IRSTI 34.29.35 https://doi.org/10.26577/eb.2023.v94.i1.02

[1,2]R.E. Kaparbay*, [1]A.D. Tolenova, [1]D.M. Almabek,
[3]A.A. Ivashchenko, [1]K.T. Abidkulova , [2]B.B. Arynov

[1]SNNP «Kolsay kolderi» of CFW MEENR RK, v. Kazakhstan, Saty
[2]Al-Farabi Kazakh National University, Kazakhstan, Almaty
[3]Institute of Zoology of KN MES RK, Kazakhstan, Almaty
*e-mail: raushan.kaparbay@mail.ru

MONITORING OF RARE FLORISTIC ELEMENTS OF THE NORTHERN TIEN-SHAN MOUNTAIN FOREST

Mountain forests of the Northern Tien Shan are distinguished by high floristic diversity and a large number of plant communities. Among the latter there are several unique relict plant communities dominated by Picea, Malus, Prunus, and Celtis spp, as well as tugai forests. The most species-rich are forests dominated by Picea schrenkiana Fisch. & C.A. Mey. (450-500 species), Malus sieversi (Ledeb.) M. Roem. (400 species), and Armeniaca vulgaris Lam. (about 250 species). The least species-rich are tugai forests with Hippophae rhamnoides L. (140 species) and hackberry forests dominated by Celtis caucasica Willd. (119 species). In these forests, there are 24 Red Book species, including Hepatica falconeri (Thoms.) Steward, Epipactis palustris (L.) Crantz, Tulipa tarda Stapf, and Gymnospermium altaicum (Pall.) Spach., which are the objects of special research. The article presents the results of the study of natural populations of the last three species, in particular, the numbers and density, age spectra and morphological variability of generative individuals. For one of the rarest species, Hepatica falconeri, the results of two years of observations of an introduced population established in the village of Saty near the central estate of Kolsay Koldery National Park. It was created by transferring generative individuals from the largest natural population (Taldy Gorge, 1693 m). Comparative data on the species phenology, including the relationship between the rate of flower opening, illumination and temperature, were obtained. The article emphasizes the lack of study of the distribution of certain rare species within the Northern Tien Shan, as evidenced by new findings of the authors: Epipactis palustris and Paeonia intermedia C.A. Mey. in the Kolsay Koldery National Park. Based on this, the authors propose to conduct special studies or include the study of rare species in the work plans of specially protected territories.

Key words: mountain forests, population, Hepatica falconeri, Epipactis palustris, Tulipa tarda, Gymnospermium altaicum.

Р.Е. Қапарбай[1,2*], А.Д. Төленова[1], Д.М. Алмабек[1],
А.А. Иващенко[3], К.Т. Абидкулова[1], Б.Б. Арынов[2]

[1]ҚР ЭГТРМ ОШЖДК «Көлсай көлдері» мемлекеттік ұлттық табиғи паркі РММ, Қазақстан,
Қ. Ұлтарақов көш., Қазақстан, Саты ауылы
[2]Әл-Фараби атындағы Қазақ Ұлттық Университеті, Қазақстан, Алматы қ.
[3]ҚР БҒМ ҒҚ «Зоология институты» ШЖҚ РМК, Қазақстан, Алматы қ.
*e-mail: raushan.kaparbay@mail.ru

Солтүстік Тянь-Шань таулы ормандарының сирек флоралық элементтерінің мониторингі

Солтүстік Тянь-Шань таулы ормандары флоралық әртүрлілігімен және өсімдіктер қауымдастығының байлығымен ерекшеленеді, олардың ішінде бірегей реликтілер: шыршалар, алма ағаштары, өрік ағаштары, таудаған және тоғайлар. Шыршалар ішінде флоралық құрамы бойынша ең байы Picea schrenkiana Fisch. & C.A. Mey. (450-500 түр), алма ағаштары Malus sieversi (Ledeb.) M. Roem. (400 түр) және өрік ағаштары Armeniaca vulgaris Lam. (250 түр шамасында), ең кедейі – тоғай Hippophae rhamnoides L. (140 түр) және таудаған Celtis caucasica Willd. (119 түр) болып табылады. Бұл ормандардың құрамында Қызыл кітапқа еңген 24 түр, соның ішінде Hepatica falconeri (Thoms.) Steward, Epipactis palustris (L.) Crantz, Tulipa tarda Stapf және Gymnospermium altaicum (Pall.) Spach. арнайы зерттеу объектілері болып табылады. Мақалада соңғы үш түрдің табиғи популяциясын, атап айтқанда, генеративтік дарақтардың саны мен тығыздығын, жас спектрлерін және морфологиялық өзгергіштігін зерттеу нәтижелері көрсетілген. Hepatica falconeri сирек кездесетін түрлерінің бірі бойынша ең ірі табиғи популяциядан көшірілген генеративтік дарақтардың «Көлсай көлдері» ұлттық паркінің орталық кеңсесі жанындағы

Саты ауылында құрылған интродукциялық популяция базасында 2 жылдық бақылаулардың нәтижелері баяндалады (Талды сайы, 1693 м). Түрдің фенологиясы, оның ішінде жарық пен температураға байланысты гүлдердің ашылу мерзімі туралы салыстырмалы мәліметтер алынды. Мақалада «Көлсай көлдері» ұлттық паркінде Epipactis palustris және Paeonia intermedia С. А. Меу авторларының жаңа тұжырымдары көрсеткендей, Солтүстік Тянь-Шаньдағы сирек кездесетін түрлердің таралуын зерттеудің жеткіліксіздігі атап өтілген. Осыған сүйене отырып, авторлар арнайы зерттеулер жүргізуді немесе сирек кездесетін түрлерді зерттеу тақырыптарын ерекше қорғалатын табиғи аумақтардың жұмыс жоспарларына енгізуді ұсынады.

Түйін сөздер: таулы ормандар, популяция, Hepatica falconeri, Epipactis palustris, Tulipa tarda, Gymnospermium altaicum.

Р.Е. Қапарбай[1,2*], А.Д. Толенова[1], Д.М. Алмабек[1], А.А. Иващенко[3], К.Т. Абидкулова[1], Б.Б. Арынов[2]

[1]«Көлсай көлдері» МҰТП ҚР ЭГЖТРМ ОШЖЖДК, Қ.Ұлтарақ к., Саты а., Қазақстан
[2]Казахский национальный университет им. аль-Фараби, Казахстан, г. Алматы
[3]Институт зоологии КН МОН РК, Казахстан, г. Алматы
*e-mail: raushan.kaparbay@mail.ru

Мониторинг редких флористических элементов горных лесов Северного Тянь-Шаня

Горные леса Северного Тянь-Шаня отличаются флористическим разнообразием и богатством растительных сообществ, среди которых уникальные реликтовые: ельники, яблонники, абрикосники, каркасники и тугаи. Самые богатые по флористическому составу ельники из Picea schrenkiana Fisch. & C.A. Mey. (450-500 видов), яблонники из Malus sieversi (Ledeb.) M. Roem. (400 видов) и абрикосники из Armeniaca vulgaris Lam. (около 250 видов), самые бедные – тугаи с Hippophae rhamnoides L. (140 видов) и каркасники из Celtis caucasica Willd. (119 видов). В составе этих лесов встречаются 24 краснокнижных вида, в том числе Hepatica falconeri (Thoms.) Steward, Epipactis palustris (L.) Crantz, Tulipa tarda Stapf и Gymnospermium altaicum (Pall.) Spach., являющихся объектами специальных исследований. В статье излагаются результаты изучения природных популяций трех последних видов, в частности, численности и плотности, возрастных спектров и морфологической изменчивости генеративных особей. По одному из редчайших видов Hepatica falconeri излагаются результаты 2-х летних наблюдений на базе интродукционной популяции, созданной в пос. Саты при центральной усадьбе национального парка «Көлсай көлдері» из живых генеративных особей, перенесенных из самой крупной природной популяции (ущ. Талды, 1693 м). Получены сравнительные данные по фенологии вида, в том числе, скорости раскрывания цветков в зависимости от освещенности и температуры.

