Ecologo-phytocenotic features of the cenopopulations of the rare, endemic species Iris alberti Regel in the Zailiysky Alatau (Northern Tien Shan, Kazakhstan) are considered in the monograph. Plant communities with the participation of Iris alberti and their floristic composition represented by 227 species are described. Of these, seven more: Tulipa ostrowskiana, Paeonia intermedia, Rheum wittrocki, Armeniaca vulgaris, Malus sieversii, Atraphaxis muschketowii and Euphorbia yaroslavii are included in the Red Data Book of Kazakhstan. In addition, data on the number and structure of its cenopopulations, seed productivity and anatomo-morphological characteristics of vegetative and generative organs are given

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The state of cenopopulations of a rare species, Iris alberti Regel

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Definitions and abbreviations

The following definitions and abbreviations were used in the present manuscript:
a.s.l. – above sea level
FPC – foliage projective cover
в.э – upper epidermis
н.э – lower epidermis
п.мф – palicade mesophyll
г.мф – spongy mesophyll
пр.п - vascular bundle
пд – periderm
в.к – secondary cortex
скл - sclerenhem
кс - xylem
фл - phloem
к – cambium
п – parenhem

Introduction

Conservation of biological diversity has a special place among the globally important challenges faced by our modern cvilization [1–3]. Recently, the importance of conservation of biological diversity has increased dramatically as a result of the growing anthropogenic pressure [4–6]. Populations of rare and endengared plants represent the most vulnerable part of any ecosystem; therefore monitoring of population trends has an important role in biodiversity studies and conservation activities. Many rare species are unique in terms of their biological characteristics; these species can be used in assessments of the scientific importance of protected territories. It has been shown [7] that the loss of rare species contributes to overall environmental degradation.

In Kazakhstan, the highest floristic and cenotic diversity can be found in the mountainous areas. It is not surprising that the majority of rare species also occur in the mountains. For example, out of 370 species of vascular plants listed in the Red book of Kazakhstan [8], 268 (72.8%) have been recorded in the mountainous areas, from western Tian Shan to Altai. Koltuhov et al. [9-10] studied populations of rare and endengared plants of the eastern Kazakhstan, while other researchers examined populations of rare plants of the Zailisky Alatau [11-17], where red-listed *Iris alberti* Regel is an endemic species.

In Kazakhstan, the genus *Iris* L. is represented by 19 species; three of them (*Iris alberti* Regel, *I. ludwigii* Maxim., and *I. tigridia* Bunge) are listed in the Red Book of Kazakhstan [8, 18]. One of these red-listed species, *I. alberti*, has been assigned to Category II because of the declining population size and rarety. This species is the object of our present study (Fig. 1). It is a perennial plant growing up to 40 cm tall, with creeping rhizomes. Leaves are located at the base of the stem, they are bluish in colour, oblong, lanceolate-linear, upright, up to 2.5 cm wide. The plants have a few large terminal flowers. The flowers are blue-violet with a yellow stripe; two or three of them develop on the main, and one or two, on lateral shots. Albino plants are rare. Spathes are film-like, swollen. Seedpods are nearly ball-shaped, seeds are large, brown, laterally compressed [8]. The roots contain essential oils and tannins, they are used in medicine for treatment of gastrointestinal diseases [19].

Trans-Ily Alatay (its central part and Kasteksky ridge) is the main distribution area of *I. alberti*. The plants can be found on the loess slopes of foothills, along the floors of mountain gorges and in the meadow-steppe herbaceous and shrub thickets. The plants emerge in April, the flowering period lasts from the end of April till May, and the seeds are produced in July. The species reproduces vegetatevely and by seeds. It is a valuable ornamental plant [8]. Besschetnova et al [20] described *I. alberti* as a promising species in terms of selecton, because it is one of a few wild irises that do not suffer from bacterial infections.

In the last fifty years, population numbers of *I. alberti* have declined in response to land use change, including conversiton of hill slopes to allotments and expansion of urban areas. Being highly ornamental, the species suffers from increasing levels of recreation pressure.

Figure 1. *Iris alberti.*

Globally, over 300 species of *Iris* have been described [21-23]. According to Radionenko [24-25] who excludes bulbous species, the true irises comprise not more than 200 species; many of those are used in horticulture and the pharmaceutical industry. Several species contain essential oils and xanthones which can be used in perfumery and medicine [21, 22, 26]. Some other species have attractive flowers of different colours and shades and can have ornamental applications in horticulture and landscape design [22, 27]. The irises are among the most popular ornamental herbaceous perennials. They are easy to grow, do not require cover in winter, can tolerate summer drought and can be used for multiple ornamental purposes in countries with temperate climate [20, 28]. This is why the main body of literature on irises has been focused on the uses of wild and cultivated irises in urban and rural landscaping, the ways of increasing their seed production, and on methods of generative and vegetative propagation [29].

The purpose of the presented research was to study population structure of a rare narrow endemic, *Iris alberti,* using the major characteristics of cenopopulations, such as population size, density, and age structure.

To achieve the above goal, the following tasks were set up:

1. To count the number of individuals in six cenopopulations;
2. To study the age structure of each cenopopulation;
3. To study the anatomical structure of vegetative and generative organs;
4. To characterize the condition of the studied cenopopulations using estimates of abundance and age spectrum.

The research was conducted in 2015 - 2017 in the framework of grant project 0497/GF4 "Assessment of the condition of cenopopulations of some rare, medicinal plant species of Zailiyskiy Alatau with using botanical and molecular genetic methods" of the Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan. One of the main performers of this Project was Karime Abidkulova, who is the fourth author of this monograph. Karime Abidkulova works at the Faculty of Biology and Biotechnology of Al-Farabi Kazakh National University, is author and co-author over 140 scientific publications.

1. Material and methods

There is a growing recognition of the population approach in botanical and ecological studies, because it is based not only on the visual methods, but also on several quantitative characteristics describing the development of a species within a particular plant community.

Depending on a research school, an individual plant of generative or vegetative origin (particle), a clone (i.e. an aggregate of individuals of vegetative origin), or a part of an individual plant (i.e. a phytomer, shoot, leaf, or partial clump) can be adopted as a structural unit of a cenopopulation. To identify biological characteristics of *I. alberti*, we used a detailed analysis of cenopopulations: spatial and age structure, etc. [30-35].

Morphogenesis of the species and the ontogenetic structure of the cenopopulations were studied using standard methods of research adopted in population biology following Rabotnov [36], Uranov [37] and his followers [30, 38].

For the purposes of the present study, the ontogenetic structure of a cenopopulation was defined as a relative contributions of different ontogenetic stages to the population structure as a whole. We used classifications based on the absolute maximum of an ontogenetic stage proposed by Uranov and Smirnova [39].

To describe the age structure, we used a method proposed by Uranov [40]. The following notation was used: p - seedlings and shoots; j - juveniles; im - immature individuals; v - virginal or young vegetative individuals; g^1 - young generative individuals; g^2 - medium or mature generative individuals; g^3 - old generative individuals; ss – sub-senile; s - senile; sc - dying off individuals.

To study the age structure, in each sampling area longitudinal transects were made. A total of 40 sampling plots, 1 m^2 in size each, were established at a distance of 10 to 20 m, depending on the terrain. In each sampling plot, we recorded all shoots of the studied species and marked their age group. Population density was estimated as a number of individuals per 1 m^2.

Phytocenotic and ecological characteristics of a site were defined according to the major parameters. The environmental conditions of the plant communities were studied [41, 42]. The species composition was recorded [41, 42] and life forms identified [42, 43]. Population abundance [42, 44], total numbers and foliage projective cover (FPC) were recorded in plots with the size of 1 m^2.

A starting point of a study of a rare species within a plant community is the geographical location of a site and the date of survey. Then, according to the main parameters, phytocenotic and ecological features of the habitat can be established. In our study, a primary survey of populations and a detailed description of plant communities was conducted in May, during the flowering period of the studied species. The locations of the studied populations are shown in Fig. 2.

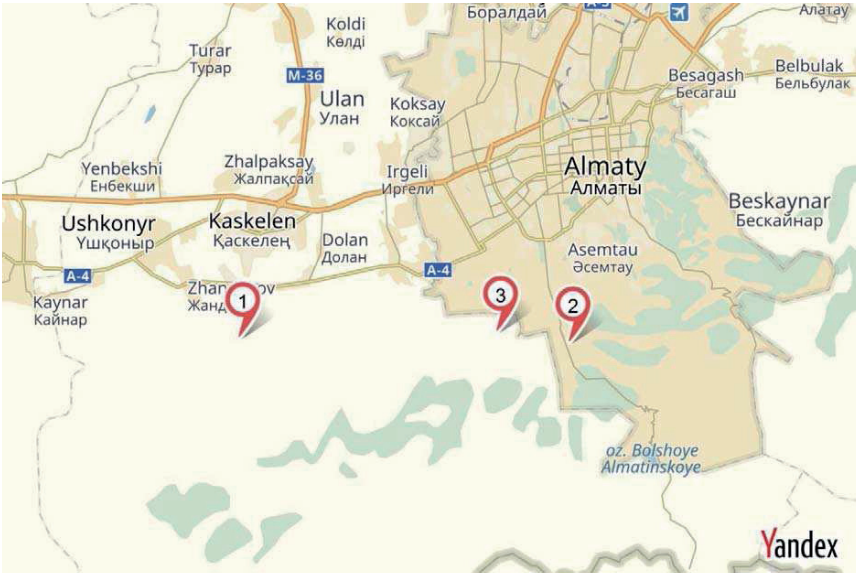


Fig.2. Map of the study area with the locations of the three studied populations marked by red circles with numbers (1 – 3).

Population 1 (P1) was located in the Kaskelen gorge, on the east-facing slope (Fig.3); population 2 (P2) was found in the Great Almaty gorge (Fig.4); and population 3 (P3), in the Oizhailau gorge (Fig.5). All populations were found on the territory of the Ile-Alatau State National Park created in the vicinity of Almaty in 1996.

Fig.3. The Kaskelen gorge.

Fig.4. The Great Almaty gorge.

Fig.5. the Oizhailau gorge.

In the course of the fieldwork, we collected herbarium material, and collected and preserved samples of underground and aboveground vegetative parts of the studied species to be used in anatomical studies. The plant material was cut into pieces ca 40 mm in size and placed in a container with a well ground glass stopper with a fixing liquid. Preservation of plants was carried out according to the Strasbourg-Fleming technique. The preservative liquid was a mixture: alcohol-glycerin-water in a ratio of 1: 1: 1.

In the laboratory, anatomical preparations were made using a microtome with a TOS-2 freezing device. Sections were encapsulated in glycerin in accordance with the methods of Prozina [45], Permyakova [46], and Barykina [47]. The thickness of the anatomical sections was 10-15 mm. We made ca 100 temporary preparations for microphotography and morphometric analysis. For quantitative analysis, the morphometric parameters were measured using the eyepiece micrometer MOV-1-15 (with x9 lens, x10.7 magnification).

Microphotographs of the anatomical sections were made on an MC300 microscope with a CAM V400/1/3m camcorder. Statistical analysis of morphometric parameters was carried out according to the method of Lakin [48] and Udolskaya [49] in Microsoft Office Excel 2007.

In the course of the study, descriptions of the internal structure of the aboveground and underground organs of the studied species were made, and a comparative study of the structure of the populations was carried out. For the purposes of the anatomical description, the conventional terminology was used [50, 51].

