UDC 582.675.3
IRSTI 34.29.25
DOI 10.37238/2960-1371.2960-138X.2025.97(1).47

[1]Abidkulova Karime, [1]Almabek Dayana, [1]Mukhitdinov Nashtay, [1]Kurbatova Natalia, [2]Karasholakova Lazzat, [3]Turalin Baurzhan

[1]al-Farabi Kazakh National University, Almaty, Kazakhstan
[2]Zhetysu University named after I. Zhansugurov, Taldykorgan, Kazakhstan
[3]K. Zhubanov Aktobe Regional University, Aktobe, Kazakhstan

E-mail: karime_58@mail.ru, mizzadm@gmail.com, nashtay41@yahoo.com, kurbatova_nv77@mail.ru, karasholakova.lazzat@mail.ru, bauke_1982@mail.ru

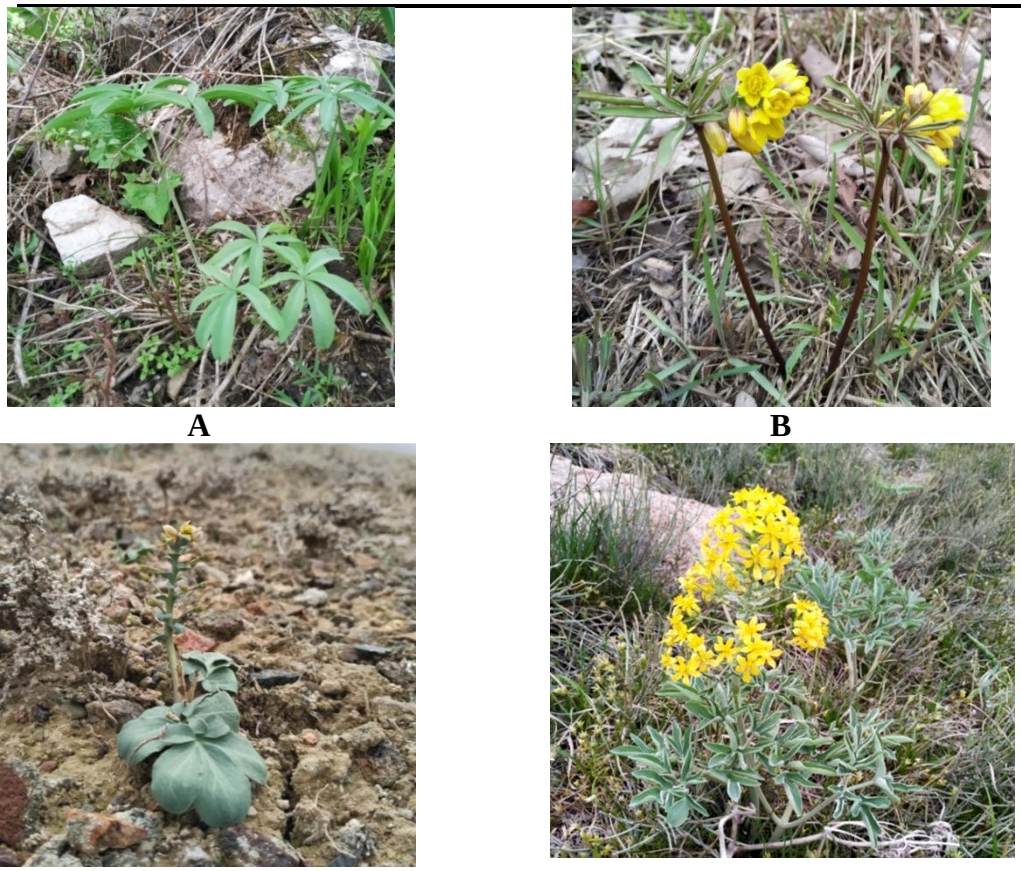
SEEDS AS A CHARACTERISTIC OF KAZAKH SPECIES OF *GYMNOSPERMIUM* AND *LEONTICE* WITH DIFFERENT ECOLOGICAL DISTRIBUTION

Annotation. Seed parameters are one of the main characteristics of plants used in taxonomy and a necessary component for plant identification. The morphological and morphometric parameters of seeds are routinely used when describing a particular species. In this article, we present the analysis of the morphometric parameters of *Gymnospermium alberti* (Regel) Takht., *Gymnospermium altaicum* (Pall.) Spach, *Leontice incerta* Pall., and *Leontice ewersmannii* Bunge (Berberidaceae) growing in different environmental conditions in Kazakhstan. The seed length and width, and the weight of 1000 seeds were the largest in the populations of *Leontice ewersmannii*, and the smallest, in those of *Gymnospermium altaicum.* In terms of the shape coefficient, the seeds of *Gymnospermium alberti* and *Leontice ewersmannii* were spherical, and those of *Gymnospermium altaicum*, oblong. *Gymnospermium* seeds differed from *Leontice* seeds in the presence of strophioles, the seed coat outgrowths. The variability of morphometric parameters was very low or low in all taxa studied, which indicates the stability of these characters.

