IRSTI 34.29.25 https://doi.org/10.26577/eb.2021.v86.i1.02

D.M. Abidkulova[1*], A.A. Ivashchenko[2], G. Sramko[3], N.V. Kurbatova[1], K.T. Abidkulova[1]

[1]Al-Farabi Kazakh National University, Kazakhstan, Almaty
[2]Institute of Zoology, KN MES RK, Kazakhstan, Almaty
[3]MTA-DE 'Lendulet' Evolutionary Phylogenomics Research Group,
Hungarian Academy of Sciences, Hungary, Debrecen
*e-mail: mizzadm@gmail.com

GYMNOSPERMIUM ALTAICUM (PALL.) SPACH (BERBERIDACEAE), AN EARLY SPRING ELEMENT OF WILD FRUIT FORESTS OF THE TRANS-ILI ALATAU

The floristic composition of communities of apple and hawthorn forests with the participation of the rare species Gymnospermium altaicum (Pall.) Spach was studied in the Trans-Ili (Zailiyskiy) Alatau . The list of higher plants includes 156 species from 121 genera and 48 families. Most of them (84%) are herbaceous plants; there are 25 tree and shrub species, nine of which are wild non-native species (Ulmus laevis, Ulmus pumila, Morus nigra**,** Juglans regia, Malus domestica, Acer negundo, Acer platanoides, Viburnum opulus and Parthenocissus quinquefolia). Representatives of ten families make up 65% of the total number of species: Asteraceae, Poaceae, Rosaceae, Lamiaceae, Apiaceae, Fabaceae, Ranunculaceae, Caryophyllaceae, Boraginaceae, and Scrophulariaceae. The floristic core of the surveyed communities consists of 39 species, which mainly belong to the group of forest and forest-meadow ecological elements. Also other rare species listed in the Red Book of Kazakhstan, Malus sieversii, Armeniaca vulgaris and Paeonia intermedia, were found in these communities. We noticed signs of anthropogenic disturbance in the studied communities, including the presence of adventive and wild non-native species. We recommend to organize regular monitoring and strengthen the protection of the communities surveyed.

Key words: Gymnospermium, Berberidaceae, Red Data Book of Kazakhstan, plant communities, floristic composition, Trans-Ili Alatau.

Д.М. Абидкулова[1*], А.А. Иващенко[2], Г. Шрамко[3],
Н.В. Курбатова[1], К.Т. Абидкулова[1]

[1]Әл-Фараби атындағы Қазақ ұлттық университеті, Қазақстан, Алматы қ.
[2]Қазақстан Республикасы БҒМ ҰҒА зоология институты, Қазақстан, Алматы қ.
[3]MTA-DE 'Lendulet' эволюциялық филогеномиканың зерттеу тобы,
Венгр ғылыми академиясы, Венгрия, Дебрецен қ.
*e-mail: mizzadm@gmail.com

Gymnospermium altaicum (Pall.) Spach (Berberidaceae) – Іле-Алатауының жабайы жемісті ормандарының ерте көктемгі элементі

Мақалада Іле Алатауындағы жабайы жемісті алмалы және доланалы ормандар қауымдастығының флоралық құрамы сирек түр Gymnospermum altaicum (Pall.) Spach қатысуымен ұсынылды. Жоғары өсімдіктер флорасының жалпы тізімі 156 түрді, 121 туыс және 48 тұқымдасты құрайды. Олардың көпшілігі (84%) – шөптесін өсімдіктер; ағашты-бұталы түрлер небәрі 25, олардың 9-ы жабайы интродуценттер болып табылады (Ulmus laevis, Ulmus pumila, Morus nigra**,** Juglans regia, Malus domestica, Acer negundo, Acer platanoides, Viburnum opulus және Parthenocissus quinquefolia). Жетекші орынды негізгі 10 тұқымдас өкілдері алады, олар флораның жалпы тізімінің 65% құрайды: Asteraceae, Poaceae, Rosaceae, Lamiaceae, Apiaceae, Fabaceae, Ranunculaceae, Caryophyllaceae, Boraginaceae және Scrophulariaceae. Зерттелген қауымдастықтардың флоралық ядросы 39 түрден тұрады, олар орманды және орманды-шалғынды экологиялық элементтер тобына жатады. Сонымен бірге, G. altaicum қатысқан қауымдастықтар құрамында Қазақстанның Қызыл кітабына енген басқа да сирек түрлер – Malus sieversii, Armeniaca vulgaris, Paeonia intermedia анықталды. Зерттелген қауымдастықтардың антропогендік бұзылысы анықталды, олардың индикаторлары тек адвентивті түрлер ғана емес, сонымен бірге, жабайы интродуценттер де болып табылады. Соған байланысты, зерттелген қауымдастықтарды қорғауды күшейту және тұрақты мониторинг жүргізу ұсынылады.

Түйін сөздер: Gymnospermium, Berberidaceae, Қазақстанның Қызыл кітабы, өсімдік қауымдастықтары, флоралық құрам, Іле-Алатауы.