When studying characteristics of rare, endangered plants, it is important to determine the reproductive capacity of a given species in a specific habitat. In this case, the average seed productivity of plants is defined as the average number of seeds per individual or generative shoot, and the total productivity, as the number of seeds produced per unit area [52]. According to Rabotnov [52], Golubev and Molchanov [53], seed productivity is defined as the number of seeds per generative shoot or individual. At the same time, seed productivity can be described as potential (the number of ovules on the shoot or individual) or actual (the number of seeds per shoot or individual) productivity [54].

In the present study, taxonomic treatment of plants was adopted following Abdulina [18].

2. Description of plant communities containing *Iris alberti*

The first population of *I. alberti* was found in the herbaceous and shrub belt in the Kaskelen gorge of the Trans-Ili Alatau. Within this population, we identified two cenopopulations of *I. alberti* (further in the text referred to as CP1 and CP2). In both cenopopulations the studied species do not produce a continuous cover, but forms individual clumps on the open, sunlit south, south-east and south-west facing slopes.

CP1 was located on the south-east facing slope of the herbaceous and shrub belt at an altitude of 1187 m a.s.l. The GPS coordinates were: $43^0 07.796'$ N and $076^0 36.688'$ E. The soil type was identified as mountainous dark chestnut, the terrain was uneven with large surface stones, and the site was sloping ($35\text{-}40^0$). The vegetation cover was formed by the herbaceous and shrub association (*Spiraea hypericifolia, Rosa platyacantha, Cerasus tianschanica, Lonicera microphylla, Poa bulbosa, Carex turkestanica, Astragalus abramovii, Iris alberti*). The FPC was 75-80%. At the time of the survey, a five-layered structure of the vegetation cover was observed. The first layer, 115-150 cm tall, was formed by *Atraphaxis muschketowii, Caragana camilli-schneideri, Spiraea hypericifolia, Rosa platyacantha,* and *Lonicera microphylla*; the second layer, 50-65 cm tall, by *Euphorbia yaroslavii, Iris alberti, Phlomoides speciosa, Inula macrophylla,* and *Inula helenium*; the third layer, 30-45 cm tall, by *Cerasus tianschanica, Marrubium anisodon, Allium pallasii,* and *Phlomoides tuberosa*; the fourth layer, 15-25 cm tall, by *Poa bulbosa, Carex turkestanica, Tulipa ostrowskiana,* and *Ranunculus regelianus*; and the fifth layer, 5-10 cm tall, by *Ajania fastigiata, Nonea caspica, Gagea bulbifera, Alyssum desertotum, Ceratocephalus testiculatus,* and *Trigonella arcuate*.

The floristic composition of the site where CP1 was found was relatively species-rich; it contained 122 species of plants from two divisions, 31 families and 104 genera. The main components (i.e. the dominant herbaceous and shrub species) of the plant communities containing *I. alberti* were: *Poa bulbosa, Carex turkestanica*, *Astragalus abramovii*, *Ajania fastigiata, Artemisia santolinifolia*, *A. dracunculus*, *Spiraea hypericifolia, Caragana camilli-schneideri, Rosa platyacantha*, *Cerasus tianschanica.*

CP2 was located near CP1 at the same altitude (1187 m a.s.l.). CP2 was found on a well-warmed south-west facing slope; the site was considerably drier compared with the site of CP1. There were no large stones or boulders. The vegetation cover was formed by the herbaceous and grass association (*Poa bulbosa, Festuca valesiaca, Agropyron pectinatum, Iris alberti, Carex turkestanica*, *Phlomoides tuberosa, Ajania fastigiata, Tulipa ostrowskiana).* The FPC was 75-80%. The soil was mountainous dark-chestnut. The aspect was green.

On the site where CP2 was found, *Poa bulbosa* was dominant. *Eremurus altaicus* and *Tulipa ostrowskiana* uniformly covered the site and grew well. Annual plants were well represented, among them ephemeral plants from the families Brassicaceae, Caryophyllaceae and Boraginaceae. Within CP2, *I. alberti* formed separate clumps. The vegetation cover had four layers. The first layer, 115-140 cm tall, was formed by *Caragana camilli-schneideri* and *Spiraea hypericifolia*; the second, 50-65 cm tall, by

Eremurus altaicus, Euphorbia yaroslavii and *Iris alberti*; the third, 30-45 cm tall, by *Poa bulbosa, Marrubium anisodon* and *Phlomoides tuberosa*; and the fourth, 5-15 cm tall, by *Alyssum desertotum, Ceratocephalus testiculatus* and *Trigonella arcuate*.

The vegetation cover of this site was shorter and somewhat sparser than that of the site of CP1. The floristic composition was very similar. The only noticeable difference was the site of CP2 had fewer shrubs than the site of CP1, for instance, *Atraphaxis muschketowii* and *Rosa platyacantha* were absent.

This difference was likely due to the fact that CP2 was far away from any water sources, and that the slope was well warmed by the sun. On the site where CP2 was found, 113 species of plants from 30 families and 99 genera were identified.

Overall, the flora of the plant communities containing the first population comprised 124 species from 106 genera and 35 families. The class Gnetopsida was represented by one species, *Ephedra intermedia*, the class Magnoliopsida, by 105 species, and the class Liliopsida by 18 species (Table 1).

Table 1. The first population: Floristic composition of the plant communities.

№	Taxa
Class Gnetopsida	
I	**Family Ephedraceae Dumort.**
1	*Ephedra intermedia* Shrenk et C.A. Mey.
Class Liliopsida	
II	**Family Poaceae Barnhart**
2	*Agropyron cristatum* (L.) Beauv.
3	*Anisantha tectorum* (L.) Nevski
4	*Dactylis glomerata* L.
5	*Festuca valesiaca* Gaud.
6	*Poa angustifolia* L.
7	*Poa bulbosa* L.
8	*Stipa capillata* L.
9	*Stipa caucasica* Schmalh.
III	**Family Cyperaceae Juss.**
10	*Carex pachystylis* J. Gay
11	*Carex turkestanica* Regel
IV	**Family Alliaceae J. Agardh**
12	*Allium caesium* Schrenk
13	*Allium pallasii* Murr.
V	**Family Liliaceae Juss.**
14	*Gagea bulbifera* (Pall.) Roem. et Schult.
15	*Gagea turkestanica* Pascher
16	*Tulipa ostrowskiana* Regel
VI	**Family Asphodelaceae Juss.**
17	*Eremurus altaicus* (Pall.) Stev.
VII	**Family Ixioliriaceae Nakai**

18	*Ixiolirion tataricum* (Pall.) Herb.
VIII	**Family Iridaceae Juss.**
19	*Iris alberti* Regel
Class Magnoliopsida	
IX	**Family Cannabaceae Endl.**
20	*Cannabis ruderalis* Janisch.
X	**Family Urticaceae Juss.**
21	*Urtica dioica* L.
XI	**Family Polygonaceae Juss.**
22	*Atraphaxis muschketowii* Krasn.
23	*Polygonum aviculare* L.
XII	**Family Chenopodiaceae Vent.**
24	*Ceratocarpus utriculosus* Bluk.
25	*Chenopodium foliosum* (Moench) Aschers.
26	*Kochia prostrata* (L.) Schrad.
27	*Krascheninnikovia ceratoides* (L.) Gueldenst.
XIII	**Family Caryophyllaceae Juss.**
28	*Cerastium bungeanum* Vved.
29	*Cerastium inflatum* Link
30	*Cerastium perfoliatum* L.
31	*Dianthus hoeltzeri* C. Winkl.
32	*Holosteum umbellatum* L.
33	*Silene wallichiana* Klotzsch.
34	*Stellaria media* (L.) Vill.
XIV	**Family Ranunculaceae Juss.**
35	*Ceratocephalus testiculatus* (Crantz) Bess.
36	*Delphinium iliense* Huth
37	*Ranunculus regelianus* Ovcz.
38	*Thalictrum collinum* Wallr.
XV	**Family Papaveraceae Juss.**
39	*Papaver pavoninum* Schrenk
40	*Roemeria refracta* (Stev.) DC.
XVI	**Family Fumariaceae DC.**
41	*Corydalis ledebouriana* Kar. et Kir.
XVII	**Family Brassicaceae Burnett**
42	*Alyssum dasycarpum* Steph.
43	*Alyssum desertorum* Stapf
44	*Arabis montbretiana* Boiss.
45	*Berteroa incana* (L.) DC.
46	*Camelina microcarpa* Andrz.
47	*Capsella bursa-pastoris* (L.) Medik.
48	*Cardaria draba* (L.) Desv.
49	*Descurainia sophia* (L.) Webb ex Prantl

50	*Litwinowia tenuissima* (Pall.) Woronow ex Pavl.
51	*Sisymbrium brassiciforme* C. A. Mey.
52	*Strigosella trichocarpa* (Boiss. et Buhse) Botsch.
53	*Thlaspi arvense* L.
54	*Thlaspi perfoliatum* L.
XVIII	**Family Rosaceae Juss.**
55	*Cerasus tianschanica* Pojark.
56	*Geum urbanum* L.
57	*Potentilla orientalis* Juz. (= *P. bifurca* L.)
58	*Potentilla virgata* Lehm.
59	*Rosa alberti* Regel
60	*Rosa platyacantha* Schrenk
61	*Spiraea hypericifolia* L.
XIX	**Family Fabaceae Lindl.**
62	*Astragalus abramovii* Gontsch.
63	*Astragalus macronyx* Bunge
64	*Astragalus sieversianus* Pall.
65	*Caragana camilli-schneideri* Kom.
66	*Hedysarum montanum* (B. Fedtsch.) B. Fedtsch.
67	*Medicago falcata* L.
68	*Melilotus officinalis* (L.) Pall.
69	*Oxytropis macrocarpa* Kar. et Kir.
70	*Trifolium pratense* L.
71	*Trigonella arcuata* C. A. Mey.
72	*Vicia subvillosa* (Ledeb.) Boiss.
XX	**Family Geraniaceae Juss.**
73	*Geranium transversale* (Kar. et Kir.) Vved.
XXI	**Family Euphorbiaceae Juss.**
74	*Euphorbia glomerulans* Prokh.
75	*Euphorbia yaroslavii* Poljak.
XXII	**Family Balsaminaceae Rich.**
76	*Impatiens parviflora* DC.
XXIII	**Family Apiaceae Lindl.**
77	*Bunium setaceum* (Schrenk) H. Wolff
XXIV	**Family Convolvulaceae Juss.**
78	*Convolvulus arvensis* L.
XXV	**Family Boraginaceae Juss.**
79	*Asperugo procumbens* L.
80	*Lappula microcarpa* (Ledeb.) Gṻerke
81	*Lithospermum arvense* L.
82	*Lithospermum tenuiflorum* L. fil.
83	*Nonea caspica* (Willd.) G. Don fil.
84	*Rochelia retorta* (Pall.) Lipsky

