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DISTRIBUTION AND COENOFLORA OF *DAPHNE ALTAICA* (THYMELAEACEAE) – A RARE ENDEMIC SPECIES FROM EASTERN KAZAKHSTAN

Daphne altaica is a insufficiently explored rare endemic species from East Kazakhstan, which is of great scientific interest. The main goal of this study is to establish the actual habitats based on historical collections stored in the main herbarium repositories, as well as to study the flora of associated species for D. altaica. As a result of the study, data were obtained on the distribution and coenoflora of the rare endemic species Daphne altaica in East Kazakhstan. For additional clarification of the distribution sites of the species, herbarium materials dated 1840-1973 from the main repositories were studied: the Institute of Botany and Phytointroduction (AA), Altai State University (ALTB), Siberian Botanical Garden (NS) and Lomonosov Moscow State University (MW). The analysis carried out confirmed the narrow local distribution of the rare species throughout the territory of the Republic of Kazakhstan. Possible additional habitats of D. altaica included in the Red Data Book of Kazakhstan have been identified. The concentration of habitats falls on the floristic regions 22. Altai and 23. Tarbagatai. The distribution of the species is limited by the Kalba, Southern Altai, Sarymsakty, Narym, Azutau, Ulba, Uba, Tarbagatai, Western Tarbagatai and Saur ridges. When studying the coenoflora of D. altaica, the completeness of the species composition of the communities was established. The coenoflora of D. altaica includes 175 species of higher vascular plants belonging to 127 genera and 42 families. In terms of the spectrum of the 10 leading families, the coenoflora of D. altaica is noticeably similar to the flora of the entire East Kazakhstan. The results obtained are necessary for monitoring and searching for historical habitats of D. altaica, compiling the route of field expedition trips, finding areas in natural habitats, and establishing phytocenotic relationships in D. altaica communities.

Key words: Thymelaeaceae, East Kazakhstan, herbarium funds, inventory, floristic composition.

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Шығыс Қазақстандағы сирек кездесетін эндем *Daphne altaica* (Thymelaeaceae) өсімдігінің таралуы мен ценофлорасы

Daphne altaica – Шығыс Қазақстандағы аз зерттелген сирек эндемик түр, бұл ғылыми қызығушылықты тудырады. Бұл зерттеудің негізгі мақсаты – негізгі гербарий қоймаларында сақталған тарихи коллекциялар негізінде нақты мекендеу орындарын құру, сондай-ақ D.altaica үшін сабақтас түрлердің флорасын зерттеу.Зерттеу нәтижесінде Шығыс Қазақстанда сирек кездесетін эндем Daphne altaica түрінің таралуы мен ценофлорасы туралы мәліметтер алынды. Түрдің таралу орындарын қосымша нақтылау үшін Ботаника және фитоинтродукция институты (AA), Алтай мемлекеттік университеті (ALTB), Сібір ботаникалық бағы (NS) және Ломоносов атындағы Мәскеу мемлекеттік университетінің (MW) негізгі репозиторийлерінен 1840-1973 жылдардағы гербарий материалдары зерттелді. Жүргізілген талдау нәтижесінде сирек кездесетін түрдің Қазақстан Республикасының бүкіл аумағында сирек таралғанын растады. Қазақстанның Қызыл кітабына енгізілген D. altaica түрінің өсуі мүмкін жерлер белгіленді. Тіршілік ету ортасының шоғырлануы мынандай флористикалық аймақтарға келеді 22. Алтай және 23. Тарбағатай. Түрдің таралуы Қалба, Оңтүстік Алтай, Сарымсақты, Нарым, Азутау, Үлбі, Үбі, Тарбағатай, Батыс Тарбағатай және Сауыр жоталарымен шектелген. D.altaica ценофлорасын зерттеу кезінде

қауымдастықтардың түрлік құрамының толықтығы анықталды. D.altaica ценофлорасына 127 туыс және 42 тұқымдасқа жататын жоғары сатыдағы өсімдіктердің 175 түрі кіреді. Жетекші 10 тұқымдастың спектрі бойынша D. altaica ценофлорасы бүкіл Шығыс Қазақстанның флорасымен айтарлықтай ұқсас келеді. Алынған нәтижелер D.altaica өсімдігінің тарихи мекендеу орындарын бақылау және іздестіру, далалық экспедициялардың маршрутын құрастыру, табиғи мекендеу орындарында ареалдарды табу, D. altaica қатысатын қауымдастықтарда фитоценоздық байланыстарды орнату үшін қажет.

