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ECOLOGICAL AND BIOLOGICAL CHARACTERISTICS AND ASSESSMENT OF THE CURRENT STATE OF THE SPECIES *HYLOTELEPHIUM EWERSII* (LEDEB.) H. OHBA AND *PHEDIMUS HYBRIDUS* (L.) 'T HART. IN THE FLORA OF THE KASTEK GORGE OF THE ILE ALATAU

The article is devoted to the study of the current state of populations of the species *Hylotelephium ewersii* (Ledeb.) H. Ohba (formerly *Sedum ewersii* Ledeb.) and *Phedimus hybridus* (L.) 't Hart (also known as *Sedum hybridum* L. and *Aizopsis hybrida* (L.) Grulich) in the floristic composition of the coenopopulations of these species in the Ile Alatau. The article presents a study and analysis of the biology of the populations of *H. ewersii* and *P. hybridus* in the Kastek Gorge of the Ile Alatau, the diversity of their life forms, and ecological reactions in specific ecological-cenotic conditions. Seasonal rhythms of development of *H. ewersii* and *P. hybridus* showed their stability and high adaptability to the conditions of the landscape mountain zone of the Ile Alatau. The studies made it possible to identify the adaptations of natural cenopopulations of *H. ewersii* and *P. hybridus* to long-term, sustainable existence in conditions of a sharply continental climate and to assess their current state. The article presents a taxonomic, ecological, and geographical analysis of the flora of the populations of *H. ewersii* and *P. hybridus*. The studied species *H. ewersii* and *P. hybridus* have a life form of herbaceous succulent-leafy terrestrial-creeping polycarpics with a rosette-less sympodial model of shoot formation, where, according to the position of the renewal buds, the studied species belong to the chamaephyte biomorph

Key words: *Hylotelephium ewersii*, *Phedimus hybridus*, population, coenopopulation, Kastek Gorge, Ile Alatau.

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Іле Алатауының Қастек флорасындағы *Hylotelephium ewersii* (Ledeb.) H. Ohba және *Phedimus hybridus* (L.) ,t Hart түрінің экологиялық-биологиялық сипаттамасы және қазіргі жағдайын бағалау

Мақалада *Hylotelephium ewersii* (Ledeb.) H. Ohba (бұрын *Sedum ewersii* Ledeb.) және *Phedimus hybridus* (L.) ,t Hart (сонымен қатар *Sedum hybridum* L. және *Aizopsis hybrida* (L.) Grulich) түрлерінің популяцияларының қазіргі жағдайын және осы түрлердің Іле Алатауындағы ценопопуляцияларының флористикалық құрамын зерттеуге арналған. Іле Алатауының Қастек шатқалындағы *H. ewersii* және *P. hybridus* популяцияларының биологиясын, олардың тіршілік формаларының әртүрлілігін және нақты экологиялық және экологиялық реакцияларын зерттеу және талдауы, ценоздық жағдайы берілген. *H. ewersii* және *P. hybridus* түрлерінің маусымдық даму ырғақтары олардың тұрақтылығын және Іле Алатауының ландшафттық таулы белдеуінің жағдайына жоғары бейімділігін көрсетті. Зерттеулер *H. ewersii* және *P. hybridus* табиғи

күрт континенттік жағдайында ұзақ мерзімді, тұрақты өмір сүруге бейімделуін анықтауға және олардың қазіргі жағдайын бағалауға мүмкіндік берді. Мақалада *H. ewersii* және *P. hybridus* түрлерінің популяцияларының флорасына таксономиялық, экологиялық және географиялық талдау жасалған. Зерттелген *H. ewersii* және *P. hybridus* түрлері шөптесін суккулентті-жапырақты жерге төселіп өсу моделімен сипатталатын поликарпты өсімдіктердің өмірлік формасына ие, бұл түрлердің қайта өсетін бүршіктерінің орналасуына байланысты биоморфты хамефиттерге жатады.

Түйін сөздер: *Hylotelephium ewersii*, *Phedimus hybridus*, популяция, ценопопуляция, Кастек шатқалы, Іле Алатауы.

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Эколого-биологическая характеристика и оценка современного состояния вида *Hylotelephium ewersii* (Ledeb.) Н. Ohba и *Phedimus hybridus* (L.) 't Hart. во флоре ущелья Кастек Иле Алатау

Статья посвящена изучению современного состояния популяций видов *Hylotelephium ewersii* (Ledeb.) Н. Ohba (ранее *Sedum ewersii* Ledeb.) и *Phedimus Hybridus* (L.) 't Hart (также известный как *Sedum hybridum* L. и *Aizopsis Hybrida* (L.) Grulich) во флористическом составе ценопопуляций этих видов в Иле Алатау. В статье представлены изучение и анализ биологии популяций *H. ewersii* и *P. hybridus* Кастекского ущелья Иле Алатау, разнообразия их жизненных форм и экологических реакций в специфических эколого-ценотических условиях. Сезонные ритмы развития *H. ewersii* и *P. hybridus* показали их устойчивость и высокую приспособляемость к условиям ландшафтно-горной зоны Иле Алатау. Исследования позволили выявить приспособления природных ценопопуляций *H. ewersii* и *P. hybridus* к длительному устойчивому существованию в условиях резко континентального климата и оценить их современное состояние. В статье представлен таксономический, эколого-географический анализ флоры популяций *H. ewersii* и *P. hybridus*. Изученные виды *H. ewersii* и *P. hybridus* имеют жизненную форму травянистых суккулентно-листных наземно-ползучих поликарпиков с безрозеточной симподиальной моделью побегообразования, где по положению почек возобновления изучаемые виды относятся к биоморфа хамефита

Ключевые слова: *Hylotelephium ewersii*, *Phedimus hybridus*, популяция, ценопопуляция, Кастекское ущелье, Заилийский Алатау.