XXVI	**Family Lamiaceae Lindl.**
85	*Dracocephalum integrifolium* Bunge
86	*Lagochilus platycalyx* Schrenk ex Fisch. et C.A. Mey.
87	*Lamium amplexicaule* L.
88	*Leonurus turkestanicus* V. Krecz. et Kuprian.
89	*Marrubium anisodon* C. Koch
90	*Phlomoides speciosa* (Rupr.) Adyl., R. Kam. et Machmedov
91	*Phlomoides tuberosa* (L.) Moench
92	*Scutellaria transiliensis* Juz.
93	*Thymus marschallianus* Willd.
94	*Ziziphora bungeana* Juz.
XXVII	**Family Solanaceae Juss.**
95	*Hyoscyamus niger* L.
XXVIII	**Family Scrophulariaceae Juss.**
96	*Rhinanthus songaricus* (Sterneck) B. Fedtsch.
97	*Scrophularia heucheriiflora* Schrenk
98	*Verbascum songoricum* Schrenk ex Fisch. et C. A. Mey.
99	*Veronica polita* Fries
XXIX	**Family Plantaginaceae Juss.**
100	*Plantago lanceolata* L.
101	*Plantago major* L.
XXX	**Family Rubiaceae Juss.**
102	*Galium aparine* L.
XXXI	**Family Caprifoliaceae Juss.**
103	*Lonicera microphylla* Willd. ex Roem. et Schult.
XXXII	**Family Valerianaceae Batsch.**
104	*Valerianella szovitsiana* Fisch. et C. A. Mey.
XXXIII	**Family Dipsacaceae Juss.**
105	*Dipsacus dipsacoides* (Kar. et Kir.) Botsch.
106	*Scabiosa micrantha* Desf.
XXXIV	**Family Campanulaceae Juss.**
107	*Campanula glomerata* L.
XXXV	**Family Asteraceae Dumort.**
108	*Acroptilon repens* (L.) DC.
109	*Ajania fastigiata* (C. Winkl.) Poljak.
110	*Arctium tomentosum* Mill.
111	*Artemisia absinthium* L
112	*Artemisia. dracunculus* L
113	*Artemisia santolinifolia* (Turcz. ex Pamp.) Krasch.
114	*Artemisia. vulgaris* L.
115	*Centaurea squarrosa* Willd.
116	*Cichorium intybus* L.
117	*Cirsium polyacanthum* Kar. et Kir.

118	*Crupina vulgaris* Cass.
119	*Inula helenium* L.
120	*Inula macrophylla* Kar. et Kir.
121	*Onopordon acanthium* L.
122	*Scorzonera pubescens* DC.
123	*Taraxacum officinale* Wigg.
124	*Tragopogon marginifolius* Pavl.

The family Asteraceae was represented by the largest number of species (17 or 13.8% of all species) and followed by Brassicaceae (13 species or 10.6%), Fabaceae (11 species or 8.9%), Lamiaceae (10 species or 8.1%), Poaceae (8 species or 6.5%), Rosaceae and Caryophyllaceae (7 species or 5.7% each), and Boraginaceae (6 species or 4.9%).

Hemicryptophytes was the most dominant life form; in the second place were terophytes, or annual and biennial plants with a short life cycle. Microphanerophytes and hamefites were represented by a relatively small number of species.

With 72 species (58.5%), mesophytes was the most dominant ecological group. They were followed by mezoxerophytes (35 species or 28.4%) and xerophytes (15 species or 12.2%). Such distribution reflects the ecological conditions of the herbaceous and shrub belt of the Kaskelen gorge of the Trans-Ili Alatau.

On the site of the first population, we found 15 groups of useful plants. Anti-erosion plants was the most species rich group represented by 90 species (73.2%). It was followed by weeds (35 species or 28.4%), medicinal plants (20 species or 16.3%) and fodder plants (19 species or 15.4%). Other groups of useful plants were represented by only a small number of species. In addition, we identified four endemic species: *Iris alberti, Atraphaxis muschketowii, Euphorbia yaroslavii,* and *Oxytropis macrocarpa*; the first three of them have been listed in the Red Book of Kazakhstan [8]. All these species are in need of further research and protection.

The second population of *Iris alberti* was found at the upper limit of the herbaceous and shrub belt of the Great Almaty gorge. Within this population, we described two cenopopulations (further in the text referred to as CP3 and CP4).

CP3 was found on the west-facing slope of the Teris-Butak gorge (1367 m a.s.l.). The GPS coordinates were: $43^{0}07.650'$ N and E $076^{0}54.751'$E. The vegetation cover was formed by plants of the herbaceous-iris-and-shrub association with occasional contribution from *Crataegus songorica*, *Rosa platyacantha, Spiraea hypericifolia, Lonicera microphylla, Iris alberti, Anisantha tectorum, Poa bulbosa, Potentilla orientalis, Eremurus altaicus, Carex turkestanica,* and *Hedysarum montanum*. The FPC was 85-90%. The soil type was identified as mountainous chernozem. The spring aspect was green.

The bright flowers of *Iris alberti* and *Eremurus altaicus* were abundant. On the site, there were many large stones and boulders, as well as some gravel. Shrubs (such as *Spiraea hypericifolia, Rosa platyacantha, Lonicera microphylla*) and *Iris alberti* formed clumps along rock crevices and around gravel and fine earth hillocks. The vegetation cover consisted of five layers. The first layer, up to 330 cm tall, was formed by *Crataegus songorica*; the second, 110-120 cm tall, by *Rosa platyacantha*, *R. alberti, Spiraea hypericifolia*; the third, 60-85 cm tall, by *Cerasus tianschanica, Melilotus officinalis*, *Lonicera microphylla*; the forth, 40-50 cm tall, by *Eremurus altaicus, Iris alberti, Verbascum songoricum*, *Artemisia dracunculus*; and the fifth, 15-30 cm tall, by *Geranium transversale*, *Poa bulbosa, Anisantha tectorum*, *Lithospermum arvense*, *Lappula microcarpa*. CP3 occupied a large area, almost the entire west-facing slope; therefore the floristic diversity of the site was relatively high and comprised 160 species of vascular plants.

CP4 was found down the gorge on a south-east facing slope in the herbaceous and shrub belt (1319 m a.s.l.). The GPS coordinates were: $43^{0}07.996'$N and 076054.153'E. The vegetation cover was formed by representatives of the iris and herbaceous association (*Geum urbanum, Ligularia macrophylla, Campanula glomerata, Dactylis glomerata, Lamium album, Iris alberti*). FPC was 75-80%. The soil type was identified as mountainous dark chestnut.

The vegetation cover consisted of five layers. The first layer, up to 200 cm tall was formed by *Crataegus songorica*; the second, 150-160 cm tall, by *Rosa platyacantha, R. alberti, Spiraea hypericifolia*; the third, 60-80 cm tall, by *Inula helenium*, *Inula macrophylla, Artemisia vulgaris*, *Cirsium polyacanthum*, *Ligularia macrophylla*; the fourth, 40-55 cm tall, by *Eremurus altaicus, Galatella coriacea*, *Dactylis glomerata*, *Aegopodium alpestre*; the fifth, 20-35 cm tall, by *Origanum vulgare*, *Artemisia dracunculus, Ajania fastigiata, Achillea millefolium*, *Lamium album*. The site was undisturbed, and the vegetation was in prime condition. The weedy annual species were nearly absent. Overall, we identified 115 species of plants, this was 45 fewer than on the site of CP3.

Overall, on the site of the second population of *Iris alberti* we identified 167 species form 135 genera and 39 families. The class Gnetopsida was represented by one species only, *Ephedra intermedia*; the class Liliopsida by 25 species, and class Magnoliopsida by 141 species (Table 2).

Table 2. The second population: Floristic composition of the plant communities present on the site.

№	Taxa
	Class Gnetopsida
I	**Family Ephedraceae Dumort.**
1	*Ephedra intermedia* Schrenk et C.A. Mey.
	Class Liliopsida
II	**Family Poaceae Barnhart**
2	*Agropyron cristatum* (L.) Beauv.
3	*Alopecurus pratensis* L.
4	*Anisantha tectorum* (L.) Nevski
5	*Bromus japonicus* Thunb.
6	*Dactylis glomerata* L.
7	*Festuca valesiaca* Gaud.
8	*Koeleria cristata* (L.) Pers.

9	*Milium vernale* M. Bieb.
10	*Phleum phleoides* (L.) Karst.
11	*Poa angustifolia* L.
12	*Poa annua* L.
13	*Poa bulbosa* L.
14	*Poa pratensis* L.
15	*Stipa capillata* L.
16	*Stipa caucasica* Schmalh.
III	**Family Cyperaceae Juss.**
17	*Carex pachystylis* J. Gay
18	*Carex turkestanica* Regel
IV	**Family Alliaceae J. Agardh**
19	*Allium caesium* Schrenk
20	*Allium pallasii* Murr.
V	**Family Liliaceae Juss.**
21	*Gagea bulbifera* (Pall.) Roem. et Schult.
22	*Gagea turkestanica* Pascher
23	*Tulipa ostrowskiana* Regel
VI	**Family Asphodelaceae Juss.**
24	*Eremurus altaicus* (Pall.) Stev.
VII	**Family Ixioliriaceae Nakai**
25	*Ixiolirion tataricum* (Pall.) Herb.
VIII	**Family Iridaceae Juss.**
26	*Iris alberti* Regel
	Class Magnoliopsida
IX	**Family Cannabaceae Endl.**
27	*Cannabis ruderalis* Janisch.
X	**Family Urticaceae Juss.**
28	*Urtica dioica* L.
XI	**Family Polygonaceae Juss.**
29	*Atraphaxis muschketowii* Krasn.
30	*Atraphaxis pyrifolia* Bunge
31	*Polygonum aviculare* L.
32	*Rumex tianschanicus* Losinsk.
XII	**Family Chenopodiaceae Vent.**
33	*Ceratocarpus utriculosus* Bluk.
34	*Chenopodium album* L.
35	*Chenopodium foliosum* (Moench) Aschers.
36	*Kochia prostrata* (L.) Schrad.
37	*Krascheninnikovia ceratoides* (L.) Gueldenst.
XIII	**Family Caryophyllaceae Juss.**
38	*Cerastium inflatum* Link.
39	*Cerastium perfoliatum* L.

40	*Dianthus hoeltzeri* C. Winkl.
41	*Holosteum umbellatum* L.
42	*Silene wallichiana* Klotzsch.
43	*Stellaria media* (L.) Vill.
XIV	**Family Ranunculaceae Juss.**
44	*Adonis aestivalis* L.
45	*Ceratocephalus testiculatus* (Crantz) Bess.
46	*Delphinium iliense* Huth
47	*Ranunculus regelianus* Ovcz.
48	*Thalictrum collinum* Wallr.
XV	**Family Papaveraceae Juss.**
49	*Chelidonium majus* L.
50	*Papaver pavoninum* Schrenk
51	*Roemeria refracta* (Stev.) DC.
XVI	**Family Fumariaceae DC.**
52	*Corydalis ledebouriana* Kar. et. Kir.
XVII	**Family Brassicaceae Burnett**
53	*Alyssum dasycarpum* Steph.
54	*Alyssum desertorum* Stapf
55	*Arabis auriculata* Lam.
56	*Arabis montbretiana* Boiss.
57	*Berteroa incana* (L.) DC.
58	*Camelina microcarpa* Andrz.
59	*Capsella bursa-pastoris* (L.) Medik.
60	*Cardamine impatiens* L.
61	*Cardaria draba* (L.) Desv.
62	*Cardaria repens* (Schrenk) Jarm.
63	*Descurainia sophia* (L.) Webb ex Prantl
64	*Erysimum diffusum* Ehrh.
65	*Litwinowia tenuissima* (Pall.) Woronow ex Pavl.
66	*Meniocus linifolius* (Steph.) DC.
67	*Neslia paniculata* (L.) Desv.
68	*Sisymbrium brassiciforme* C. A. Mey.
69	*Strigosella trichocarpa* (Boiss. et Buhse) Botsch.
70	*Turritis glabra* L.
71	*Thlaspi arvense* L.
72	*Thlaspi perfoliatum* L.
XVIII	**Family Rosaceae Juss.**
73	*Armeniaca vulgaris* Lam.
74	*Cerasus tianschanica* Pojark.
75	*Crataegus songorica* C. Koch
76	*Geum urbanum* L.
77	*Malus sieversii* (Ledeb.) M. Roem.