Түйін сөздер: Thymelaeaceae, Шығыс Қазақстан, гербарий фонды, инвентаризация, флоралық құрамы.

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Распространение и ценофлора *Daphne altaica* (Thymelaeaceae) – редкого эндемичного вида из Восточного Казахстана

Daphne altaica является малоизученным редким эндемичным видов из Восточного Казахстана, который вызывает повышенный научный интерес. Основной целью данного исследования является установление фактических мест произрастания на основе исторических сборов, хранящихся в основных гербарных репозитариях, а также изучение флоры сопутствующих видов для D. altaica. В результате проведенного исследования получены данные по распространению и ценофлоре редкого эндемичного вида Daphne altaica в Восточном Казахстане. Для дополнительного уточнения мест распространения произрастания вида были изучены гербарные материалы датированные 1840-1973 гг. из основных репозитариев: Институт ботаники и фитоинтродукции (AA), Алтайский государственный университет (ALTB), Сибирский ботанический сад (NS) и МГУ им Ломоносова (MW). Проведенный анализ подтвердил узколокальное распространение редкого вида на всей территории Республики Казахстан. Установлены возможные дополнительные места произрастания D. altaica, включенного в Красную Книгу Казахстана. Концентрация мест произрастания приходится на флористические районы 22. Алтай и 23. Тарбагатай. Распространение вида ограничено хребтами Калбинский, Южный Алтай, Сарымсакты, Нарымский, Азутау, Ульбинский, Убинский, Тарбагатай, Западный Тарбагатай и Саур. При изучении ценофлоры D. altaica, установлена полночленность видового состава сообществ. Ценофлора D. altaica насчитывает 175 видов высших сосудистых растений, принадлежащих к 127 родам и 42 семействам. По спектру 10 ведущих семейств ценофлора D. altaica заметно схожа со флорой всего Восточного Казахстана. Полученные результаты необходимы для мониторинга и поиска исторических мест произрастания D. altaica, составлению маршрута полевых экспедиционных выездов, нахождению ареалов в естественных местах произрастания и установлению фитоценотических связей в сообществах с участием D. altaica.

Ключевые слова: Thymelaeaceae, Восточный Казахстан, гербарные фонды, инвентаризация, флористический состав.

Introduction

Daphne altaica is an endemic, relict species with a limited abundance and narrow ecology (Figure 1) [1]. It is used in official and traditional medicine [2]. It has anticancer properties [3, 4] and other highly valuable chemical properties [5, 6]. Degree of rarity: according to the Red Book of the Republic of Kazakhstan – a rare species [1]; included in the IUCN list: status Data Deficient (DD) [7].

Much research has been done on the biology of *D. altaica* in phytochemistry [8, 9], introduction [10], pharmacology [11, 12, 13], and anatomy [14]. At the same time, there is a limited number of studies on the distribution of *D. altaica* populations (Figure 2) in natural areas and in East Kazakhstan, in particular [15, 16, 17]. One of the effective methods for studying distribution is the inventory of herbarium collections.

Herbarium funds of the world contain about 480 million items [18]. They serve as a central resource for taxonomic and floristic research, including species discovery and description; means of verifying species identification; and accessible storage for formal deposit, for confirmation and

repeatability of botanical research. The following usual functions of herbariums remain important to botanical research: new species continue to be described, systematic relationships are always subject to revision, nomenclature is regularly updated, and documentation and biodiversity studies become increasingly important. Research increasingly uses herbarium specimens to answer questions on time and space scales. Herbarium samples have been used to test the prevalence of rapid evolution in introduced species [19], to quantify long-term phenological shifts as a result of climate change [20], to evolve secondary production of metabolites [21], to determine the phylogeography of a fungal strain [22], and to map the spread of diseases plants [23].

Figure 1 – Flowers of *D. altaica*

Figure 2 – Populations of *D. altaica*

The study of individual species collected at different times makes it possible to compare fluctuations in the size of populations of rare species and track colonization routes of invasive species [24, 25]. The herbarium fund is also of interest for the ecology of the species – to assess progress in achieving global conservation goals and promote the adoption of environmentally sustainable solutions to biodiversity problems [26, 27, 28].

The climatic conditions of the studied region – East Kazakhstan are determined, first of all, by its location in the center of the Eurasian continent with a relatively equal distance from the oceans, the proximity of the deserts of Mongolia and Central Asia, as well as the position in the system of continental-ocean transport of air masses [29]. Soils, as a rule, are light chestnut soils, which form the main background, against which the vertical range of soils characteristic of the region is manifested: dark chestnut, steppe chernozems and forest-steppe, gray forest soils, mountain taiga acid soils, and mountain meadow soils [30].

