DOI 10.54596/2958-0048-2026-1-45-56
UDK 582.998
IRSTI 68.35.57

DIGITALIZATION OF THE *ASTERACEAE* FAMILY COLLECTION IN THE HERBARIUM FUND OF THE DEPARTMENT OF BIOLOGY AND ITS PUBLICATION ON THE GBIF PLATFORM

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Abstract

This article presents the digitization of the herbarium collection of the *Asteraceae* family, housed in the herbarium collection of the Department of Biology at North Kazakhstan University. The study included 200 herbarium specimens collected between 1970 and 2025, including both historical specimens and modern field collections. All data were standardized in the Darwin Core (DwC) format, verified using the GBIF validator, and published through the IPT platform on the GBIF global portal, ensuring open accessibility of the collection and its integration into the international scientific infrastructure.

The paper presents the results of an analysis of the taxonomic composition, temporal distribution, and geography of the collections. It was established that the majority of the specimens belong to dominant meadow-steppe genera (*Achillea, Pentanema, Centaurea*, and *Leucanthemum*), reflecting the structure of the plant communities of the region. The temporal distribution is characterized by peak activity in different years and covers more than fifty years of collection development. Geographic analysis revealed an uneven distribution of finds across regions, with a predominance of materials from the Kyzylzhar district.

The resulting digital dataset is of scientific value for floristic, ecogeographical, and taxonomic research, contributes to the preservation of the herbarium collection, and expands its potential for educational and conservation use.

Keywords: *Asteraceae*; digitization; GBIF; Darwin Core; IPT; flora; georeferencing; herbarium collections; digital databases.

БИОЛОГИЯ КАФЕДРАСЫНЫҢ ГЕРБАРИЙ ҚОРЫНДАҒЫ *ASTERACEAE* КОЛЛЕКЦИЯСЫН ЦИФРЛАНДЫРУ ЖӘНЕ ОНЫ GBIF ПЛАТФОРМАСЫНДА ЖАРИЯЛАУ

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Аңдатпа

Бұл мақалада Солтүстік Қазақстан университетінің биология кафедрасының гербарий коллекциясында сақталған *Asteraceae* тұқымдасының гербарий коллекциясын сандық форматқа көшіру ұсынылған. Зерттеуге 1970 және 2025 жылдар аралығында жиналған 200 гербарий үлгісі, соның ішінде тарихи үлгілер мен қазіргі заманғы далалық коллекциялар кірді. Барлық деректер Darwin Core (DwC) форматында стандартталған, GBIF валидаторы арқылы тексерілген және GBIF жаһандық порталындағы IPT платформасы арқылы жарияланған, бұл коллекцияның ашық қолжетімділігін және оның халықаралық ғылыми инфрақұрылымға интеграциялануын қамтамасыз етеді.

Мақалада коллекциялардың таксономиялық құрамын, уақытша таралуын және географиясын талдау нәтижелері ұсынылған. Үлгілердің көпшілігі басым шалғынды-дала тұқымдастарына (*Achillea, Pentanema, Centaurea* және *Leucanthemum*) жататыны анықталды, бұл аймақтың өсімдік қауымдастықтарының құрылымын көрсетеді. Уақытша таралу әр түрлі жылдардағы ең жоғары белсенділікпен сипатталады және

коллекцияның елу жылдан астам дамуын қамтиды. Географиялық талдау нәтижесінде табылған заттардың аймақтар бойынша біркелкі емес таралуы анықталды, Қызылжар ауданынан алынған материалдар басым болды.
Нәтижесінде алынған сандық деректер жиынтығы флористикалық, экогеографиялық және таксономиялық зерттеулер үшін ғылыми құндылыққа ие, гербарий коллекциясын сақтауға ықпал етеді және оның білім беру және қорғау мақсатындағы әлеуетін кеңейтеді.

Кілт сөздер: *Asteraceae*; цифрландыру; GBIF; Дарвин Core; IPT; флора; георeференсация; гербарий коллекциялары; сандық дерекқорлар.