В статье подчеркивается недостаточность изученности распространения отдельных редких видов в пределах Северного Тянь-Шаня, о чем свидетельствуют новые находки авторов Epipactis palustris и Paeonia intermedia С.А. Меу. в национальном парке «Көлсай көлдері». На основе этого, авторы предлагают проводить специальные исследования или включать тематики по изучению редких видов в планы работы особо охраняемых природных территорий.

Ключевые слова: горные леса, популяция, Hepatica falconeri, Epipactis palustris, Tulipa tarda, Gymnospermium altaicum.

Mountainous regions (together with the mountain-foothills and desert-steppe plain) occupy a relatively small area, about 15% of the entire territory of the Republic of Kazakhstan. They are famous for their high floristic diversity and a large number of plant communities. These regions host three quarters of all plant species and more than 30 plant communities [1,2]. The mountain vegetation is very important to the biosphere. However, the conditions of its existence are extreme, and it is especially vulnerable to various adverse factors, both natural and man-made (agricultural, technogenic and recreational). In this mountains, unique coniferous forests (over 0.5 million hectares) and deciduous forests (0.3 million hectares) are concentrated, contributing to climate stabilization, especially in the vicinity of large settlements [2]. The problems of preserving, studying and monitoring not only all forest ecosystems of the mountain regions, but also the rarest and most vulnerable of them, as well as all components of their biological diversity are extremely relevant. Of paramount importance are the mountains of the Northern Tien Shan. They experience the largest anthropogenic load due to relatively easy access and dense population (the presence of settlements at the foot of the mountains making a strong impact on the environment).

Materials and Methods

The research was carried out mainly in the two state national parks, Ile-Alatau and Kolsay Koldery, as well as in the adjacent territories of the Northern Tien Shan. The identification of natural populations was carried out by the method of reconnaissance routes designed on the basis of literary and herbarium data available for individual species. Ecological and phytocenotic characteristics of species were compiled on the basis of descriptions of geobotanical sample plots established according to the generally accepted methodology [3,4]. To clarify the taxonomic affiliation of individual species, a herbarium was collected; species were identified according to large regional summaries [5,6,7]. Population and cenopopulation density and age distribution of herbaceous species were recorded along transects with a size of 20x1 m or 10x1 m, divided into subplots with a size of 1x1 m (to determine the occurrence in %), and of tree and shrub species, on plots with a size of 25 to 100-400 m^2.

The surveys were carried out mainly in four age groups: juvenile – *j,* immature – *im*, virgin – *v*, and generative – *g*, in accordance with the methodological instructions of T.A. Rabotnov [8], A.A. Uranov [9], A.A. Uranov and O.V. Smirnova [10], Yu.A. Zlobin and others. [11]. In some cases (if any), sprouts (*p*), senile and sub-senile (*s, ss*) individuals were recorded, whereas generative individuals were divided into several groups – g_1, g_2, etc., according to their size. In introduced naturalized populations (Botanical Garden and Boulevard of Almaty, a collection site in the village of Saty, near the central manor of Kolsay Koldery National Park), more detailed observations were carried out over the past 2-3 years, taking into account phenology and morphological variability. Generally accepted methods of phenological observations were used [12], and the morphometric data were processed in Microsoft Office Excel 2007. Seed productivity was determined according to a method of I.V. Vainagy [13], by using 30-50 fruits at each point, and in introduction, sometimes by surveying all individuals. The taxonomic treatment was according to S.A. Abdulina [14].

Results and Discussion

Since the early 1990s, research has been carried out by all authors in forest communities of five types: spruce forests, near a stream tugai forests with sea-buckthorn, apricot forests, apple tree forests, and hackberry forests. With the exception of tugai forests, all forest types belong to the category of rare and in need of special protection and monitoring [15]. In the forest ecosystems listed, there are 24 species of rare plants (Table 1) listed in the Red Book of Kazakhstan [16].

Table 1 – Distribution of rare plant species by mountain forests

№	Species	Spruce forest	Tugai	Apricot forest	Apple tree forest	Hackberry forest
1	2	3	4	5	6	7
	Armeniaca vulgaris Lam.	+	+	+	+	+
	Atraphaxis muschketowii Krasn.	-	-	+	+	+
	Berberis iliensis Popov	-	+	-	-	-
	Celtis caucasica Willd.	-	-	+	+	+
	Corydalis semenovii Regel	+	+	-	-	-
	Crocus alatavicus Regel et Semen.	+	-	-	+	-
	Epipactis palustris (L.) Crantz	-	+	-	-	-
	Erysimum croceum Popov	+	-	+	-	-
	Gymnospermium altaicum (Pall.) Spach	-	-	+	+	-
	Hepatica falconeri (Thoms.) Steward	+	-	-	-	-
	Hieracium kumbelicum B. Fedtsch. et Nevski	+	-	-	-	-
	Iridodictyum kolpakowskianum (Regel) Rodion.	-	-	+	+	-
	Iris alberti Regel	-	-	+	+	+
	Kaufmannia semenovii (Herder) Regel	+	-	-	-	-
	Lonicera iliensis Pojark.	-	+	-	-	-
	Malus niedzwetzkyana Dieck	-	-	-	+	-

1	2	3	4	5	6	7
	Malus sieversii (Ledeb.) M. Roem.	+	+	+	+	+
	Paeonia intermedia C.A. Mey.	+	-	+	+	-
	Rheum wittrockii Lundstr.	+	-	+	+	+
	Ribes janczewskii Pojark.	+	-	-	-	-
	Sibiraea tianschanica Pojark.	+	-	-	-	-
	Tulipa ostrowskiana Regel	-	-	+	+	+
	Tulipa tarda Stapf	-	-	+	+	-
	Veronica alatavica Popov	+	-	-	-	-
Total		**13**	**6**	**12**	**13**	**7**

We provide a brief description of these forest types based on the results of our survey, taking into account literary sources [17,20].

The relict forests dominated by *Picea schrenkiana* Fisch. & C.A. Mey. occupy a fairly large area in the Northern Tien Shan, although the area has significantly decreased over the last century, similarly to the area of all forests, as a result of the ever-increasing anthropogenic pressure. In spruce forests of the area surveyed, at least 450-500 species were found; 630 species have been recorded for the entire Northern Tien Shan [17], including 13 Red Book listed species (Table 1).

The most valuable of all forest types are: Chinturgen moss spruce forests on the preserved permafrost (Ile-Alatau National Park); spruce forests with *Hepatica falconeri*, *Kaufmannia semenovii*, and *Corydalis semenovii* (Kolsay Koldery National Park); and deciduous spruce forests with apple tree and apricot, preserved in separate gorges in the Zailiysky Alatau, the protection of which in the natural monument category was recommended by I.I. Roldugin [17]. Spruce forests are very important as an environment-stabilizing and sanitary-improving ecosystem with a large recreational potential, therefore they are in need of special protection and constant monitoring of their condition. Populations of rare species, especially small ones and located on the border of the distribution range should be the objects of special monitoring.