Д.М. Абидкулова[1*], А.А. Иващенко[2], Г. Шрамко[3],
Н.В. Курбатова[1], К.Т. Абидкулова[1]
[1]Казахский национальный университет им. аль-Фараби, Казахстан, г. Алматы
[2]Институт зоологии КН МОН РК, Казахстан, г. Алматы
[3]MTA-DE 'Lendulet' Исследовательская группа эволюционной филогеномики,
Венгерская академия наук, Венгрия, г. Дебрецен
*e-mail: mizzadm@gmail.com

Gymnospermium altaicum (Pall.) Spach (berberidaceae) – ранневесенний элемент дикоплодовых лесов Заилийского Алатау

Изучен флористический состав сообществ дикоплодовых яблоневых и боярышниковых лесов с участием редкого вида Gymnospermium altaicum (Pall.) Spach в Заилийском Алатау. Общий список флоры высших растений включает 156 видов из 121 рода и 48 семейств. Большинство из них (84%) – травянистые растения; древесно-кустарниковых пород всего 25 видов, 9 из которых являются одичавшими интродуцентами (Ulmus laevis, Ulmus pumila, Morus nigra, Juglans regia, Malus domestica, Acer negundo, Acer platanoides, Viburnum opulus и Parthenocissus quinquefolia). Ведущее положение занимают представители 10 основных семейств, составляющих 65% от общего списка флоры: Asteraceae, Poaceae, Rosaceae, Lamiaceae, Apiaceae, Fabaceae, Ranunculaceae, Caryophyllaceae, Boraginaceae и Scrophulariaceae. Флористическое ядро обследованных сообществ состоит из 39 видов, которые, преимущественно, относятся к группе лесных и лесолуговых экологических элементов. Также выявлено, что в составе данных сообществ встречаются другие редкие виды, занесенные в Красную книгу Казахстана – Malus sieversii, Armeniaca vulgaris, Paeonia intermedia. Отмечена антропогенная нарушенность изученных сообществ, индикаторами которой являются не только адвентивные виды, но и одичавшие интродуценты. В связи с этим рекомендуется организация регулярного мониторинга и усиление охраны обследованных сообществ.

Ключевые слова: Gymnospermium, Berberidaceae, Красная книга Казахстана, растительные сообщества, флористический состав, Заилийский Алатау.

Introduction

The genus *Gymnospermium* Spach. (Berberidaceae Juss.) was described by the French botanist E. Spach in 1839. Originally, *Gymnospermium* was part of the genus *Leontice* L., and the independence of the former had been repeatedly questioned by various botanists. The history of separation and the distinctive features of these two genera in terms of the structure of seeds and fruits were described in detail by A.L. Takhtadzhyan [1], who noted that the independence of the genera was first adopted in the Flora Europea [2]. According to different authors, the size of the genus *Gymnosperimium* **varies** from 7 to 12 species distributed from Eastern China to the Balkans [3]. We provide a visual representation of the distribution range of the genus *Gymnospermium* (Fig. 1) according to the Plants of the World Online database [4].

Only two species of *Gynmospermium* are found in Kazakhstan*: G. alberti* (Regel) Takht. and *G. altaicum* (Pall.) Spach, which are confined mainly to mountain broadleaved forests; the latter species has been found in the Northern Tien Shan, Dzhungarskiy Alatau and Altai, and the former, in Syrdarya Karatau and Western Tien Shan [5,6,7].

Gymnospermium altaicum (Pall.) Spach is a perennial herbaceous plant with a globular tuber about 1.0–1.5 cm in diameter (Fig. 2). Stem erect, up to 15–20 cm in height with a long petiolate basal leaf and an almost sessile stem leaf located directly under the inflorescence; the latter is a single raceme 4–5 cm long with 6–12 yellow flowers. The stem leaf is terminal, three-leaved and palmate. Its segments have a solid margin; they are oblong or oblong-lanceolate and obtuse at the apex. The fruit is a capsule with the diameter of about 8 mm and 3-4 seeds. The fruit opens at the top with rounded blades even before the seeds ripen. *G. altaicum* is one of the earliest flowering plants in the mountainous regions of eastern and south-eastern Kazakhstan; it blooms in March–April, and its seeds ripen in June. The plants can reproduce by seed and vegetatively. This species grows at 200-1500 m above sea level along mountain foothills, on rocky mountain slopes, among shrubs, in steppe meadows, and in forests. Its distribution range is discontinuous. It extends in the southern and southwestern directions (Fig. 3) from Central and Western Altai, and south-west of Siberia to the Trans-Ili Alatau and Xinjiang in northwest China [5,8-10]. Human activities including intensive pasture management, agricultural plowing, and harvesting of herbs contribute to the reduction in the size of the populations of *G. altaicum*. It is listed as rare in the Red Book of Kazakhstan and other regional reports [4,11,12].

