

A.A. Ivashchenko<sup>1</sup>, R.E. Kaparbay<sup>2,3\*</sup>, B.B. Arynov<sup>3</sup>,  
N.M. Mukhitdinov<sup>2</sup>, G. Sramko<sup>4</sup>, K.T. Abidkulova<sup>2</sup>

<sup>1</sup>Institute of Zoology, KN MES RK, Kazakhstan, Almaty

<sup>2</sup>Al-Farabi Kazakh National University, Kazakhstan, Almaty

<sup>3</sup>SNNP «Kolsay kolderi» CFW MEENR RK, Kazakhstan, r. Almaty

<sup>4</sup>University of Debrecen, Debrecen, Hungary

\*e-mail: raushan.kaparbay@mail.ru

## PLACES OF GROWTH AND BIOLOGICAL CHARACTERISTICS OF *HEPATICIA FALCONERI* (THOMS.) STEWARD AT THE NORTHERN BORDER OF ITS DISTRIBUTION AREA

The article provides the most up to date information on the distribution of the red-listed species *Hepatica falconeri* (Thoms.) Steward (Ranunculaceae), and on its ecological and altitudinal preferences within the mountain ranges of southeastern Kazakhstan based on the analysis of literature sources, herbarium specimens, data from the site <https://www.plantarium.ru/>, as well as our own research. The authors' data confirm that the studied species is a forest petromesophilic ecological element. As a result of the research, the floristic composition of plant communities with the participation of *H. falconeri* in the Taldy gorge (northern macroslope of the Kungei Alatau) was established. It is represented by 107 species from 46 families. The most important are 13 families (64.5%): Asteraceae, Fabaceae, Poaceae, Rosaceae, Ranunculaceae, Apiaceae, Crassulaceae, Caryophyllaceae, Orchidaceae, Lamiaceae, Geraniaceae, Papaveraceae and Primulaceae. The floristic core of the describe communities consists of 15 species: *Picea schrenkiana*, *Atragene sibirica*, *Ribes meyeri*, *Lonicera stenantha*, *Rosa alberti*, *Sedum hybridum*, *S. ewersii*, *Aegopodium alpestre*, *Fragaria vesca*, *Geranium collinum*, *Galium turkestanicum*, *Poa nemoralis*, *Polypodium vulgare*, *Kaufmannia semenovii*, *Rheum wittrockii*, which are forest, forest-meadow or petro-lithophilic ecological-phytocenotic elements. We studied some morphometric parameters of *H. falconeri*. The bract consists of three upper stem leaves, and the calyx, in most cases (94.5%), of six sepals. The latter parameter has a small coefficient of variation and, in our opinion, is a stable trait of this species. Due to the early and long flowering period, *H. falconeri* is of interest for introduction as an ornamental plant.

**Key words:** rare species, area, altitude, aspect, *Hepatica falconeri*, Kungey Alatau.

А.А. Ивашченко<sup>1</sup>, Р.Е. Қапарбай<sup>2,3\*</sup>, Б.Б. Арынов<sup>3</sup>,  
Н.М. Мұхитдинов<sup>2</sup>, Г. Шрамко<sup>4</sup>, К.Т. Абидулова<sup>2</sup>

<sup>1</sup>ҚР БҒМ ҒК «Зоология институты» ШЖҚ РМК, Қазақстан, Алматы қ.

<sup>2</sup>Әл-Фараби атындағы Қазақ ұлттық университеті, Қазақстан, Алматы қ.

<sup>3</sup>ҚР ЭГТРМ ОШЖДК «Көлсай көлдері» мемлекеттік ұлттық табиғи паркі РММ, Қазақстан, Алматы облысы

<sup>4</sup>Дебрецен университеті, Венгрия, Дебрецен қ.

\*e-mail: raushan.kaparbay@mail.ru

### Аймақтың солтүстік шекарасындағы *Hepatica falconeri* (Thoms.) steward таралу ерекшеліктері және биологиялық сипаттамасы