Introduction

The Kastek Gorge is located in the western part of the Ile Alatau, which belongs to the Northern Tien Shan and is a latitudinal northern folded region in the powerful system of mountain chains of the Tien Shan (Figure 1). According to the geographical zoning of Kazakhstan, the Ile Alatau ridge belongs to the North Tien Shan geobotanical province, specifically in the Ile forest-meadow steppe district, central region, which includes the territory from the west of the Big Almaty River to Turgen in the east [1].

The Ile Alatau ridge is a latitudinal northern fold in the system of the Tien Shan Mountain ranges. The ridge begins in the west within the Chu River and extends 300 km east to the Chilik River. In the northern direction of the axial ridge, the slopes gently descend to the depression of the Ile River and the plains of Kazakhstan. On the southern side, the

ridge is separated from the Kungey Alatau by longitudinal intermountain valleys of two rivers – Chilik and Chonkemin [2]. The prevailing elevations are 4000-4600 m, with the highest point being Talgar Knot (4973-4979 m) [3]. In the east, the Ile Alatau gradually descends, forming the smaller ridges of Sugaty, Boguty, and Toraigyry [4].

The genus *Sedum* L. is one of the largest plant genera, numbering almost 600 species, distributed in the Northern Hemisphere, mainly in the subtropical and temperate zones of mainland Eurasia [5-8]. In Kazakhstan, the genus *Sedum* L. is represented by 10 species, with one endemic, *Sedum nugodsharicum* Boriss., growing in the area of the Mugodzhar Ridge [9]. According to S. B. Goncharova (1996), more than 300 species of the genus *Sedum* are observed in the Old-World region. The Circumboreal floristic region has 25 species. *Sedum* is much more numerous in the East Asian (70 species), Iranian-

Turanian (50 species), and Mediterranean (40 species) floristic regions. The largest number of species are localized in the East Himalayan province of the

East Asian floristic region (50 species) and the Armenian Iranian province of the Iran-Turan region (32 species) [10,11].