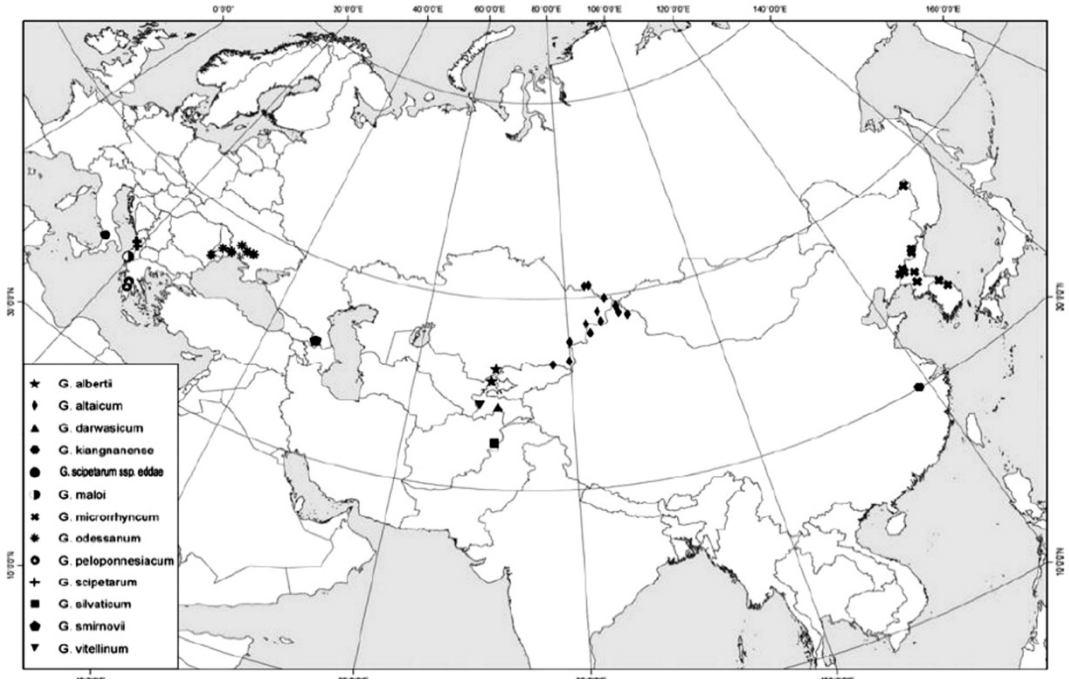

Figure 1 – Distribution range of the genus *Gymnospermium* [3]

Figure 2 – *Gymnospermium altaicum* (Pall.) Spach. in Turgen gorge of the Trans-Ili Alatau

Figure 3 – Distribution range of *Gymnospermium altaicum* [4]

G. altaicum was described by I. Pallas in 1779 as *Leontice altaica* Pallas based on his collections from Altai [13]; later the species was transferred to the genus *Gymnospermium* Spach described by the French botanist E. Spach in 1839. Various features of representatives of these two genera have been studied by a number of botanists. For instance, D.B. Arkhangelsky and A.L. Takhtajan [14] studied the morphology of pollen grains in representatives of *Leontice* L., *Gymnospermium* Spach and other genera of the family Berberidaceae to find differences between individual species and genera. There is still no consensus on the systematics and size of *G. altaicum*. Some Western European taxonomists [2,15] believe that this species is distributed from Central Asia to Eastern Europe, including Ukraine and Romania. Moreover, they remarked that, despite the geographical separation of the two areas within the distribution range, typical samples from Mountainous Altai were very similar to those from Europe; therefore the division at the species level could not be justified.

However, A.L. Takhtajan [1] considered populations from the Black Sea region as *G. odessanum* (DC.) Takht. Isolated populations from the Peloponnese (Greece) included in the latter species by the same author were later allocated to the new species *G. peloponnesiacum* (Phitos) Strid [16].

To understand interrelationships and spatio-temporal diversification of European populations of *Gymnospermium*, a group of scientists recently employed modern methods of AFLP, and used nuclear and plastid DNA sequences. The analysis of these indicators made it possible to identify two main evolutionary lineages in the group *G. altaicum*. The results suggest two separate parallel migrations of representatives of the genus to the Balkan Peninsula. One of them gave rise to the Greek endemic *G. peloponnesiacum* and the Pontic species *G. odessanum,* the closest relative of which, *G. altaicum* is distributed in the north of Central Asia. The second line includes the Caucasian species *G. smirnovii* (Trautv.) Takht., which is related to the Balkan species *G. maloi* Kit Tan & Shuka and *G. scipetarum* Paparisto & Qosja ex E. Mayer & Pulević [17].

Other taxonomists studied relationships between various genera of the family Berberidaceae including *Gymnospermium*. For example, Wang *et al*. [18] used the sequences of the matK and rbcL chloroplast genes and nuclear ribosomal ITS2 for phylogenetic analysis of Berberidaceae. They identified three main clades. Moreover, they found that the desert xerophytes of Berberidaceae in southwestern Asia arose as a result of changes in climate aridity at different times; *Bongardia* separated from its closest relatives after 46.5 ± 3.6 million years, and *Leontice* separated from *Gymnospermium* after 10.3 ± 3.2 million years. The genetic diversity of the rare endemic species *Gymnospermium microrrhynchum* (S. Moore) Takht., which has a limited distribution area in the mountainous regions of the Korean Peninsula, has also been studied to develop successful strategies for its conservation [19]. Some taxonomists continued to revise the size of the genus *Gymnospermium* at the western border of its range, i.e. in the Balkans [20].

The information about Kazakh representatives of the genus *Gymnospermium* is limited. There are

scattered data on the species as elements of the synusia of the ephemeretum of deciduous forests of the Northern and Western Tien Shan and Altai [7,21,22] and their use in traditional medicine [23]. Thus, *Leontice altaica* (syn. *G. altaicum*) is used in traditional medicine to treat epilepsy and the common cold. It has been established that this species contains quinolizidine and benzylisoquinoline alkaloids, as well as triterpene saponins, which have antioxidant, anticholinesterase, and anti-inflammatory activity [24].

G. altaicum has passed the initial tests in cultivation in the botanical gardens of Moscow, Almaty and Ridder. Its introduction turned out to be successful; it reproduces well and proved to be self-seeding [25,26]. Other authors point out its popularity as a decorative plant, especially in Western Europe and the Baltic states [27-29].

At the same time, there is insufficient information about this rare ornamental, medicinal and melliferous plant, the main area of which is located in Kazakhstan and requires special protection. Even information about its distribution range in Kazakhstan is far from complete, as we found out after studying all the available literary sources. V.P. Goloskokov [30] classified this distribution range as Altai-Tien Shan. However, in the west, according to most authors, the distribution area is limited to the Chu-Ili mountains [5,31]. The latest summary on the flora of this region [32] does not mentioned this fact. The distribution range of the species in Altai has been sufficiently studied [33]; there, the species is regarded one of the tertiary relict elements of the Pre-Boreal group. According to the available literature, the species occurs in all regions of the Kazakh part of Altai: Western, Southern and Kalbinskiy Altai, as well as in several specific locations of the Azutau, Kurchum, Southern Altai ranges and in protected areas [22,34-36]. At the same time, there is no specific data on its distribution in Tarbagatai and the Dzhungarskiy Alatau [21,30]. In the Northern Tien Shan, in particular in the Trans-Ili Alatau, its occurrence is very fragmentary. For example, it is absent from many gorges of the central part of the ridge, but abundant in the valleys of the Turgen, Tauturgen and Kotyrbulak rivers; it is also absent from the west of Almaty, and from Aksai and Kaskelen [37]. After a large, almost 200-kilometer gap, it is found in abundance in the valley of the Karakunuz River [38].