Keywords: seeds; *Gymnospermium alberti; Gymnospermium altaicum; Leontice incerta; Leontice ewersmannii;* Berberidaceae; morphometric parameters; Kazakhstan.

Introduction

The family Berberidaceae Juss (Ranunculales) includes the subfamilies Berberidoideae Eaton, Podophylloideae Eaton, and Nandinoideae Heintze. The genera *Gymnospermium* Spach, *Leontice* L., *Nandina* Thunb., and *Caulophyllum* Michx. are included in the subfamily Nandinoideae [1].



A **B**

C **D**

A – *Gymnospermium alberti,* B – *Gymnospermium altaicum,* C – *Leontice incerta,* D – *Leontice ewersmanni*

Figure 1 – Studied species (Photo by K. Abidkulova)

In Kazakhstan, Gymnospermium and Leontice (Berberidaceae) are represented by four species (fig.1), two of each genus, found in different environmental conditions [2, p. 52; 3, p. 91].

Species of *Gymnospermium*, *G. alberti* (Regel) Takht. and *G. altaicum* (Pall.) Spach are found in deciduous forests or at their edges. The first species occurs as an Iranian-Turanian element on fine-grained, loess soils, on rocky-crushed stone and clay slopes, among shrubs, in pistachio, apple, *Celtis*, and *Juniperus* forests from the foothills to the middle belt in the mountains of the Western Tien Shan, including Talas Alatau, Boroldaitau, Ugam, and Karzhantau (within Kazakhstan) [4, p. 231-233; 5; 44; 6; 7]. The second species is an Altai-Tian Shan [8, p. 58] or Altai-Dzhungarian [9] element; it grows at the mountain foothills, on mountain slopes, among shrubs, in steppe meadows, and in wild fruit and fir forests at an altitude of 200 to 1500 m above sea level and has a fragmented range stretched in the southern and south-western direction from Altai to the Zailiysky Alatau (Northern Tien Shan) [10, p. 132-136; 11]. The distribution of *G. alberti* and *G. altaicum* within Central Asia according to the GBIF data is presented in Figure 2 [12].

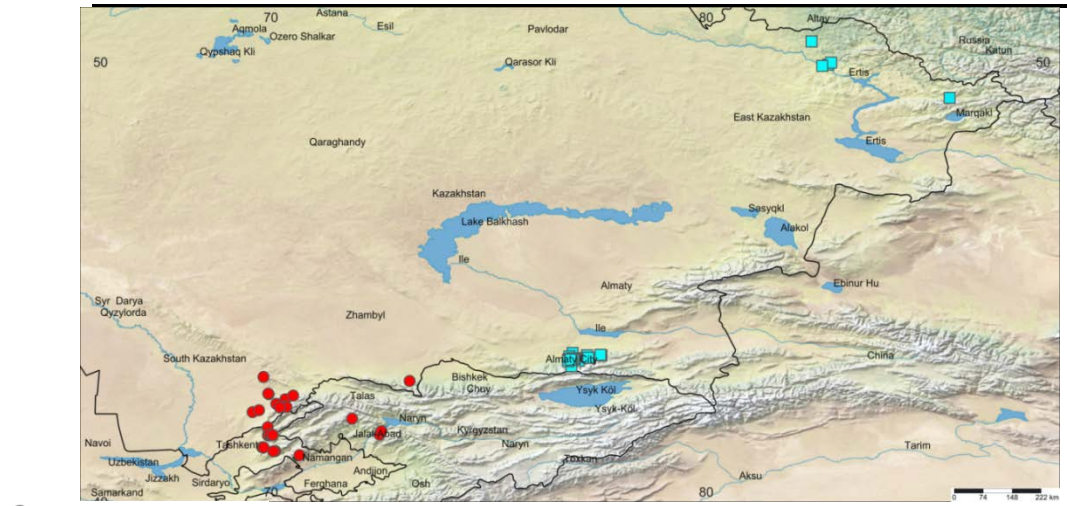


Figure 2 – Distribution ranges of *Gymnospermium alberti* and *G. altaicum* in Central Asia [12].