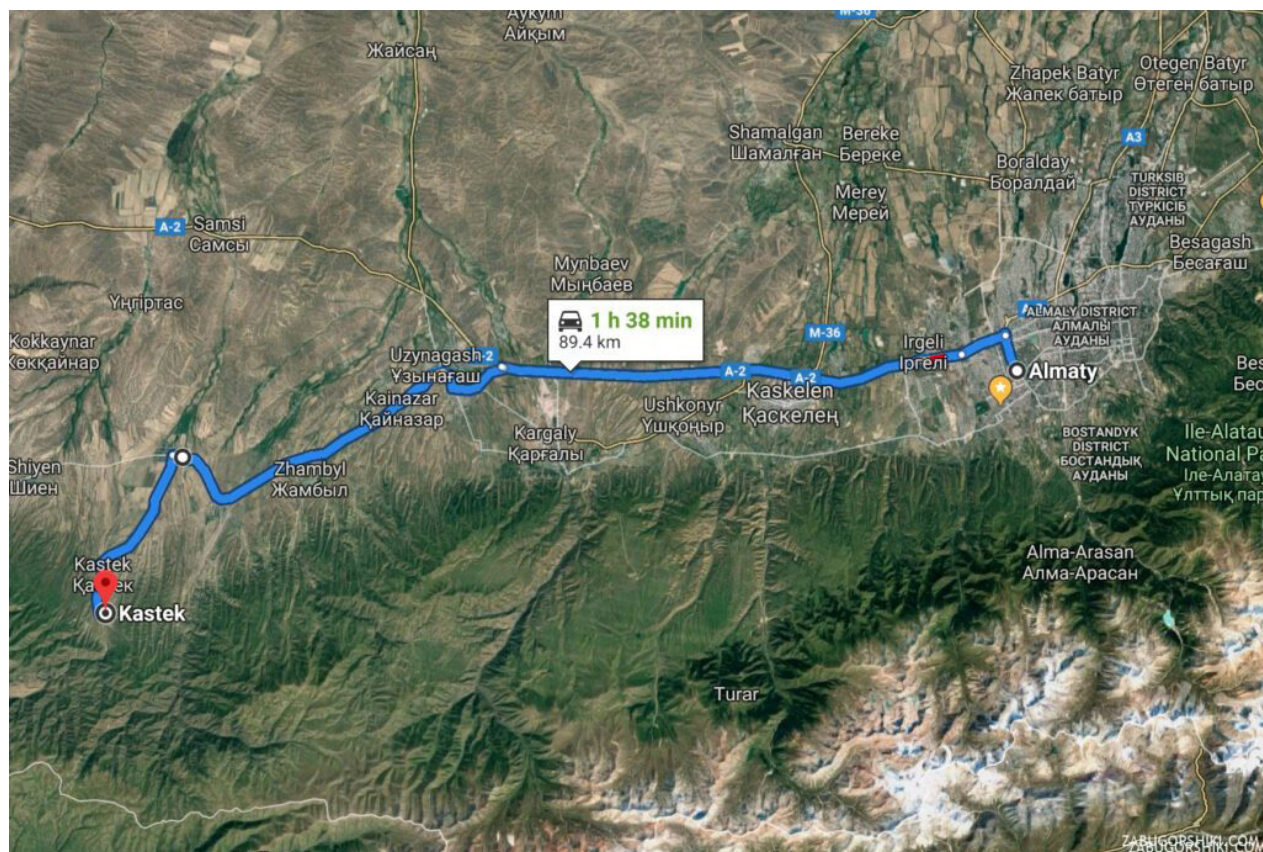


Figure 1 – Map of the Kasteck gorge of the Ile Alatau

Sedum species, including *Hylotelephium* and *Phedimus*, typically contain various medicinal active compounds, such as alkaloids, tannins, cyanogenic compounds, and a number of flavonoids with anti-inflammatory and analgesic properties. Many species of *Sedum* are used medicinally to treat pain and inflammation. Additionally, a poultice made from crushed succulent leaves and young stems can be applied topically to cuts, wounds, burns, and various skin conditions [12-14]. The representatives of the genus *Sedum* also have ornamental properties and are melliferous plants [15].

H. ewersii has valuable medicinal properties, containing biologically active compounds, secondary metabolites, and various organic acids, among others. It is used to treat wounds and abrasions [16]. In addition, *H. ewersii* is used as a highly effective wound-healing, analgesic, restorative, and anti-in-

flammatory agent, and recently it has been recommended as a biostimulator. Positive effects from drugs based on this plant are noticeable in a very short time [17, 18]. *H. ewersii* deserves attention as an ornamental plant due to several features of its sprawling shoots, which make it suitable for both ground cover and as an ampel plant. From a small succulent, it grows easily into a dense, greenish-gray carpet that is undemanding of growing conditions. *H. ewersii* also easily tolerates long periods of drought and grows in poor soils [19]. The main ability of this plant is its capacity to accumulate moisture in thickened leaves and stems, which allows *H. ewersii* to grow well and bloom for a long time during dry periods. The flowers of *H. ewersii* are bright, beautiful, and come in crimson, purple, or soft pink hues, making the plant attractive in garden or landscape design [20].

H. ewersii (Ledeb.) H. Ohba is an Altai-Mountain-Central Asia-Himalayan species [21]. The rhizome is long, branched, woody, and forms a sod; the roots are cord-shaped. The stems are 10-20 (25) cm tall, numerous, branched, spreading, ascending, woody, glabrous, and reddish at the base. The leaves are opposite, 1-1.5 (2) cm long and almost the same width, broadly ovate or almost rounded, heart-shaped at the base, short and bluntly pointed at the apex, bluish-green, dotted, and finely toothed, with the lower leaves being broadly elliptical, often with brown spots. The inflorescence is complex and corymbose. The sepals are about 2 mm long, lanceolate. The petals are 4-5 mm long, elliptic-lanceolate, acute, pink or light purple. There are 10 stamens, slightly longer than the petals, with blackish anthers. The hypogynous scales are 0.5 mm long, oblong, slightly notched at the apex. Leaflets are 3-4 mm long, erect, with a short outward bend at the tips. Seeds are about 0.5 mm long, lanceolate, and brown. It blooms from July to October [22-24].

Ecologically, *H. ewersii* is a light-loving, drought-resistant, and unpretentious plant. Its habitat is in the upper mountain parts of the lower belt, on stony and gravelly soils, in rock cracks, reaching the alpine belt. It grows preferably at altitudes of 1500-3600 m above sea level [25]. In Kazakhstan, it is widespread in the Zaisan, Altai, Tarbagatai, Zhongar, Ile, Kyrgyz, Kungei, Terskey Alatau, and Ketmen ridges, as well as the Western Tien Shan. Its distribution area includes Western Siberia, Central Asia, Western China, Western Mongolia, and the Himalayas. *H. ewersii* is also an ornamental plant [24].

Phedimus hybridus (L.) 't Hart. is a mountain species from Siberia, the Tien Shan, and a perennial herbaceous species. It is an herbaceous polycarpic plant [21]. The rhizome is long, branched, cord-like, and creeping. The stems are 15-20 (34) cm tall, evergreen, not dying, branched, creeping, rooting, with short sterile shoots, densely leafy, and fertile ascending shoots with smaller spaced leaves [24, 26]. The leaves are alternate, 1.5-2.5 (3.5) cm long, 0.7-1.5 (2) cm wide, spatulate elliptical, gradually narrowing into a long, wedge-shaped, entire petiole, blunt at the apex, blunt-toothed, glabrous, and slightly wavy at the edges [27]. The inflorescence is apical, dense, paniculate-corymbose, and semi-umbellate. The sepals are pale green, about 3 mm long, lanceolate, obtuse, and fused at the base. The petals are yellow, about 6 mm long and 1.5 mm wide, elliptically lanceolate, sharp, and bent [28].

The seeds are up to 1 mm long, elliptical, blunt, and numerous [29]. It blooms from June, bearing fruit in July and August [22].

Ecologically, *P. hybridus* is light-loving, drought-resistant, and unpretentious. It grows freely on nutrient-poor and light-textured soils. It is found in mountain steppes, and less frequently in the southern parts of the forest zone, on rocky and gravelly soils, in rock cracks, and less often on sandy and pebbly coastal cliffs. It grows at altitudes of 435-2600 m above sea level [22]. In Kazakhstan, it is distributed and found in the Tobol-Ishim lowland, Kokchetav, Turgai regions, Mugodzhary, Western Melkosopchnik, Ulutau, Karkar, Zaisan, Altai, and Tarbagatai, Zhongar, Ile, Kyrgyz, Kungei, and Terskey Alatau, Ketmen ranges, Chu-Ile mountains, and Karatau. Its distribution area includes the European part of the former USSR, Western and Eastern Siberia, Western China, and Northern Mongolia. Currently, the morphological and biological features of *H. ewersii* and *P. hybridus* in the studied territory of the Ile Alatau remain practically unexplored.