All this indicates the need for a special study of the distribution of the species in the western part of the range, as well as of the number and state of its populations in order to develop improved conservation strategies for this species. Of particular interest is the study of morphological and genetic variability of plants growing at different locations within the distribution range of the species, in particular, of the isolated Karakunuz population.

These studies have been the main goal of our project. As a first step, we studied and analyzed in detail the floristic composition of forest communities with the participation of *G. altaicum* in the central part of the Trans-Ili Alatau. The results of the study are presented in this article.

Aim of research. To establish the characteristic peculiarities of the plant communities with participation of the rare species *G. altaicum* in wild fruit forests of the Trans-Ili Alatau.

Materials and methods

The research was carried out in 2008–2014 and in 2020, in different seasons (from April to October). In the central part of the Trans-Ili Alatau, on the northern slope, we examined and described in detail four forest communities with the participation of *G. altaicum*. The dimensions of the plots varied from 20 x 20 m to 40 x 40 m. These plots represent several types of apple tree (*Malus sieversii* (Ledeb.) M. Roem.) and hawthorn (*Crataegus songorica* C. Koch.) plant communities in the following gorges of the Trans-Ili Alatau:

1) **KB** – Kotyr-Bulak gorge, hawthorn forest, the lower part of the slope (952 m above sea level);

2) $\mathbf{K_1}$ – the northern slope in the Kuznetsovo tract, a herb and apple tree forest (1600 m above sea level);

3) $\mathbf{K_2}$ – the Kuznetsovo tract (the right bank of the Tauturgen River), a herb-grass and apple tree forest (1550 m above sea level);

4) **S** – Soldatsay gorge, cocksfoot and ground elder and apple tree forest (1540 m above sea level);

Geobotanical descriptions of the plots were carried out according to generally accepted methods as well as species abundance according to the Drude scale [39], and identification of plants, by using regional and republican summaries, keys and reference books [5,13,31]. The nomenclature of taxa is based on the summary by S.A. Abdulina [6].

Results and Discussion

The complete species list of the surveyed communities is presented in Table 1. Species listed in the Red Book of Kazakhstan [12] are in bold, and alien species (adventive and invasive introduced species) are marked with an asterisk (*).

Table 1 – Composition of the cenoflora of the surveyed communities. For abbreviations, see Materials and Methods

Species	Abundance in the surveyed plots			
	KB	**К$_1$**	**К$_2$**	**S**
1	2	3	4	5
Trees and shrubs				
Ulmaceae Mirb.				
**Ulmus laevis* Pall.	Un	-	-	-
**Ulmus pumila* L.	Un	-	-	-
Moraceae Link				
**Morus nigra* L.	Un	-	-	-
Juglandaceae A. Rich. ex Kunth				
**Juglans regia* L.	Un	-	-	-
Rosaceae Juss.				
***Armeniaca vulgaris* Lam.**	Un	-	-	Un
Crataegus songorica C. Koch	Sp–Cop1	-	Sp	Sol
**Malus domestica* Borkh.	-		Un	-
***Malus sieversii* (Ledeb.) M. Roem.**	Un	Sp	Sp	Sp
Padus avium Mill.	-	-	Sol	Sol
Rosa alberti Regel	-	-	-	Un
Rosa laxa Retz.	-	-	-	Un
Rosa platyacantha Schrenk	-	Sol	Sol	Un
Rubus caesius L.	Sp–Cop1	-	Sp	Sp-
Rubus idaeus L.	-	-	Sol	Sol
Rhanmaceae Juss.				
Rhamnus cathartica L.	Un	-	Sol	-
Berberidaceae Juss.				
Berberis sphaerocarpa Kar. et Kir.	-	-	Sol	Un
Caprifoliaceae Juss.				
Lonicera altmannii Regel et Schmalh.	-	Un	Un	Un
Lonicera tatarica L.	-	-	Sol	Un
Celastraceae R. Br.				
Euonymus semenovii Regel et Herd.	-	Sol	Sol	Sol
Aceraceae Juss.				
**Acer negundo* L.	Un	-	-	Un
**Acer platanoides* L.	-	-	-	Un
Salicaceae Mirb.				
Populus tremula L.	-	-	-	Un
Salix cinerea L.	-	-	-	Un
Viburnaceae Rafin.				
**Viburnum opulus* L.	-	-	-	Un
Vitaceae Juss.				
**Parthenocissus quinquefolia* (L.) Planch.	Un	-	-	-
Herbs				
Aspidiaceae Mett. ex Frank				