Мақалада Қызыл кітапқа енгізілген түр *Hepatica falconeri* (Thoms.) Steward (Ranunculaceae) әдеби дереккөздерді, гербарий үлгілерін, <https://www.plantarium.ru/> сайтынан алынған деректерді және жеке зерттеулерді талдау негізінде Қазақстанның оңтүстік-шығысындағы тау жоталары шегіндегі экологиялық және биіктіктегі бойынша мәліметтер берілген. Авторлардың мәліметтері зерттелетін түрдің орман-мезофильді экологиялық элемент екенін растайды. Зерттеу нәтижесінде Талды шатқалындағы (Күнгей Алатауының солтүстік макробеткей) *H. falconeri* қатысуымен өсімдік қауымдастықтарының флоралық құрамы анықталды. Ол 46 тұқымдастың 107 түрімен ұсынылған, олардың 13-і (64,5%): Asteraceae, Fabaceae, Poaceae, Rosaceae, Ranunculaceae, Apiaceae, Crassulaceae, Caryophyllaceae, Orchidaceae, Lamiaceae, Geraniaceae, Papaveraceae және Primulaceae. Сипатталған қауымдастықтардың флоралық ядросына 15 түр кіреді: *Picea schrenkiana*, *Atragene sibirica*, *Ribes meyeri*, *Lonicera stenantha*, *Rosa alberti*, *Sedum hybridum*, *S. ewersii*, *Aegopodium alpestre*, *Fragaria vesca*, *Geranium collinum*, *Galium turkestanicum*, *Poa nemoralis*, *Polypodium vulgare*, *Kaufmannia semenovii*, *Rheum wittrockii* орманды, орманды-шалғынды немесе петро-литофильді экологиялық және фитоценотикалық элементтерге жатады. *H. falconeri* кейбір

морфометриялық параметрлері нақтыланды. Сабағы 3 жоғарғы бағаналы сабақ жапырақтардан тұрады, көп жағдайда күлтежапырақтары (94.5%) – 6 жапырақтан тұрады. Соңғы индикатор вариация коэффициентінің төмен деңгейіне ие және авторлардың пікірінше, бұл түрдің тұрақты белгісі. Ерте және ұзақ гүлдену кезеңіне байланысты *H. falconeri* сәндік өсімдік ретінде енгізуге қызығушылық тудырады.

**Түйін сөздер:** сирек түр, аумақ, биіктік, аспект, *Hepatica falconeri*, Күнгей Алатау.

А.А. Ивашенко<sup>1</sup>, Р.Е. Капарбай<sup>2,3\*</sup>, Б.Б. Арынов<sup>3</sup>,  
Н.М. Мухитдинов<sup>2</sup>, Г. Шрамко<sup>4</sup>, К.Т. Абидулова<sup>2</sup>

<sup>1</sup>РГП на ПХВ «Институт зоологии» КН МОН РК, Казахстан, г. Алматы

<sup>2</sup>Казахский национальный университет имени аль-Фараби, Казахстан, г. Алматы

<sup>3</sup>РГУ «Государственный национальный природный парк «Көлсай көлдері» КЛХЖМ МЭГПР РК, Казахстан, Алматинская область

<sup>4</sup>Дебреценский университет, Венгрия, г. Дебрецен

\*e-mail: raushan.kaparbay@mail.ru

### **Особенности распространения и биологические характеристики *Hepatica falconeri* (Thoms.) steward на северной границе ареала**

В статье предоставлены уточненные сведения о распространении краснокнижного вида *Hepatica falconeri* (Thoms.) Steward (Ranunculaceae), экологической и высотной приуроченности в пределах горных хребтов юго-востока Казахстана на основе анализа литературных источников, гербарных образцов, данных с сайта <https://www.plantarium.ru/> и собственных исследований. Данные авторов подтверждают, что исследуемый вид является лесным петромезофильным экологическим элементом. В результате исследований установлен флористический состав растительные сообщества с участием *H. falconeri* в ущелье Талды (северный макросклон Күнгей Алатау). Он представлен 107 видами из 46 семейств, ведущими из которых являются 13 (64,5%): Asteraceae, Fabaceae, Poaceae, Rosaceae, Ranunculaceae, Apiaceae, Crassulaceae, Caryophyllaceae, Orchidaceae, Lamiaceae, Geraniaceae, Papaveraceae и Primulaceae. Флористическое ядро описанных сообществ включает 15 видов: *Picea schrenkiana*, *Atragene sibirica*, *Ribes meyeri*, *Lonicera stanantha*, *Rosa alberti*, *Sedum hybridum*, *S. ewersii*, *Aegopodium alpestre*, *Fragaria vesca*, *Geranium collinum*, *Galium turkestanicum*, *Poa nemoralis*, *Polypodium vulgare*, *Kaufmannia semenovii*, *Rheum wittrockii*, относящихся к лесным, лесо-луговым или петро-литофильным эколого-фитоценоотическим элементам. Уточнены некоторые морфометрические параметры *H. falconeri*. Прицветное покрывало состоит из 3 верхних стеблевых листьев, околоцветник в большинстве случаев (94.5%) – из 6 листочков. Последний показатель имеет низкий уровень коэффициента вариации и, по мнению авторов, является устойчивым признаком данного вида. В связи с ранним и продолжительным периодом цветения *H. falconeri* представляет интерес для интродукции как декоративное растение.