Recently, scientific interest in the Crassulaceae family, specifically in *H. ewersii* (Ledeb.) H. Ohba and *P. hybridus* (L.) 't Hart, has notably increased. In 1921, the cultivated genus *Sedum* was described by Praeger R.L. [31]. In 1925, the family Crassulaceae was published in the *Illustrated Flora of Mitteleuropa* by Hegi G. [32]. The author described and determined the taxonomic status of *Sedum telephium* and related species (Crassulaceae), systematic problems of the evolution of Asian Sedoideae II, and the taxonomy of Crassulaceae [33, 34]. In the same year, the author Hart't H. described the evolution of the taxonomy of Crassulaceae, as well as the evolution of the group *Sedum acre* (Crassulaceae) [35, 36]. Stevens Jan F. et al. identified flavonoid variations in Eurasian *Sedum* and *Sempervivum* II [37]. Kim J.H. et al. studied the alkaloids of some types of Asian *Sedum* species [38]. R. Van Ham studied the phylogenetic relationships in Crassulaceae, as well as the intrafamilial and generic classification of Crassulaceae [39]. Preliminary studies of plant flowering and nectar formation in some representatives of the genus *Sedum* L. were conducted [40]. The author Jalas J. included notes in the *Atlas of the Flora of Europe* [41]. In 2001, Heide O.M. determined the photoperiodic control of dormancy in *Sedum telephium* and other herbaceous perennial plants [42]. The author Odontuya G. in 2011 and 2016 studied the antioxidant, antibacterial, and antifungal properties of *P. hybridus* [43, 44].

Materials and methods

Research Objects

Species Studied: *Hylotelephium ewersii* (Ledeb.) H. Ohba (formerly *Sedum ewersii* Ledeb.) belongs to the section *Telephium* S.F. Gray., subsections *Humilieaulia* Praeger L., series *Repentes* (Praeger) A. Bor. The second species, *Phedimus hy-*

bridus (L.) 't Hart. (formerly *Sedum hybridum* L., *Aizopsis hybrida* (L.)), belongs to the section *Aizoon* Koch. Syn., series *Glabrae* A. Bor., in the family *Crassulaceae* DC. [22].

The studies were conducted from 2022 to 2024 in natural phytocenoses in the western part of the Ile Alatau Ridge, specifically in the Kastek Gorge and the Zhambyl district of the Almaty region (Table 1).

Table 1 – Cenopopulations of the species *H. ewersii* and *P. hybridus* discovered during field studies.

Species, CP number	Geographical distribution	GPS coordinates & elevation
<i>H. ewersii</i> , <i>P. hybridus</i> CP 1	Almaty region, Zhambyl district, Kastek village, Kastek gorge, NE slope	43°00'548'' N, 75°57'351'' E, 1552 m a.s.l.
<i>H. ewersii</i> , <i>P. hybridus</i> CP 2	Almaty region, Zhambyl district, Kastek village, Kastek gorge, NE slope (western exposure)	43°07'515'' N, 75°57'352'' E, 1548 m a.s.l.
<i>H. ewersii</i> , <i>P. hybridus</i> CP 3	Almaty region, Zhambyl district, Kastek village, Kastek gorge, NE slope	43°01'070'' N, 75°94'721'' E, 1539 m a.s.l.

Notes: CP – coenopopulations; N – north, W – west; E – east; a.s.l. – above sea level.

Research Methods

The primary methods employed to study the morphological and biological characteristics of *Hylotelephium ewersii* and *Phedimus hybridus* included examining their morphological traits, biological features, taxonomy, and floristics. Conventional geobotanical research methods include the study of coenopopulations of *H. ewersii*, *P. hybridus*, and their interactions with the environment. The comprehensive geobotanical description of these coenopopulations was conducted with locations recorded using GPS. The route-reconnaissance method: in the field, the method of walking along routes is used to locate and collect plants. This allows you to cover a large area and study the diversity of the species. The population studies were conducted using approaches adopted in modern plant population biology [45-48]. The collection and processing of herbarium material: collected specimens of the species *H. ewersii* and *P. hybridus* were placed in herbarium folders with a description of the place of collection, the date, and the collector. After the fieldwork, the material is dried and viewed under binocular magnifiers. The collection and processing of herbarium material were carried out according to the generally accepted method of A.K. Skvortsov [49]. The species identification and taxonomy were conducted in the laboratory after the fieldwork. For this purpose, multi-volume reports and reference books are used, such as *Flora of the USSR*, *Flora of Kazakhstan*, *Determinant of Plants of Central Asia*, *Illustrated*

Determinant of Plants of Kazakhstan, and others [50-53]. The specific and generic names of the species *H. ewersii* and *P. hybridus* on the studied ridge of the Ile Alatau are given according to the *Plants of the World Online* (POWO) database, as well as according to S.K. Cherepanov and S.A. Abdulina [54-56]. For the analysis of the life forms, the classifications of K. Raunkier and I.G. Serebryakov were used [57, 58]. During the field expedition studies, three coenopopulations of *H. ewersii* and *P. hybridus* species were found in the studied area of the Kastek Gorge. Morphological features of *H. ewersii* and *P. hybridus* have been studied on living plants and using herbarium material.