Tugai forests with sea-buckthorn (*Hippophae rhamnoides* L.) were surveyed in the valleys of the Chilik (Kungei Alatau), Issyk and Malaya Almaty rivers (Zailiysky Alatau). According to our data, in these forests there are more than 140 species from 38 families, including six Red Book listed species: *Lonicera iliensis*, *Berberis iliensis*, *Armeniaca vulgaris*, *Malus sieversii*, *Epipactis palustris*, and *Corydalis semenovii.*

Forests dominated by *Armeniaca vulgaris* occupy smaller areas than the apple tree forests and are found on drier stony slopes of the southern and southeastern exposures. Stand density and species richness are lower than in the apple tree forests. There are about 250 species including such accompanying tree species as *Crataegus songorica* K. Koch and *C. almaatensis* Pojark., and shrubs *Spiraea hypericifolia* L. and *S. lasiocarpa* Kar. & Kir. The best apricot stands are concentrated in the valley of the Kotyrbulak River, while sparser stands are quite common in other gorges (Turgen, Malaya and Bolshaya Almatinka, and Kazachka). The floristic core of the apricot forests is made up of other species, with *Artemisia santolinifolia* Turcz. ex Besser and *A. dracunculus* L. playing an important role; *Galium verum* L., *Melica transsilvanica* Schur, *Glycyrrhiza uralensis* Fisch. ex DC., as well as various ephemeroids are common. Of the 12 Red Book listed species, *Iris alberti* and *Tulipa ostrowskiana* are common, while *Atraphaxis muschketowii*, *Paeonia intermedia*, *Gymnospermium altaicumare* occur less often.

Relict forests dominated by *Malus sieversii* are a valuable source of plant germplasm, which is the progenitor of many cultivated varieties [18]. Wild fruit forests form a special sub-belt in the central part of the Zailiysky Alatau, complementing the high-altitude belt zonation in this region. That is why geobotanists refer to this territory as part of a special Zailiysko-Dzhungar belt type [19]. Apple forests play an important role in preserving plant species diversity. There are 400 species of higher plants from 251 genera and 74 families. The floristic core (occurrence of more than 50%) of these communities consists of 34 species, including 7 tree and shrub species [20]. Of the rare species listed in the Red Book of Kazakhstan [16], in addition to apple tree, there are 12 more species (Table 1).

In the Northern Tien Shan, **forests dominated by *Celtis caucasica*** have been found in two locations only, with the largest stand located in the valley of the Malaya Almaty River. This is a unique

refugium of a relict species located on the northeastern border of the distribution range. There are 119 species of higher plants from 86 genera and 36 families, among which there are 6 more Red Book plants in addition to *Celtis caucasica* (Table 1).

Of the 24 Red Book listed species recorded by us in the above five forest types, four species were studied in detail: *Hepatica falconeri, Epipactis palustris, Tulipa tarda* and *Gymnospermium altaicum*.

One of the rare, poorly studied elements of the spruce forests is *Hepatica falconeri* (Thoms.) Steward (Ranunculaceae). It is a rhizomatous perennial with a Dzungaro-Primalayan distribution range type [21], the only representative of the genus *Hepatica* in Kazakhstan listed in the Red Book as a "rarest" species [16]. A detailed study of the morphological variability, phenology, population state and numbers are being carried out by the authors on the territory of the Kolsay Koldery National Park, including a study of the largest population in the valley of the river Taldy (1693 m), where in 2016 specialists of the Institute of Botany I. G. Otradnykh and I. A. S'edina established a monitoring plot in a dense spruce forest of the lower part of a rocky slope of the north-western exposition. There, *Hepatica falconeri* was found in abundance [22]. In the fall of 2020, we moved four clumps of generative individuals from this largest population (in the vicinity of the monitoring site) to a site on the central estate of the National Park in the village of Saty (1444 m). Thus, an introduced population was created for regular studies on phenology and adaptation of the species to different environmental conditions (250 m lower, the site is open, without shading, the soil is soft, practically without stony inclusions). The survival rate of individuals was 100%; in the first year they all bloomed and bore fruit [23]. In 2022, the vegetation period started 12 days earlier than in the previous year, but the difference in the subsequent phases of development gradually decreased: the start of budding, down to 6 days (15.03 as opposed to 21.03), and the start of flowering, down to 4 days (25.03 as opposed to 29.03). Due to a warmer and drier spring of 2022, the first individuals that stopped flowering appeared earlier (06.04 as opposed to 20.04), and the overall life expectancy of the first flowers also decreased (down to 13 days as opposed to 17 days). However, post-generative vegetation continued as in the previous year, until the snow cover settled.

Thanks to the introduction population established in 2022, it was possible to obtain not only new data on the phenology of *Hepatica falconeri* in cultivation, but also to find out the influence of other environmental factors on this process. The first experience of cultivation was gained in the conditions of Almaty [24], where the introduced individuals stopped flowering after two years. We conducted our observations in the introduced population (Saty) on April 18, 2022. The proportion of buds was 39.1%, and that of the opened flowers was 60.9%, respectively. In the Taldy Gorge, on the same slope we observed a very large difference between the ratio of the open flower to bud numbers. Under the spruce canopy, there were 66.7% of buds, and on a sunlit rock, only 19.5%. The remaining flowers had already opened (Fig. 1).

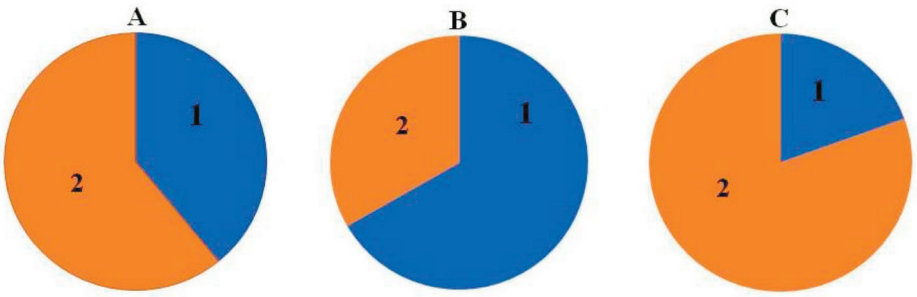

Figure 1 – Ratio of buds (1) to open flowers (2) of *H. falconeri* recorded on 18.04.2022 in different conditions: A – introduced population in the village of Saty; B – natural population in the Taldy Gorge, under the spruce canopy; C – same as B, on a sunlit rock.

In the last two cases, not only the light intensity, but also the temperature (lower on wet soil under the spruce canopy and higher on the exposed rock) had the effect on the flowering rate. On the same

day, in the village of Saty the proportion of open flowers was almost by a quarter smaller than on the rock in the Taldy Gorge, despite the differences in the altitude.

The data on the morphology of generative individuals in the three habitats listed above are also of interest. In particular, the average flower numbers in one generative clump were: 5.7 (from 1 to 18) in the first case (Saty); 4.5 (from 3 to 6) in the second case (under the canopy in the Taldy Gorge); and 16.4 (from 7 to 30) in the third case (in the Taldy Gorge, on the exposed rock).

Thus, cultivation of *Hepatica falconeri*, a rare, highly decorative species will be most successful in rockeries (providing the level of atmospheric humidity is sufficiently high).

In the tugai forests of the Northern Tien Shan with *Hippophae rhamnoides* L., the rarest representative of higher plants is *Epipactis palustris* (L.) Crantz (Orchidaceae). This is a species with a wide Palearctic distribution range, growing in wet swampy meadows and forests, in river valleys of the northern plain and almost the entire mountainous Kazakhstan, from Altai to the Western Tien Shan [6,16]. However, until recently the only reliable record in the Northern Tien Shan was the information obtained more than 60 years ago: the findings of M. G. Popov [25] in the valley of the Chilik River (without precise location). In June 2012, one of the authors managed to describe a single micropopulation consisting of seven generative individuals in a willow-birch tugai forest with sea buckthorn located in the Issyk River delta [26]. The second unique find from this region was made by the authors of this article, R.E. Kaparbay and B.B. Arynov. A small population of *Epipactis palustris* (not larger than 100 individuals) is located in a sea buckthorn forest of the left bank of the Tau-Chilik River (1557 m above sea level). On August 11, 2022, most individuals were in the fruiting phase (immature fruits), with only one individual found in the shade of shrubs still in bloom (Figure 2).