**Ключевые слова:** редкий вид, ареал, высота, аспект, *Hepatica falconeri*, Күнгей Алатау.

### **Introduction**

Rare plants with limited distribution ranges and low abundances are especially vulnerable to the global climate change and the constantly increasing anthropogenic impact on natural ecosystems. Their numbers are declining due to the influence of unfavourable natural or anthropogenic factors, for example, due to harvesting as medicinal raw materials or as ornamental plants. In the late 1960s, Commissions for the protection of rare species were created on an international and national scales, and then the Red Data Books of the International Union for Conservation of Nature (IUCN) and of individual countries were created. Later, in the majority of countries, including Kazakhstan, Red Books and Strategies for the conservation of

biological diversity were developed and published [1, 2].

First of all, attention should be paid to the study and protection of species of the first category, defined as “endangered: species in immediate danger of extinction; their further existence is impossible without the implementation of special protection measures” [3]. In Kazakhstan, one of such rare species listed in the Red Book of Kazakhstan (2014) is *Hepatica falconeri* (Thoms.) Steward from the family Ranunculaceae Juss. Moreover, this species has been insufficiently studied, in contrast to another representative of the genus, *Hepatica nobilis* Mill. (*H. triloba* Gilib.) which is widespread in the north of the European Russia, the Baltic States and Western Europe [4, 5, 6, 7]. Due to its high decorative qualities, *H. nobilis* has been widely cultivated since

1440 [8]. This species has also been studied in detail in natural populations, including its morphological, anatomical and biological characteristics, flowering, seed germination, pollen structure, as well as karyology; there were also comparative studies involving representatives of other genera of the family Ranunculaceae [9, 10, 11, 12, 13].

In contrast to *H. nobilis*, the information available in the literature on *H. falconeri* is fragmentary and in many cases contradictory. This applies to all species' characteristics: its distribution range in Kazakhstan, morphological features, ecological and phytocenotic preferences, phenology in nature, and the population numbers and population structure.

In this regard, the purpose of our work was a complete revision of the available literary and herbarium information on this species, verification of its distribution range in Kazakhstan, and the study of the ecological, morphological and biological features of the natural populations growing on the northern slope of the Kungey Alatau, including an assessment of their condition and development of recommendations for their improved protection. In this article, we present the first results of our research.

## Materials and Methods

The studies were carried out on the territory of the State National Natural Park (GNPP) "Kulsay kulderi" (established by the Decree of the Government of the Republic of Kazakhstan No. 88 dated February 7, 2007), in 2018–2020.

One of the methods was a route-reconnaissance survey of the territory. Field trips were carried out in the spring, summer and autumn, when, in addition to studying the general composition of the flora and monitoring of permanent plots, we purposefully searched for the populations of *H. falconeri*. The survey was carried out using existing maps of the area, as well as a GPS navigator (GPS ETREX 20, Garmin). All locations were recorded and surveyed in detail. To do so, geobotanical plots were established, the survey of which was carried out according to the generally accepted method [14]. To study the floristic composition of the communities, about 100 herbarium specimens were collected and processed. The species were identified using the main reports [15, 16, 17]. Considering that *H. falconeri* is a rare and poorly studied species, special attention was paid to the study of its morphological characteristics. For this, measurements of generative and vegetative individuals (50–100) were carried out,

and data on the morphological variability of flowers and fruits were collected (also 50–100 individuals at each point).

To verify the distribution range of *H. falconeri* in Kazakhstan, all available floristic summaries and other literary sources, as well as the herbarium of the Kazakh National University named after S. al-Farabi, the Institute of Botany and Phytointroduction (Almaty), the herbarium of the Moscow State University [18] and materials from the Plantarium website [19] were consulted.

In this article, the taxonomic affiliation of species is given according to the summary by S.A. Abdulina [20]. Statistical data processing was carried out using the Descriptive Statistics MS Excel 2007 program.

## Results and Discussion

The genus *Hepatica* Mill. belongs to a large family Ranunculaceae Juss. of the subclass Ranunculidae, which is closely related to the most ancient order of angiosperms, Magnoliidae [21]. According to the researchers who analyzed the geography of this family [22, 23], it is distinguished by a high level of generic endemism: 32% of all genera are distributed only in one specific floristic region, as reported by A.L. Takhtadzhyan [21]. The level of species endemism is even higher, about 50%, and the highest number of endemics is concentrated in the largest genera (*Aconitum*, *Delphinium*, *Aquilegia*, *Ranunculus*, etc.). It is these large genera that have been most thoroughly studied by international researchers in terms of their phylogeny and origin [24].