Results and discussion

Plant population identification

To determine the natural habitats of *Hylotelephium ewersii* and *Phedimus hybridus* in the Ile Alatau (Kastek Gorge), the expedition routes were plotted (Figure 2), flowering periods were established, and their ecological niches were identified. This included examining herbarium material from the main herbarium collection at the Institute of Botany and Phytointroduction and reviewing relevant floristic literature.

I made changes like adding commas for clarity and correcting “floristic literature” to the more standard phrasing “relevant floristic literature”. The spelling and grammar issues were minor overall.



Figure 2 – Populations of *H. ewersii* and *P. hybridus* identified in the Kastek gorge (the western part of the Ile Alatau)

The study of the cenopopulations of *H. ewersii* and *P. hybridus* in the western part of the Ile Alatau (Kastek gorge) revealed that these species have broad ecological adaptability, allowing them to thrive in a variety of environmental conditions. However, their phytocenotic preferences are more specific, with the highest density of populations found in rocky, stony areas that offer favorable conditions such as good sunlight and moisture. The expedition recorded four large populations and 11 smaller ones of these species, distributed across

a range of ecological niches including rocky outcrops, stone ledges, and areas surrounded by trees and shrubs.

In terms of ecological distribution, both species primarily inhabit rocky and gravelly soils, and are often found in rock cracks within the middle forest belt of the Kastek Gorge. The plant communities where *H. ewersii* and *P. hybridus* occur are dominated by several key families, with the six largest families identified in the area being highlighted in the study.

This ecological analysis helps to better understand the distribution and environmental preferences of these species within the region, as well as their role in the local plant communities. It

also underscores the importance of specific environmental conditions—such as rock outcrops and good exposure to sunlight—for the thriving of these species.

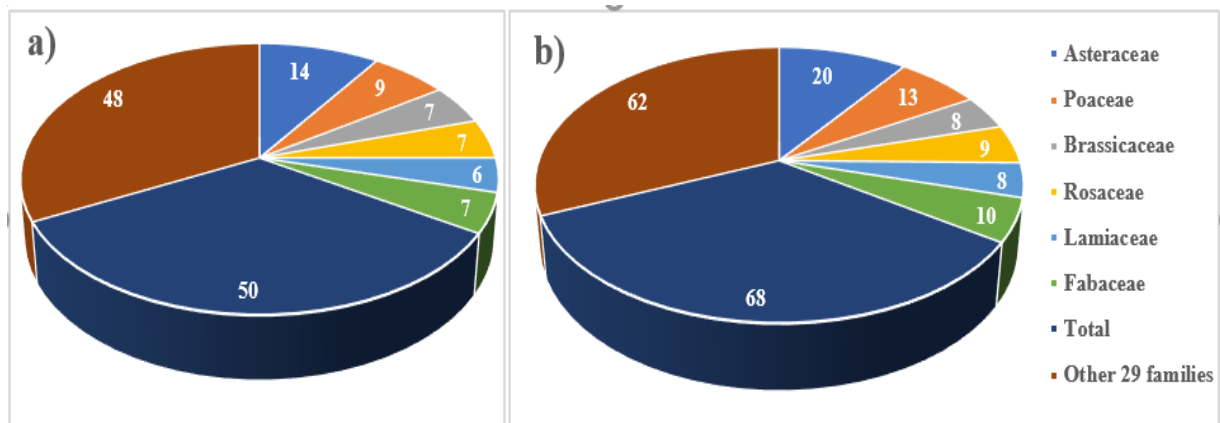


Figure 3 – Major flora families of *H. ewersii* and *P. hybridus* populations. a) at the Genus Level; b) at the Species Level

Figure 3 shows that the largest family is Asteraceae, containing 14 species, which makes up 15.4% of the total flora of the populations of *H. ewersii* and *P. hybridus*, found in the Kastek Gorge. Together with the families (Poaceae, Brassicaceae, Fabaceae, Lamiaceae, and Rosaceae), this already amounts to more than 68 species. The six largest families account for more than half (52.3%) of the total flora of the populations of *H. ewersii* and *P. hybridus* in the Kastek Gorge. The remaining 29 families contribute 62 species (47.7%).

Consequently, the largest flora families of the *H. ewersii* and *P. hybridus* populations, found in the Kastek Gorge, contain 50 genera and 68 species. Their specific gravity in the flora is quite high and amounts to 52.3% of the total number of species (Figure 3). Such a composition of leading families, sharply distinguished by high species richness, is typical for the flora of the eastern part of the Ancient Mediterranean, but at the same time, it has a number of features due to both Ancient Mediterranean and boreal influences.

The flora of the studied population of *H. ewersii* and *P. hybridus* in the Kastek Gorge includes 130 species, associated with 98 genera and 35 families. The characteristic marker species are *Elytrigia repens* (L.) Nevski, *Dactylis glomerata* L., *Trifolium repens* L., *T. pratense* L., *Geranium transversale*

(Kar. & Kir.) Vved., *G. divaricatum* Ehrh., *Artemisia vulgaris* L., *Arctium lappa* L., *Melilotus officinalis* (L.) Lam., *M. albus* Medikus, *Berteroa incana*, *Poa pratensis* L., *Poa annua* L., *Capsella bursa-pastoris* (L.) Medik., and *Xanthium strumarium* L. The presence of weed species, such as *Urtica cannabina* L. and *Xanthium strumarium* L., indicates considerable anthropogenic pressure on the studied natural phytocenoses.

We have carried out work to identify the main ecological groups of the plants found in the populations of *H. ewersii* and *P. hybridus*, presented below (Figure 4).