The purpose of the research was to clarify and supplement the information on the presence and distribution of *D. altaica* in various floristic regions of East Kazakhstan, as well as to study the coenoflora of communities with the participation of *D. altaica*.

Materials and methods

To further clarify the species composition and distribution of species of the genus Daphne, an inventory of the herbarium material of the study area was carried out. To compile a summary of the species, materials from the main repositories were processed: the Herbarium Fund of the Institute of Botany and Phytointroduction (AA) – more than 50 herbarium sheets, Altai State University (ALTB) – 10 sheets, the Siberian Botanical Garden (NS) – 10 sheets, and Lomonosov Moscow State University (MW) – more than 20 herbarium sheets [31]. Herbarium samples are presented from different places of the Republic of Kazakhstan and dated 1840-1973.

The Latin names of the species are given according to the international platform Plants of World (POWO). Nomenclature citations are based on the "World checklist of selected plant families" system [32]. Geographical zoning and names of mountain ranges are indicated according to the "Physical Map of Kazakhstan". The names

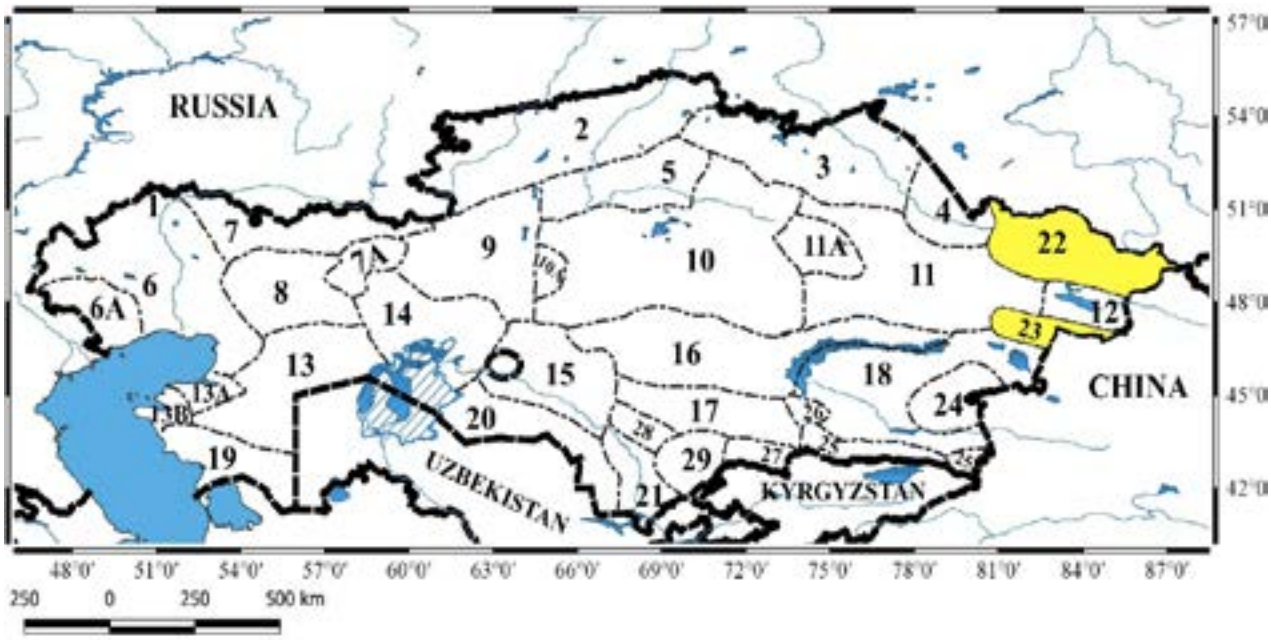
of floristic regions are given according to the academic publication "Flora of Kazakhstan" [33].

Mapping of locations was carried out in the Qgis 3.12.0-București program. The rarity category and species status are specified in accordance with "The IUCN Red List of Threatened Species" [7].

Results and discussion

The disappearance of populations poses a serious threat to plants, leading to a reduction in the range, fragmentation, and isolation of species [34, 35, 36, 37].

As a result of the inventory of herbarium samples of *D. altaica* in the Herbarium Fund of the Institute of Botany (AA), Altai State University (ALTB), Siberian Botanical Garden (NS) and in the digital herbarium of Moscow State University – Depository of Living Systems "Noah's Ark" (MW), were found additional actual places of growth. The main concentration of historical finds is given for the floristic regions 22. Altai and 23. Tarbagatai (Figure 3).