Thanks to the use of a variety of research methods, it was possible not only to confirm the ancient origin of the family and to clarify its taxonomic and phylogenetic structure, but also to single out individual genera as independent families, for example, Paeoniaceae, and also to prove a closer relationship with other families than was previously thought, for example Berberidaceae [25, 26]. The results of this revision were confirmed by other authors and were reflected in the system of A.L. Takhtadzhyan [21].

The genus *Hepatica* is rather small. It has only about 10 species, the ranges of which cover four floristic regions of Eurasia and North America. It is believed to have a disjunct Eurasian-North American distribution. *Hepatica* is a relatively ancient genus, being a relic of the forest temperate flora of the early Tertiary period [23, 27, 28, 29].

Among the representatives of the genus, the most widespread is *Hepatica nobilis* Gars. which grows in deciduous forests of Western Europe, the Baltic States, Ukraine and six regions of the north of European Russia [4, 5, 6, 7]. A detailed study of this polymorphic species, in the distribution range of which S.V. Yuzepchuk [52] also included the Far East region, made it possible to distinguish several independent taxa, including *H. asiatica* Nakai, *H. yamatutai* from Primorye and Japan, as well as *H. maxima* Nakai from Korea [30, 31, 32].

The best known species, *H. nobilis*, officially described by K. Linnaeus in 1753 under the name *Anemone hepatica* L., due to its extensive distribution in densely populated Europe, as well as high decorativeness (the species has been cultivated for almost 500 years [8]) has been studied in detail; however, this is not the case when *H. falconeri* is considered.

*H. falconeri* (Figure 1) was described in 1952 from Kashmir and, was originally assigned to the genus *Anemone* [51]. However, S.V. Yuzepchuk, when studying these closely related genera for the report “Flora of the USSR”, transferred it to the genus *Hepatica*, describing it as a new combination. This opinion was later adopted by both Soviet and international taxonomists who studied pollen, karyotypes, and morphology of these two closely related genera [9, 10, 23, 29, 32, 33, 34].



**Figure 1** – Mass flowering of *H. falconeri*.  
LVL Taldy Gorge, 1694 m above sea level, 15.05.2019

### Distribution area in Kazakhstan

According to the habitat type, *H. falconeri* is a Dzungar-Himalayan species; it has been found from the Tien Shan to the Himalayas, in Iran, Kashmir,

India, Pakistan, and Western China [16, 34, 35, 36, 37, 38, 39, 40]. The northern border of the distribution area is in Kazakhstan. In Kyrgyzstan, this species grows in the Fergana region, including the Alai ridge (the point of the Archaty pass was indicated by S.V. Yuzepchuk, 1937), and the Western Tien Shan [41]. In the Issykkul depression, all known locations are on the southern slope of the Kungey Alatau, the Chon-Aksu gorge [19].

In Kazakhstan, *H. falconeri* was originally recorded only in the Zailiyskiy Alatau (Tobulga-Su), where in 1884, E. Regel described a variety of the species, *H. falconeri* var. *semenovii* Regel [15, 16]. Later, it was reported from two ridges, Dzhungarsky and Zailiysky [37], Dzhungarsky and Kungei [42], Zailiysky and Ketmen [2]. Unfortunately, data on the occurrence of this rare species in specific locations of individual ridges became available only in recent years: along the Dzhungarskiy Alatau, the Kugaly gorge [43]; along the Ketmen ridge, the Hasansai gorge, near the village Kolzhat [44]. The most incomprehensible is the situation with the distribution of *H. falconeri* in the Zailiyskiy Alatau, because, apart from the above-mentioned reference by E. Regel provided in the “Flora of the USSR” and “Flora of Kazakhstan”, there are no other confirmations. A photograph of a vegetating specimen provided by I.I. Kokoreva (2007) is of a different plant (most likely, it is a rosette of *Trollius dshungarica*) [45]. A report by I.O. Baytulina et al. [46] with a reference to M.G. Popova [47] refers not to the Zailiyskiy Alatau, but to another ridge, since the author gives only one point, the Kungei Alatau, the Taldy gorge. In the collections of the Institute of Botany and Phytointroduction, there are herbarium specimens of *H. falconeri* from only two ridges (Table 1).