78	*Potentilla orientalis* Juz. (= *P. bifurca* L.)
79	*Potentilla soongarica* Bunge
80	*Potentilla virgata* Lehm.
81	*Rosa alberti* Regel
82	*Rosa platyacantha* Schrenk
83	*Spiraea hypericifolia* L.
XIX	**Family Fabaceae Lindl.**
84	*Astragalus abramovii* Gontsch.
85	*Astragalus macronyx* Bunge
86	*Astragalus sieversianus* Pall.
87	*Caragana camilli-schneideri* Kom.
88	*Glycyrrhiza uralensis* Fisch.
89	*Hedysarum montanum* (B. Fedtsch.) B. Fedtsch.
90	*Lathyrus tuberosus* L.
91	*Medicago falcata* L.
92	*Melilotus officinalis* (L.) Pall.
93	*Onobrychis arenaria* (Kit. ex Willd.) DC.
94	*Oxytropis macrocarpa* Kar. et Kir.
95	*Trifolium pratense* L.
96	*Trifolium repens* L.
97	*Trigonella arcuata* C. A. Mey.
98	*Vicia tenuifolia* Roth
99	*Vicia subvillosa* (Ledeb.) Boiss.
XX	**Family Geraniaceae Juss.**
100	*Geranium pusillum* L.
101	*Geranium transversale* (Kar. et Kir.) Vved.
XXI	**Family Euphorbiaceae Juss.**
102	*Euphorbia lamprocarpa* Prokh.
XXII	**Family Rhamnaceae Juss.**
103	*Rhamnus cathartica* L.
XXIII	**Family Malvaceae Juss.**
104	*Alcea nudiflora* (Lindl.) Boiss.
105	*Lavatera thuringiaca* L.
XXIV	**Family Balsaminaceae Rich.**
106	*Impatiens parviflora* DC.
XXV	**Family Hypericaceae Juss.**
107	*Hypericum perforatum* L.
XXVI	**Family Apiaceae Lindl.**
108	*Aegopodium tadschikorum* Schischk.
109	*Bunium setaceum* (Schrenk) H. Wolff
110	*Bupleurum aureum* Fisch.
XXVII	**Family Primulaceae Vent.**
111	*Primula algida* Adams

XXVIII	**Family Convolvulaceae Juss.**
112	*Convolvulus arvensis* L.
XXIX	**Family Boraginaceae Juss.**
113	*Arnebia decumbens* (Vent.) Coss. et Kral.
114	*Lappula microcarpa* (Ledeb.) Gǖerke
115	*Lithospermum arvense* L.
116	*Lithospermum tenuiflorum* L. fil.
117	*Nonea caspica* (Willd.) G. Don fil.
118	*Rochelia retorta* (Pall.) Lipsky
119	*Ulugbekia tschimganica* (B. Fedtsch.) Zak.
XXX	**Family Lamiaceae Lindl.**
120	*Dracocephalum integrifolium* Bunge
121	*Lagochilus platycalyx* Schrenk ex Fisch. et C. A. Mey
122	*Lamium album* L.
123	*Lamium amplexicaule* L.
124	*Leonurus turkestanicus* V. Krecz. et Kuprian.
125	*Marrubium anisodon* C. Koch
126	*Nepeta pannonica* L.
125	*Origanum vulgare* L.
126	*Phlomoides speciosa* (Rupr.) Adyl., R. Kam. et Machmedov
127	*Scutellaria transiliensis* Juz.
128	*Thymus marschallianus* Willd.
129	*Ziziphora bungeana* Juz.
XXXI	**Family Solanaceae Juss.**
130	*Hyoscyamus niger* L.
XXXII	**Family Scrophulariaceae Juss.**
131	*Rhinanthus songaricus* (Sterneck) B. Fedtsch.
132	*Scrophularia heucheriiflora* Schrenk
133	*Verbascum songoricum* Schrenk ex Fisch. et C. A. Mey.
134	*Veronica chamaedrys* L.
135	*Veronica hederifolia* L.
136	*Veronica polita* Fries
XXXIII	**Family Plantaginaceae Juss.**
137	*Plantago lanceolata* L.
XXXIV	**Family Rubiaceae Juss.**
138	*Galium aparine* L.
139	*Galium verum* L.
XXXV	**Family Caprifoliaceae Juss.**
140	*Lonicera microphylla* Willd. ex Roem. et Schult.
141	*Lonicera tatarica* L.
XXXVI	**Family Valerianaceae Batsch.**
142	*Valerianella szovitsiana* Fisch. et C. A. Mey.
XXXVII	**Family Dipsacaceae Juss.**

143	*Dipsacus dipsacoides* (Kar. et Kir.) Botsch.
144	*Scabiosa micrantha* Desf.
XXXVIII	**Family Campanulaceae Juss.**
145	*Campanula glomerata* L.
XXXIX	**Family Asteraceae Dumort.**
146	*Achillea millefolium* L.
147	*Acroptilon repens* (L.) DC.
148	*Ajania fastigiata* (C. Winkl.) Poljak.
149	*Arctium tomentosum* Mill.
150	*Artemisia absinthium* L
151	*Artemisia dracunculus* L
152	*Artemisia santolinifolia* (Turcz. ex Pamp.) Krasch.
153	*Artemisia vulgaris* L
154	*Centaurea squarrosa* Willd.
155	*Cichorium intybus* L.
156	*Cirsium polyacanthum* Kar. et Kir.
157	*Crepis sibirica* L.
158	*Galatella coriacea* Novopokr.
159	*Inula helenium* L.
160	*Inula macrophylla* Kar. et Kir.
161	*Ligularia macrophylla* (Ledeb.) DC.
162	*Onopordon acanthium* L.
163	*Scorzonera pubescens* DC.
164	*Taraxacum officinale* Wigg.
165	*Taraxacum tianschanicum* Pavl.
166	*Tragopogon marginifolius* Pavl.
167	*Tragopogon songoricus* S. Nikit.

The best represented families were Asteraceae (22 species or 13.2%), Brassicaceae (20 species or 12.0%), Fabaceae (16 species or 9.6%), Poaceae (15 species or 9.0%), Lamiaceae (12 species or 7.2%), Rosaceae (11 species 6.6%), Boraginaceae (7 species or 4.2%), Caryophyllaceae and Scrophulariaceae with 6 species each (3.6%). The share of these nine families in the total species pull was 69.0% (115 species). The remining families were represented by a relatively small number of species, five or less.

Hemicryptophytes or perennial herbaceous plants was the most abundant life form, followed by terophytes (annual and biennial plants), and microphanerophytes (shrubs and shrubs). Nanophanerophytes (trees) were represented by only four species, but they played an important role in the plant community.

With 115 species (68.9%), mesophytes was the most ecologically dominant group; they were followed by mezoxerophytes (37 species or 22.1%). Xerophytes were represented by only 15 species (9.0%). Such distribution reflected the ecological conditions of the site.

On the site of CP2, we identified 15 groups of useful plants. Anti-erosion plants represented by 128 species (76.6%) were the most abundant group. They were mostly represented by trees or shrubs, as well as by perennial herbaceous plants. In terms of anti-erosion activity, rhizomatous plants were of primary importance. Annual plants were also somewhat important in terms of erosion control. Weedy plants were the second most abundant group represented by 42 species (25.1%). The fodder, medicinal and honey plants were represented by 22, 21 and 20 species respectively. The food plants were the least abundant (12 species or 7.2%). The remaining groups were represented by only a few species. For example, essential oil plants and weeds were represented by nine species each; tannin and vitamin-containing plants, by eight species each; and oilseed plants, by four species. Spices, technical and adhesive plants were represented by one species each. It is worth mentioning that some plants have several uses. For instance, *Armeniaca vulgaris, Crataegus songorica, Cerasus tianschanica, Malus sieversii, Melilotus officinalis* can be used as food and vitamin source, as well as honey-bearing, ornamental and anti-erosion plants.

On the site of the second population of *Iris alberti* we found four rare species listed in the Red Book of Kazakhstan: *Tulipa ostrowskiana, Armeniaca vulgaris, Atraphaxis muschketowii* and *Malus sieversii* [8]. All species are in need of special protection and require monitoring of population trends.

The third population was found in the herbaceous and shrub belt in the Oizhailau gorge. The middle and bottom parts of the belt were entirely occupied by fruit orchards and summer cottages. Only along terraces, on the slopes, a thick cover of *Ligularia macrophylla* could be observed. It was interspersed with grasses, such as *Dactylis glomerata*, *Poa pratensis*, *Bromus oxyodon*, and very occasionally with *Agropyron cristatum*, *Poa relaxa*, *Calamagrostis sp*.

Herbaceous plants, such as *Ranunculus polyanthemus*, *Geum urbanum*, *Potentilla virgata*, *Cerastium bungeanum*, *Silene wallichiana*, *Delphinium iliense*, *Paeonia intermedia*, *Iris alberti* also were common. On the edges of the artificial terraces where the soil was loose, giant weeds thrived, among them *Rumex tianschanicus*, *Artemisia absinthium*, *A. vulgaris*, *A. dracunculus*, *Arctium tomentosum*, *Urtica dioica*, and *Cannabis ruderalis.* To achieve high yields of apples, these weeds are occasionally cut down. The soils were of the mountainous chernozem type, the soil structure disturbed by terrace building.

Within the third population of *Iris alberti* we identified two cenopopulations (further in the text referred to as CP5 and CP6). CP5 was located on the north-west slope of a small hill in the herbaceous and shrub belt (1442 m a.s.l.). The GPS coordinates were: $43^0 08.081^/$N and $076^0 50.771^/$E. The soil type was identified as mountainous chernozem. The terrain was sloping ($30\text{-}35^0$).

The vegetation cover was formed by the ligularia-herbaceous and grass association. The FPC was 95-100%. The vegetation cover consisted of five layers. The first layer, 110-130 cm tall, was formed by *Ligularia macrophylla, Rumex tianschanicus*; the second layer, 70-90 cm tall, by *Paeonia intermedia, Artemisia absinthium*, *A. dracunculus, Thalictrum collinum, Euphorbia lamprocarpa*; the third layer, 45-60 cm tall, by *Nepeta pannonica, Vicia tenuifolia, Iris alberti, Centaurea* *ruthenica*; the fourth layer, 30-40 cm tall, by *Potentilla virgata, Ulugbekia tschimganica, Poa relaxa*; and the fifth layer, up to 15-25 cm tall, by *Thlaspi perfoliatum, Carex turkestanica, Trifoilium pratense, Taraxacum officinale*.