1. Spurs of the General Syrt (Sp. gen. Syrt); 2. Tobol-Ishim (Tob.-Ishim); 3. Irtysh (Irt.); 4. Semipalatinsk pinery (Semip. pin.); 5. Kokchetav (Kokch.); 6. Caspian (Casp.); 6a. Bukeyev; 7. Aktobe; 7a. Mugodzhary (Mugodzh.); 8. Emba; 9. Turgai; 10. Western upland (West. upl.); 10a. Ulutau; 11. East upland (East upl.); 11a. Karkaraly (Kark.); 12. Zaysan; 13. Northern Ust-Urt (North. Ust-Urt); 13a. Buzachi; 13b. Mangyshlak (Mangysh.); 14. Aral; 15. Kzyl Orda; 16. Betpak-Dala; 17. Muyunkum; 18. Balkhash-Alakol (Balkh.-Alak.); 19. South Ust-Urt; 20. Kzyl-Kum; 21. Turkestan (Turk.); 22. Altai; 23. Tarbagatai (Tarb.); 24. Dzungarian Alatau (Dzung. Alat.); 25. Ile Kungei Alatau (Ile Kung. Alat.); 25a. Ketmen Terskey Alatau (Ketm.Tersk. Alat.); 26. Chu-Ili mountains (Chu-Ili moun.); 27. Kyrgyz Alatau (Kyrg. Alat.); 28. Karatau (Karat.); 29. Western Tien Shan (West T.Sh.).

Figure 3 – Map-scheme of floristic regions of Kazakhstan

The summaries of herbarium sheets of *D. altaica* identified during the inventory of repositories are given below. Nomenclature quotations were compiled with a list of generally accepted synonyms. Original labels have been cited for actual growing locations.

Family Thymelaeaceae Juss., Gen. Pl. [Jussieu] 76. 1789 [4 Aug 1789] (as "Thymelaeae") (1789).

Genus *Daphne* Tourn. ex L., Sp. Pl.: 356 (1753). – ***Mezereum* C.A. Mey,** Bull. Cl. Phys.-Math. Acad. Imp. Sci. Saint-Pétersbourg 1: 358

(1843). – ***Thymelaea*** **All.,** Stirp. Litt. Agri Nicaeen.: 25 (1757).

Daphne altaica **Pall.**, Fl. Ross. 1(1): 53 1784. – ***Daphne altaica*** **subsp.** ***fasciculiflora*** **(T.Z. Hsu) Halda**, Acta Mus. Richnov., Sect. Nat. 4: 67 (1997), ***Daphne fasciculiflora*** **T.Z. Hsu,** Guihaia 10: 290 (1990), – ***Daphne indica*** **Schangin**, Neueste Nord. Beytr. Phys. Geogr. Erd- Völkerbeschreib. 6: 109 1793. – ***Daphne undulata*** **Raf.**, Autik. Bot. 145 1840.

22. Altai:

Kalba Highlands: Kalba Ridge (small hills on the way to Kokpekty, 10.VII.1967, Stepanova E.F. (AA); Ulansky district, Koktau mountains, sporadically in the shrub belt, 11.VI.1970, Snegirev V.A. (AA), 5 km N. Asu-Bulak, 05.VIII.1971, Mikheeva N.N. (AA), Ergentau, 06.VIII.1971, Mikheeva N.N. (AA)).

Southern Altai: Southern Altai Ridge (1840, Karelin G., Kirilow J. (AA); tract "Cheeks" on the tract Malokrasnoyarsky settlement, Katon, Karakaba, 23.VII.1919, Vereshchagin V. (NS)); Sarymsakty Ridge (Bolshenarymsky district, vicinity of Maimyr settlement, 11.VIII.1972, M.G. Pimenov, L. Sdobnina, E. Klyuykov (MW)); Narym Range (Baltabay Mountains, 28.VII.1966, Stepanova E.F. (AA)); Azutau Ridge (Markakolsky district, Mramornaya town, north of Nikolaevka village, 1.VIII.1972, M.G. Pimenov, L. Sdobnina, E. Klyuykov (MW); Mramornaya Gora Pass at the foot of rocks, on shale talus, 23.VI.1988, Nesterenko V.P. (ALTB)).