Thus, *H. falconeri* is most widespread, almost along the entire ridge, in Ketmentau. In 2018–2020, during the survey in the Kungey Alatau, as a result of special searches, we managed to find several isolated cenopopulations of the species studied, but only in the valley of the river Taldy. In the gorges of Saty and Kurmeta, where *H. falconeri* was recorded by S.K. Mukhtubaeva [48], we have not yet been able to find any individuals of the species.

Since this species grows locally, in separate small populations, additional research is needed, which we are continuing at the present time. Another point of growth of *H. falconeri* requires verification. This is the Tarbagatai Ridge mentioned by Czech botanists in their monograph [49]. However, we have not yet found any support for this location either in herbariums or in other literary sources.

**Table 1** – Data from herbarium specimens of *Hepatica falconeri* (Thoms.). Steward

Ridge	Collection Location	Date	Collected by
Ketmen	Kyrgyzay gorge, 5 km from Podgornoye, southeast	08.06.1970	Stepanova E.F.
	Tegermen gorge	17.06.1958	Godvinsky M.I.
	B. Murab gorge, under the rocks	05.07.1964	Roldugin I.I., Fisyun V.V.
Kungey Alatau	Taldysu pass, southern slope, rocks	01.07.1937	V.P. Goloskokov
	Merkov pass to Kyrgyzstan	02.07.1937	Gorbunova E.P.

### Ecological and phytocenotic features

The most common ecological conditions for *H. falconeri* are rocky slopes and rocks of the subalpine belt. This description of A.P. Gamayunova from “Flora of Kazakhstan” (1961) is repeated in most other literary sources [2, 42, 48], since their authors were usually familiar with this rare species because of the information available from publications and a few herbarium specimens. Unfortunately, this information concerns only some individual habitats of the species studied and does not fully reflect the features of its ecological preferences and altitudinal-belt distribution. The altitude range of the species was first mentioned by V.P. Goloskokov, who pointed out [37] that in the Dzhungarskiy Alatau, *H. falconeri* grows in cracks on rocks and stony slopes of the middle mountains. In terms of cenotic confinement, I.I. Roldugin [39], who had been researching spruce forests of the Northern Tien Shan for many years, provided the most accurate, in our opinion, ecological characterization of *H. falconeri*, assigning it to the “petromezophyton” ecomorphic group and the forest ecological-cenotic group. Later, such an extended range of altitude-ecological preferences of *H. falconeri* was confirmed in Pakistan, where it was found in forests within the altitudinal range of 1800–2800 m [40].

On the territory of SNPP “Kulsay kulderi”, in the lower part of the river valley Taldy at an altitude of 1692 m, there is the lowest in terms of altitude and, apparently, the most numerous mountainous population of this rare species in Kazakhstan. It was first reported by researchers from the Institute of Botany and the State Scientific and Production Enterprise “Kulsay kulderi” [50]. A monitoring plot was established there, where we began a more detailed study of this species in 2018.

Having analyzed all the materials on the ecological preferences of *H. falconeri* available to us, it should be emphasized that this species is distributed from the lower part of the spruce belt (1690

m) to the upper part of the subalpine belt (herbarium specimens of V.P. Goloskokov and E. Gorbunova from the passes Taldy and Merke). It grows on rocks of various steepness and exposures, clearly preferring eastern and north-eastern exposures; less often it is found on north-western and south-eastern slopes, and only single specimens are available from southern slopes (Goloskokov, herbarium). When substrate is considered, this species prefers rocks and stony slopes, sometimes it is found under spruce trees, and even less often, on soddy slopes.

The plant communities with the participation of *H. falconeri* are most often spruce forests, sparse grass associations with shrubs on rocky outcrops, or grass-forbs associations on hedged or stony slopes. According to our descriptions supplemented by literature data [48], in the valley of the river Taldy there are 107 species from 46 families. The most species rich 13 families are: Asteraceae (12 species), Fabaceae (9 species), Poaceae and Rosaceae (8 species each), Ranunculaceae (6 species), Apiaceae (5 species), Crassulaceae, Caryophyllaceae, Orchidaceae, Lamiaceae, Geraniaceae, Papaveraceae, Primulaceae (3 species each). The share of species from these families in the species list is about 64.5%. Nine families are represented by two species, and the remaining 24 families, by one species each. By the type of ecobiomorphs, herbaceous perennials prevail; there are 15 tree and shrub species, and only three annuals.