Ligularia macrophylla clearly dominated the vegetation cover. The second most abundant species was *Euphorbia lamprocarpa.* The main accompanying species had relatively equal numbers. Some species occurred individually or in small groups; *Iris alberti* was one of those. The flowers of *Paeonia intermedia* and *Iris alberti* could be seen everywhere rendering the vegetation cover a particularly colorful appearance. Near the valley, where a small stream was flowing, shrub thickets (*Rosa platyacantha*, *Berberis sphaerocarpa*, *Lonicera tatarica*) and broadleaf trees (*Armeniaca vulgaris, Malus sieversii,* and *Acer semenovii*) could be observed.

CP6 was found on another hill, not far from CP5. The hill slope was facing west with an inclination of 45-50^0. The altitude was 1414 m a.s.l. The GPS coordinates were: 43^{0}08.822$^/$N, 076^{0}50.457$^/$E. The hill slope was rocky, unsuitable for cultivation; as a result the vegetation cover remained undisturbed. *Iris alberti* was growing in small groups on the open, sunlit parts of the hill slope, near the top of the hill.

The area occupied by CP6 was not large, 100-120 m long and not more than 45-50 m wide. The vegetation cover was formed by the ligularia-herbaceous association (*Euphorbia lamprocarpa, Dictamnus angustifolius, Silene wallichiana, Thalictrum collinum, Ligularia macrophylla).*The FPC was 95-100%. The soil type was identified as the mountainous chernozem. In the vegetation cover, *Ligularia macrophylla* clearly dominated. In any part of the site, this species had the largest numbers of individuals per unit area and was the most abundant. The second most abundant species was *Euphorbia lamprocarpa,* followed by *Dictamnus angustifolius.*The remaining species were more or less evenly distributed. However, the relative contribution of grasses was small, although the species composition was similar to that of CP5.

The vegetation cover consisted of four layers. The first layer, 80-100 cm tall, was formed by *Ligularia macrophylla, Euphorbia lamprocarpa, Thalictrum collinum*; the second, 60-70 cm tall, by *Iris alberti, Vicia tenuifolia, Ranunculus polyanthemus;* the third, 40-55 cm tall, by *Geum urbanum*, *Eremurus altaicus*, *Paeonia intermedia;* and the fourth, 15-35 cm tall, by *Taraxacum officinale, Potentilla orientalis, Trifolium pratense, Carex turkestanica*. The most distinctive feature of CP6 was a short and thin, passable grass cover, despite the FPC of 95-100%. This was likely due to a thin humus layer, and/or the aridity of the slope closer to the top of the hill and the presence of shallow boulder and pebble deposits.

Overall, the floristic composition of the third site was characterised by the absence of pteridophytes and gymnosperms. The vegetation cover was formed by the 165 species from 128 genera and 41 families. Twenty two species belonged to class Liliopsida, and 143, to class Magnoliopsida (Table 3).

Table 3. The third population: Floristic composition of the plant communities present on the site.

№	Taxa
	Class Liliopsida

I	**Family Poaceae Barnhart**
1.	*Agropyron cristatum* (L.) Beauv.
2.	*Brachypodium sylvaticum* (Huds.) Beauv.
3.	*Bromus oxyodon* Schrenk
4.	*Calamagrostis epigeios* (L.) Roth
5.	*Dactylis glomerata* L.
6.	*Elymus dahuricus* Turcz. ex Griseb.
7.	*Festuca valesiaca* Gaud.
8.	*Koeleria cristata* (L.) Pers.
9.	*Poa nemoralis* L.
10.	*Poa pratensis* L.
11.	*Poa relaxa* Ovcz. (= *P. versicolor* Bess.)
II	**Family Cyperaceae Juss.**
12.	*Carex polyphylla* Kar. et Kir.
13.	*Carex turkestanica* Regel
III	**Family Alliaceae J. Agardh**
14.	*Allium caesium* Schrenk
15.	*Allium coeruleum* Pall.
16.	*Allium pallasii* Murr.
IV	**Family Liliaceae Juss.**
17.	*Gagea bulbifera* (Pall.) Roem. et Schult.
18.	*Gagea turkestanica* Pasch.
19.	*Tulipa ostrowskiana* Regel
V	**Family Asphodelaceae Juss.**
20.	*Eremurus altaicus* (Pall.) Stev.
VI	**Family Ixioliriaceae Nakai**
21.	*Ixiolirion tataricum* (Pall.) Herb.
VII	**Family Iridaceae Juss.**
22.	*Iris alberti* Regel
	Class Magnoliopsida
VIII	**Family Cannabaceae Endl.**
23.	*Cannabis ruderalis* Janisch.
IX	**Family Urticaceae Juss.**
24.	*Urtica dioica* L.
X	**Family Polygonaceae Juss.**
25.	*Polygonum aviculare* L.
26.	*Polygonum coriarium* Grig.
27.	*Rheum wittrockii* Lundstr.
28.	*Rumex crispus* L.
29.	*Rumex tianschanicus* Losinsk.
XI	**Family Chenopodiaceae Vent.**
30.	*Chenopodium album* L.
XII	**Family Amaranthaceae Juss.**

31.	*Amaranthus cruentus* L.
XIII	**Family Caryophyllaceae Juss.**
32.	*Arenaria leptoclada* Guss.
33.	*Cerastium bungeanum* Vved.
34.	*Cerastium davuricum* Fisch. ex Spreng.
35.	*Cerastium inflatum* Link.
36.	*Cerastium perfoliatum* L.
37.	*Dianthus hoeltzeri* C. Winkl.
38.	*Holosteum umbellatum* L.
39.	*Melandrium viscosum* (L.) Čelak.
40.	*Silene wallichiana* Klotzsch.
41.	*Stellaria graminea* L.
XIV	**Family Ranunculaceae Juss.**
42.	*Aconitum leucostomum* Worosch.
43.	*Anemone almaatensis* Juz.
44.	*Atragene sibirica* L.
45.	*Clematis orientalis* L.
46.	*Delphinium iliense* Huth
47.	*Ranunculus polyanthemus* L.
48.	*Thalictrum collinum* Wallr.
49.	*Trollius dschungaricus* Regel
XV	**Family Paeoniaceae Rudolphi**
50.	*Paeonia intermedia* C. A. Mey.
XVI	**Family Berberidaceae Juss.**
51.	*Berberis sphaerocarpa* Kar. et Kir.
XVII	**Family Papaveraceae Juss.**
52.	*Chelidonium majus* L.
53.	*Roemeria refracta* (Stev.) DC.
XVIII	**Family Fumariaceae DC.**
54.	*Corydalis ledebouriana* Kar. et Kir.
55.	*Fumaria vaillantii* Loisel.
XIX	**Family Brassicaceae Burnett**
56.	*Alyssum turkestanicum* Regel et Schmalh.(= *A. desertorum* Stapf)
57.	*Arabis auriculata* Lam.
58.	*Berteroa incana* (L.) DC.
59.	*Camelina microcarpa* Andrz.
60.	*Capsella bursa-pastoris* (L.) Medik.
61.	*Cardamine impatiens* L.
62.	*Descurainia sophia* (L.) Webb ex Prantl
63.	*Erysimum diffusum* Ehrh.
64.	*Isatis costata* C. A. Mey.
65.	*Sisymbrium loeselii* Jusl.
66.	*Turritis glabra* L.

67.	*Thlaspi arvense* L.
68.	*Thlaspi perfoliatum* L.
XX	**Family Rosaceae Juss.**
69.	*Agrimonia asiatica* Juz.
70.	*Armeniaca vulgaris* Lam.
71.	*Cerasus tianschanica* Pojark.
72.	*Crataegus songorica* C. Koch
73.	*Geum urbanum* L.
74.	*Malus sieversii* (Ledeb.) M. Roem.
75.	*Potentilla orientalis* Juz. (= *P. bifurca* L.)
76.	*Potentilla transcaspia* Th. Wolf
77.	*Potentilla virgata* Lehm.
78.	*Rosa alberti* Regel
79.	*Rosa platyacantha* Schrenk
80.	*Rubus caesius* L.
81.	*Spiraea hypericifolia* L.
XXI	**Family Fabaceae Lindl.**
82.	*Astragalus abramovii* Gontsch.
83.	*Astragalus macronyx* Bunge
84.	*Glycyrrhiza uralensis* Fisch.
85.	*Hedysarum montanum* (B. Fedtsch.) B. Fedtsch.
86.	*Lathyrus gmelinii* (Fisch.) Fritsch
87.	*Lathyrus pisiformis* L.
88.	*Lathyrus pratensis* L.
89.	*Lathyrus tuberosus* L.
90.	*Lotus sergievskiae* R. Kam. et Kovalevsk.
91.	*Medicago falcata* L.
92.	*Medicago lupulina* L.
93.	*Melilotus officinalis* (L.) Pall.
94.	*Oxytropis macrocarpa* Kar. et Kir.
95.	*Trifolium pratense* L.
96.	*Trifolium repens* L.
97.	*Trigonella arcuata* C. A. Mey.
98.	*Vicia tenuifolia* Roth
XXII	**Family Geraniaceae Juss.**
99.	*Geranium collinum* Steph. ex Willd.
100.	*Geranium pratense* L.
101.	*Geranium rectum* Trautv.
102.	*Geranium transversale* (Kar. et Kir.) Vved.
XXIII	**Family Rutaceae Juss.**
103.	*Dictamnus angustifolius* G. Don fil. ex Sweet
XXIV	**Family Euphorbiaceae Juss.**
104.	*Euphorbia glomerulans* Prokh.

105.	*Euphorbia lamprocarpa* Prokh.
XXV	**Family Aceraceae Juss.**
106.	*Acer semenovii* Regel et Herd.
XXVI	**Family Balsaminaceae A. Rich.**
107.	*Impatiens parviflora* DC.
XXVII	**Family Rhamnaceae Juss.**
108.	*Rhamnus cathartica* L.
XXVIII	**Family Malvaceae Juss.**
109.	*Alcea nudiflora* (Lindl.) Boiss.
110.	*Lavatera thuringiaca* L.
XXIX	**Family Hypericaceae Juss.**
111.	*Hypericum hirsutum* L.
112.	*Hypericum perforatum* L.
XXX	**Family Violaceae Batsch**
113.	*Viola suavis* M. Bieb.
XXXI	**Family Apiaceae Lindl.**
114.	*Aegopodium tadschikorum* Schischk.
115.	*Bunium setaceum* (Schrenk) H. Wolff
116.	*Bupleurum aureum* Fisch.
117.	*Ferula kelleri* K.-Pol.
118.	*Seseli schrenkianum* (C. A. Mey. ex Schischk.) M. Pimen. et Sdobnina
XXXII	**Family Boraginaceae Juss.**
119.	*Echium vulgare* L.
120.	*Lappula microcarpa* (Ledeb.) Gṻerke
121.	*Lithospermum arvense* L.
122.	*Lithospermum officinale* L.
123.	*Lithospermum tenuiflorum* L. fil.
124.	*Nonea caspica* (Willd.) G. Don fil.
125.	*Rochelia retorta* (Pall.) Lipsky
126.	*Ulugbekia tschimganica* (B. Fedtsch.) Zak.
XXXIII	**Family Lamiaceae Lindl.**
127.	*Betonica foliosa* Rupr.
128.	*Dracocephalum integrifolium* Bunge
129.	*Leonurus turkestanicus* V. Krecz. et Kuprian.
130.	*Marrubium anisodon* C. Koch
131.	*Nepeta pannonica* L.
132.	*Origanum vulgare* L.
133.	*Phlomoides tuberosa* (L.) Moench
134.	*Thymus marschallianus* Willd.
XXXIV	**Family Solanaceae Juss.**
135.	*Hyoscyamus niger* L.
XXXV	**Family Scrophulariaceae Juss.**
136.	*Veronica polita* Fries