Figure 2 – *Epipactis palustris*

The species composition of the community described is represented by 46 species of higher plants, of which 7 species belong to the trees and shrubs, with the general projective cover (GPC) of 95%. The grassland is dominated by graminoids, as well as by *Rubus saxatilis* L. According to our data, the occurrence of *Epipactis palustris* is 80%, the average density is 6.2 (up to 13) individuals /m^2. In another isolated area (an open area along a small stream), the population density was twice as high, 25 individuals/m^2. According to morphological indicators, we managed to distinguish three age groups: immature (*im*), virgin (*v*), and generative g_1 (flowering, but not bearing fruit this year) and g_2 (with normally developed fruits from 1 to 14 per individual). The measurements of individuals of the groups listed above are presented in Table 2.

Table 2 – Morphometric indicators of different age groups of *Epipactis palustris*

Age group	Height, cm	Number of leaves	Number of fruits
im	10.6±0.8	6.3±0.4	-
v	21.9±0.9	7.2±0.3	-
g_1	37.2±1.5	8.0±0.3	-
g_2	44.4±4.8	6.6±0.7	6.6±2.2

The age spectrum of the surveyed population is as follows: im – 18.1%; v – 36.4%; g1 – 36.4%; g2 – 9.1%. A low regeneration potential of this species should be noted. Since there were no juvenile individuals, and the ratio of young and adult individuals (1.8/8.2) had a clear bias towards the latter, it is possible to classify this population as aging. Consequently, it needs special protection and regular monitoring. We consider it necessary to take special measures to preserve the only known population of *Epipactis palustris*, such as fencing for protection against grazing and blocking a road in this area.

One of the rarest elements of the apricot forests, as it was recently discovered by the authors, is the Northern Tian Shan endemic *Tulipa tarda* Stapf (Liliaceae), hitherto known only as a member of the steppe and shrub communities of Kazakhstan and Kyrgyzstan [16,27]. In 2021-2022, we examined a population of this species on the eastern slope of the left bank of the Kargaly River (1130 m above sea level). There were various types of overexposed apricot forests on a steep (up to 50^0) scree slope of the eastern exposition (Figure 3).

Figure 3 – Apricot forest with *Tulipa tarda* (the Kargaly Gorge)

The basal area of the tree-shrub layer varied from 0.2 to 0.8; and the total projective cover was from 40% to 90%. There were 44 species from 23 families, including 13 tree and shrub species. Interestingly, in addition to apricot, another 10 species complement the previously published list of communities with *T. tarda* [27]: *Malus sieversii, Lonicera tatarica* L., *Clematis orientalis* L., *Erem-*

urus altaicus (Pall.) Steven, *Poterium polygamum* Waldst. & Kit., *Rubus caesius* L., *Centaurea squarrosa* Willd., *Lactuca serriola* L., *Hieracium virosum* Pall., and *Scorzonera racemosa* Franch.

On that slope, we examined two cenopopopulations of *T. tarda*: the first one was in an overexposed apricot forest on an unstable scree, with a significant area of "bald" spots (projective cover of 40%); the second one had a thicker vegetation cover (projective cover from 70% to 90%), and was dominated by *Rubus caesius* L. and *Poa relaxa* Ovcz. stabilizing the scree on the slope.

In both cenopopulations *T. tarda* is very abundant (cop_{1-2}), forming the dominant grass layer. Its density sometimes exceeds 200 individuals/m^2. In both cases, cenopopopulations were complete (i.e. individuals of all age groups were present, from juvenile to senile and sub-senile). Their age spectrum is as follows: *j* – 31.6%; *im* – 30.7%; *v* – 13.8%; *g* – 16.9%; *ss* – 7% (CP No.1); *j* – 15%; *im* – 25.6%; *v* – 21.5%, *g* – 23.6%; *ss* – 13.7% (CP No.2). In Figure 4, they are represented by two-peak curves, with peaks of generative (in both cases), juvenile (in the first case) and immature (in the second case). The ratio of young to adult individuals in CP No.1 is 6.2:3.8, and in CP No.2, 4.1:5.9, which makes it possible to describe the first CP as a younger, and the second CP as a more mature. In general, the state of this *T. tarda* population in one plant community turned out to be better than in the steppe-type communities, where the density of the studied species is much lower and its composition is more homogeneous and can be graphically represented as a single-peak curve [28].

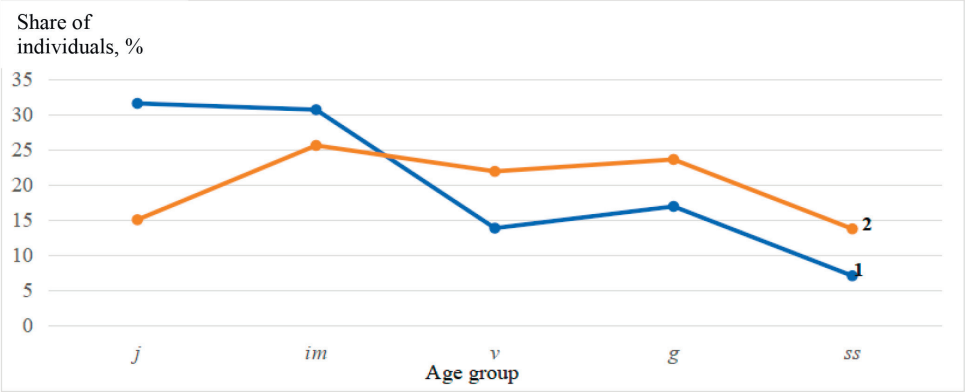

Figure 4 – Age spectrum of different *Tulipa tarda* populations: CP1-1, CP2-2.

One can discuss the best growing conditions of *T. tarda* in forest communities using the development of generative individuals as an example. Table 3 presents data on their morphological variability in the two above-mentioned cenopopopulations, as well as in population No.2 surveyed as a member of a shrub community (*Spiraea hypericifolia* L., *Rosa platyacantha* Schrenk) with a steppe grass layer in the valley of the Karakunuz River (1041 m above sea level) in 2022 .

Table 3 – Distribution of generative individuals of *Tulipa tarda* by the number of leaves and flowers in different cenopopulations

Population	CP	Number of flowers	Share of individuals with different number of leaves					Total
			2	3	4	5	6	
1	1	1	2.6	25.8	45.2	15.5	0.6	**89.7**
		2	-	-	1.9	5.8	2.6	**10.3**
		total	**2.6**	**25.8**	**47.1**	**21.3**	**3.2**	
	2	1	3.4	3.0	42.2	8.0	0.6	**90.2**
		2	-	-	2.9	4.6	1.7	**9.2**
		3	-	-	-	-	0.6	**0.6**
		total	**3.4**	**36.0**	**43.1**	**12.6**	**2.9**	

2	1	1	2.9	33.6	47.2	11.4	1.4	**96.5**
		2	-	0.7	-	0.7	-	**1.4**
		3	-	-	0.7	0.7	0.7	**2.1**
		total	**2.9**	**34.3**	**47.9**	**12.8**	**2.1**	

In apricot forests, the more favorable growing conditions for *Tulipa tarda* are evidenced by the density of its population compared to that in other habitats (Table 4).

Table 4 – Density and occurrence of *Tulipa tarda* in various habitats

Location, elevation a.s.l.	Density, individuals/m^2		Occurrence, %
	Mean	Confidence interval	
Kargaly, 1135 m, CP №1	64.1	2-219	100
Karakunuz, 1041 m	17.3	0-51	90
Kastek, 1484 m, rocky slope	18.3	0-73	90
Kastek, 1480 m, grassy slope	6.2	0-63	67
Zhamanty, 1656 m	18.3	3-55	100

Consequently, the *T. tarda* population described by us in the apricot forest in the Kargaly Gorge needs special protection and regular monitoring of its condition. In our opinion, it is necessary to establish a specialized botanical reserve, as in the Karakunuz Gorge, which has a similar status since 1970. Clarification is also required of the species independent status based on genetic studies, since some international taxonomists [29] identify it with the Iranian *Tulipa urumiensis* Stapf.