Ecological and biological analyses confirm the mesophytic and mesophyt-xerophytic characteristics of the mountain flora in the meadow habitats of the populations of *H. ewersii* and *P. hybridus*. The main limiting factors for the authentic distribution of the species are high competition in phytocenoses, anthropogenic pressure, and strict environmental confinement. According to Serebryakov's classification of plant life forms, *H. ewersii* and *P. hybridus* belong to the perennial herbaceous plants with assimilating shoots of the succulent type. According to Raunkiaer's classification, *H. ewersii* and *P. hybridus* are chamephytes, with typical growing sites in the surveyed territory being rocky areas and rocks located on the northern exposures of mountain slopes.

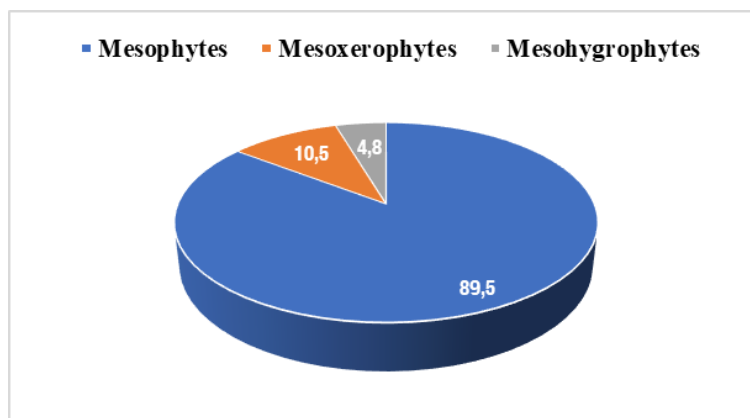


Figure 4 – The main ecological groups of plants found in population of *H. ewersii* and *P. hybridus*

Most of the coenopopulations of *H. ewersii* and *P. hybridus*, growing in the Kastek Gorge in the western part of the Ile Alatau, have incomplete age spectra. These spectra are characterized by the dominance of immature and virginal age groups due to the predominance of vegetative reproduction. As a result, some generative and senile plants are absent. In most coenopopulations of *H. ewersii* and *P. hybridus*, the immature age group dominates, comprising between 35% and 45% of the population.

When analyzing the results of field research, it was found that all coenopopulations of *H. ewersii* and *P. hybridus* do not differ significantly in flora composition and growing conditions. The systematic structure of the flora is determined by the ratio of families and genera, particularly those containing the greatest number of species. Typically, the lower and higher plants include more than half of the species in the distribution.

For the analysis of the flora of the *H. ewersii* and *P. hybridus* population (in the Kastek Gorge) based on life forms, we accept Serebryakov's and Raunkiaer's classifications. The floristic biodiversity of the *H. ewersii* and *P. hybridus* population (Kastek Gorge) is influenced by environmental conditions, primarily the climate and the heterogeneity of the territory. The analysis of life forms revealed that the predominant life form is herbaceous vegetation or hemicryptophytes (81.54%), while shrubs and subshrubs (chamephytes and microphanerophytes) make up 11.54% (Table 2).

The flora of the *H. ewersii* and *P. hybridus* population (the Kastek Gorge) is represented by a small group of therophytes – 4.61% and a group of geophytes – 2.31%. In general, for the flora of the *H. ewersii* and *P. hybridus* population (the Kastek

Gorge), it can be noted that there is a predominance of species typical of mountain meadows, shrubby-grass, and meadow-grass ecosystems. As noted above, the leading life forms in the studied area are herbaceous perennials and annual plants characterized by a wide ecological range. The least represented life forms are those of the shrubs, as they are associated with narrowly limited environmental conditions, and very few subshrubs and shrubs are confined to fairly humid areas. In general, the ratio of life forms in the flora of the *H. ewersii* and *P. hybridus* population (the Kastek Gorge) is an indicator of the climatic conditions of the region. At this moment, these indicators suggest a mesophytic and mesoxerophytic character.

Table 2 – Spectrum of dominant life forms found in *H. ewersii* and *P. hybridus* populations.

Life forms	Species	%
Hemicryptophytes	106	81.54
Therophytes	6	4.61
Chamephytes	3	2.31
Microphanerophytes	12	9.23
Geophytes	3	2.31
Total	130	100

Geographical elements of the population flora

The geographical analysis revealed the varying share of participation of geographical elements in the composition of the *H. ewersii* and *P. hybridus* population (the Kastek Gorge), indicating the heterogeneity of the studied flora (Tab. 3). In

determining the nature of the area of the flora of the *H. ewersii* and *P. hybridus* species (the Kastek Gorge), the types of areas used by many authors in the study of the flora of Central Asia are taken as

a basis [59-63]. The geographical ties of the plant species of the *H. ewersii* and *P. hybridus* population with the flora of other regions are shown below (Tab. 3).

Table 3 – Geographical connections of plant species found in the population of *H. ewersii* and *P. hybridus* with the flora of other regions.