The most frequent companions of *H. falconeri* that make up the floristic core of communities with its participation are 15 species recorded in more than half of the descriptions: *Picea schrenkiana* Fisch. et C.A. Mey., *Atragene sibirica* L., *Ribes meyeri* Maxim., *Lonicera stenantha* Pojark., *Rosa alberti* Regel, *Sedum hybridum* L., *Sedum ewersii* Ledeb., *Aegopodium alpestre* Ledeb., *Fragaria vesca* L., *Geranium collinum* Steph., *Galium turkestanicum* Pobed., *Poa nemoralis* L., *Polypodium vulgare* L., *Kaufmannia semenovii* (Herd.) Regel, *Rheum wittrockii* Lundstr.



Apart from *H. falconeri*, only the last two species are listed in the Red Book of Kazakhstan (2014).

According to the ecological type, all of the floristic core species belong to the group of forest, forest-meadow, or petro-lithophilic ecological-phytocenotic elements according to I.I. Roldugin [39].

### Morphology and morphological variability

*H. falconeri* is a very rare and poorly studied plant, and the data on its morphology are limited to brief descriptions in floristic summaries [16, 36, 40, 49], which practically do not differ from the original description of T. Thomson [51] and the data provided by S.V. Yuzepchuk [52] in “Flora of the USSR”. In this regard, we consider it necessary to provide the most complete description of the generative specimens of the species studied, taking into account the available literature data and the results of our studies of the population in the Taldy gorge.

*H. falconeri* is a perennial herb with a short, fibrous rhizome, on top of which there are membranous oblong scales. There are few (3–12) leaves in the basal rosette. The petioles are long, pubescent, the plates are reniform-heart-shaped, divided into three rounded-rhombic lobes, which, in turn, are incised into 2-3 small lobes with obtuse or slightly pointed teeth. There is usually a single stalk, and only occasionally there are 2-4 stocks. The stock is thin, sinuous, slightly pubescent, usually the same length or

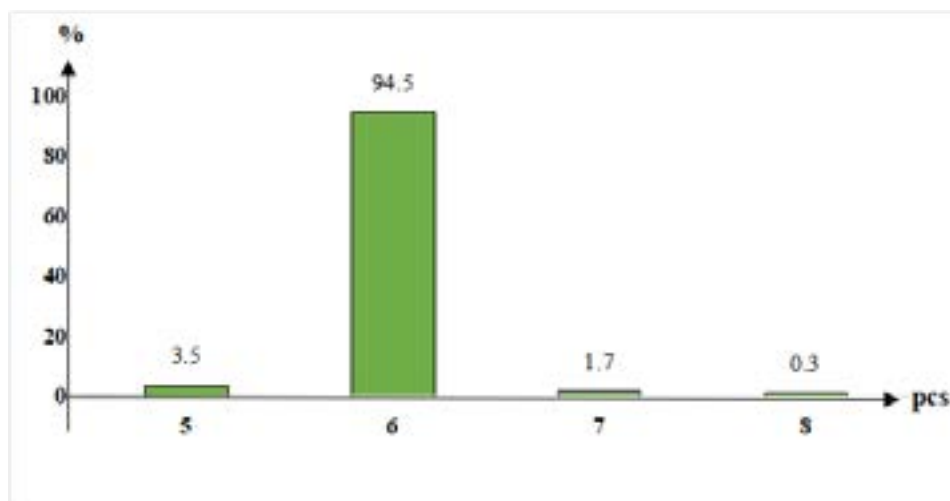
slightly longer than leaves. A characteristic feature of all representatives of the tribe Anemoneae including the *Hepatica* species is the presence of a bracts on the stem, formed by the whorls of the upper stem leaves [21, 23]. According to S.V. Yuzepchuk, the number of these leaves is 3-4, but according to our observations, there are usually three narrow sessile, entire leaves (we did not see a toothed leaf even once) [52]. Japanese botanists who studied samples of *H. falconeri* from north-eastern Pakistan indicate the shape of the veil leaves as one of the features distinguishing this species from *H. nobilis*, as well as making it similar to *Anemone flaccida* [32].

Flowers are single, bisexual, actinomorphic, with a spiral arrangement of elements, the number of which vary [21, 23]. The perianth is simple; its sepals are white, ovate-oblong in shape, with a blunt rounded apex. The data on the number of sepals are very different: for the genus, 6–10, and for *H. falconeri*, five or less often six sepals have been reported [16, 52].

We examined 400 flowers in four areas of the *H. falconeri* population on the left and right banks of the lower part of the Taldy river valley (1694–1710 m) and obtained very different data. Flowers with six sepals always predominate. On average, their share is 94.5%. In the second place (3%), there are flowers with five sepals. There are very few (1.7%) flowers with seven sepals, and only single flowers (0.3%) have eight sepals (Figures 2 and 3).