Another rare species of Northern Tien Shan is *Gymnospermium altaicum* (Pall.) Spach (Berberidaceae). In the Trans-Ili Alatau it occurs fragmentarily; for example, it is absent in the central part of the ridge, abundant in the gorges of Tauturgen, Turgen, Soldatsay, and Kotyrbulak, but not found to the west of Almaty, from Aksai and Kaskelen [30]. In the Kotyrbulak gorge of the Zailiysky Alatau, it is found in a hawthorn forest, karagach plantatiion and in an apple tree stand (Figure 5).

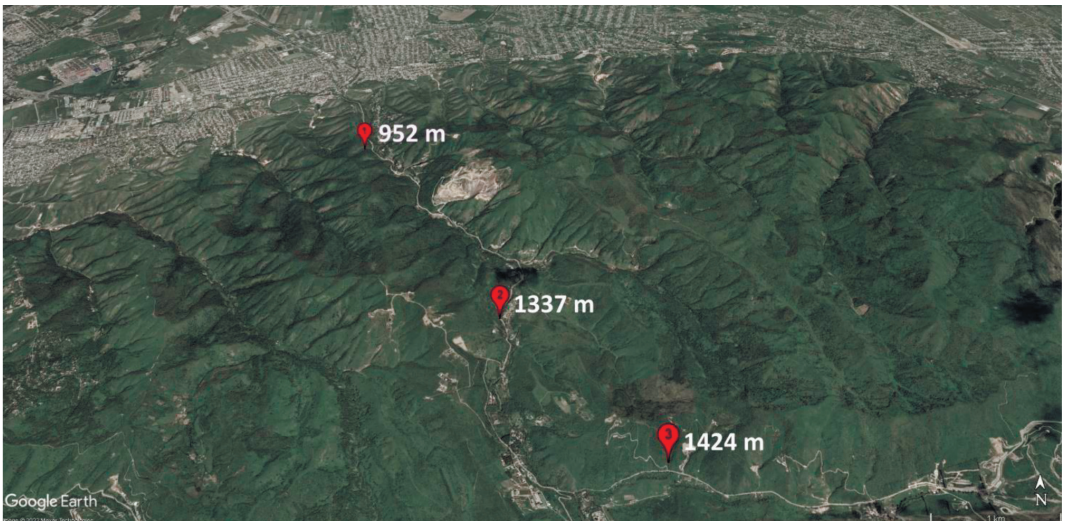

Figure 5 – Locations of the three *Gymnospermium altaicum* cenopopulations in the Kotyrbulak Gorge: 1- howthorn forest; 2- karagach plantation; 3- apple tree stand.

The first coenopopulation (952 m) is located in a hawthorn (*Crataegus songorica* C. Koch) forest in the lower part of a grassy slope of the south-eastern exposure; the basal area of the tree-shrub layer is 0.7-0.8; GPC – 95%. There are 39 species from 24 families, of which 11 are tree and shrub species. The floristic composition is described in more detail in one of the previous publications [30].

The second cenopopulation (1337 m) is located in an *Ulmus scabra* Mill. plantation in the lower part of a slope of the north-eastern exposure; the basal area of the tree-shrub layer is 0.5, GPC – 90%. There are 19 species from 14 families, including four tree and shrub species.

The third cenopopulation (1424 m) is located in the dry right slit in a sparse apple tree forest, in the lower part of a slope of the west-north-west exposure; the basal area of the tree layer is 0.1; GPC – 95%. There are 36 species from 18 families, and the tree layer is formed by apple tree.

In the sample plots, the density and occurrence of the studied species was uneven (Table 5).

Table 5 – Density and occurrence of *Gymnospermium altaicum* in cenopopopulations (the Kotyrbulak Gorge)

Cenopopulation, elevation a.s.l.	Density, individuals/m^2		Occurrence, %
	Mean	Confidence interval	
CP №1, 952 m	22.1	3-57	100
CP №2, 1337 m	8.6	0-62	50
CP №3, 1424 m	12.3	0-30	95

In all cases, the cenopopulations were complete (i.e. individuals from juvenile to generative were present). It was not possible to identify sub-senile and senile individuals without complete excavation of plants. The age spectrum of all coenopopulations was identical, with a maximum in the virgin age group: 52.3%, 41.3% and 49.1%, respectively (Figure 6). At the same time, in the age composition of CP1 located at the lower boundary of the species habitat, the proportion of immature individuals was high (26.7%), and that of generative individuals, very low (5.9%), whereas in CP2 (1337 m), the second largest age group consisted of generative individuals (34.2%), while juvenile and immature individuals were poorly represented, 11.32% and 13.2%, respectively.

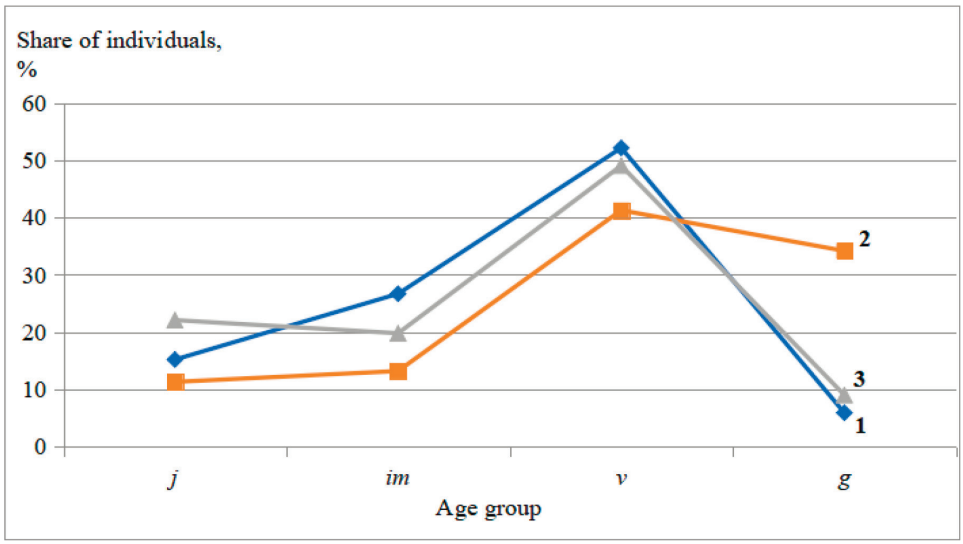

Figure 6 – Age spectrum of *Gymnospermium altaicum* in three coenopopopulations gorge (the Kotyrbulak Gorge): 1-CP No.1; 2- CP No.2; 3-CP No.3.

Morphometric parameters were also measured in generative individuals of *G. altaicum* in all cenopopulations (Figs. 7-10).