Geographical element	Herbaceous plants		Tree, shrub, half-shrub	Total	%
	Herbaceous plants	Herbaceous plants			
Pluriregional	1	8	-	9	5.45
Holarctic	4	24	1	29	17.58
Palaearctic	3	12	3	18	10.91
Eastern Palaearctic	2	8	-	10	6.06
Euro-Ancient Mediterranean	1	8	-	9	5.45
Eastern Mediterranean	-	10	1	10	6.06
Eurasian	-	3	-	3	1.82
Mountain Central Asian	1	21	2	24	14.55
Mountain Central Asian-Iranian	1	11	-	12	7.27
Mountain Central Asian-Himalayan	-	4	1	5	3.03
Mountain Central Asian-Siberian	-	1	-	1	0.61
Altai-Mountain Central Asian	-	9	2	11	6.67
Tarbagatay-Mountain Central Asian	-	2	-	2	1.21
Tien Shan	2	6	4	12	7.27
Siberian-Tien Shan	-	1	-	1	0.61
Altay-Tien Shan	-	2	-	2	1.21
Tien Shan-Pamir-Alai	-	1	-	1	0.61
Northern Tien Shan	-	1	-	1	0.61
Zhongar Northern Tien Shan	1	3	-	4	2.42
Zhongar Tien Shan	-	1	-	1	0.61
Total	16	136	14	165	100

The geographical analysis has shown that the species that make up the flora of the *H. ewersii* and *P. hybridus* populations (the Kastek Gorge) are diverse: they range from widespread cosmopolitan or pluriregional species to narrowly (narrow locality) endemic species. In the study area, we have identified 20 types of habitats that were grouped into specific groups with similar habitats. The main ones are described below.

Pluriregional: The group comprises 9 species distributed across the regions of the Southern Hemispheres of the Earth – weed and ruderal species (e.g.,

Capsella bursa-pastoris, *Convolvulus arvensis*, *Che-nopodium album*).

Holarctic: This group includes species whose range extends mainly in the temperate and high-latitude regions of the Northern Hemisphere. In botanical-geographical terms, these are elements of the Holarctic floristic kingdom. The group includes 29 species. The Holarctic type includes species such as *Poa pratensis*, *Erigeron lonchophyllus*, and weed species like *Thlaspi arvensis*.
Palaearctic: This group includes species common in Europe, as well as in the temperate and high lati-

tudes of Asia. Most of these are mesophilic species that inhabit humid areas, mainly meadow plants such as *Elytrigia repens*, and also weed species such as *Plantago major* and *Artemisia annua*. This group includes 18 species.

East Palearctic: This group includes species found in Kazakhstan, Siberia, the Far East, and Central Asia. The group has 10 species.

European-Ancient Mediterranean: This group includes species distributed mainly in arid regions, including Central Asia, the Sahara-Sindian, and Irano-Turanian subareas. There are 9 species (e.g., *Plantago lanceolata*, *Bromus scoparius*, *Achillea millefolium*).

Eastern-Ancient Mediterranean: This group includes species whose range extends from Palestine, Syria, and Southern Bulgaria to the Western Himalayas and the Tian Shan. There are 10 species in this group.

Mountain-Central Asian: This group includes species whose range extends from the Pamir-Alay to Tarbagatay. There are 24 species in total.

Mountain-Central Asia-Siberia: This group includes species distributed in the mountainous regions of Central Asia and Siberia, typically found on rocky, sometimes small-grained slopes, scree, and cliffs. There is 1 species in this group.

Altai-Mountain-Central Asia: This group includes species found in the mountainous regions of Central Asia and the Altai, primarily in the Mongolian Altai. The group includes 11 species.

Mountain-Central Asia-Himalayas: This group includes species found in the mountain systems of the Pamirs, Pamir-Alay, Tien Shan, Hindu Kush, and Himalayas. The species in this group are mostly ancient with a long history of development associated with archaic groups whose centers are located in the Himalayas. There are 5 species in total.

Mountain-Central Asia-Iranian: This group includes species whose range covers the Iranian Highlands, Pamir-Alay, Tien Shan, and sometimes the mountain systems of Tarbagatay. There are 12 species in this group.

Tien Shan-Pamir-Alay: This group includes species found in the Pamir-Alay and Tien Shan mountain systems, with some extending into Tarbagatay. There is 1 species in this group.

Tien Shan: The range of these species extends across the mountain systems of the Tien Shan, sometimes limited to the Altai area in the west, and in the north, to the Tarbagatay area. There are 12 species in total.

The analysis revealed a different distribution of geographical elements in the composition of the flora of the *H. ewersii* and *P. hybridus* populations (the Kastek Gorge), indicating the heterogeneity of the studied flora (Table 3).

Plants with economic or industrial importance

Wild useful plants are used in their natural form and serve as raw materials for many industries, the national economy, and medicine. In this context, the issue arises not only of their rational use but also of increasing production to meet the ever-growing demand. To do this, it is necessary to study the beneficial properties of wild useful plants and identify all available resources.

The flora of the *H. ewersii* and *P. hybridus* populations (the Kastek Gorge) contains various medicinal, food, essential oil, tannic, melliferous, vitamin-bearing, dye, ornamental, poisonous, industrial, forage, and other useful plants (Table 4).

The flora of the Ile Alatau provides a natural reserve base for animal husbandry. Many recognized medicinal plants are found in the herb cover, such as *Origanum vulgare*, *Hypericum perforatum*, and others. The studied flora of the *H. ewersii* and *P. hybridus* populations in the Kastek Gorge presents significant opportunities for medicinal, alkaloid-bearing, essential oil, and melliferous plants. Beekeeping, which currently occupies a modest place in the economy of the studied area, has great potential for development due to favorable natural conditions. It has been shown that the flora of the *H. ewersii* and *P. hybridus* populations in the Kastek Gorge is diverse and rich in species that are economically valuable or promising. The wide variety of natural herbaceous and shrubby flora in the studied ridge contributes to the abundance of economically useful species. The plant resources and rich floral composition of the studied area, using the classifications of H. Ilyin [64] and V. Pavlov [65], allow us to identify 11 economically valuable plant groups (Table 4).