Unlike *Gymnospermium* species, representatives of the genus *Leontice* are common in semi-arid and arid regions of Central Asia, including Kazakhstan. The Dzhungar-Iranian species *L. ewersmannii* Bunge is found on plains up to the lower belt of the mountains, on sands and clay-saline soils, loess gypsum-bearing, rocky, crushed stone and fine-grained slopes, and on abandoned arable lands and deposits [4; 13; 14, p. 96; 15, p. 83; 16, p.97]. The Turanian species *L. incerta* Pall. is found from plains to foothills, on clayey, crushed stone slopes, sandy and saline soils, salt marshes, and in *Haloxylon* thickets [4, p. 231-233; 13; 17]. The distribution range of *L. ewersmannii* and *L. incerta* within Kazakhstan according to the GBIF data is presented in Figure 3 [18].

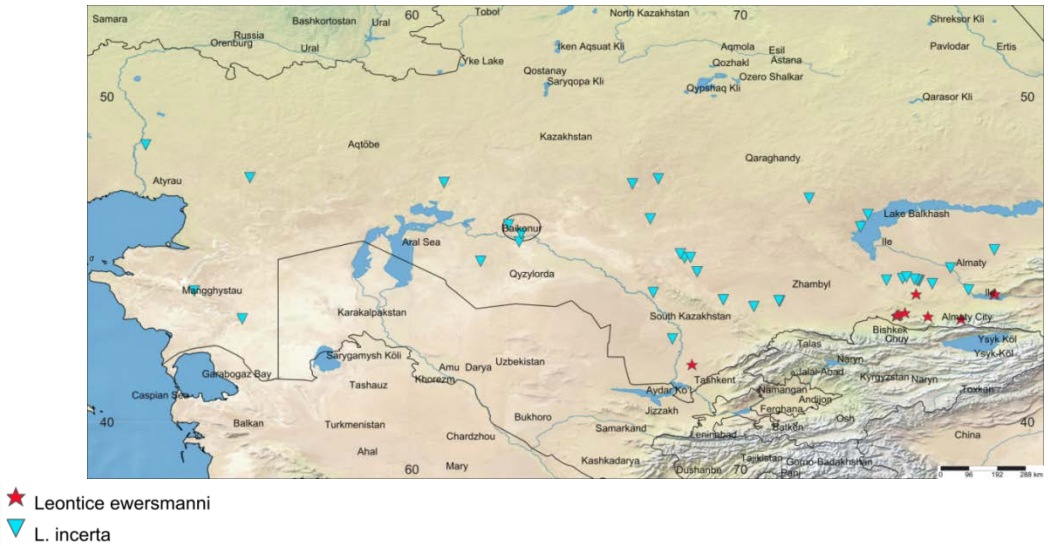


Figure 3 – Distribution ranges of *Leontice ewersmannii and L. incerta* within Kazakhstan [18].