Western Altai: Ulba Ridge (Zyryanovsky mine, in thickets of steppe shrubs, 06/25/1925, Vereshchagin V.N. (NS); outskirts of Ust-Kamenogorsk, in shrubs on a steep slope of the left bank of the Ulba river above the city, 05. VI.1931, B.K. Gornaya Ulbinka, 25.VIII.1972, Pimenov M.G., Sdobnina L., Klyuykov E. (MW)); Uba Ridge (spurs, near the village of Sekisovka, 29.VII.1972, Pimenov M.G. (MW); near the village of Verkhnyaya Ubinka, 29.VIII.1972, Pimenov M.G. (MW); spurs, near the village of Belokamenka, 29.VIII.1973, Pimenov M.G. (MW)).

23. Tarbagatai:

Tarbagatai: Tarbagatai Ridge (Songaria, In m. Tarbagatai, 1841, Schrenk A.G. (AA); intermontane valley between Western Tarbagatai and Kzyl-Beltau mountains, floodplain of the Terektinka River, 17.VII.1947, Gamayunova A.P. (AA) ; Urdzharsky District, intermountain plain, floodplain of the Terektinka river along Blagodatnoe village, thickets of shrubs, 17.VII.1947, Gamayunova A.P. (AA); southern slope, gorge of the Ak-Choka river, among rose gardens, 28. VII.1948, Stepanova E.F. (AA), Baymurza pass, northern slope, 06.VII.1958, Stepanova E.F. (AA), southern slopes, 30 km northeast of Urdzhar village, rocky gorge, 11.VIII.1959, Goloskokov V.P. (NS); Semipalatinsk oblast, steppe forestry enterprise, Urdzhar tract, mountain macroslope of Central Tarbagatai, 03.IX.1972, Gribanov L.N. (AA)); Urdzharsky district, Besterek, Valet tract, 23.V.1977, Petrova T. (NS); Semipalat. region, Urdzhar district, southern slope of Tarbagatai, 8 km from the village Alekseevka, 23.VIII.1979, Klyuykov E. (MW)); Western Tarbagatai Ridge (near the village of Urdzhar, 29.VI.1956, Bykov B.A. (AA); southern slopes, 30 km northeast of the village of Urdzhar, rocky gorge, 11.VIII.1959, Blokhin V.G.(AA)).

Sauro-Manrak: Saur ridge (Zaisan forestry, Temir-su river valley, below the forest cordon, 11.VIII.1969, L.N. Gribanov (AA); 5 km south of Shargutsu village, 84º48′ e. and 47º16′ N, thickets of shrubs, May 26, 2000, Smirnov S.V., Antonyuk E.V. (ALTB)).

As a result of the inventory, it was found that the distribution of the endemic species is limited by the Kalba, Southern Altai, Sarymsakty, Narym, Azutau, Ulba, Uba, Tarbagatai, Western Tarbagatai, Saur ridges (Figure 4). The data obtained additionally confirm the high endemism of the studied species and the need for full protection of all known localities.

The second important task in the study of *D. altaica* was the study of the coenoflora of the communities that this species may belong to. An analysis of the species composition of the communities, with the participation of *D. altaica*, showed the completeness of the flora of the populations. It was found that the coenoflora of *D. altaica* includes 175 species of higher vascular plants belonging to 127 genera and 42 families. In ecological terms (Figure 5), the basis of coenoflora is mesophytes – 53%, xeromesophytes 24%, xerophytes 18% and mesohygrophytes – 5% are represented in a smaller proportion. The predominant life form is herbaceous vegetation – 141 (80%) species, a small proportion of shrubs and trees – 34 (20%) species. The main species abundance falls on the families Poaceae Barnhart (13.7%), Asteraceae Dumort. (13.1%), Fabaceae Lindl. (10.8%), Rosaceae Juss. (10.3%), Ranunculaceae Juss. (6.2%), Apiaceae Lindl. (5.1%), Lamiaceae Martinov (4.5%).