ЦИФРОВИЗАЦИЯ КОЛЛЕКЦИИ СЕМЕЙСТВА *ASTERACEAE* В ГЕРБАРНОМ ФОНДЕ КАФЕДРЫ БИОЛОГИИ И ЕЁ ПУБЛИКАЦИЯ НА ПЛАТФОРМУ GBIF

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Аннотация

В статье представлена работа по оцифровке гербарной коллекции семейства *Asteraceae*, хранящейся в гербарном фонде кафедры биологии Северо-Казахстанского университета. Материалом исследования послужили 200 гербарных образцов, собранных в период с 1970 по 2025 год, включающих как исторические экземпляры, так и современные полевые сборы. Все данные были стандартизированы в формате Darwin Core (DwC), проверены с помощью валидатора GBIF и опубликованы через платформу IPT на глобальном портале GBIF, что обеспечило открытую доступность набора и его интеграцию в международную научную инфраструктуру.
В работе представлены результаты анализа таксономического состава, временного распределения и географии сборов. Установлено, что основная часть образцов относится к доминирующим лугово-степным родам (*Achillea, Pentanema, Centaurea, Leucanthemum*), что отражает структуру растительных сообществ региона. Временное распределение характеризуется пиковой активностью в разные годы и охватывает более чем пятидесятилетний период формирования коллекции. Географический анализ показал неравномерное распределение находок по районам, с преобладанием материалов из Кызылжарского района.
Полученный цифровой набор данных представляет научную ценность для флористических, эколого-географических и таксономических исследований, способствует сохранению гербарного фонда и расширяет возможности его использования в образовательных и природоохранных целях.

Ключевые слова: *Asteraceae*; оцифровка; GBIF; Darwin Core; IPT; флора; геопривязка; гербарные коллекции; цифровые базы данных.

Introduction

The *Asteraceae* family is one of the largest and most ecologically flexible families of flowering plants, comprising over 30,000 species worldwide. In the North Kazakhstan region, Asteraceae members form a key component of the vegetation cover, occurring in a wide range of natural and anthropogenically modified habitats. They play an important role in the structure of meadow, steppe, and forest-steppe ecosystems, participate in the formation of phytocenoses, serve as indicators of the ecological state of territories, and are significant for the region's agrolandscape systems.

Many species of the *Asteraceae* family exhibit high environmental tolerance and can successfully colonize various types of biotopes, from virgin steppes to urban and agricultural areas. This makes them suitable for studying floristic diversity, ecological patterns,

biogeography, and vegetation dynamics. According to published data, the *Asteraceae* family dominates the flora of the North Kazakhstan region, comprising 131 plant species (17.2%). This family includes 53 (13.6%) plant genera [1].

A number of scientific papers have been devoted to studying the biodiversity of Asteraceae family representatives in the North Kazakhstan region, including a complete list of species and the first chorological analysis of the family [2, 3, 4].

Herbarium collections serve not only as scientific material but also as an important element of historical heritage. They allow us to reconstruct the floristic landscape of past decades, track changes in species distribution, document rare or endangered taxa, and provide a basis for systematic and monitoring research. However, many regional collections remain inaccessible to the general public for a long time due to the lack of digital representation. The Herbarium of the Institute of Botany and Phytointroduction has the international designation AA and is not only the largest collection in the Republic but also one of the largest and most prestigious botanical collections in the former USSR. The collection, founded in 1946, contains over 250,000 herbarium specimens.

In 2022, the Institute began work on creating an electronic database of herbarium specimens. The AA Herbarium database, created in Excel, organizes material hierarchically – from general to specific, from family to species, and from floristic region to collection point [5].

The Herbarium Fund of the Astana Botanical Garden was established in 2019 and is part of the Laboratory of Flora and Plant Resources. As of 2022, the herbarium collection comprised 13,492 herbarium sheets, including 10,733 sheets from duplicate funds of other herbaria and personal collections, and 2,759 sheets collected during expeditions across Central and Northern Kazakhstan (2019–2022). In 2021, the Herbarium of the Astana Botanical Garden was included in the international Index Herbariorum database and received the acronym NUR [6].

The Herbarium Fund of North Kazakhstan University has existed since 1960. According to the Herbarium Fund, the region's flora contains 881 plant species, including mosses, higher vascular and angiosperms [7].