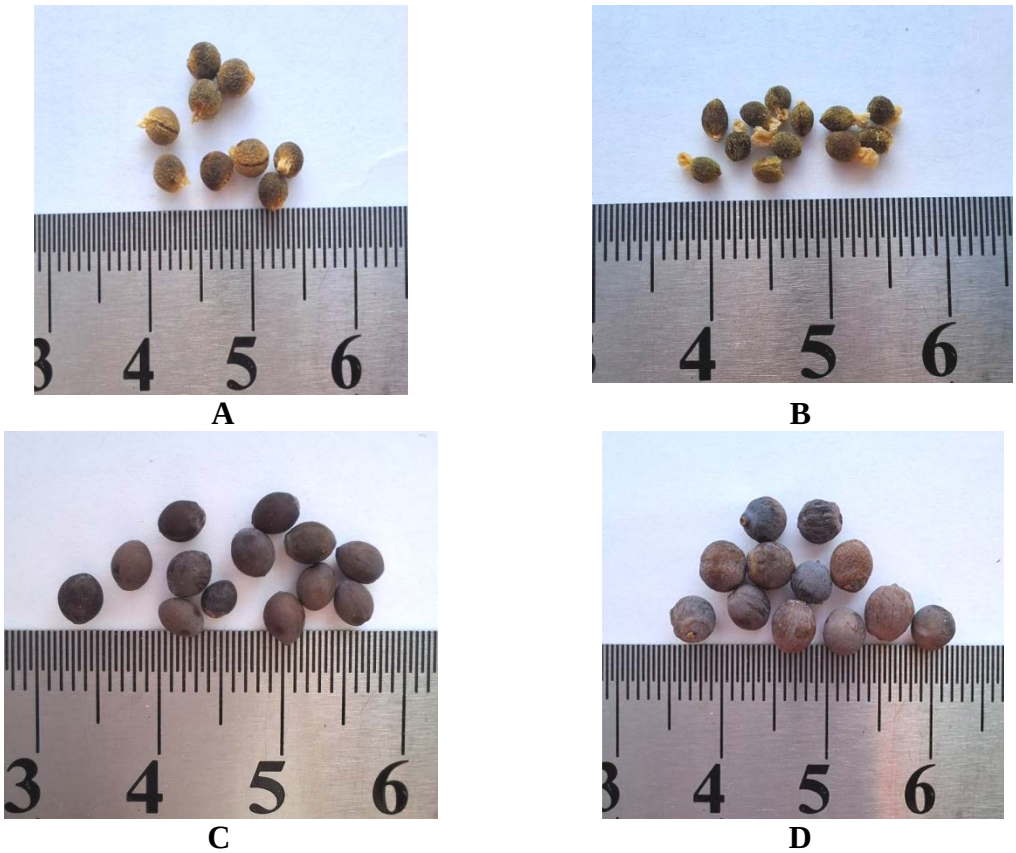
The study of seed morphology is of great importance, since the morphometric parameters of vegetative and generative organs of various plant species are useful in the study of their biology and taxonomy [19; 20; 21; 22]. The purpose of our research was to compare and analyze the morphological features of the seeds of the species of *Gymnospermium* and *Leontice* selected for the study.

Materials and Methods

The seeds of *Gymnospermium alberti, G. altaicum, Leontice ewersmanni,* and *L. incerta* were collected in natural populations in the south and southeast of Kazakhstan. The search for populations was carried out by the route-reconnaissance method. The length and width of 30-40 seeds of each species were measured, and the weight of 1000 seeds was determined using electronic laboratory scales Scout Pro SPS402F. The measurements were carried out using a binocular stereoscopic microscope MBS-10 (Biolam). Statistical data processing was carried out using Excel 2019. Species names are in accordance with the International POWO database [23].

Results and Discussion

Gymnospermium alberti is a subendemic in Kyrgyzstan and Tajikistan, but not in Kazakhstan [24, p. 38; 25, p. 222]. Seed samples were collected in the Karakunuz gorge of the Zhetyzhol ridge, which is the western spur of the Ili Alatau (fig.4A).



A – *Gymnospermium alberti,* B – *Gymnospermium altaicum,* C – *Leontice incerta,* D – *Leontice ewersmanni*

Figure 4 – Seeds of the species studied with a scale bar (ruler).

Gymnospermium altaicum is listed in the regional Red Books of Russia [26, p. 77; 27, p. 50] and in the Red Book of Kazakhstan [28, p. 88] as a rare species threatened by economic activity, grazing, spring fires, and excessive recreational load. The seeds were collected in the lower part of the Kotyrbulak gorge of the Ili Alatau (fig.3B).

The samples of *Leontice ewersmanni* seeds were collected near the Kordai Pass in a forest belt (fig.3C). The seeds of *Leontice incerta* were collected in the Zhyngylsu gorge of the Syugaty mountains (fig.3D).