Figure 4 – Distribution of *D. altaica* in East Kazakhstan

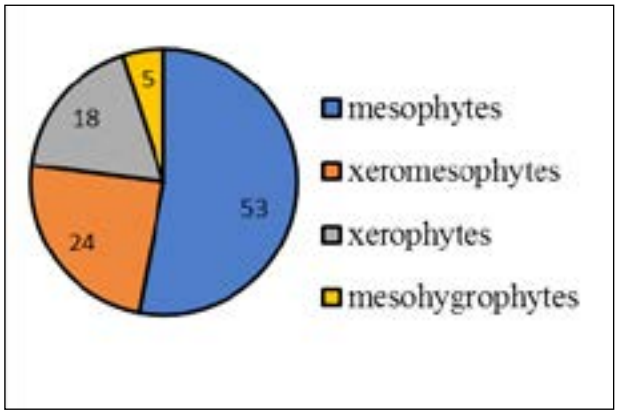


Figure 5 – Ecological structure of *D. altaica* coenoflora

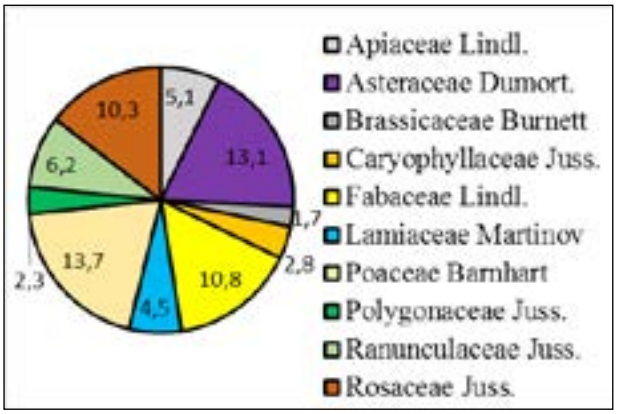


Figure 6 – Leading families of the *D. altaica* coenoflora

Composition of *D. altaica* coenoflora:
Alliaceae J.G. Agardh.
Allium caeruleum Pall.

Amaranthaceae Juss.
Chenopodium album L.

Apiaceae Lindl.
Angelica sylvestris L.; *Anthriscus sylvestris* (L.) Hoffm.; *Bupleurum longifolium subsp. aureum* (Fisch. ex Hoffm.) Soo; *B. scorzonerifolium* Willd.; *Conium maculatum* L.; *Heracleum sibiricum* L.; *Ferula soongarica* Pall. ex Spreng.; *Peucedanum ruthenicum* Bieb.; *Pleurospermum uralense* Hoffm.

Asparagaceae Juss.
Asparagus officinalis L.

Asteraceae Dumort.
Achillea millefolium L.; *Alfredia cernua* (L.) Cass.; *Artemisia absinthium* L.; *A. austriaca* Jacq.; *A. glauca* Pall. ex Willd.; *A. sericea* Web.; *A.*

sieversiana Willd.; *A. vulgaris* L.; *Cacalia hastata* L.; *Centaurea sibirica* L.; *Cichorium intubus* L.; *Cirsium helenioides* (L.) Hill; *C. serratuloides* (L.) Hill.; *Echinops sphaerocephalus* L.; *Echium vulgare* L.; *Galatella punctata* (Wakdst. Et Kit.) Nees; *Hieracium umbellatum* L.; *Ligularia glauca* (L.) O. Hoffm.; *Pyrethrum kelleri* (Kryl. et Plotn.) Krasch.; *Serratula coronata* L.; *Solidago virgaurea* L., *Sonchus arvensis* L.; *Tragopogon pratensis* L.

Betulaceae Gray
Betula pendula Roth.

Boraginaceae Juss.
Myosotis krylovii Serg.; *M. sparsiflora* Pohl.; *Pulmonaria mollis* Wulf. ex Hornem.

Brassicaceae Burnett
Bunias orientalis L.; *Draba sibirica* (Pall.) Thell.; *Hesperis sibirica* L.

Campanulaceae Juss.
Campanula glomerata L.; *Adenophora lilifolia* (L.) A. DC.

Cannabaceae Martinov
Cannabis ruderalis Janisch.; *Humulus lupulus* L.

Caprifoliaceae Juss.
Lonicera altaica Pall.; *L. tatarica* L.,

Caryophyllaceae Juss.
Dianthus superbus L.; *Cerastium pauciflorum* Stev. ex Ser.; *Melandrium album* (Mill.) Garcke; *M. latifolium* (Poir.) Maire; *Stellaria graminea* L.

Convolvulaceae Juss.
Calystegia sepium (L.) R. Br.; *Convolvulus arvensis* L.; *Cuscuta europaea* L.

Cupressaceae Bartlett
Juniperus sibirica Burgsd.

Cyperaceae Juss.
Carex macroura Meinsh.; *C. pallescens* L.

Euphorbiaceae Juss.
Euphorbia latifolia C.A. Mey.