Herbarium of the North Kazakhstan University named after for the first time in its history, the M. Kozybaev Herbarium Collection was registered in the international herbarium database, Index Herbariorum. It became the tenth organization in Kazakhstan to be registered with the Global Biodiversity Fund (GBIF), and the fourth organization in the country to publish a dataset of 400 digitized herbarium specimens on an international platform. The herbarium has an international index, SQU. According to rough estimates, the collection contains 8,000 herbarium specimens [8, 9, 10].

With the development of modern digital technologies, the process of digitizing herbarium collections is particularly important. This includes data systematization, standardization in international formats, and publication in open global systems such as GBIF (Global Biodiversity Information Facility).

The transition from local paper collections to digital resources significantly expands the scientific use of materials, improves data accessibility, and integrates regional biodiversity data into global analytical databases [7, 8]. The digitization of the Department of Biology's *Asteraceae* herbarium is particularly significant because it reflects the floristic diversity of the North Kazakhstan region over a period of more than fifty years (1970-2025). The creation of a digital dataset, its verification, standardization, and publication on the GBIF platform ensure the preservation of the information, its scientific transparency, and its long-term value for biology, ecology, and conservation research.

In recent decades, herbarium collections have been considered a key source of information on global and regional biodiversity. They provide a historical retrospective of species distribution, enable the analysis of range changes, phenological shifts, and the consequences of anthropogenic impact [11].

Modern research emphasizes that the digitalization of herbaria significantly expands their potential for use, transforming local collections into globally accessible scientific resources [12]. Digitization of natural science collections includes the creation of high-quality digital images, transcription of label data, georeferencing, metadata standardization, and publication in international formats, primarily Darwin Core [13]. Data standardization ensures their interoperability and the possibility of integration into global biodiversity aggregators such as GBIF (Global Biodiversity Information Facility) [14].

Publication of herbarium data through the GBIF infrastructure increases the citation rate of collections, expands the user base, and enables the inclusion of regional data in major analytical studies on macroecology and biogeography [15]. According to recent reviews, data mobilization is one of the key areas for the development of digital herbaria in the 21st century [16].

Furthermore, the development of digital platforms is facilitating the emergence of the concept of the "herbarium of the future," in which physical collections are complemented by digital twins, open metadata, and automated image analysis capabilities [17]. This is especially important for regional university collections, previously limited to local use.

Thus, the digitization and publication of herbarium materials from the *Asteraceae* family on the GBIF platform aligns with current global trends in the development of natural science collections and ensures the integration of regional floristic material from the North Kazakhstan region into the global information space. This work is devoted to the analysis of the herbarium collection of the *Asteraceae* family, the process of its digitization, systematization and publication, as well as the assessment of the taxonomic, temporal and geographical structure of the digitized material.

Materials and Methods

The study sample consisted of 200 herbarium specimens of the *Asteraceae* family, collected in the North Kazakhstan region. The collection includes both previously collected materials from the Department of Biology's herbarium collection and our own field collections conducted in 2025.

Specimen Collection. Current field collections were conducted in the North Kazakhstan region in areas near Petropavlovsk and adjacent territories. Collections were made during the flowering and fruiting stages of plants. For each specimen, the following information was recorded: family, genus, species, location, habitat, date, and collector. After collection, the plants were dried in a herbarium press and mounted on standard sheets with labels.

Digitization and database creation were carried out according to the guidelines for preparing datasets for publication [19].

All label data was transferred to a Darwin Core (DwC) spreadsheet (Figure 1).

The following key fields were populated: occurrenceID, family, scientificName, organismQuantity, organismQuantityType, lifeStage, verbatimEventDate, eventDate, year, month, day, countryCode, country, stateProvince, county, locality, verbatimLocality, habitat, language, recordedBy, identifiedBy, dateIdentified, decimalLatitude, decimalLongitude, coordinateUncertaintyInMeters, coordinatePrecision, geodeticDatum, georeferencedBy, georeferencedDate, vernacularName, taxonRank, kingdom, disposition, occurrenceStatus, collectionCode, institutionID, basisOfRecord, continent [19].