137.	*Veronica spuria* L.
XXXVI	**Family Plantaginaceae Juss.**
138.	*Plantago major* L.
XXXVII	**Сем. Rubiaceae Juss.**
139.	*Galium aparine* L.
140.	*Galium turkestanicum* Pobed.
XXXVIII	**Сем. Caprifoliaceae Juss.**
141.	*Lonicara tatarica* L.
XXXIX	**Family Dipsacaceae Juss.**
142.	*Dipsacus dipsacoides* (Kar. et Kir.) Botsch.
XL	**Family Campanulaceae Juss.**
143.	*Campanula glomerata* L.
XLI	**Family Asteraceae Dumort.**
144.	*Achillea millefolium* L.
145.	*Acroptilon repens* (L.) DC.
146.	*Ajania fastigiata* (C. Winkl.) Poljak.
147.	*Arctium tomentosum* Mill.
148.	*Artemisia absinthium* L.
149.	*Artemisia dracunculus* L.
150.	*Artemisia rutifolia* Steph. ex Spreng.
151.	*Artemisia santolinifolia* (Turcz. ex Pamp.) Krasch.
152.	*Artemisia vulgaris* L.
153.	*Centaurea ruthenica* Lam.
154.	*Centaurea squarrosa* Willd.
155.	*Cichorium intybus* L.
156.	*Cirsium polyacanthum* Kar. et Kir.
157.	*Cirsium vulgare* (Savi) Ten.
158.	*Crepis sibirica* L.
159.	*Echinops chantavicus* Trautv.
160.	*Galatella coriacea* Novopokr.
161.	*Inula helenium* L.
162.	*Ligularia macrophylla* (Ledeb.) DC.
163.	*Onopordon acanthium* L.
164.	*Saussurea elegans* Ledeb.
165.	*Taraxacum officinale* Wigg.

Asteraceae represented by 22 species (13.3%) was the most species rich family followed by Fabaceae (17 species or 10.3%), Brassicaceae and Rosaceae (13 species or 7.9% each), Poaceae (11 species or 6.7%), Caryophyllaceae (10 species or 6.1%), Ranunculaceae, Boraginaceae and Lamiaceae (8 species or 4.8% each).

As it was the case in the earlier described populations, hemicryptophytes, or perennial herbaceous plants, were the most dominant life form. Terophytes (annual or biannual plants) were in the second place. Macrophanerophytes (shrubs) were represented by eight species. Among them, larger shrubs were particularly noticeable; for example, *Rosa platyacantha* occupied a large area and played an important role in the formation of the vegetation cover. Nanophanerophytes (trees) were represented by four species sparsely distributed on the hill slopes; their role in the formation of the vegetation cover was not substantial.

Of all ecological groups, mesophytes represented by 131 species (79.4%) were dominant; they were followed by mesoxerophytes represented by 30 species (18.2%). The typical xerophytes were represented by only four species (2.4%). The relative contribution of different life forms and ecologically types was representative of the current state of the herbaceous and shrub belt of the Trans-Ily Alatau.

On the site where the third population was found, we identified 19 groups of useful plants. Anti-erosion plants were the most abundant group (106 species or 64.2% of all flora). This group mostly consisted of trees, shrubs and perennial grasses. It was followed by weeds represented by 45 species (27.3%). This was not surprising; the herbaceous and shrub belt of the Oizhailau gorge was located in the vicinity of Almaty and surrounding villages. The belt was exposed to human activity; the lower part of the belt was occupied by fruit orchards, and the less suitable for agriculture areas, by summer cottages and allotments. The upper part of the belt was used as a summer pasture and had a high concentration of cattle. As a result, the soil and vegetation of this belt were disturbed and saturated by weedy plants. In the third place there were fodder plants represented by 23 species (13.9%). These species were the most suitable for grazing. In addition, there were 10-15 moderately suitable for grazing species; about the same number of species were not suitable for grazing and would be consumed only in the absence of more palatable species.

The species that were not suitable for grazing were mostly represented by weeds. Medicinal plants represented by 25 species (15.1%) were in the fourth place; they were followed by ornamental (20 species or 12.1%); edible (18 species or 10.9%); honey-bearing (17 species or 10.3%); poisonous (13 species or 7.9%); sources of dyes (11 species or 6.7%); sources of essential oils (10 species 6.1%); and tanning (9 species) plants.

The remaining groups of useful plants were represented by a small number of species. Among them, food plants such as *Malus sieversii, Armeniaca vulgaris, Cerasus tianschanica,* and *Rubus caesius* occupied a special place. Plants that could be used as sources of vitamins, e.g. *Rosa alberti, R. platyacantha, Crataegus songorica*, are worth mentioning. Some plants had multiple uses, among them *Malus sieversii, Armeniaca vulgaris, Cerasus tianschanica, Melilotus officinalis*; these species could be used as food, sources of vitamins, honey-bearing plants, as well as for ornamental purposes.

On the site where the third population was found, we identified five rare species listed in the Red Book of Kazakhstan [8]: *Tulipa ostrowskiana, Paeonia intermedia, Rheum wittrocki, Armeniaca vulgaris, Malus sieversii*. These species are in need of protection and monitoring of population trends.

Overall, the plant communities where all six described cenopopulations were found comprised 227 species from 165 genera and 45 families.

Nine families were represented by ten or more species, among them Asteraceae (28), Brassicaceae (22), Poaceae and Fabaceae (21 species each), Rosaceae and Lamiaceae (14 species each), Caryophyllaceae and Ranunculaceae (11 species each), and Boraginaceae (10). The plants listed in the Red Book of Kazakhstan are of particular interest [8]. In addition to the studied species, *Iris alberti*, we found seven red-listed species: *Tulipa ostrowskiana, Paeonia intermedia, Rheum wittrocki, Armeniaca vulgaris, Malus sieversii, Atraphaxis muschketowii* и *Euphorbia yaroslavii.* Many of them have not been studied in detail; therefore further population studies are necessary in addition to conservation actions and monitoring of population trends.

3. Population numbers and structure

We identified and described three populations and six cenopopulations of *Iris alberti* within its distribution area (Fig. 2). All populations were located on the northern slope of the central part of the Trans-Ily Alatau, on the territory of the Ile-Alatau National Park. The first population was found in the Kaskelen gorge (CP1 and CP2), the second, in the Great Almaty gorge (CP3 and CP4), and the third, in the Oizhailau gorge (CP5 and CP6). Characteristics of the studies cenopopulations are provided in Table 4.

Table 4. Ecological and cenotic characteristics of the cenopopulations (CP)

Population	CP	Location, soil type, GPS coordinates	Association	Dominant species	FPC
1	1	The Kaskelen gorge. South-east facing slope, inclination of 35-40^0 Soils are mountainous dark-chestnut, with large stones. GPS coordinates: N 43^{0}07.796$'$, E 076^{0}36.688$'$, 1187 m a.s.l.	Herbaceous and bush	*Spiraea hypericifolia, Rosa platyacantha, Cerasus tianschanica, Lonicera microphylla Poa bulbosa, Carex turkestanica, Astragalus abramovii, Iris alberti*	75-80%.
	2	The Kaskelen gorge. South-facing slope, inclination 35-40^0 Soils are mountainous dark-chestnut without stones. GPS coordinates: N 43^{0}07.732$'$, E 076^{0}36.633$'$, 1187 m a.s.l.	Herbaceous and grass	*Poa bulbosa, Festuca valesiaca, Agropyron pectinatum, Iris alberti, Carex turkestanica, Phlomoides tuberosa, Ajania fastigiata, Tulipa ostrowskiana*	75-80%

2	3	The Great Almaty gorge, the right-hand bank of the river Teris-Butak. West-facing slope, inclination 45-50^0. Soils are mountainous dark-chestnut with large rocks, rocky protrusions and patches of stony talus. GPS coordinates: N $43^0 07.650'$, E $076^0 54.751'$, 1367 m a.s.l.	Herbaceous – iris – and bush with occasional hawthorn plants	*Rosa platyacantha, Spiraea hypericifolia, Lonicera microphylla, Iris alberti, Anisantha tectorum, Poa bulbosa, Potentilla orientalis, Eremurus altaicus, Carex turkestanica, Hedysarum montanum*	85-90 %
	4	The Great Almaty gorge, left-hand side of the river B. Almatinka. South-east facing slope, inclination 35-40^0. Soils are mountainous dark-chestnut. GPS coordinates: N$43^0 07.996'$, E$076^0 54.153'$, 1319 m a.s.l.	Iris and herbaceous	*Geum urbanum, Ligularia macrophylla, Campanula glomerata, Dactylis glomerata, Lamium album, Iris alberti*	75-80%
3	5	The Oizhailau gorge. North-west facing slope, inclination 35-40^0. Soils are mountainous chernozem. GPS coordinates: N $43^0 08.081'$, E $076^0 50.771'$, 1442 m a.s.l.	Mouse-ear chickweed, herbaceous and grass	*Dactylis glomerata, Poa pratensis, Cerastium davuricum, Silene wallichiana, Delphinium iliense, Ligularia macrophylla*	95-100 %
	6	The Oizhailau gorge. West slope, inclination 45-50^0. Soils are mountainous	Mouse-ear chickweed, herbaceous	*Euphorbia lamprocarpa, Dictamnus angustifolius,*	95-100 %

		chernozem. GPS coordinates: N $43^{0}08.822'$, E $076^{0}50.457'$, 1414 m a.s.l.		*Silene wallichiana, Thalictrum collinum, Ligularia macrophylla*	

In all cenopopulations, we studied morphological characters of *Iris alberti*. Biometric characters of generative and mature vegetative shoots are provided in Tables 5 and 6. Because *Iris alberti* is a rhizome-forming species, it is nearly impossible to distinguish individual plants. Therefore we counted generative and mature vegetative shoots separately [53].

The morphometric parameters of the mature generative shoots from different sites were largely similar (Table 5). Leaf counts were in the range 5-7; the average leaf length was in the range 35.4 – 55.1 cm, and width, 2.5 – 3.5 cm.

Table 5. Morphological characters of mature vegetative shoots.

CP	Number of leaves	Average leaf size, cm	
		Length	Width
1	7,0±0,3	41,0±0,6	2,9±0,04
2	6,3±0,2	39,4±0,6	3,0±0,05
3	6,1±0,1	38,0±0,4	3,0±0,05
4	5,6±0,1	35,4±0,7	2,5±0,05
5	6,8±0,2	51,5±1,4	3,3±0,1
6	6,9±0,3	55,1±1,4	3,5±0,1

The differences between cenopopulations are also presented in Fig.6; the largest shoots were observed in CP3 (Oizhailau) where the soils were more fertile.