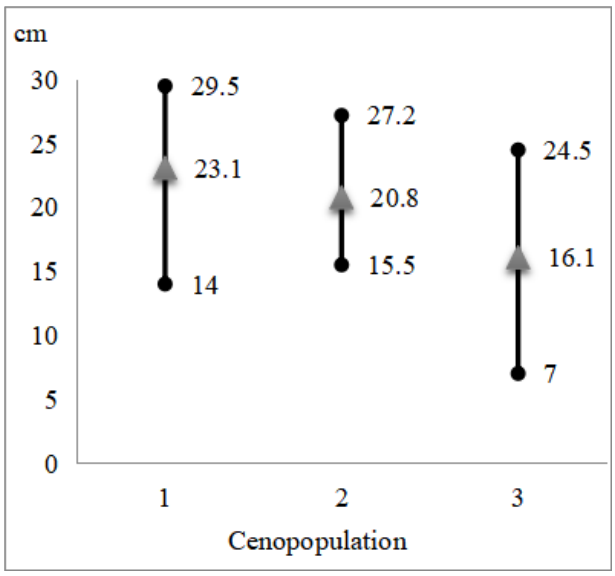

Figure 7 – Height of generative individuals of *G. altaicum* in different cenopopopulations

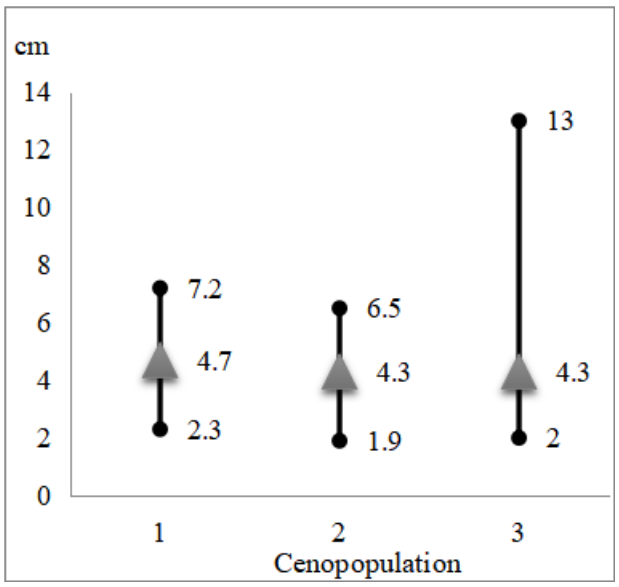

Figure 8 – Length of inflorescence of *G. altaicum* in different cenopopulations

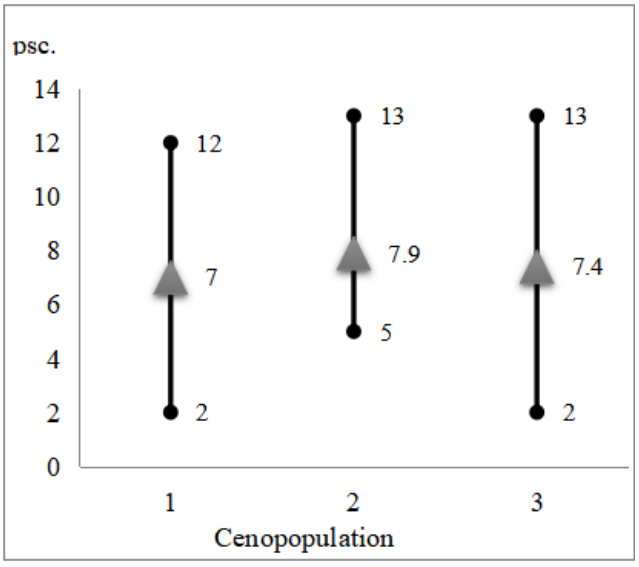

Figure 9 – The number of flowers of *G. altaicum* in different cenopopopulations

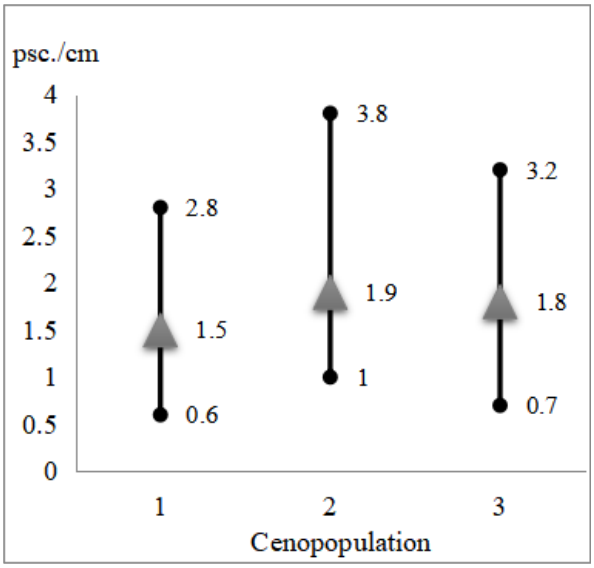

Figure 10 – Density of inflorescence of *G. altaicum* in different cenopopulations

The maximum average height of generative individuals (23.1 cm) was recorded in CP No.1, in a hawthorn forest, and the minimum (16.1 cm), in CP No.3, in the sparse apple tree forest; the difference in plant height was also the largest there (Figure 7). The average inflorescences length varied from 4.7 to 4.3 cm, but the maximum difference in the inflorescences length was observed in CP No.3, in the apple tree forest (Figure 8). The average number of flowers varied from 7 in CP No.1 to 7.9 in CP No.2, and the maximum number (12-13 flowers) was almost the same in all cenopopulations, while the minimum

was 2 flowers in CP No.1 and CP No.3, and 5 flowers in CP No.2 (Figure 9). The maximum difference (11) was observed in CP No.3, in the sparse apple tree forest.

The average inflorescence density ranged from 1.5 to 1.8-1.9 pcs./cm (Figure 9). The maximum difference in density was observed in CP No.2 in the karagach plantation and was 2.8 pcs./cm.

In terms of the density of cenopopopulations, occurrence, average height of generative individuals and the inflorescences length, the best condition of *G. altaicum* was recorded in CP No.1 in the hawthorn forest (952 m), while the density of the inflorescence varied slightly in all three cenopopopulations.

As a result of our observations, a preliminary analysis of the condition and abundance of 24 rare species recorded by us in five types of forest communities was provided. There are seven most threatened species to date. Five of them (*Malus niedzwetzkyana, Epipactis palustris, Veronica alatavica, Ribes janczewskii, Corydalis semenovii*) are represented by single individuals or a few isolated populations with a total population from ten to a hundred individuals. Two more species (*Hepatica falconeri, Kaufmannia semenovii)* are represented by a dozen populations with a total population numbers of hardly more than 1000 individuals. The total population numbers of the remaining 17 species significantly exceed the above figures, although they also need protection and regular monitoring.

On the territory of Kolsay Koldery National Park and in the immediate environs, verification is required of the presence of such rare forest elements as *Fraxinus sogdiana* Bunge recorded in the Kungei Alatau ridge by S. K. Mukhtubayeva [31]; *Lonicera iliensis* Pojark. collected in the floodplain of the Taldybulak River by V. P. Goloskokov (24.07.1953) and the Kensu Gorge; and *Gymnospermium altaicum* as well as the first species recorded by S.K. Mukhtubayeva [31] in the Kungei Alatau without any specific data.

For one of these dubious species mentioned in the above monograph without a specific collection point, *Paeonia intermedia* C.A. Mey. (*Paeonia hybrida var. intermedia* (C.A.Mey.) Krylov) confirmation has already been found. This is the finding of inspector A.T. Nurpeis of a micropopulation of a dozen generative individuals on a slope of the Karasai Gorge in the spruce forest belt (2630 m above sea level), which once again confirms the need for additional research on the distribution of rare plant species in the Northern Tien Shan.