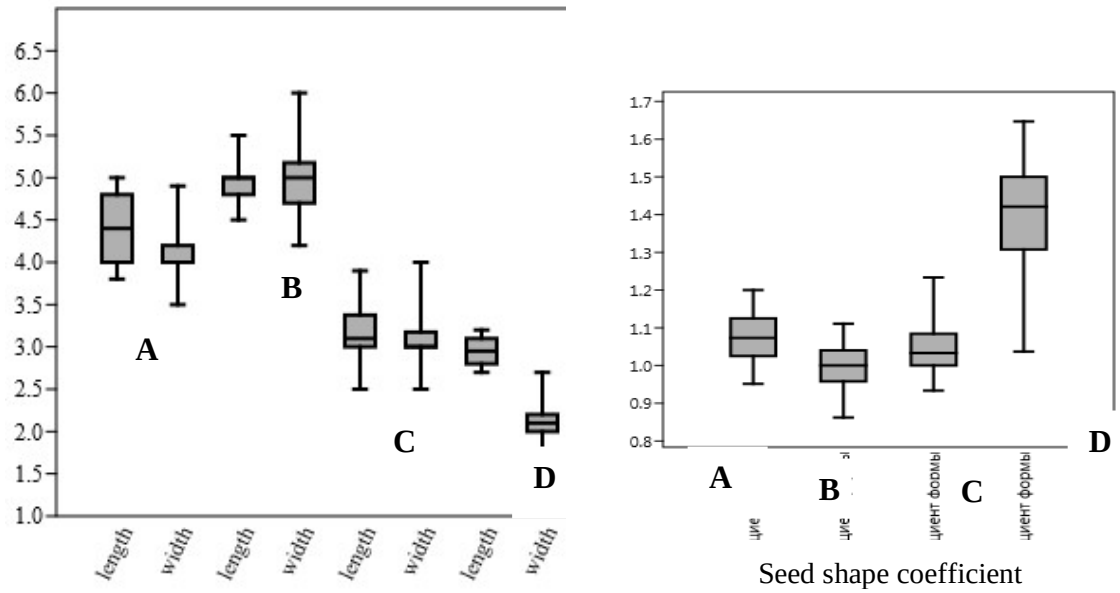
The morphometric parameters of seeds are shown in Table 1 and Figure 4.

Table 1 – The morphometric parameters of seeds of the species studied.

Species	Seed length, mm	Seed width, mm	Seed shape coefficient	Weight of 1000 seeds, g
Gymnospermium alberti	3.2±0.05 2.5-3.9	3.05±0.04 2.5-4.0	1.04±0.01 0.93-1.23	20.0±1.5
Gymnospermium altaicum	2.9±0.02 2.7-3.2	2.1±0.04 1.7-2.7	1.4±0.02 1.04-1.65	8.97±0.23
Leontice incerta	4.4±0.06 3.8-5.0	4.1±0.05 3.5-4.9	1.07±0.01 0.95-1.2	23.2±0.6
Leontice ewersmanni	4.96±0.04 4.5-5.5	4.98±0.06 4.2-6.0	1.0±0.01 0.86-1.11	30.2±0.03

Note: in the numerator, there is the mean with the mean error, and in the denominator, there are the minimum and maximum values of the parameter measured.

Seed size, shape, and morphology are important features used in species identification and characterization. The obtained data showed that the length of seeds of the two *Leontice* species ranged from 3.8 to 5.5 mm, the width, from 3.5 to 6.0 mm, and the coefficient of seed shape, from 0.86 to 1.2 (table 1, fig. 5) 9. In the two species of *Gymnospermium*, the seed length varied from 2.5 to 3.9 mm, the width, from 1.7 to 4.0 mm, and the shape coefficient, from 0.93 to 1.65. The seeds of *Leontice ewersmanni* were the largest of all species, and those of *Gymnospermium altaicum*, the smallest. The seeds of *L. ewersmanni* and *Gymnospermium alberti* were spherical, i.e. the average shape coefficient was 1.0. The seeds of *Leontice incerta* were slightly oblong, and those of *G. altaicum* had an elongated shape (table 1, fig. 4, 5) 9. The seeds of *Leontice ewersmanni* were the heaviest, 23.2 g per 1000 seeds, and those of *Gymnospermium altaicum* were the lightest, 8.97 g per 1000 seeds (table 1). In the photographs of *Gymnospermium alberti* and *G. altaicum* seeds (fig. 4) the seed coat outgrowths, the so-called strophioles are clearly visible [29], which contribute to the spread of seeds by ants [30].



A – *Leontice incerta*, B – *Leontice ewersmanni*, C – *Gymnospermium alberti*, D – *Gymnospermium altaicum*, the seed length and diameter are given in mm.

Figure 5 – Seed parameters of the species studied.

The calculated coefficients of variation of the morphometric parameters were compared with the scale for assessing the degree of character variation proposed by Mamaev [31]. In accordance with it, the coefficients of variation of the seed width, length, and shape ranged from very low (less than 7%) to low (8-12%) in all taxa (Table 2).

Table 2 – Coefficient of variation of the seed morphometric parameters, Cv.