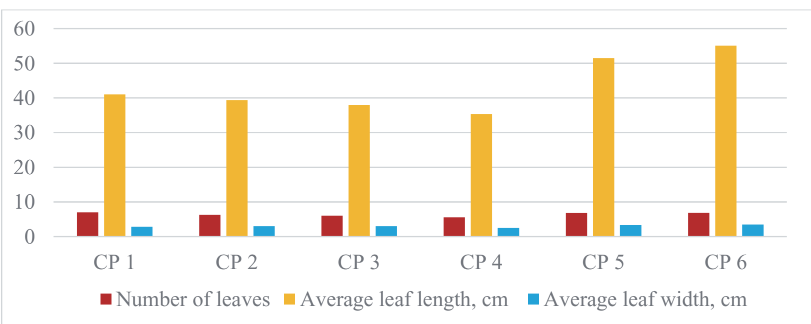


Fig. 6. Morphometric characters of mature vegetative shoots: leaf counts; average leaf length, cm; average leaf width, cm.

Morphometric characters of generative shoots from different sites were also similar (Table 6, Fig. 7). Leaf counts were 14 – 17, the average leaf length, 41.2 – 58.5 cm; the average leaf width, 2.7 – 3.5 cm; the length of flowering shoots, 45.1 – 53.5 cm; and the number of flowers, 4 – 5.

Table 6. Morphological characters of generative shoots.

CP	Number of leaves	Average leaf size		Shoot size, cm	Number of flowers per shoot
		Length, cm	Width, cm		
1	15,6±0,5	44,2±0,9	2,7±0,1	47,1±1,3	4,8±0,2
2	15,8±0,7	41,6±1,1	3,1±0,1	45,1±1,1	4,5±0,2
3	17,1±0,9	41,2±1,1	3,2±0,1	47,9±1,4	5,0±0,2
4	14,0±0,5	44,9±1,0	3,0±0,1	48,4±1,8	4,9±0,2
5	15,1±0,8	58,5±1,6	3,4±1,2	52,8±1,6	4,7±0,2
6	13,2±1,0	55,4±2,1	3,5±0,1	53,5±2,2	5,0±0,4

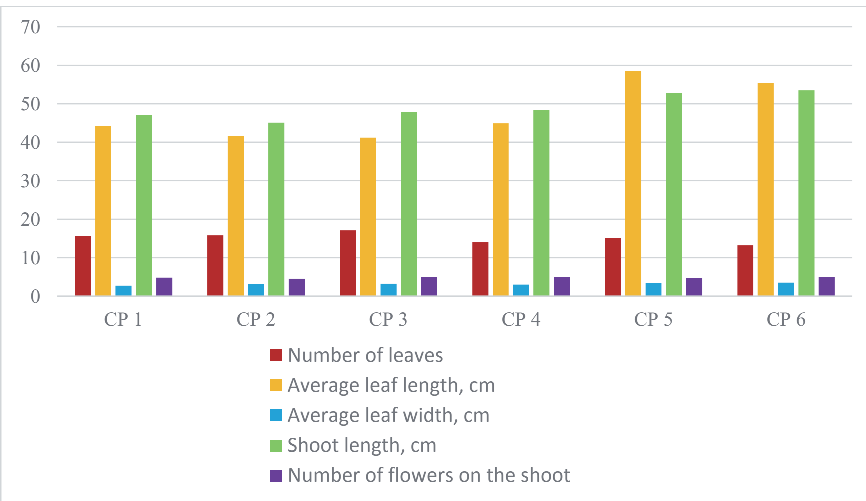


Fig. 7. Morphometric characters of generative shoots.

The analysis of the cenopopulation age structure (Fig. 8) revealed that the age spectrum was dominated by mature vegetative shoots (75.3-91.6%), while the numbers of generative shoots were low (8.4-24.7%).

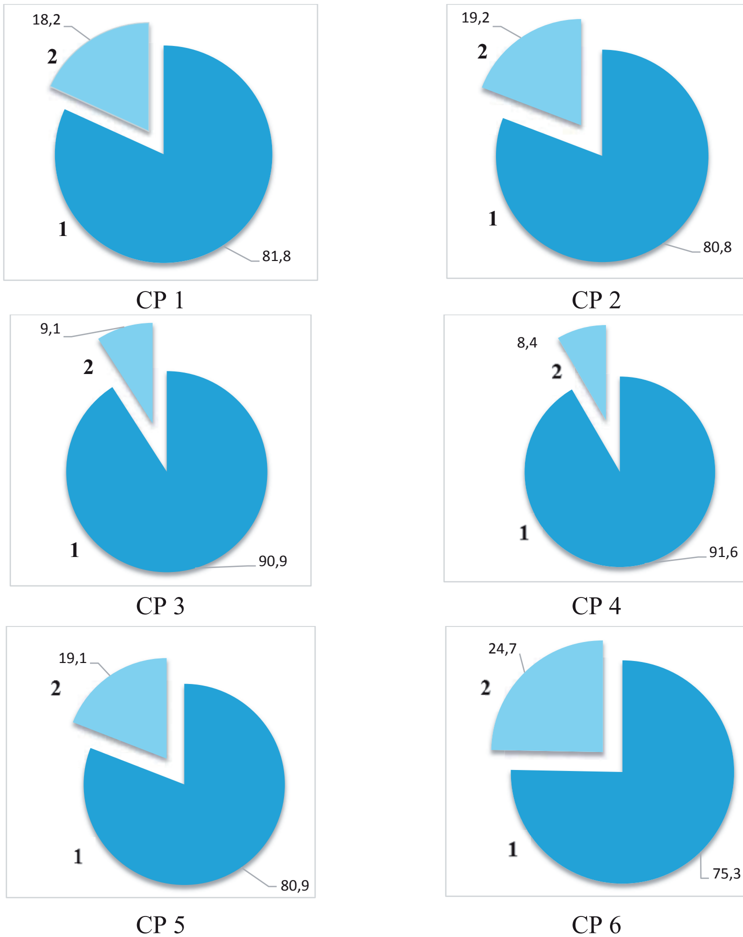


Fig. 8. Share of mature vegetative (1) and generative (2) shoots, %, in different cenopopulations.

Population density (defined as the number of shoots per m^2) varied considerably between cenopopulations (Fig. 9).

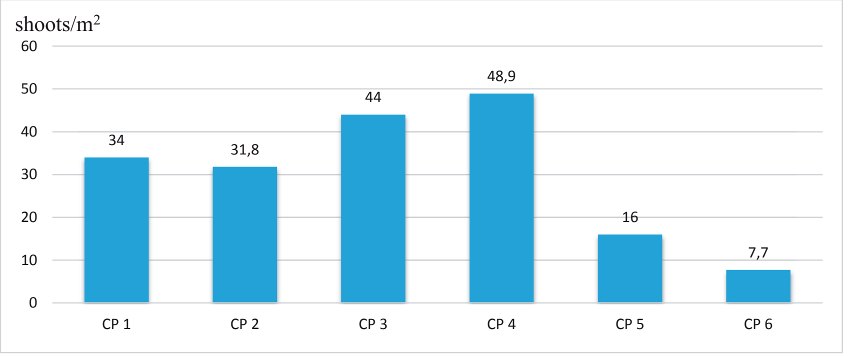


Fig. 9. Population density of *Iris alberti* in six cenopopulations.

As Fig. 9 shows, the highest density of *Iris alberti* was recorded in the Great Almaty gorge, in CP3 and CP4 (44.0 and 48.9 shoots per m^2 respectively). The population from the Oizhailau gorge (CP5 and CP6) had the lowest density (16.0 and 7.7 shoots per m^2 respectively). The population from the Kaskelen gorge represented by CP1 and CP2 had the intermediate density, 31.8 and 34.0 shoots per m^2 respectively. These difference in population density can be explained not so much by the difference in the ecological conditions as by the difference in the levels of anthropogenic pressure.

4. Indices of seed productivity

To study seed productivity of *Iris alberti*, in the first and second populations (further in the text referred to as P1 and P2) we counted generative shoots, collected and measured all normally developed fruits, and also counted, weighted and measured the seeds (Tables 7 and 8).

Iris alberti produced only a small number of generative shouts per m^2, four in P2 and six in P1 (Table 7, Fig. 8). In both populations, on average there were five flowers per generative shoot.

Fruit set (defined as the proportion of flowers that developed into fruit) was 40% in P1, and only 20% in P2. On average, the numbers of ripe fruits per generative shoot were one in P1 and two in P2. In P2, the average seed productivity was substantially higher than in P1, 105 and 45 seeds per generative shoot respectively. Poor fruit set in *Iris alberti* has been reported by S'edina [55] who carried out her research in the botanical garden of Almaty.

Table 7. Average seed productivity in the studied populations

Population	Indices of seed productivity				Fruit set, %
	Shoots per m^2	Flowers per soot	Fruits per shoot	Seeds per shoot	
1	6,0±1,0	5,0±0,1	1,0±0,08	45,0±6,6	20
2	4,0±0,4	5,0±0,2	2,0±0,1	105,0±15,0	40

The fruit of *Iris alberti* is a lower syncarpous box (Fig. 10). Seeds are released by unfolding of the seed pods. The seeds are brown, semi-circular, laterally compressed (Fig. 11). The average seed size is: length - 6.2 ± 0.12 mm, width - 4.7 ± 0.11 mm (Table 8).

Table 8. The average biometric indices of fruits and seeds in the studied populations

Population	Fruit size		Number of seeds per seed pod	Weight of 1000 seeds, g
	Length, cm	Width, cm		
1	4,9 ±0,1	2,5±0,05	29,4±7,3	64,2±0,3
2	5,8±0,1	2,9±0,05	34,6±5,4	72,8±1,9

Fig.10. Seed pods of *Iris alberti.*

Fig.11. Seeds of *Iris alberti.*

In P2, the average size of a seed pod, the number of seeds per pod and weight of 1000 seeds were larger than in P1 (Table 8). It was likely due to a more favorable temperature regime and higher water availability on the site of P2.

5 Comparative anatomo-morphological structure of vegetative and generative organs

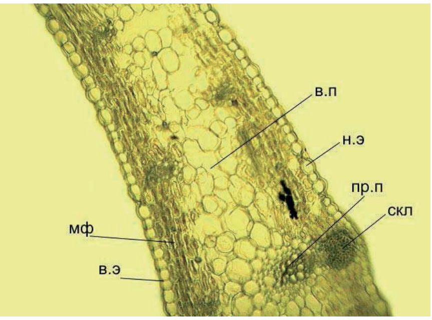
The anatomical structure of *Iris alberti* was studied in virginal state in P1 and P2. The results have already been published elsewhere [56].

Leaf

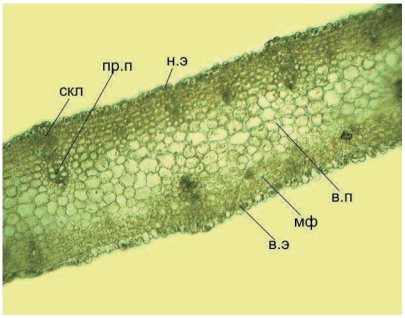
The dermal tissue of the leaf blade of *Iris alberti* is represented by the epidermis with a typical structure. On the cross section of the leaf, the cells of the epidermis appear to be nearly rectangular, arranged very tightly together without intercellular spaces, covered with a cuticle, surface hairs are absent.

Below the epidermis, there are six or seven rows of cells forming the mesophyll. The bulk of the mesophyll is formed by the parenchyma cells containing chlorophyll. The cells of the upper mesophyll (palisade parenchyma) are smaller in size and have a larger number of chloroplasts compared with the cells in the inward part of the leaf (spongy parenchyma). Deeper, in the middle part of the leaf blade, almost colorless large rounded cells are arranged in three or four rows; they serve as ventilation ducts.