Continuation of table 1

Species	Abundance in the surveyed plots			
	KB	**K$_1$**	**K$_2$**	**S**
1	2	3	4	5
Dryopteris filix-max (L.) Schott	Sol	-	Un	Un
Athyriaceae Alston				
Cystopteris fragilis (L.) Bernh,	Sol	-	-	-
Poaceae Barnhart				
Agrostis gigantea Roth	-	-	Sp	Sol
Brachypodium pinnatum (L.) Beauv.	-	-	-	Sol
Brachypodium sylvaticum (Huds.) Beauv.	Cop$_1$	Cop2	Cop1	Sol
Bromopsis inermis (Leyss.) Holub	-	-	Sol	-
Bromopsis benekenii (Lange) Holub	-	-	Sol	-
Calamagrostis epigeios (L.) Roth	-	-	Un	Sol
Dactylis glomerata L.	-	Sp	Sp	Cop1
Elymus tschimganicus (Drob.) Tzvel.	-	Sol	Sol	Un
Elytrigia repens (L.) Nevski	-	Sol	Un	-
Festuca gigantea (L.) Vill.	Sol		Sol	Sol
Helictotrichon pubescens (Huds.) Pilg.	-	Sol	Sp	-
Melica nutans L.	-	-	Sol	Un
Milium effusum L.	Sol	Sp	Sol	Sol
Phalaroides arundinacea (L.) Rauschert	-	-	Un	Sol
Phragmites australis (Cav.) Trin. ex Steud.	-	-	-	Un
Poa angustifolia L.	-	-	Sol	Sol
Poa nemoralis L.	Sol-Sp	Sp-Cop1	-	-
Cyperaceae Juss.				
Carex polyphylla Kar. et Kir.	-	Sp	Sol	Un
Juncaceae Juss.				
Juncus sp.	-	-	-	Un
Liliaceae Juss.				
Gagea filiformis (Ledeb.) Kunth	-	-	Sol	Sol
Gagea turkestanica Pascher	-	-	Sol	Sol
Asphodelaceae Juss.				
Eremurus robustus (Regel) Regel	-	-	-	Un
Cannabaceae Endl.				
Humulus lupulus L.	Sol	-	Sol	Sol
Urticaceae Juss.				
Urtica dioica L.	Sol	Sol	Sp	Sol
Polygonaceae Juss.				
Polygonum aviculare L.	-	-	Sol	-
Polygonum coriarium Grig.	-	Sol	Sol	Sol
Rumex crispus L.	-	-	Un	Un
Caryophyllaceae Juss.				
Cerastium arvense L.	-	-	-	Sol
Cerastium davuricum Fisch. ex Spreng.	-	Un	Sol	Sol

Continuation of table 1

Species	Abundance in the surveyed plots			
	KB	**К$_1$**	**К$_2$**	**S**
1	2	3	4	5
Silene wallichiana Klotzsch.	-	Un	Un	Sol
Stellaria media (L.) Vill.	-	-	Sol	-
Melandrium viscosum (L.) Čelak.	Sol	-	Un	Un
Paeoniaceae Rudolphi				
Paeonia intermedia C.A. Mey.	-	-	-	Un
Ranunculaceae Juss.				
Aconitum leucostomum Worosch.	-	Sol-Sp	Sp	Sol
Aquilegia atrovinosa M. Pop. ex Gamajun.	-		-	Sol
Delphinium iliensis Huth	-	Sol	-	-
Ranunculus polyanthemus L.	-	-	-	Sol
Ranunculus repens L.	-	-	-	Sol
Thalictrum flavum L.	-	Un	Un	Un
Fumariaceae DC.				
Corydalis glaucescens Regel	Sol	-	Sol	-
Corydalis ledebouriana Kar. et Kir.	-	-	Sol	Sol
Berberidaceae Juss.				
***Gymnospermium altaicum* (Pall.) Spach**	Sp	Sol	Sp	Sp
Brassicaceae Burnett				
Berteroa incana (L.) DC.	-	-	Sol	-
Cardamine impatiens L.	-	-	-	Sol
Rosaceae Juss.				
Agrimonia asiatica Juz.	-	-	Sol	Sol
Alchimilla sibirica Zam.	-	-	-	Sol
Fragaria vesca L.	-	-	-	Sol
Geum aleppicum Jacq.	-	-	-	Un
Geum rivale L.	-	-	-	Sol
Geum urbanum L.	Sp	Sp	Cop	Sp
Fabaceae Lindl.				
Lathyrus gmelinii (Fisch.)Fritsch	-	-	-	Un
Lathyrus pratensis L.	-	-	Sol	Sol
Medicago lupulina L.	-	Un	Sol	-
Trifolium pratense L.	-	Un	-	Sol
Trifolium repens L.	-	-	Sol	-
Vicia cracca L.	-	Sol	Sol	Sol
Vicia sepium L.	-	-	Un	Sol
Geraniaceae Juss.				
Geranium divaricatum Ehrh.	-	-	-	-
Geranium pratense L.	Sp-Sol	Sol	Sp	Sp
Geranium rectum Trautv.	-	-	Sol	Sol
Geranium robertianum L.	Sol	-	-	Sol
Balsaminaceae A. Rich.				