The completed table was validated using the built-in "GBIF data validator" service. The system automatically checked for the following: correct Latin names, unique occurrenceIDs, correct coordinates and their correspondence to the region, formatting of dates and text fields, and the presence of structural errors. Validator errors and warnings were manually corrected: in our case, these included errors in the date format and coordinates in some strings. After all the issues were resolved, the validator returned a "no errors" status, allowing us to proceed to the next step [11].

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	occurrenceID	family	scientificName	organism Quantity	organism Quantity Type	lifeStage	verbatimEventDate	eventDate	year	month	day	countryCode	country	stateProvince	county	locality
2	SQU00401	Asteraceae	Senecio jacobaea L.		Drude scale	flowering	08.07.2003r	2003-07-08	2003	7	8	KZ	Kazakhstan	North Kazakhstan Region	Kyzyltzhar district	Petropavlovsk sity
3	SQU00402	Asteraceae	Senecio jacobaea L.		Drude scale	flowering	08.07.99r	1999-07-08	1999	7	8	KZ	Kazakhstan	North Kazakhstan Region	Kyzyltzhar district	Petropavlovsk sity
4	SQU00403	Asteraceae	Senecio jacobaea L.		Drude scale	flowering	12.07.72r	1972-07-12	1972	7	12	KZ	Kazakhstan	North Kazakhstan Region	Kyzyltzhar district	Krasnoyarka village
5	SQU00404	Asteraceae	Tephroseris czernjaevii Holub.		Drude scale	flowering	8.06.93r	1993-06-08	1993	6	8	KZ	Kazakhstan	North Kazakhstan Region	Kyzyltzhar district	Petropavlovsk sity
6	SQU00405	Asteraceae	Antennaria dioica L.		Drude scale	flowering	29.06.71r	1971-06-29	1971	6	29	KZ	Kazakhstan	North Kazakhstan Region	Kyzyltzhar district	Krasnoyarka village
7	SQU00406	Asteraceae	Antennaria dioica L.		Drude scale	flowering	июнь 1974r	1974-06	1974	6		KZ	Kazakhstan	North Kazakhstan Region	Kyzyltzhar district	Krasnoyarka village
8	SQU00407	Asteraceae	Antennaria dioica L.		Drude scale	flowering	июнь 1971r	1971-06	1971	6		KZ	Kazakhstan	North Kazakhstan Region	Kyzyltzhar district	Sokolovka village
9	SQU00408	Asteraceae	Antennaria dioica L.		Drude scale	flowering	20.07.79r	1979-07-20	1979	7	20	KZ	Kazakhstan	North Kazakhstan Region	Kyzyltzhar district	Sokolovka village
10	SQU00409	Asteraceae	Echinops ritro L.		Drude scale	flowering	04.07.06r	2006-07-04	2006	7	4	KZ	Kazakhstan	North Kazakhstan Region	Kyzyltzhar district	Ivanovka village

Figure 1. Fragment of a completed Darwin Core (DwC) table

Next, the metadata was completed. This was formatted in the IPT interface and included a description of the dataset itself, the objectives of the study, and the significance of digitization for the herbarium collection. Correctly completed metadata ensures transparency of the data's origin and enhances the scientific value of the published collection. It also increases the likelihood of citation [18].

After the table and metadata were verified, the dataset was published on the GBIF platform. IPT automatically generated a Darwin Core Archive and assigned a unique DOI to the dataset. The data was indexed and made available to the international scientific community (Figure 2).