Into the thickness of the mesophyll, closed collateral conductive bundles are immersed. The bundles are surrounded by small cells of the mechanical tissue, sclerenchyma, which provides the mechanical strength to the entire leaf blade. The phloem is in contact with the sclerenchyma cord (Fig. 12).



Population 1



Population 2

Fig.12. Anatomical structure of the leaf blade: в.э – upper epidermis, н.э – lower epidermis, мф –mesophyll, в.п – air cavities, скл – sclerenchyma, пр.п – conductive bundle.

The morphometric analysis of the internal structure of leaf blades in P1 and P2 showed that the average size of all leaf structures was larger in P1. In particular, the thickness of the water retaining tissue was 0.74 μm in P1, and only 0.57 μm in P2. This type of tissue develops mostly in plants experiencing water deficit.

The plants from P1 had a more xeromorphic structure, which was confirmed by the dimensions of the conducting tissues, since their main function is to carry water with dissolved minerals. When water availability is limited, plants are forced to use every milliliter of soil and atmospheric moisture by increasing the diameter of the conducting vessels. In the plants of P1, the diameter of the conducting beams was 0.10 μm larger than in the plants of P2 (Table 9).

Table 9. The morphometric indices of the anatomical structure of the leaf blade (μm).

Population	Thickness of the							Diameter of the conducting bundles
	Leaf blade	Epidermis		Mesophyll		Air-retaining tissue	Sclerenchyma	
		upper	lower	palisade	spongy			
1	1,5±0,59	0,12±0,01	0,11±0,02	0,29±0,07	0,27±0,04	0,74±0,39	0,28±0,06	0,36±0,08
2	1,11±0,19	0,08±0,01	0,09±0,01	0,27±0,03	0,3±0,02	0,57±0,16	0,15±0,02	0,26±0,03

Root

On the cross section of the root with a primary structure, three main parts can be distinguished: the protective and absorbing tissue, the primary cortex and the central cylinder.

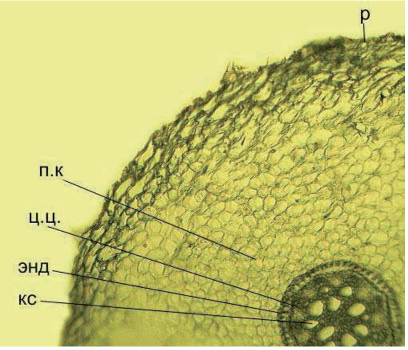
The outer most cell layer of the root, the rhizodermis (also referred to as epiblem) has a protective function, as well as a function of intensive absorption of water and minerals from the soil. The cells of the rhizodermis are alive, they have a thin cellulose wall. Some of them form the root hairs. Over time, the epilblem may peel off, in which case the protective function is performed by the exodermis.

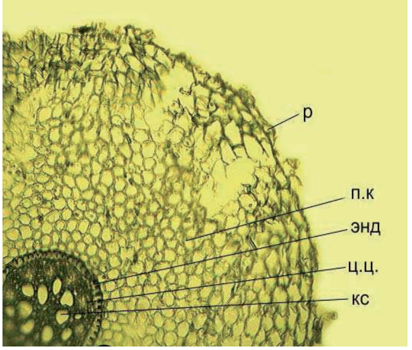
The primary root cortex is more developed than the central axial cylinder and consists of three layers: exoderm, mesoderm and endoderm. The widest part of the primary cortex is the mesoderm, the cells of which perform a storage function, as well as the function of conducting water and dissolved minerals from the root hairs into the central axial cylinder.

The inner single-row layer of the primary cortex is represented by the endoderm, the cells of which are arranged very tightly together and almost square in cross section. The endoderm serves as a so-called hydraulic barrier, promoting the flow of minerals and water from the primary cortex to the central axial cylinder and preventing the outflow.

The central cylinder begins with the pericycle, consisting of the living thin-walled parenchymal cells arranged in a single row. The central part of the central cylinder is occupied by a conductive system represented by a single radial vascular bundle in which groups of the primary xylem elements alternate with regions of the primary phloem.

The roots of *Iris alberti* do not have a core, because they contain the rays of the primary xylem forming protrusions between which the phloem segments are located (Fig. 13).





Population 1 Population 2

Fig. 13. Root anatomy: р – rhizodermis, п.к – primary cortex, энд – endoderm, ц.ц – central cylinder, кс – xylem.

When root anatomy of plants from different populations was considered, we noticed the roots of plants from P1 had a well-developed primary cortex serving as a place for synthesis and storage of various substances; as a result the plants from P1 had thicker roots. However, the plants of P1 had slightly thinner rhizodermis (0.07 μm), and smaller diameter of the central cylinder (1.03 μm) and the conducting beams (0.11 μm) than the plants of P2 (Table 10).

The root anatomy was a reflection of water availability. Rhizoderma is the tissue responsible for the absorption of water. With an increase in its size, the area of absorption of water solutions increases. Xylem vessels, as elements of conductive tissues, ensure the flow of water. In turn, the diameter of the central cylinder depends directly on the diameter of the xylem vessels, since its inner part is occupied by the conducting system.

Table 10. Morphometric indices of the root anatomy, μm

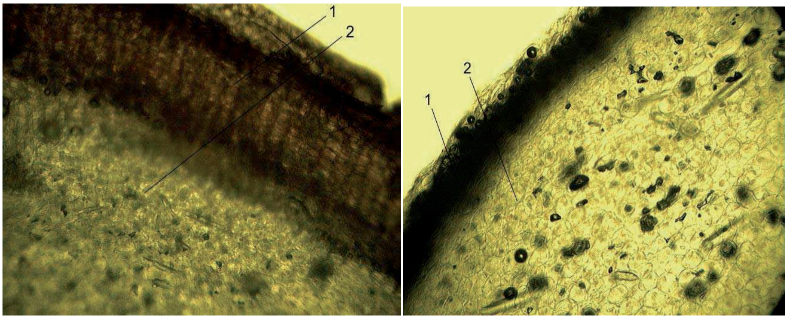
Population	Thickness of			Diameter of	
	Rhizodermis	Primary cortex	Endoderm	Central cylinder	Xylem vessels
1	0,07±0,01	1,84±0,68	0,08±0,01	1,03±0,06	0,11±0,02
2	0,09±0,02	1,63±0,10	0,08±0,01	1,55±0,09	0,13±0,01

Rhizome

The rhizome of *Iris alberti* is a thick, root-like, greatly shortened part of a modified underground shoot. Its surface is covered with several layers of dead cork cells of tabular form arranged in several rows.

It is known that the periderm protects against desiccation much better than the cuticle or wax layer. Because of such reliable protection the rhizomes of irises are the most drought-resistant (xeromorphic) organs. After drying, they retain the viability of the buds for many months.

The parenchyma consisting of white cells containing modified plastids – starch grains (Fig. 14).



Population 1 Population 2

Fig. 14. Rhizome anatomy: 1 – periderm, 2 – parenchyma

Figure 14 shows that the plants form P1 had a thicker periderm than the plants from P2; this could be due to the more arid conditions at the site of P1.

Seeds

Seeds of *Iris alberti* are typical for monocotyledonous plants and consist of the embryo, endosperm and seed coat. The large flattened seeds are covered with a dense brown skin. The largest part of a seed is occupied by the endosperm consisting of rounded cells of a storage tissue; the latter contains starch grains or drops of fatty oils, often mixed with spare proteins (Fig. 15).

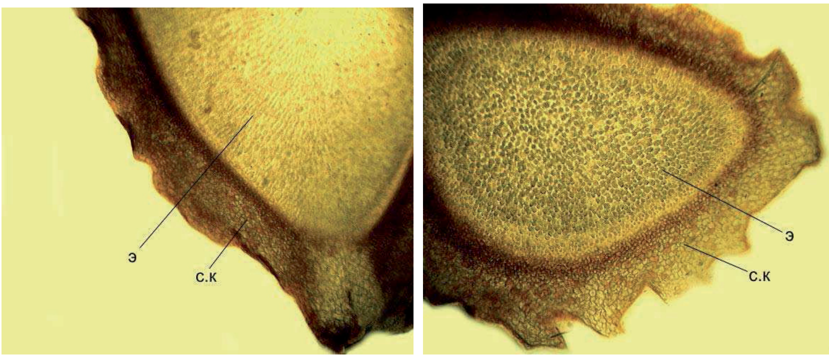


Fig.15. Seed anatomy: с.к – seed coat, э – endosperm.

A white straight embryo located in the center of the seed is immersed in the endosperm. It is stick-shaped, its length is about 4 mm. The cotyledon occupies most of the embryo.

CONCLUSIONS

As a result of our research, we identified characteristic features of plant communities containing *Iris alberti*. Overall, the plant communities of the studied cenopopulations comprised 227 species from 165 genera and 45 families. Of particular interest were rare plants listed in the Red Book of Kazakhstan [8]: *Tulipa ostrowskiana, Paeonia intermedia, Rheum wittrocki, Armeniaca vulgaris, Malus sieversii, Atraphaxis muschketowii* и *Euphorbia yaroslavii;* these species require special protection and monitoring of population trends.

Morphometric parameters of mature vegetative and generative shoots differed slightly depending on the site. In vegetative shoots, the number of leaves varied in the range 5-7; the length of the middle leaf, 35.4-55.1 cm; and the width, 2.5-3.5 cm. In generative shoots, the number of leaves increased to 14-17, the length of the average shoot, to 41.2-58.5 cm, while the width remained nearly the same. The height of a flower-bearing shoot with 4-5 flowers was in the range 45.1-53.5 cm.

The analysis of the population counts, density and age structure of the six cenopopulations showed that the maximum in the age spectrum falls on adult vegetative shoots, and the minimum, on generative shoots. The maximum density (the number of shoots per m^2) was recorded in CP4, and the minimum, in CP6. The reason for this was not so much in the difference in the environmental conditions of the sites as in varying degrees of anthropogenic pressure.

The analysis of seed productivity in the two populations (P1 and P2) showed that the percentage of fruit set was relatively low, 20-40%. The average number of seeds per generative shoot was also small and varied between 45 and 105. The size of the fruit, the number of seeds and the weight of 1000 seeds were higher in the individuals from P2, which may be due to a more favorable temperature and water regime also confirmed by indicators of the anatomical structure of individual organs.

Those differences were:

In the leaves,

- Significant development of the water-retaining tissue, reaching a maximum in individuals growing in arid conditions and characterizing the xeromorphic type of structure;
- Increase in the size of conducting tissues.

In the roots,

- Increase in the size of the primary cortex, acting a place of synthesis and storage of various substances;
- Increase in the size of the rhizodermis due to the formation of root hairs, which are necessary for the increased absorption of water;
- Increase in the diameter of the central axial cylinder due to the better development of conductive elements.

In the rhizomes:

- Thickening of the cork tissue, which serves as a protection against desiccation.

The studied species is listed in the Red Book of Kazakhstan and requires special attention and protection. The population size of the species has decreased, first of all as a result of habitat destruction, including expansion of the urban areas and settlements, development of slopes for summer cottages, road building, and terracing of slopes [57]. It is necessary to continue further research to elucidate the detailed distribution of *Iris alberti* within the entire distribution range, to study the status of the most threatened populations and to establish regular monitoring. Considering the high decorativeness and ease of cultivation, it is necessary to practice the introduction of this rare species in culture for landscaping purposes.

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