Conclusion

Summing up the initial stages of monitoring populations of some rare floristic elements of the forests of the Northern Tien Shan, it should be emphasized that spruce forests and apple tree forests are the richest in rare species (13 species in each), and tugai forests and hackberry forests are the poorest (6-7 species). This corresponds to the area occupied by these forest types in the surveyed region: the first forest type has the largest, and the last forest type, the smallest area. A detailed study of populations of four species (*Hepatica falconeri, Epipactus palustris, Tulipa tarda, Gymnospermium altaicum)* suggests their relatively good condition, since they are, with the exception of *Tulipa tarda,* in protected areas. A certain drawback in the scientific research of these protected areas is insufficient attention to the monitoring of rare species. Thus, only 11 Red Book listed species (*Armeniaca vulgaris, Atraphaxis muschketowii, Malus sieversi, Celtis caucasica, Ribes janczewskii, Crocus alatavicus, Iris alberti, Tulipa ostrowskiana, Paeonia media, Rheum wittrockii, Gymnospermium altaicum)* are found on 17 monitoring sites in Ile-Alatau National Park, and only four (*Crocus alatavicus, Hepatica falconeri, Rheum wittrockii, Kaufmania semenovii*) are found on seven monitoring sites in Kolsay Kolderi National Park. Several more species of this category can be found on phenological sites, where the only phenological observations are conducted by an inspector, which does not allow for an assessment of the state and dynamics of the populations.

Thus, we consider it expedient to increase the number of monitoring sites, taking into account the distribution of the Red Book listed species, as well as the advancement of research on their distribution. The lack of study is evidenced by the findings of recent years (*Paeonia intermedia, Epipactus palustris*) in Kolsay Koldery. There is also the need for a special study of the status and dynamics of populations of highly threatened species.

Acknowledgments.

The authors are sincerely grateful to their colleagues who organized many site visits, in particular, O.V. Belyalov, M.E. Abidkulov, as well as to the employees of Ile Alatau National Park and Kolsay Koldery National Park: P.V. Korobko, R.M. Turekhanova, E.Zh. Ismagulov, inspectors A.T. Nurpeis and A. Mergenbayev, and other inspectors who provided assistance on the routes, and valuable information and photographs of rare plants.

References

1 Национальная стратегия и план действий по сохранению и сбалансированному использованию биологического разнообразия Республики Казахстан. Кокшетау. – 1999. – С.336.

2 Арыстангалиев С.А. Очерки по геоботанике. Растительный покров горных районов Казахстана. Алматы: LEM, 2022. – С. 144.

3 Быков Б.А. Геоботаника. – Алма-Ата, 1978. – С.288.

4 Полевая геоботаника. Тт. 1-5. М.– Л.: Наука, 1959-1976

5 Флора СССР. Тт. 1-30. – М.–Л., 1934-1964.

6 Флора Казахстана. Тт. 1-9. – Алма-Ата, – 1956-1966.

7 Определитель растений Средней Азии. Критический конспект флоры. Тт. – 1-10. – Ташкент,1968-1993.

8 Работнов Т.А. Жизненные состояния вида в растительном сообществе // Бюл. МОИП. Отд. биол. 1960, т. 64, вып.3.

9 Уранов А.А. Онтогенез и возрастной состав популяций (вместо предисловия) // Онтогенез и возрастной состав популяций цветковых растений, М.: Наука, 1967, С. 3-8.

10 Уранов А.А., Смирнова О.В. Классификация и основные черты развития популяций многолетних растений // Бюлл. МОНП. Отд. биол. – 1969. Т.74. Вып. 1. – С.119-135.

11 Злобин Ю.А., Скляр В.Г., Клименко А.А. Популяции редких видов растений: теоретические основы и методика изучения. Сумы: Университетская книга. – 2013. – 439 с.

12 Методики интродукционных исследовании в Казахстане. Алма-Ата: Наука, 1987. – С.4-11.

13 Вайнагий И.В. О методике изучения семенной продуктивности растений / Ботан. ж. – 1974. – Т. 59. – № 6. – С. 826 – 831.

14 Абдулина С.А. Список сосудистых растений Казахстана. – Алматы. – 1999. – С.187.

15 Kurochkina L., Rachkovskaya E., Roldugin I., Makulbekova G., Ogar N., Stogova L. Map-Scheme of Endangered Plant Commuinites Distribution // The National Strategy and Action Plan on Conservation and Sustainable Use of Biological Diversity of the Republic of Kazakhstan. – Kokshetau, 1999. – P. 91-93.

16 Красная книга Казахстана. Т.2, Ч. 2. Растения. – Астана: LTD «Art-Print XXI», 2014. – 452 с.

17 Roldugin I.I. Spruce forests of the Tien Shan (flora classification and dynamics) // Alma-Ata: Nauka. – 1989. – P. 304.

18 Dzhangaliev A.D., Salova T.N., Turekhanova R.M. The wild fruit and nut of Kazakhstan // Horticultural Reviews. Vol. 29. Wild Apple and Fruit of Central Asia. 2003. – P.305-370.

19 Рачковская Е.И., Сафронова И.Н., Волкова Е.А. Ботаника – географическое районирование // Ботаническая география Казахстана и Средней Азии (в пределах пустынной области). М. – СПб, 2005. – С.192-222.

20 Иващенко А.А. Редкие растения и растительные сообщества Иле-Алатауского национального парка: распространение и состояние // Терра. Научный журнал. – 2012. – Вып.13. – С. 53-65.

21 Ogisu M., Awan M.R., Mabuchi T., Mikanagi Y. Morphology, phenology and citology of Hepatica falconeri in Pakistan // Kew Bull. – 2002. – 2002. – Vol. 57 (4). – P.948-953.

22 Капарбай Р.Е., Иващенко А.А., Мухитдинов Н.М., Арынов Б.Б. Қазақстандағы фальконер бауыршөбі (*Hepatica falconeri* (Thoms.) Steward) сирек кездесетін түрдің таралуы мен экологиясына арналған материалдар // Experimental Biology. №1 (86). 2021. Алматы. – С. 27-36.

23 Капарбай Р.Е., Иващенко А.А. Печеночница фальконера (*Hepatica falconeri* (Thoms.) Steward) в Кунгей Алатау: изучение в природе и опыт культивирования // Материалы Международной научно-практической конференции «Независимость Казахстана: Аспекты сохранения биоразнообразия» посвященная 80-летию доктора биологических наук, профессора, Почетного члена Национальной академии Наук Республики Казахстан, академика КазНАЕН Мухитдинова Наштая Мухитдиновича. (Алматы. 26 ноября 2021 г.) – Алматы: Изд. Казак университеті, С. 86-88.

24 Съедина И.А., Отрадных И.Г. Опыт первичной интродукции редких видов Северного Тянь-Шаня в условиях предгорий Заилийского Алатау // «Проблемы ботаники Южной Сибири и Монголии» – XVIII Международная научно-практическая конференция. Барнаул. – 2019. С.623-626.

25 Попов М.Г. Флора Алматинского государственного заповедника. – Алма-Ата, 1940. – С.50.

26 Иващенко А.А., Белялов О.В. Новые флористические находки на юге и юге-востоке Казахстана // Ботанические исследования Сибири и Казахстана. Кемерово, 2015. Вып. 21. – С.94-100.

27 Tolenova A.D., Ivashchenko A.A., Moysiyenko I.I.. Plant communities with the participation of *Tulipa tarda* Stapf in Kazakhstan: floristic composition and analysis // The Bulletin Of KazNU., Ser. ecological. – 2021. №1 (66). – С. 61-74.

28 Иващенко А.А., Алмабек Д.М., Толенова А.Д., Абидкулова К.Т. Редкие виды эфемероидных геофитов степного пояса Казахстанского Тянь – Шаня.// Материалы IV международной научной конференции, Костанай -2022 – С.303-310.

29 Christenhusz M. J. M., Govaerts R., David J.C., Hall T., Borland K., Roberts P.S., Tuomisto A., Buerki S., Chase M. W., Fay M.F. Tiptoe through the tulips – cultural history, molecular phylogenetics and classification of Tulipa (Liliaceae) // Bot. Journ. Linn. V. 172. Soc. 2013.