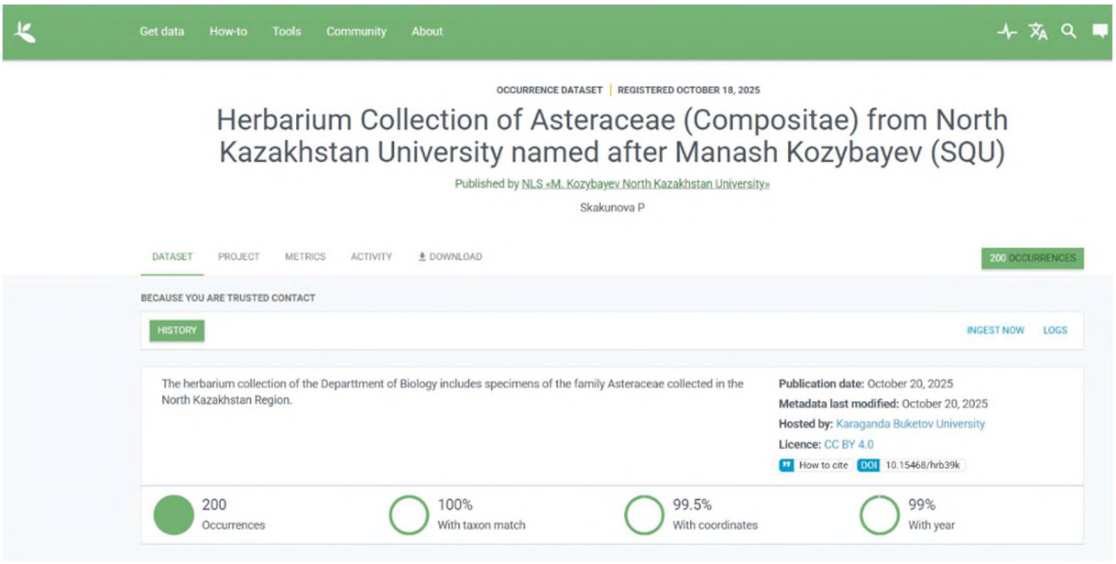

Figure 2. Main page of the published Asteraceae family dataset on the GBIF platform

All records are correctly displayed in the finds catalog, with filters available for species, coordinates, collection year, and habitat. The dataset is open for use by researchers, ecologists, botanists, and biodiversity specialists.

Research Results

Following the publication of the digital collection of the Asteraceae family on the GBIF platform, a detailed analysis of the metrics automatically generated by the GBIF system was conducted [20].

The taxonomic composition section presents a complete list of the genera of the Asteraceae family, indicating the number of specimens in each genus. This format is more informative than standard diagrams, as it demonstrates the precise numerical distribution of taxa (Figure 3).

The digital dataset includes 200 herbarium specimens of *Asteraceae*, distributed across a wide range of genera. A complete list of genera and their abundances is presented on the main page of the dataset (Figure 5). Key observations on the taxonomic composition are presented below.

The genus *Achillea* accounts for the largest share of the collection, with 37 specimens (18.5%), followed by *Pentanema* (21) (10.5%), *Centaurea* (14) (7.0%), and *Leucanthemum* (13) (6.5%). Together, these four genera constitute a significant portion of the dataset and reflect the predominance of meadow-steppe species in the material. Moderately represented genera – *Tragopogon* (8), *Crepis* (8), *Erigeron* (8), *Tripleurospermum* (6), and *Tanacetum* (6) – show that the collecting routes focused not only on the most common but also on associated components of meadow communities.

The assemblage includes numerous isolated genera (e.g., *Saussurea, Aster, Tripolium, Bidens, Tephroseris, Hieracium, Tussilago*, and *Scorzoneroides* – one specimen each). Records of these genera are important: they enhance the taxonomic value of the collection, highlight local finds, and point to directions for future collections.

Figure 3. Taxonomic composition of digitized specimens of the *Asteraceae* family

The dominance of *Achillea, Pentanema, Centaurea, Leucanthemum*, and other meadow genera correlates with the fact that the majority of collections occurred in meadow and steppe biotopes. This profile confirms that the collection route and habitat selection were focused on herbaceous communities typical of the North Kazakhstan region.

The presence of both common and rare genera makes the collection suitable for: floristic summaries and comparative reviews, studies of community structure, and targeted subsequent collections of rare genera.

The temporal distribution of herbarium specimens is an important indicator reflecting both the history of the collection's formation and the nature of fieldwork in different years. An analysis of the dynamics across years allows us to assess the uniformity and systematicity of collections, identify periods of intensive fieldwork, and identify years in which data were virtually nonexistent (Figure 4).