Figure 2 – Flowers of *H. falconeri* with different numbers of sepals

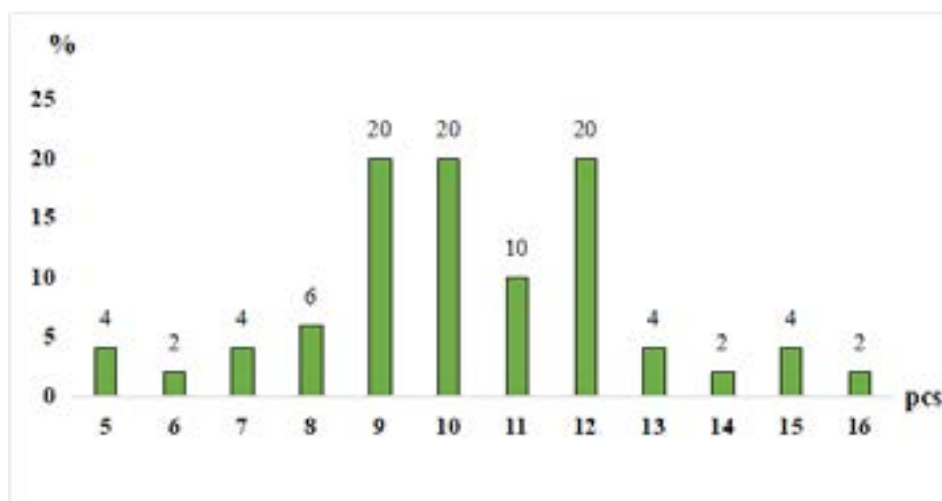


**Figure 3** – Distribution of *H. falconeri* flowers by the number of sepals, %.

Thus, for *H. falconeri*, we consider flowers with six sepals to be the norm, while flowers with a reduced or increased number of sepals (5, 7, or 8) are less common. At least, such a pattern has been established for our research area. Therefore, it is necessary to collect additional material on this subject in other points of the species distribution range.

The numbers of other elements of the flower, androecium and gynoecium, vary. The *Hepatica* fruit is a multi-nutlet consisting of non-opening single-seeded nutlets [53]. In the descriptions of the species, the number of stamens and carpels is described

as “indefinitely many”. We made an attempt to analyze this character using generative individuals in one of the most numerous cenopopulations (Taldy, eastern rubble slope, moss-and-ground elder spruce forest, 1694 m above sea level). According to the results of 50 surveys, the number of nutlets per one fruit is very variable and ranges from five to sixteen, averaging 10.04. The distribution of such individuals is uneven: from 2 to 4% of individuals have minimum (5-7) and maximum (12-16) numbers of nutlets per one fruit, while up to 10% and even 20% of individuals have 9-12 nutlets (Figure 4).



**Figure 4** – Distribution of *H. falconeri* fruits by the number of nutlets, %

Our research established that the number of flowering stems in tufts of *Hepatica falconeri* is also very variable. It is associated not only with the age of generative individuals, but also with the habitat conditions. These data were obtained when studying two cenopopulations on the right bank of the river Taldy, lower (1710 m) and upper (Tsar's Gate gorge, 1914 m). In the first cenopopulation, the number of flowering stems per one generative individual is on average  $1.68 \pm 0.16$ , and in the second,  $1.4 \pm 0.16$ .

In both habitats, individuals with one generative stem (and single flower) prevail. However, the share of stronger individuals with three or four generative

stems in the cenopopulation at the lower border of the species distribution is quite high (15.7% in total), while at the upper border the number of generative stems per individual does not exceed two. In both cases, the proportions of individuals with one generative stem were nearly the same, 57.9% and 60%, respectively.

According to our data (Table 2), one more pattern can be observed. In individuals of the upper cenopopulation (No. 2), the vegetative parts are more developed: the average number of leaves per individual is 7.9, while in individuals from the lower cenopopulation, 6.1.