Species	Coefficient of variation, %		
	Seed length	Seed width	Seed shape
Leontice incerta	8.5	12.3	5.7
Leontice ewersmanni	4.6	7.4	5.5
Gymnospermium alberti	10.0	7.9	6.7
Gymnospermium altaicum	5.1	11.7	11.0

Conclusions

As a result of the analysis of the seed morphometric parameters of the Kazakh species of *Leontice* and *Gymnospermium* confined to ecologically different habitats, we found that the seeds of *Leontice ewersmanni* were the largest in size and the heaviest, while the seeds of *Gymnospermium altaicum* were the smallest. The seeds of *Leontice ewersmanni* and *Gymnospermium alberti* were spherical in shape, those of *Leontice incerta*, slightly rounded, and those of *Gymnospermium altaicum*, oblong. In the seeds of *Gymnospermium*, the presence of the seed coat outgrowth, strophiole, was clearly visible, which was absent in the seeds of *Leontice*. The variability of morphometric

parameters was very low or low, which indicates the stability of these characters. The latter can be used in species identification and solving taxonomic problems.

REFERENCES

[1] Song, S., Zubov, D., Comes, H., Li, H., Liu, X., Zhong, X. et al. (2022). Evolution of Nandinoideae (Berberidaceae). *Frontiers in Plant Science, 13, 913011*.doi: 10.3389/fpls.2022.913011.

[2] Abdulina, S. (1999). *Checklist of vascular plants of Kazakhstan.* Almaty.

[3] Baitenov, M.S. (2001). Flora Kazahstana. Rodovoj kompleks flory. [*Flora of Kazakhstan. Generic complex of flora]*. (V. 2). Almaty [in Rassian].

[4] Bondarenko O.N., Nabiev N. M. (Eds.). (1972). *Conspectus Florae Asiae Mediae* (Vols. 1-11; V. 3). Taschkent: Fan. [in Rassian]

[5] Karmysheva, N.H. (1973). Flora i rastitel'nost' zapovednika Aksu-Dzhabagly (Talasskij Alatau) [*Flora and vegetation of the Aksu-Dzhabagly Nature Reserve (Talas Alatau)]*. Alma-Ata: "Nauka" Kazahskoj SSR [in Rassian].

[6] Ivashhenko, A.A. (2015). Spisok flory ohranjaemyh territorij Boroldajtau. [List of flora of Boroldaytau protected areas]. *Botanicheskie issledovanija Sibiri i Kazahstana –Botanical studies of Siberia and Kazakhstan, 21, 88-92* [in Rassian].

[7] Ivashhenko, A.A. (2020). Spisok flory Sajram-Ugamskogo gosudarstvennogo nacional'nogo prirodnogo parka (Kazahstan) [List of flora of Sairam-Ugam State National Nature Park (Kazakhstan)]. *Botanicheskie issledovanija Sibiri i Kazahstana – Botanical studies of Siberia and Kazakhstan, 26, 52-63*. [in Rassian].

[8] Goloskokov, V.P. (1984). Flora Dzhungarskogo Alatau (konspekt i analiz) [*Flora of the Dzungarian Alatau (outline and analysis)*]. Alma-Ata: "Nauka" Kazahskoj SSR [in Rassian].

[9] Kamelin, R.V. (1998). Materialy po istorii flory Azii (Altajskaja gornaja strana). *[Materials on the history of the flora of Asia (Altai mountainous country*)]. Barnaul: Izdatel'stvo Altajskogo universiteta [in Rassian].

[10] Pavlov, N.V. (Eds.). (1961). Flora Kazahstana [*Flora of Kazakhstan*] (Vols. 1-9; Vol. 4). Alma-Ata: "Nauka" Kazahskoj SSR [in Rassian].

[11] Abidkulova, D.M., Ivashchenko, A.A., Sramko, G., Kurbatova, N.V., Abidkulova, K.T. (2021). *Gymnospermium altaicum* (Pall.) Spach (Berberidaceae), an early spring element of wild fruit forests of the Trans-Ili Alatau . *Experimental Biology, 86(1), 14-26*.

[12] GBIF.org (24 December 2024). *GBIF Occurrence Download* https://doi.org/10.15468/dl.mf5njm. (24.12.2024). Retrieved from GBIF.org: https://www.gbif.org/occurrence/download/0047266-241126133413365

[13] Roldugin, I.I. & Fisjun, V.V. (2018). Flora Chu-Ilijskih gor (konspekt i analiz). [*Flora of the Chu-Ili Mountains (synopsis and analysis)]*. Almaty: Areket-Print [in Rassian].

[14] Tozhibaev K.Sh., Beshko, N.Ju., Shomurodov, H.F., Kodirov, U.H., Turginov, O.T., Sharipova, V.K. (2018). Kadastr flory Uzbekistana Kashkadar'inskaja oblast' [*Cadastre of Flora of Uzbekistan Kashkadarya province*]. Tashkent: Fan [in Rassian].