Continuation of table 1

Species	Abundance in the surveyed plots			
	KB	**K$_1$**	**K$_2$**	**S**
1	2	3	4	5
Impatiens parviflora DC.	Sol	Sp	-	-
Malvaceae Juss.				
Lavatera thuringiaca L.	Sol	Un	Sol	Un
Rutaceae Juss.				
Dictamnus angustifolius G. Don fil. ex Sweet	-	-	Sol	Un
Euphorbiaceae Juss.				
Euphorbia lamprocarpa Proch.	-	-	Un	-
Hypericaceae Juss.				
Hypericum hirsutum L.	Sol	Sol	Sol	Sol
Hypericum perforatum L.	-	Un	Un	Un
Violaceae Batsch				
Viola collina Bess.	Sol	-	-	Sol
Viola suavis M. Bieb.	Sol	Un	Sol	Sol
Onagraceae Juss.				
Epilobium velutinum Nevski	-	-	-	Sol
Apiaceae Lindl.				
Aegopodium alpestre Ledeb.	-	-	-	Cop1
Aegopodium tadshikorum Schischk.	Sp	Sol	-	-
Anthriscus sylvestris (L.) Hoffm.	-	-	-	Un
Bunium setaceum (Schrenk) H. Wolff	-	Un	Un	-
Bupleurum aureum Fisch.	Sol	Un	Sol	Sol
Conioselinum tataricum Fisch. ex Hoffm.	-	Sol	Sol	Sol
Conium maculatum L.	-	-	-	Un
Daucus carota L.	-	-	-	Un
Heracleum dissectum Ledeb.	-	Un	Un	Un
Polemoniaceae Juss.				
Polemonium caucasicum N. Busch	-	-	-	Sol
Boraginaceae Juss.				
Echium vulgare L.	-	-	Un	Un
Lithospermum officinale L.	-	-	Un	Un
Myosotis sparsiflora Mikan. ex Pohl	-	-	-	Sol
Rochelia peduncularis Boiss.	-	Sol	-	-
Solenanthus circinnatus Ledeb.	-	Sol	-	-
Lamiaceae Lindl.				
Clinopodium integerrimum Boriss.	-	-	Sol	-
Lamium album L.	-	Sol	-	Sol
Leonurus turkestanicus V. Krecz. et Kuprian.	Un	Sol	Un	-
**Melissa oficinalis* L.	Sol	-	-	-
Mentha asiatica Boriss.	-	-	Un	Sol
Nepeta cataria L.	Sol	-	-	-
Nepeta pannonica L.	-	Un	Un	-

Continuation of table 1

Species	Abundance in the surveyed plots			
	KB	**К$_1$**	**К$_2$**	**S**
1	2	3	4	5
Origanum vulgare L.	Sol	-	Sol	Sp
Phlomoides pratensis (Kar. et Kir.) Adyl., R. Kam. et Machmedov	-	Un	Sol	Sol
Prunella vulgaris L.	-	-	Sol	Sp
Stachys sylvatica L.	-	-	-	Sol
Scrophulariaceae Juss.				
Scrophularia umbrosa Dumort.	-	-	-	Sol
Verbascum thapsus L.	-	-	Un	-
Veronica chamaedrys L.	-	-	Sol	Sol
Veronica cardiocarpa (Kar. et Kir.) Walpers	-	Sp	-	-
Plantaginaceae Juss.				
Plantago major L.	-	-	-	Un
Campanulaceae Juss.				
Campanula glomerata L.	-		-	Sol
Codonopsis clematidea (Schrenk) Clarke	-	Un	-	-
Rubiaceae Juss.				
Galium aparine L.	-	Sp	Sp	Un
Galium karataviense (Pavl.) Pobed.	-	-	Sol	Sol
Galium turkestanicum Pobed.	-	Sol	Sol	Un
Orobanchaceae Vent.				
Orobanche sp.	-	-	Un	-
Asteraceae Dumort.				
Achillea millefolium L.	-	-	-	Sol
Arctium leiospermum Juz. et C. Sergievska	-	Un	Un	Sol
Artemisia absinthium L.	-	-	Sol	Un
Artemisia annua L.	Un	-	-	-
Artemisia dracunculus L.	-	-	Un	-
Artemisia vulgaris L.	-	Un	Un	-
Cirsium semenovii Regel	-	-	Un	Un
Cirsium vulgare (Savi) Ten.	-	-	Un	Un
Cousinia umbrosa Bunge	-	-	Un	-
Crepis sibirica L.	-	Sol	Sol	Sol
Echinops chantavicus Trautv.	-	-	Sol	-
Galatella coriacea Novopokr.	-	-	Un	-
Hieracium virosum Pall.	-	-	-	Sol
Inula helenium L.	-	-	Sol	Sol
Lapsana communis L.	-	-	-	Un
**Lapsana intermedia* M. Bieb.	Sol	-	-	-
Ligularia macrophylla (Ledeb.) DC.	-	Sp	Sp	Sp
Matricaria inodora L.	-	-	Un	Un
Picris nuristanica Bornm.	-	-	Un	Un

Continuation of table 1

Species	Abundance in the surveyed plots			
	КВ	$К_1$	$К_2$	S
1	2	3	4	5
Solidago dahurica Kitag.	-	-	Un	Sol
Tanacetum vulgare L.	-	-	Un	Sol
Taraxacum officinale Wigg.	Sol	-	-	Sol

Note: Cop2 (copiosae 2) – abundant, there are many individuals of this species; Cop1 (copiosae 1) – quite abundant, plants are found occasionally, scattered; Sp (sparsae) – scattered, plants are found occasionally, scattered, in small numbers; Sol (solitariae) – singly, very few plants (only a few specimens in the plot); Un (unicum) – a single specimen, the species is represented by a single specimen in the plot.

Thus, the flora of the surveyed communities comprised 156 species from 121 genera and 48 families. Of the 25 species of trees and shrubs, nine were non-native, wild introduced species found in apple and hawthorn communities located near summer cottage areas (Kotyrbulak and Soldatsay). Representatives of the following ten families made up 65% of the total number of species: Asteraceae, Poaceae, Rosaceae, Lamiaceae, Apiaceae, Fabaceae, Ranunculaceae, Caryophyllaceae, Boraginaceae, and Scrophulariaceae.

The order of the most species rich families is very similar to that characteristic of the entire flora of the Trans-Ili Alatau [40] with the exception of Brassicaceae and Chenopodiaceae which are not included in the top ten families on our list, being replaced by two others, Apiaceae and Boraginaceae (the fifth and eighth places, respectively). This is explained by the specificity of the habitats of *G. altaicum*, both in terms of the altitudinal distribution (according to Baitulin et al. [40] it occurs in the steppe and shrub-forest-meadow altitudinal belts at 800-1500 m), and in relation to its phytocenotic affiliation (forest communities).

