms, and explicitly separates direct occurrence coverage from national checklist richness.

Practically, the resulting framework can be used to prioritize specimen revision, direct future expeditions, identify historical localities requiring resurvey, support Red Book assessments, and prepare specimen-level supplementary data for international biodiversity infrastructures.

Study limitations

First, coordinates reconstructed from historical labels are estimates and may carry substantial uncertainty where toponyms are broad, obsolete or ambiguous. They should not be equated with GPS measurements taken at the time of collection.

Second, exact duplicate removal and stable-identifier matching cannot detect every possible duplicate. Two databases may represent the same physical sheet using different identifiers or slightly different transcriptions.

Third, occurrence density is strongly biased by expedition history, accessibility and digitization. Record counts are not a proxy for population size or abundance.

Fourth, the national checklist is constrained by the taxonomic concepts adopted. The case of *E. stenophyllus subsp. ambigens* illustrates how species-level richness changes when a taxon is treated at species versus subspecies rank.

Fifth, the status of *E. cristatus* in Tajikistan remains unresolved in the present synthesis because the 2025 monograph and current POWO country backbone are not fully concordant. The original voucher material and locality evidence should be re-examined before the record is treated as unambiguously confirmed.

Finally, the phrase “all herbarium data” is restricted to the records assembled in the supplied databases. Additional non-digitized specimens may remain in regional and international collections.

## Conclusions

The integrated analysis demonstrates that Tajikistan possesses one of the richest national assemblages of *Eremurus*. The principal coordinate database yielded 1,510 raw Tajikistan records and 1,286 unique records after exact duplicate removal. Integration with 113 GBIF natural-only records, while removing 35 directly traceable overlaps, produced a conservative total of 1,364 occurrence records.

After taxonomic quality control, 1,345 records provide direct georeferenced evidence for 25 accepted species plus *E. stenophyllus subsp. ambigens*. This figure describes the present specimen/occurrence database, not total floristic richness.

Critical comparison of the 2025 global monograph, Flora Tadzhikskoi SSR, recent Tajikistan biodiversity literature and current POWO/WCVP supports a working modern checklist of 33 species for Tajikistan, with *E. cristatus* retained provisionally pending voucher confirmation. Under a strictly current POWO country assignment, 32 species are accepted, plus *E. stenophyllus subsp. ambigens*.

Except for GBIF occurrences already supplied with coordinates, examined herbarium specimens were individually georeferenced using Google Earth from specimen-label locality information. This preserves the value of historical collections while making their spatial uncertainty explicit.

Herbarium vouchers remain indispensable for checklist research because their identities, labels and geographic interpretations can be revisited. The combined specimen, literature and digital-occurrence approach used here provides a reproducible foundation for future taxonomic revision, targeted collection, conservation assessment and historical-biogeographic analysis of *Eremurus* in Tajikistan.

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