Fabaceae Lindl.
Astragalus danicus Retz.; *A. schanginianus* Pall.; *A. veresczaginii* Kryl. et Sumn.; *Caragana arborescens* Lam.; *C. frutex* (L.) C. Koch; *Lathyrus gmelinii* Fritsch., *L. pisiformis* L.; *L. pratensis* L.; *L. tuberosus* L.; *L. vernus* (L.) Bernh.; *Medicago falcata* L.; *M. lupulina* L.; *Trifolium lupinaster* L.; *T. pratense* L., *Vicia megalotropis* Ledeb.; *V. sepium* L.; *V. cracca* L.; *V. sepium* L.; *V. tetrasperma* (L.) Schreb.

Geraniaceae Juss.
Geranium pseudosibiricum J. Mayer; *G. pretense* L.

Hypericaceae Juss.
Hypericum perforatum L.

Iridaceae Juss.
Iris ruthenica Ker-Gawl.

Lamiaceae Martinov
Dracocephalum nutans L.; *Galeopsis tetrahit* L.; *Glechoma hederaceae* L.; *Lamium album* L.; *Leonurus glaucescens* Bunge; *Origanum vulgare* L.; *Phlomoides tuberosa* (L.) Moench; *Salvia nemorosa* L.

Liliaceae Juss.
Erythronium sibiricum (Fisch. et C.A. Mey.) Kryl.; *Lilium pilosiusculum* (Freyn) Miscz.

Malvaceae Juss.
Lavatera thuringiaca L.

Melanthiaceae Batch ex Borkh.
Veratrum nigrum L.

Onagraceae Juss.
Chamaenerion angustifolium (L.) Scop.

Paeoniaceae Rudolphi
Paeonia anomala L.; *P. hybrida* Pall.

Papaveraceae Juss.
Chelidonium majus L.

Pinaceae Lindl.
Abies sibirica Ledeb.; *Larix sibirica* Ledeb.; *Picea obovata* Ledeb.

Plantaginaceae Juss.
Plantago media L. *P. major* L.; *Veronica krylovii* Schischk.

Poaceae Barnhart
Agropyron pectinatum (Bieb.) Beauv.; *Alopecurus pratensis* L.; *Brachypodium pinnatum* (L.)Beauv.; *B. inermis* (Leyss.)Holub; *Calamagrostis*

epigeios (L.) Roth; *Dactylis glomerata* L.; *Elymus mutabilis* (Drob). Tzvel.; *Elytrigia repens* (L.) Nevski; *E. nevskii* Tzvel.; *Festuca altissima* All.; *F. pratensis* Huds.; *F. valesiaca* Gaudin; *Koeleria cristata* (L.) Pers.; *Melica altissima* L.; *M. nutans* L.; *Phleum phleoides* (L.) Karst.; *P. pretense* L.; *Phragmites australis* (Cav.) Trin. ex Steud.; *Poa angustifolia* L.; *P. attenuata* Trin.; *P. pratensis* L.; *P. sibirica* Roshev.; *Schizachne callosa* (Turcz.ex Griseb.) Ohwi; *Setaria virides* (L.) Beauv.

Polygonaceae Juss.
Aconogonom alpinum (All.) Schur; *Fallopia convolvulus* (L.) A. Löve; *Rumex confertus* Willd.; *Polygonum aviculare* L.

Primulaceae Vent.
Primula macrocalyx Bunge

Ranunculaceae Juss.
Aconitum septentrionale Koelle; *A. volubile* Pall. ex Koelle; *Adonis wolgensis* Stev.; *Anemone sylvestris* L.; *Cimicifuga foetida* L.; *Clematis integrifolia* L.; *Delphinium dictyocarpum* DC.; *D. elatum* L.; *Pulsatilla patens* Mill.; *Thalictrum flavum* L.; *T. simplex* L.

Rhamnaceae Juss.
Rhamnus cathartica L.

Rosaceae Juss.
Agrimonia pilosa Ledeb.; *Cotoneaster melanocarpus* Fisch.ex Blytt; *Crataegus chlorocarpa* Lenné et C. Koch.; *C. sanguiea* Pall.; *Filipendula ulmaria* (L.) Maxim.; *F. vulgaris* Moench; *Fragaria virides* Duch; *Padus avium* Mill.; *Potentilla chrysantha* Trev.; *Rosa acicularis* Lindl.; *R. pimpinellifolia* L.; *Rubus caesius* L.; *R. saxatilis* L.; *Sorbus sibirica* Hedl.; *Spiraea chamaedrifolia* L.; *S. hypericifolia* L.; *S. media* Franz Schmidt; *S. trilobata* L.

Rubiaceae Juss.
Galium boreale L.; *G. verum* L.