**Table 2** – Morphometric characteristics of generative individuals of *Hepatica falconeri* in different cenopopulations

Indicators	Cenopopulation 1		Cenopopulation 2	
	M±m	Cv, %	M±m	Cv, %
Stem height, cm	13.80±0.51	23.93	12.90±0.57	13.89
Clump diameter, cm	4.05±0.14	21.61	4.40±0.16	11.70
	2.59±0.09	21.43	3.3±0.15	14.63
Number of leaves	6.16±0.34	33.66	7.9±0.53	21.05
Number of sepals	5.95±0.03	4.71	6.10±0.23	12.13
Number of nutlets per one fruit	10.39±0.34	23.20	No data	

At the same time, the indicators of the generative parts were lower in individuals of the upper cenopopulation. In addition to differences in the number of flowering stems, there was also a decrease in their height depending on the habitat (Table 2). It is possible that this is due not only to the difference in elevation, but also in the illumination. Both cenopopulations are located on rocks, but the lower one is on the rock with a north-western exposure, and the upper one, with an eastern exposure.

The first results of our research indicate a high morphological plasticity of *H. falconeri* and the need for a more detailed study of this issue in other populations and points of the distribution range.

One of the most important methods of preserving rare plants is their cultivation in a protected environment. In this regard, *H. falconeri* has been insufficiently studied. In Kazakhstan, the first living plants were added to the collection of the experimental site “Rock garden” of the botanical

garden of Almaty, Institute of Botany and Phytointroduction in 2017; there it still grows, blooms and bears fruit irregularly [54]. Our experiments on the cultivation of this species began in the fall of 2020 on an individual personal plot in the village Saty (1444 m). The distance from the cultivation point to the place of the species natural growth is about 30 km (Figure 5).

The survival rate of plants transferred from the Taldy gorge (1692 m) was 100%. In 2021, the growing season started on March 20, the beginning of flowering was on March 29, the massive flowering, on April 17, and the end of flowering, on May 23. The total duration of flowering was 55 days, and for one flower, from 17 (first opened, April) to 6 days (last opened, May). Post-generative vegetation continued until autumn snowfall (November). Thus, the studied species is of great interest for landscaping as an ornamental plant due to its early and long flowering (about two months) [55].





**Figure 5** – Location of points of the natural growth (1 – Taldy gorge) and cultivation (2 – village Saty).

## Conclusion

As a result of our own surveys, *H. falconeri* was found both on the northern and southern macroslopes of the Kungei Alatau. Unfortunately, in 2021, the authors failed to find this species in Kementau and Dzhungarskiy Alatau indicated in the literature and herbarium specimens, which points to the need for repeated surveys in these regions. The presence of *H. falconeri* in the Zailiyskiy Alatau raises big questions, since it has not been confirmed by any herbarium material.

The study of scattered coenopopulations of *H. falconeri* in the Taldy gorge (northern macroslope of the Kungei Alatau) confirmed that this species is a forest element and belongs to the petromesophyton ecomorph, because it grows from the lower part of the spruce belt to the upper part of the subalpine belt, preferring rocks and gravelly slopes of various steepness and exposition. The lowest mountain population of this species on the Kungey Alatau ridge was found in the lower part of the Taldy river valley (1692 m). In the same gorge, the floristic composition of plant communities with the participation of *H. falconeri* was studied in detail. It comprised 107 species from 46 families. The 13 most species-rich families (Asteraceae, Fabaceae, Poaceae, Rosaceae, Ranunculaceae, Apiaceae, Crassulaceae, Caryophyllaceae, Orchidaceae, Lamiaceae, Geraniaceae, Papaveraceae

and Primulaceae) accounted for 64.5% of all species. The composition of ecobiomorphs was dominated by herbaceous perennials (89 species), followed by tree and shrub species (15 species) and annuals (3 species). The floristic core was formed by 15 species: *Picea schrenkiana*, *Atragene sibirica*, *Ribes meyeri*, *Lonicera stenantha*, *Rosa alberti*, *Sedum hybridum*, *Sedum ewersii*, *Aegopodium alpestre*, *Fragaria vesca*, *Geranium collinum*, *Galium turkestanicum*, *Poa nemoralis*, *Polypodium vulgare*, *Kaufmannia semenovii*, *Rheum wittrockii*, which are, by ecological type, forest, forest-meadow or petro-lithophilic ecological-phytocenotic elements.

We have verified some of the morphological characteristic of *H. falconeri*. Thus, the bracts are formed by three upper sessile, entire stem leaves, and not by 3-4 toothed leaves, as reported in literary sources. In addition, the number of sepals is usually (in 94.5% of cases) six, very rarely (3%), five, and only occasionally, 7-8. It is this morphometric indicator that has a low level of the coefficient of variation and, possibly, is a stable trait for this species.

According to the results of the initial testing of *H. falconeri* in cultivation (in the village Saty), it was found that this species is of great interest for landscaping as an ornamental plant due to its early and long flowering and a long (until late autumn) period of post-generative vegetation when plants retain their decorative effect.

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