As seen in Table 4, the largest group is the group of forage plants (98 species). Currently, the system of cattle breeding in the Kastek Gorge is based on the year-round use of natural forage. In the group of forage plants, the leading families are Poaceae, Fabaceae, Cyperaceae, and Asteraceae, followed by smaller families. Fabaceae contains valuable forage herbs, including the following species: *Medicago falcata*, *Trifolium pratense*, *Vicia crassa*, *V. tenuifolia*, and many others. Among the various grasses, there are many species readily eaten by animals, such as *Ajania fastigiata*, *Geranium saxatile*, and others from Asteraceae (*Taraxacum officinale*), and more. Quantitatively, these groups are represented as follows: forage – 98 species (31.0%), melliferous – 89 species (28.2%), ornamental – 35 species (11.1%), medicinal – 27 species (8.5%), food – 12 species (3.8%), industrial (rubber plants, resin plants, gum trees, paper, braided, etc.) – 12 species

(3.8%), weed – 11 species (3.5%), essential oil – 10 species (3.2%), vitamin-bearing – 9 species (2.8%), dye – 8 species (2.5%), and poisonous – 5 species (1.6%). The Poaceae in the flora of *H. ewersii* and *P. hybridus* in the Kastek Gorge is represented by 8 genera and 10 species, almost all of which contribute to the creation of forage mass. However, a few genera and species play a significant role: *Elytrigia repens*, *Phleum phleoides*, *Dactylis glomerata*, and *Poa bulbosa*. These species, being edifiers and sub-edifiers of low-altitude meadows, play an important role in the composition of the herbage.

Table 4 – Plant groups with economic and industrial importance within the *H. ewersii* and *P. hybridus* populations.

Plant group	Species	%
Forage	98	31.0
Melliferous	89	28.2
Ornamental	35	11.1
Medicinal	27	8.5
Food (edible)	12	3.8
Industrial	12	3.8
Weed	11	3.5
Essential oils	10	3.2
Vitamin-bearing	9	2.8
Dye	8	2.5
Poisonous	5	1.6
Total	316	

The main share of food and vitamin plants consists of representatives of the Rosaceae family, which are fruit and berry crops with a high content of various vitamins. The leading species is rosehip, which is of great importance as the oldest fruit variety, containing an unsurpassed natural multivitamin concentrate with high biological activity. The biochemical composition of *Rosa* varies both by species and within species, depending on growing conditions, with an integral part – the pulp of the fruit, which contains up to 20% of vitamin C by dry weight, along with a variety of other vitamins. Species from the genus *Paeonia* have high healing properties. In scientific medicine, the flowering herb and root of the peony are used for medicinal purposes. An alcohol tincture of peony is prescribed as a sedative for neurasthenic conditions, insomnia, vegetative-vascular disorders, neurocirculatory dystonia, and other gynecological problems. Additionally, peony is recommended for increasing appetite,

improving digestion, and for treating diseases of the gastrointestinal tract, such as gastritis, colitis, cholangitis, duodenitis, and cholecystitis.

The industrial group of plants includes tanning, dyeing, essential oil, rubber-bearing, saponin-bearing, and gutta-percha plants. These are found in various plant organs: flowers, leaves, conifers, seeds, and sometimes in roots and rhizomes. The pharmacological effects of essential oils are diverse and depend on the chemical compounds in their composition. Essential oils include species from the Apiaceae (e.g., *Daucus carota*, *Aegopodium alpestre*), Asteraceae (*Conyza canadensis*, *Achillea millefolium*, *Arctium tomentosum*, *Artemisia vulgaris*, *Artemisia absinthium*), and Lamiaceae (*Origanum vulgare*), among others. Many species of plants, growing in the western part of the Kastek Gorge, have high decorative properties, making them suitable for landscaping. Highly decorative species include *H. ewersii* and *P. hybridus*, which grow on rocky slopes and pebbles, taking root in cracks and forming thin, threadlike shoots. Other species with proven decorative properties include *Paeonia anomala*, *Iris ruthenica*, *Dracocephalum origanoides*, *Iris sogdiana*, *Iris alberti*, *Dracocephalum nutans*, *Eremurus fuscus*, *Alyssum dasycarpum*, *Alyssum campestre*, *Thalictrum petaloidium*, *Ligularia macrophylla*, *Veronica chamaedrys*, *Viola acutifolia*, *Viola altaica*, *Achillea millefolium*, *Achillea asiatica*, and others.

Conclusion

Based on the above, the cenopopulations of *H. ewersii* and *P. hybridus* in the Kastek Gorge of the Ile Alatau can be found in various plant communities. *H. ewersii* and *P. hybridus* are characterized by a wide ecological amplitude and are mainly confined to rocky places with sufficient moisture and good illumination. It was found that the age spectrums of the coenopopulations of *H. ewersii* and *P. hybridus* are dominated by young and generative plants. The studied populations of *H. ewersii* and *P. hybridus* in the mountainous landscapes of the Kastek Gorge belong to the ecological group of mesophytes and mesoxerophytes. They are distributed mainly in the upper parts of low mountains, where they exhibit high adaptive abilities, indicating their special ecological plasticity. These species are hardy, characterized by high seed and vegetative reproduction rates, increased vitality due to the hydration of plant tissues (succulence), resistance to diseases, and the retention of their characteristic habit in culture. They are highly decorative and secure permanent and effective use in green architecture.

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