Rutaceae Juss.
Dicthamnus angustifolius G. Don. ex Sweet

Salicaceae Mirb.
Populus tremula L.; *Salix bebbiana* Sarg.; *S. caprea* L.

Thymelaeaceae Juss.
Daphne altaica Pall.

Urticaceae Martinov
Urtica dioica L.

Viburnaceae Rafin.
Viburnum opulus L.

Violaceae Batsch
Viola canina L.; *V. macroceras* Bunge

The presence of weed species: *Heracleum dissectum* Ledeb., *Sonchus arvensis* L., *Cannabis ruderalis* Janisch., *Humulus lupulus* L., *Cuscuta europaea* L. and *Urtica dioica* L. confirms the presence of anthropogenic pressure on the studied populations. When comparing the coenoflora of *D. altaica* with the flora of East Kazakhstan (Table 1), it was found that the families Apiaceae Lindl., Brassicaceae Burnett, Fabaceae Lindl., Ranunculaceae Juss. and Rosaceae Juss. differ markedly in the share of participation in the formation of the floristic composition. This is due to the low number of mesohygrophytic species and the predominant number of xerophytic and xeromesophytic species characteristic of the steppe slopes of East Kazakhstan. Spearman's rank correlation coefficient is 0.56, i.e. communication is moderate and direct. In terms of the spectrum of the 10 leading families, the coenoflora of *D. altaica* is noticeably similar to the flora of East Kazakhstan. A high percentage of species belonging to the main 10 families – 70.5%, indicates a significant degree of anthropogenic pressure and flora transformation, which is noticeably higher than the general indicators for East Kazakhstan – 51.8%.

Table 1 – Leading families of the coenoflora *D. altaica* according to the number of species and genera

Family	Coenoflora of D. altaica populations		Flora of East Kazakhstan
	Number of genera, % of the total number	Number of species, % of the total number	Number of species, % of the total number
Apiaceae Lindl.	8/6,3	9/5,1	71/2,9
Asteraceae Dumort.	17/13,4	23/13.1	324/13,3

Continuation of the table

Family	Coenoflora of D. altaica populations		Flora of East Kazakhstan
	Number of genera, % of the total number	Number of species, % of the total number	Number of species, % of the total number
Brassicaceae Burnett	3/2,4	3/1.7	120/5,2
Caryophyllaceae Juss.	4/3,1	5/2.8	81/3,3
Fabaceae Lindl.	6/4,7	19/10.8	183/7,5
Lamiaceae Martinov	8/6,3	8/4.5	77/3,2
Poaceae Barnhart	16/12,6	24/13.7	308/12,6
Polygonaceae Juss.	4/3,1	4/2.3	40/1,6
Ranunculaceae Juss.	8/6,3	11/6.2	10/4,2
Rosaceae Juss.	11/8,7	18/10.3	109/4,5
Всего	85/66,9	124/70,5	1256/51,8

Conclusion

As a result of the inventory of herbarium specimens, additional actual habitats of *D. altaica* were established. The main concentration of historical finds falls on the floristic regions 22. Altai and 23. Tarbagatai. As a result of the inventory, it was found that the distribution of the endemic species is limited by the Kalba, Southern Altai, Sarymsakty, Narym, Azutau, Ulba, Uba, Tarbagatai, Western Tarbagatai, and Saur ridges. Thus, the high narrow local endemism of the species is confirmed.

Analysis of the coenoflora of *D. altaica* showed the completeness of the flora of populations. It was found that the coenoflora of *D. altaica* includes 175 species of higher plants, from 127 genera and 42 families. In ecological terms, the basis of coenoflora is mesophytes – 53%, xeromesophytes 24%, xerophytes 18% and mesohygrophytes – 5% are represented in a smaller proportion. The predominant life form is herbaceous vegetation – 141 (80%) species, a small proportion of shrubs and trees – 34 (20%) species. The main species abundance falls on the families Poaceae Barnhart (13.7%), Asteraceae Dumort. (13.1%), Fabaceae Lindl. (10.8%), Rosaceae Juss. (10.3%), Ranunculaceae Juss. (6.2%), Apiaceae Lindl. (5.1%), Lamiaceae Martinov (4.5%). In terms of the spectrum of the 10 leading families, the coenoflora of *D. altaica* is noticeably similar to the flora of East Kazakhstan.

The results obtained are necessary for monitoring and searching for historical habitats of *D. altaica*, compiling the route of field expedition trips, finding areas in natural habitats, and establishing phytocenotic relationships in *D. altaica* communities.

Conflict of interest

All authors have read and are familiar with the content of the article and have no conflict of interest.

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