According to our data, of all plant species only ten were constant companions of *G. altaicum*: *Malus sieversii, Brachypodium sylvaticum, Milium effusum, Urtica dioica, Geum urbanum, Geranium pratense, Lavatera thuringiaca, Hypericum hirsutum, Viola suavis,* and *Bupleurum aureum.* The following 29 species were sometimes abundant in three out of four surveyed plots: *Crataegus songorica, Rosa platyacantha, Rubus caesius, Lonicera altmannii, Euonymus semenovii, Dryopteris filix-max, Dactylis glomerata, Elymus tschimganicus, Festuca gigantea, Carex polyphylla, Humulus lupulus, Polygonum coriarium, Cerastium davuricum, Silene wallichiana, Melandrium viscosum, Aconitum leucostomum, Thalictrum flavum, Vicia cracca, Hypericum perforatum, Conioselinum tataricum, Heracleum dissectum, Leonurus turkestanicus, Origanum vulgare, Phlomoides pratensis, Galium aparine, Galium turkestanicum, Arctium leiospermum, Crepis sibirica,* and *Ligularia macrophylla.* Thus, the floristic core of the communities with the participation of *G. altaicum* was represented by 39 species. The overwhelming majority (70%) of them were forest and forest-meadow ecological-cenotic elements, and the rest were meadow and occasionally meadow-steppe species.

With regard to life forms, the overwhelming majority (84%) were herbaceous plants, mainly perennials (109 species). Only 23 species were annuals and biennials. Tree and shrub species made up 16%, including nine non-native species.

Emphasizing the importance of preserving *G. altaicum* as a rare Red Data Book plant, it should be noted that three more species of the same category were recorded in the surveyed plots: *Malus sieversii, Armeniaca vulgaris,* and *Paeonia intermedia.* It is worth mentioning that on one of the described sites we found *Melissa oficinalis*, a new species for the Ile-Alatau National Park [41], and *Lapsana intermedia*, a new adventive species for the flora of Kazakhstan previously found only at one point, in the vicinity of the Shymbulak ski base [42]. The presence of these and other adventive and non-native wild species that have appeared in recent years indicates a significant anthropogenic disturbance of the surveyed communities and emphasizes the need to strengthen protection and conduct regular monitoring of their condition.

Conclusion

G. altaicum is an important early spring element of apple and hawthorn forests in the central part of the Trans-Ili Alatau. The floristic core of the com-

munities with its participation is mainly represented by forest and forest-meadow herbaceous species, the majority of which are perennials. The participation of non-native and adventive species in the plant communities of this part of the Trans-Ili Alatau indicates an increasing human impact on the native vegetation, which in turn requires constant monitoring of its condition, especially because of the presence of three other rare species listed in the Red Book of Kazakhstan. We believe that *G. altaicum* **deserves** a more detailed study, both within the entire range and in the Trans-Ili Alatau, due to the sporadic nature of its distribution in this region.

Conflict of interests

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

References

1 Takhtajan A.L. "On the genus Gymnospermium Spach". Bot. Zhurn. SSSR. Vol. 55. 1970: 1191–1193. [in Russian].

2 Stearn W.T., Webb D.A. "Gymnospermium Spach". In Flora Europaea. Vol. 1. Lycopodiaceae to Platanaceae, edited by Tutin T.G., Heywood V.H., Burges N.A., Valentine D.H., Walters S.M., Webb D.A. 244. Cambridge: Cambridge University Press, 1964. –

3 Rosati L., Coppi A., Farris E., Fascetti S., Becca G., Peregrym M., Tan K., Selvi F. "The Genus Gymnospermium (Berberidaceae) in Italy: Identity and Relationships of the Populations at the Western Limit of the Genus Range." Plant Biosystems 153 (6). (2019): 796–808. https://doi.org/10.1080/11263504.2018.1549613.

4 Plants of the World Online (POWO). Available from http://www.plantsoftheworldonline.org/ (accessed 12 January 2021).

5 Pavlov N.V. Flora of Kazakhstan: in 9 vols. Alma-Ata: Academy of Science of KazSSR, 1956-1966. [in Russian].

6 Abdulina S.A. Checklist of vascular plants of Kazakhstan. Almaty: Academy of Sciences, 1999.

7 Kokoreva I.I. Adaptation strategies of polycarpous plant species of the Northern Tien Shan. Almaty, 2011. [in Russian].

8 Yin L. Rare Endangered Endemic Higher Plants in Xinjiang of China. Urumqi: Xinjiang Science & Technology Publishing House, 2006.

9 Ying T.S., Boufford D.E., Brach A.R. Gymnospermium Spach. In Fl. China, vol. 19. Beijing: Science Press; St. Louis: Missouri Botanical Garden, 2011.

10 Baikov K.S. ed. Check-list of flora of Asian Russia: Vascular plants.Novosibirsk: Publishing house of the SB RAS, 2012. [in Russian].

11 Maneyev A.G. ed. Red Book of the Altai Republic (Plants), 3rd Gorno-Altaysk, 2017. [in Russian].

12 The Red Data Book of Kazakhstan. Volume 2. Part 1. Plants. Re-edition, completed and revised. Astana, 2014.

13 Flora of the USSR: in 30 vols. Moscow-Leningrad, 1934-1964. [in Russian].

14 Arkhangelsky D.B., Takhtajan L. "Morphology of pollen grains of Leontice L., Gymnospermium Spach and allied genera of the family Berberidaceae". Bot. Zhurn. SSSR vol. 57. (1972): 921–926. [in Russian].