[15] Tozhibaev, K.Sh., Beshko, N.Ju., Kodirov, U.H., Batoshov, A.R., Mirzalieva, D.U. (2018). Kadastr flory Uzbekistana: Samarkandskaja oblast' [*Cadastre of Flora of Uzbekistan: Samarkand province*]. Tashkent: Fan [in Rassian].

[16] Tozhibaev, K.Sh., Beshko, N.Ju., Jesankulov, A.S., Batoshov, A.R., Azimova, D.Je. (2021). Kadastr flory Uzbekistana: Dzhizakskaja oblast' *[Flora Cadastre of Uzbekistan: Jizzak Province*]. Tashkent: Fan [in Rassian].

[17] Bobokandov, N., Nomozova, Z., Tashpulatov, Y., Isomov, E., Akhmedov, A. (2024). Assessment of the current condition and ontogenetic structure of the populations of *Leontice incerta* Pall. (Berberidaceae) in the Kyzyl-Kum Desert, Uzbekistan. *Biodiversitas 25(6),* 2757-2764. DOI: 10.13057/biodiv/d250646

[18] GBIF.org (22 December 2024). *GBIF Occurrence Download https://doi.org/10.15468/dl.v6868u*. (22.12.2024). Retrieved from GBIF.org: https://www.gbif.org/occurrence/download/0046081-241126133413365

[19] Lanta, V., Havránek, P., & Ondřej, V. (2003). Morphometry analysis and seed germination of *Amaranthus cruentus, A. retroflexus* and their hybrid (*A.* × *turicensis*). *Plant, Soil and Environment, 49(8), 364-369.*

[20] Jayaprakashvel, M., Sankar, K., Venkatramani, M., & Hussain, A.J. (2014). Morphometrics and Germrination Biology of Seeds from Two Coastal Sand Dune Plants of South East Coast of India. *Biosciences biotechnology reserach Asia, 11, 103-108*.

[21] Wiwart, M., Kurasiak-Popowska, D., Suchowilska, E., Wachowska, U., & Stuper-Szablewska, K. Variation in the morphometric parameters of seeds of spring and winter genotypes of Camelina sativa (L.) Crantz,. *Industrial Crops and Products, 139, 111571*.

[22] Kubentaev, A.C., Hasenova, A.E., Imanbaeva, A.A., & Alibekov D.T. (2022). Morfologija semjan redkih i jendemichnyh rastenij Kazahstana [*Seed morphology of rare and endemic plants of Kazakhstan]*. Vestnik Karagandinskogo universiteta. Serija: Biologija. Medicina. Geografija – Bulletin of Karaganda University. Series: Biology. Medicine. Geography, *107(3), 92-98* [in Rassian].

[23] POWO (2024). *"Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. Published on the Internet.* (24.12.2024). Retrieved from https://powo.science.kew.org/

[24] Laz'kov G.A. & Sultanova B.A. (2014). Kadastr flory Kyrgyzstana. Sosudistye rastenija [*Cadastre of the flora of Kyrgyzstan. Vascular plants*]. Bishkek [in Rassian].

[25] Nowak, A., Nobis, M., Nowak, S., Nobis, A., Wróbel, A., Świerszcz, S. et al. (2020). *Illustrated flora of Tajikistan and adjacent areas.* A. Nowak, M. Nobis (Eds.). Warsaw: Polish Botanical Society.

[26] Krasnaja kniga Altajskogo kraja. T. 1. Redkie i nahodjashhiesja pod ugrozoj ischeznovenija vidy rastenij i gribov. *[Red Data Book of Altai Krai. V. 1. Rare and endangered species of plants and fungi.]* (2016). Barnaul: Izdatel'stvo Altajskogo universiteta [in Rassian].

[27] Krasnaja kniga Respubliki Altaj (rastenija) [*Red Book of the Altai Republic (plants)*]. (2017). Gorno-Altajsk [in Rassian].

[28] Krasnaja kniga Kazahstana. T. 2, ch. 1: Rastenija. *[Red Book of Kazakhstan. V. 2, p. 1: Plants.]*. (2014). Almaty: ArtPrintXXI [in Rassian, English, Kazakh].

[29] Tan, K., Shuka, L., Šiljak-Yakovlev, S., Malo, S. & Pustahija, F. (2011) The genus *Gymnospermium* (*Berberidaceae*) in the Balkans. *Phytotaxa 25, 1-17*.

[30] Korovkin, O.A. (2007). Anatomija i morfologija vysshih rastenij: slovar' terminov. [*Anatomy and morphology of higher plants: glossary of terms*]. Moskva: Drofa [in Rassian].