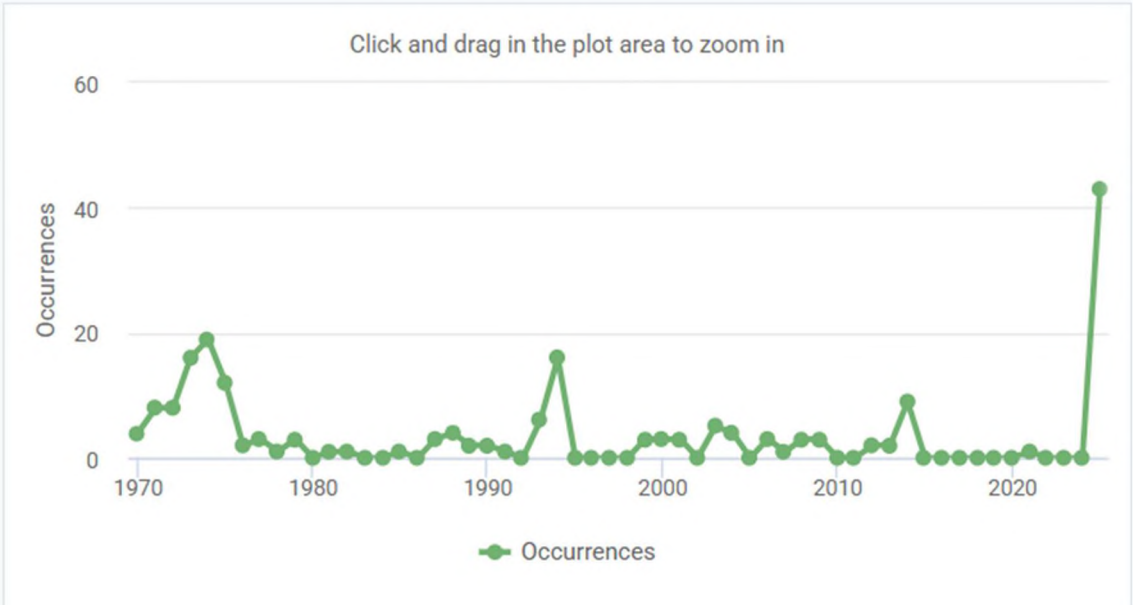

Figure 4. Temporal distribution of records by collection year

The diagram shows the distribution of all specimens uploaded to the metadata set from the 1970s to the present. The graph clearly shows fluctuations in collecting intensity, with periods of peaks and troughs, which is typical for herbarium collections formed not as part of a single project, but as a result of long-term, heterogeneous activity. The current sharp increase in the number of records, associated with active specimen collecting, reflects the collection's transition to the digitization stage and its ongoing expansion.

The graph shows several distinct peaks:

• the 1974 peak – 19 records – may reflect historical waves of collecting, such as educational fieldwork;

• the 1994 peak – 16 records;

• the moderate peak of 2014 – 9 records;

• the sharp modern peak (2025) – the largest, with 43 records in the most recent year on the graph. Between these bursts, there is a long period of low intensity or no records. This indicates not only the irregularity of collection but also that many specimens were lost or their labels did not contain complete data. Therefore, not the entire herbarium was suitable for digitization. It should be noted that approximately 10% of the herbarium specimens from the entire Asteraceae family collection, comprising at least 2,000 herbarium sheets, were used for digitization.

The geographic distribution of the collected specimens demonstrates marked spatial heterogeneity, which is related both to the actual accessibility of biotopes and to the routes of fieldwork. Overall, the collection covers seven administrative districts of the North Kazakhstan region, but the density of points is unevenly distributed (Figure 5).