15 Stearn W.T., Webb D.A. "Gymnospermium Spach". In Flora Europaea. Vol. 1. 2 ed.: Psilotaceae to Platanaceae , edited by Tutin T.G. 29–295. Cambridge: Cambridge University Press, 1993.

16 Karl R., Strid A. "Bongardia chrysogonum (Berberidaceae) rediscovered on the East Aegean island of Chios". Phytol Balcanica vol. 15. (2009): 337–342.

17 Barina Z., Cakovic D., Pifko D., Schönswetter P., Somogyi G., Frajman B. "Phylogenetic relationships, biogeography and taxonomic revision of European taxa of Gymnospermium (Berberidaceae)". Bot. J. Linnean Soc. vol. 184(3). (2017): 298–311. https://doi.org/10.1093/botlinnean/box028

18 Wang W., Zhi-Duan Chen, Yang Liu, Rui-Qi Li, and Jian-Hua Li. "Phylogenetic and Biogeographic Diversification of Berberidaceae in the Northern Hemisphere". Systematic Botany vol. 32(4). (2007): 731-742. https://doi.org/10.1043/06-16.1

19 Lee S.H., Yeon M.H., Shim J.K. "Conservation implications of the genetic diversity of Gymnospermium microrrhynchum in Korea". Genet. Mol. Res. Vol. 15(4). (2016). DOI: 10.4238/gmr15048843

20 Tan K., Shuka L., Siljak-Yakovlev S., Malo S., Pustahija F. "The genus Gymnospermium (Berberidaceae) in the Balkans". Phytotaxa vol. 25. (2011): 1–17.

21 Stepanova E.F. Vegetation and flora of the Tarbagatai ridge. Alma-Ata: Academy of Sciences of the Kazakh SSR, 1962. [in Russian].

22 Baytulin I.O., Kotukhov Yu.A. Flora of vascular plants of Kazakhstan Altai. Almaty, 2011. [in Russian].

23 Plant resources of the USSR: Flowering plants, their chemical composition, use; Family Magnoliaceae – Limoniaceae. Leningrad: Nauka, 1984. [in Russian].

24 Jenisa J., Nugrohoa A.E., Hashimotoa A., Deguchia J., Hirasawaa Yu., Wong Ch. P., Kanedaa T., Shirotac O., Moritaa H. "A New Benzylisoquinoline Alkaloid from Leontice altaica". Natural Product Communications vol. 10 (2). (2015): 291-292.

25 The introduction of plants of the natural flora of the USSR. Moscow: Nauka, 1979. [in Russian].

26 Plants of the natural flora of Kazakhstan in the introduction. Handbook. Alma-Ata: Gylym, 1990. [in Russian].

27 Poletiko O.M., A.P. Mishenkova. Ornamental herbaceous plants in open ground. Reference book on the nomenclature of genera and species. Leningrad: Nauka, 1967. [in Russian].

28 Brian M. The Smaller Bulbs. London, 1990.

29 Ruksans J. Buried Treasures: Finding and Growing the World's Choicest Bulbs. Portland, 2007.

30 Goloskokov V.P. Flora of the Dzungarian Alatau. Alma-Ata: Science, 1984. [in Russian].

31 Keys to the plants of Central Asia (Critical synopsis of flora): in 10 vols. Tashkent: FAN, 1968-1993. [in Russian].

32 Roldugin I.I., V.V. Fisyun. Flora of Chu – Ili mountains (compendium and analysis). Almaty: Ereket-print, 2018. [in Russian].

33 Kamelin R.V. Materials on the history of the flora of Asia. (Altai mountainous country). Barnaul, 1998. [in Russian].

34 Baitulin I.O., Kotukhov Yu.A., Sinitsina V.G., Ivashchenko A.A. "Flora of the Azutau ridge". in Flora of East Kazakhstan. 24–135. Alma-Ata, 1991. [in Russian].

35 Kotukhov Yu.A., A.A. Ivashchenko, J. Lyman. Flora of vascular plants of the West Altai Nature Reserve. Almaty: Tethys, 2002. [in Russian].

36 Utyasheva T.R. "Ecological-floristic connections of communities with the participation of rare and endangered ephemeroid geophytes of the Markakol depression". News of the NAS RK. Biological series vol. 2. (2007): 34-37. [in Russian].

37 Ivashchenko A.A. "Distribution of rare plant species in the central part of the Zailiyskiy Alatau". Topical issues of biodiversity conservation in the Northern Tien Shan. Proceedings of the Intern. scientific. – pract. confer. to the 10th anniversary of the SSNP "Kulsay kulderi" and Intern. day for the Protection of Snow Leopard. (2017): 222 – 226. [in Russian].

38 Wintergoller B.A. "The hackberry's forests of the western end of the Zailiyskiy Alatau". Proceedings of the Botanical Gardens of the Academy of Sciences of the Kazakh SSR. Vol. 8. (1964): 135-148. [in Russian].

39 Lavrenko E.M., A.A. Korchagin. Field Geobotany. Vol. 5. Moscow-Leningrad: Science, 1976. [in Russian].

40 Baitulin I.O., N.P. Ogar, S.G. Nesterova, Z.A. Inelova. Flora of the Ileyskiy Alatau. Almaty: Kazakh University, 2017. [in Russian].

41 Ivashchenko A.A., Zhaksylykova A.A. "Floristic diversity of apple forests on the monitoring sites of the Ile-Alatau National Park". Bulletin of KazNU. Biological series vol. 1 (63). (2015): 231-238. [in Russian].

42 Ivashchenko A.A. "New for Kazakhstan adventive plants in the flora of the Ile-Alatau National Park". Innovative ways of developing forestry and special protected natural areas: problems and prospects. (2011): 135-139. [in Russian].