[31] Mamaev, S.A. (1972). Formy vnutrividovoj izmenchivosti drevesnyh rastenij (na primere semejstva Pinaceae na Urale) [Forms of intraspecific variability of woody plants (on the example of the Pinaceae family in the Urals)]. Moskva: Nauka [in Rassian].

Абидкулова К.Т., Алмабек Д.М., Мухитдинов Н.М., Курбатова Н.В., Карашолакова Л.Н., Туралин Б.А.

ТҰҚЫМДАР ӘРТҮРЛІ ЭКОЛОГИЯЛЫҚ ЖАҒДАЙДА ӨСЕТІН ҚАЗАҚСТАНДЫҚ GYMNOSPERMIUM ЖӘНЕ LEONTICE ТҮРЛЕРІНІҢ СИПАТТАМАСЫ РЕТІНДЕ

Аңдатпа. Тұқымдар таксономияда қолданылатын өсімдіктердің негізгі сипаттамаларының бірі және өсімдіктерді анықтау үшін қажетті компонент болып табылады. Бір немесе басқа түрді сипаттау кезінде тұқымдардың морфологиялық және морфометриялық параметрлері көрсетіледі. Бұл мақалада біз Қазақстанда кездесетін және әртүрлі экологиялық жағдайларда өсетін *Gymnospermium alberti* (Regel) Takht., *Gymnospermium altaicum* (Pall.) Spach, *Leontice incerta* Pall. және *Leontice ewersmannii* Bunge (Berberidaceae) тұқымдарының морфометриялық көрсеткіштерін талдаймыз. *Leontice ewersmannii* өсімдігінің тұқымдары максималды ұзындығы мен ені, және 1000 дана салмағымен ерекшеленді, тұқымның ең аз көрсеткіштері мен салмағы *Gymnospermium altaicum* болды. Пішін коэффициентінің шамасы бойынша *Gymnospermium alberti* мен *Leontice ewersmannii* тұқымдары шартәрізді, ал *Gymnospermium altaicum* тұқымдары ұзынша (сопақтау) болды. *Gymnospermium* тұқымдары *Leontice* тұқымдарынан тұқым қабығының өсінділерінің – строфиолидың болуымен ерекшеленеді. Барлық зерттелген таксондардағы морфометриялық көрсеткіштердің өзгергіштігі өте төмен немесе төмен, бұл осы белгілердің тұрақтылығын көрсетеді.

Кілт сөздер: тұқымдар; *Gymnospermium alberti; Gymnospermium altaicum; Leontice incerta; Leontice ewersmannii;* Berberidaceae; морфометриялық көрсеткіштер; Қазақстан.

Абидкулова К.Т., Алмабек Д.М., Мухитдинов Н.М., Курбатова Н.В., Карашолакова Л.Н., Туралин А.Б.

СЕМЕНА КАК ХАРАКТЕРИСТИКА КАЗАХСТАНСКИХ ВИДОВ GYMNOSPERMIUM И LEONTICE С РАЗНЫМ ЭКОЛОГИЧЕСКИМ РАСПРОСТРАНЕНИЕМ

Аннотация. Семена являются одной из основных характеристик растений, применяемой в таксономии и необходимой составляющей для их идентификации. Именно морфологические и морфометрические параметры семян указываются

при описании того или иного вида. В данной статье мы анализируем морфометрические параметры семян *Gymnospermium alberti* (Regel) Takht., *Gymnospermium altaicum* (Pall.) Spach, *Leontice incerta* Pall. и *Leontice ewersmannii* Bunge (Berberidaceae), встречающихся в Казахстане и произрастающих в разных экологических условиях. Максимальной длиной и шириной семян и наибольшей массой 1000 штук отличалась *Leontice ewersmannii*, минимальные параметры семян и их масса была у *Gymnospermium altaicum.* По величине коэффициента формы семена у *Gymnospermium alberti* и *Leontice ewersmannii* - шаровидные, а у *Gymnospermium altaicum* - продолговатые. Семена *Gymnospermium* отличаются от семян *Leontice* наличием выростов семенной кожуры – строфиоли. Вариабельность морфометрических параметров у всех изученных таксонов является очень низкой или низкой, что говорит о стабильности данных признаков.

Ключевые слова: семена; *Gymnospermium alberti; Gymnospermium altaicum; Leontice incerta; Leontice ewersmannii;* Berberidaceae; морфометрические параметры; Казахстан.