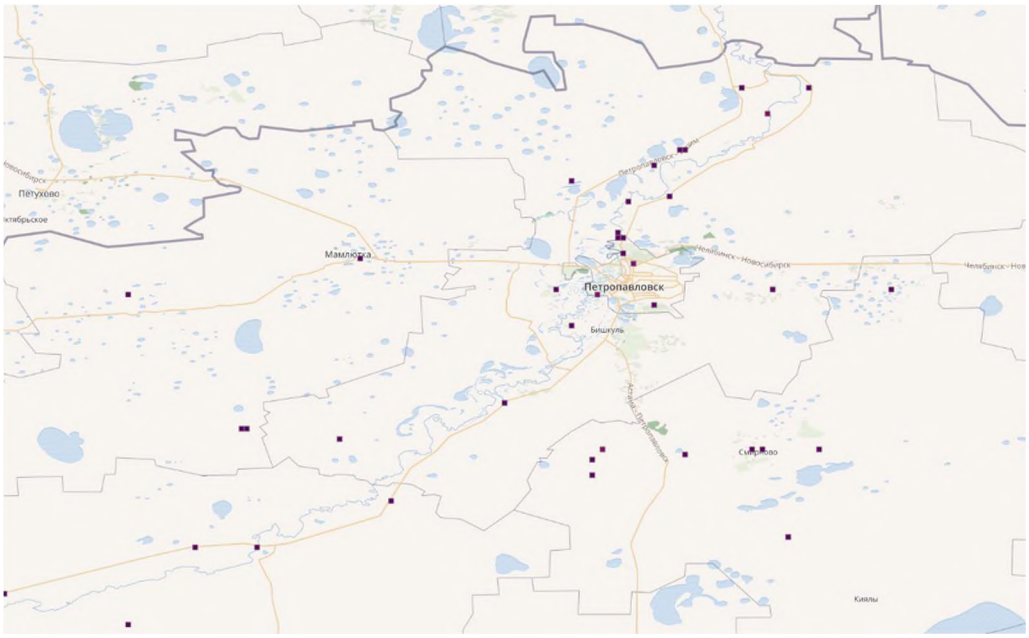

Figure 5. Map of georeferenced herbarium finds (collection points)

The overwhelming majority of all points (more than 78% of the set) are located in the Kyzylzhar district. This is explained by the fact that the majority of field trips took place in this area of the region, as it is associated with the location of our university students' field training. The UPP sites combined a variety of habitat types: meadows, pastures, field margins, river floodplains, and forest-steppe biotopes. The high data density allows for a comprehensive characterization of the *Asteraceae* flora in this region. The georeferenced map reveals a large "concentration area" of points, confirming intensive study of the area.

The Taiynshinsky district is represented by a moderate number of samples. This indicates selective routes were conducted in specific areas of the district. Despite the relative sparseness of the data, they contribute to the overall picture of the distribution of Asteraceae in the southern part of the region. The region is characterized by typical steppe and agro-landscape biotopes, which is reflected in the composition of the collected species.

Both regions have a similar number of finds and belong to the group of moderately represented areas. Their contribution provides a geographic expansion of the collection, allowing for the inclusion of flora from the northern and northeastern parts of the region.

Collections in these areas were less intensive, but were important for covering different ecological zones.

The Yesil district is poorly represented in the collection. The collected sites are of the nature of "supplementary routes" and provide only a preliminary understanding of the composition of Asteraceae in this region. This area is a priority for future expansion of the collection.

The M. Zhumabayev district is minimally represented. Such isolated sites typically relate to one-time expeditions or random routes. For further expansion of the collection, systematic collection in the district is recommended.

The Aiyrtau district has only one find, indicating the extremely low level of exploration of this administrative district. This area may be a promising zone for future research due to its high potential floristic richness.

Conclusion

This study included a comprehensive collection, systematization, digitization, and publication of herbarium specimens of the *Asteraceae* family collected in the North Kazakhstan region. The resulting digital dataset includes 200 carefully organized and georeferenced specimens, making it a significant contribution to the regional and global biodiversity dataset. Publication of the dataset on the GBIF platform ensured open access to the information, integration into the international scientific community, and the possibility of further use by researchers worldwide. Digitalization of herbarium collections not only facilitates the preservation of unique materials but also opens up new opportunities for biodiversity analysis, flora monitoring, and conservation decision-making. Thus, this work represents a significant contribution to the study of the flora of the North Kazakhstan region and serves as a basis for further research on the *Asteraceae* family, expanding the geographic scope of collections, and developing local digital herbaria.

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