30 Abidkulova D.M., Ivashchenko A.A., Sramko G., Kurbatova N.V., Abidkulova K.T. *Gymnospermium altaicum* (Pall.) Spach (Berberidaceae), an early spring element of wild fruit forests of the Trans-Ili Alatau // Вестник КазНУ. Серия биологическая, 2021. Vol.86. – Is. 1, pp. 14-26. doi:10.26577/eb.2021.v86.i1.02

31 Мухтубаева С. К. Конспект флоры восточной части хребта Кунгей Алатау. – Алматы, 2017. – 272 с.

References

1 Abdulina S.A. (1999) Spisok sosudistyh rastenij Kazahstana. Almaty, pp. 187

2 Abidkulova D.M., Ivashchenko A.A., Sramko G., Kurbatova N.V., Abidkulova K.T. (2021) Gymnospermium altaicum (Pall.) Spach (Berberidaceae), an early spring element of wild fruit forests of the Trans-Ili Alatau. Vestnik KazNU. Seriya biologicheskaya, vol.86, is. 1, pp. 14-26. doi:10.26577/eb. 2021.v86.i1.02

3 Arystangaliev S.A. (2022) Ocherki po geobotanike. Rastitelnyj pokrov gornyh rajonov Kazahstana. Almaty: LEM, pp.144 Botanika – geograficheskoe rajonirovanie. Botanicheskaya geografiya Kazahstana i Srednej Azii (v predelah pustynnoj oblasti). M.-SPb, pp.192-222.

4 Bykov B.A. (1978) Geobotanika. Alma-Ata, pp.288

5 Christenhusz M. J. M., Govaerts R., David J.C., Hall T., Borland K., Roberts P.S., Tuomisto A., Buerki S., Chase M. W., Fay M.F. (2013) Tiptoe through the tulips – cultural history, molecular phylogenetics and classification of Tulipa (Liliaceae). Bot. Journ. Linn., vol. 172, soc.

6 Dzhangaliev A.D., Salova T.N., Turekhanova R.M. (2003) The wild fruit and nut of Kazakhstan. Horticultural Reviews. Vol. 29. Wild Apple and Fruit of Central Asia, pp. 305-370.

7 Flora Kazahstana (1956-1966) Alma – Ata, Vv. 1-9.

8 Flora SSSR (1934-1964) M.-L., Vv. 1-30.

9 Ivashchenko A.A. (2012) Redkie rasteniya i rastitelnye soobshchestva Ile-Alatauskogo nacionalnogo parka: rasprostranenie i sostoyanie. Terra. Nauchnyj zhurnal, vol.13, pp. 53-65

10 Ivashchenko A.A., Almabek D.M., Tolenova A.D., Abidkulova K.T. (2022) Redkie vidy efemeroidnyh geofitov stepnogo poyasa Kazahstanskogo Tyan' – Shanya. Materialy IV mezhdunarodnoj nauchnoj konferencii, Kostanaj, pp. 303 – 310.

11 Ivashchenko A.A., Belyalov O.V. (2015) Novye floristicheskie nahodki na yuge i yuge-vostoke Kazahstana. Botanicheskie issledovaniya Sibiri i Kazahstana. Kemerovo, vol. 21, pp. 94 – 100.

12 Kaparbaj R.E., Ivashchenko A.A. (2021) Pechenochnica falkonera (Hepatica falconeri (Thoms.) Steward) v Kungej Alatau: izuchenie v prirode i opyt kultivirovaniya. Materialy Mezhdunarodnoj nauchno-prakticheskoj konferencii «Nezavisimost Kazahstana: Aspekty sohraneniya bioraznoobraziya» posvyashchennaya 80-letiyu doktora biologicheskih nauk, professora, Pochetnogo chlena Nacionalnoj akademii Nauk Respybliki Kazahstan, akademika KazNAEN Muhitdinova Nashtaya Muhitdinovicha, Almaty: Izd. Kazak universiteti, pp. 86-88.

13 Kaparbaj R.E., Ivashchenko A.A., Muhitdinov N.M., Arynov B.B. (2021) Kazakstandagy falkoner bauyrshobi (Hepatica falconeri (Thoms.) Steward) sirek kezdesetin tyrdің taraluy men ekologiyasyna arnalgan materialdar. Experimental Biology, vol. 1, no. 86, pp. 27-36.

14 Krasnaya kniga Kazahstana (2014) Vol 2, no. 2 Rasteniya, Astana: LTD "Art-Print XXI", pp. 452.

15 Kurochkina L., Rachkovskaya E., Roldugin I., Makulbekova G., Ogar N., Stogova L. (1999) Map-Scheme of Endangered Plant Commuinites Distribution. The National Strategy and Action Plan on Conservation and Sustainable Use of Biological Diversity of the Republic of Kazakhstan, Kokshetau, pp.91-93.

16 Metodiki introdukcionnyh issledovanii v Kazahstane (1987) Alma-ata: Nauka, pp.4-11.

17 Muhtubaeva S. K. (2017) Konspekt flory vostochnoj chasti hrebta Kungej Alatau. Almaty, pp. 272.

18 Nacionalnaya strategiya i plan dejstvij po sohraneniyu i sbalansirovannomu ispolzovaniyu biologicheskogo raznoobraziya Respubliki Kazahstan (1999) Kokshetau, pp. 336

19 Ogisu M., Awan M.R., Mabuchi T., Mikanagi Y. (2002) Morphology, phenology and citology of Hepatica falconeri in Pakistan. Kew Bull, vol. 57, no. 4, pp. 948-953.

20 Opredelitel rastenij Srednej Azii. Kriticheskij konspekt flory (1968-1993) Tashkent, Vv. 1-10.

21 Polevaya geobotanika (1959-1976) M. – L.: Nauka Vv. 1-5.

22 Popov M.G. (1940) Flora Almatinskogo gosudarstvennogo zapovednika. Alma-Ata, pp. 50.

23 Rabotnov T.A. (1960) Zhiznennye sostoyaniya vida v rastitelnom soobshchestve. Bul. MOIP. Otd.biol, vol 64, no. 3.

24 Rachkovskaya E.I., Safronova I.N., Volkova E.A. (2005) Botanika –

25 Roldugin I.I. (1989) Spruce forests of the Tien Shan (flora classification and dynamics). Alma-Ata: Nauka, pp. 304.

26 S"edina I.A., Otradnyh I.G. (2019) Opyt pervichnoj introdukcii redkih vidov Severnogo Tyan'-Shanya v usloviyah predgorij Zailijskogo Alatau. «Problemy botaniki Yuzhnoj Sibiri i Mongolii» – XVIII Mezhdunarodnaya nauchno-prakticheskaya konferenciya, Barnaul, pp. 623 – 626.

27 Tolenova A.D., Ivashchenko A.A., Moysiyenko I.I. (2021) Plant communities with the participation of Tulipa tarda Stapf in Kazakhstan: floristic composition and analysis. The Bulletin of KazNU., Ser. Ecological, vol. 1, no. 66, pp. 61 – 74.

28 Uranov A.A. (1967) Ontogenez i vozrastnoj sostav populyacij (vmesto predisloviya). Ontogenez i vozrastnoj sostav populyacij cvetkovyh rastenij, M: Nauka, pp.3-8.

29 Uranov A.A., Smirnova O.V. (1969) Klassifikaciya i osnovnye cherty razvitiya populyacij mnogoletnih rastenij. Bull. MOIP. Otd.biol., vol 74, no. 1, pp.119-135.

30 Vajnagij I.V. (1974) O metodike izucheniya semennoj produktivnosti rastenij. Botan.zh., vol.59, no. 6, pp. 836-831.

31 Zlobin Yu.A., Sklyar V.G., Klimenko A.A. (2013) Populyacii redkih vidov rastenij: teoreticheskie osnovy i metodika izucheniya. Sumi:Universitetskaya kniga, pp.439