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## A study of the cenopopulations and ontogenetic structure of *Adonis wolgensis* in the Akmola region

The article presents the results of study of six cenopopulations of rare medicinal plant *Adonis wolgensis* Steven ex DC. (Ranunculaceae) in Akmola region of Northern Kazakhstan. Ecological-phytocenotic characterization was given and ontogenetic structure of cenopopulations was studied. It is established that in the studied region *Adonis wolgensis* grows among steppe grasses, in bushes, occasionally on forest edges and on forest lawns. In general, the condition of the studied *Adonis wolgensis* cenopopulations is satisfactory. Analysis of age spectra showed that cenopopulations not or slightly affected by anthropogenic impact are characterized by a spectrum in which the absolute maximum falls on the age states of the pre-generative period. In the four cenopopulations, a significant proportion of individuals are in the young generative state, indicating their capacity for self-renewal. This ensures the stability of the species in the plant communities of the study areas. The condition of two cenopopulations is assessed as degrading, and urgent measures are needed to preserve them and restore their numbers. Cattle grazing in cenopopulations leads to a decrease in plant viability and suppression of seed reproduction. To preserve the species it is necessary to limit grazing, prohibit collection of raw materials, develop methods of cultivation in culture, organize reproduction of the species in industrial volumes, and strengthen protection measures. The results obtained have provided new information on the status of the species in Northern Kazakhstan and serve as a reliable basis for its further conservation.

**Keywords:** *Adonis*, Flora of Kazakhstan, rare species, biodiversity conservation, Northern Kazakhstan, state of cenopopulations.

### Introduction

Preservation of rare and endangered species has become an integral part of the general problem of plant world protection. In connection with the growth of anthropogenic impact on ecosystems, the rate of industrial development, a wide scale of economic development of new and new territories, leads to significant changes in landscapes, disruption of primary biocenoses, reduction of biodiversity reserves. Especially acute is the problem of preservation of steppe cenoses, the destruction and transformation of which leads to a decrease in species diversity, reduction in the range of typical steppe species, the formation of populations with a disturbed structure. One of them is *Adonis wolgensis* Stevex DC. (Ranunculaceae family) is a steppe Pannonian-Pontic-Transwolgian-Kazakhstan species, listed in the Red Data Book of Kazakhstan (2014) in the category of rarity III, a declining species [1]. Populations of this species are decreasing in number due to intensive action of a number of factors of anthropogenic origin: economic activity of enterprises and population, plowing of steppe areas, grazing and trampling of habitats by cattle, mowing, as well as intensive its harvesting as a medicinal raw material and collection of bouquets.

Significant imprint on the state of cenopopulations is also imposed by biological features of the species – low germination of seeds due to the short period of ontogenesis, slow development of seedlings, narrow range of ecological and cenotic conditions necessary for their germination, interspecific phytocenotic competition. The genus *Adonis* L. is represented by annual and perennial rhizomatous herbaceous plants, which belong to the tribe Adonideae T. Duncan et Keener, subfamily Ranunculoideae, family Ranunculaceae Juss. Duncan et Keener subfamily Ranunculoideae of the family Ranunculaceae Juss. [2, 3]. The genus includes 40-50 species [4], which are mainly distributed in the extratropical zones of Eurasia. About 30 species grow in Southwest Asia, Europe, North Africa, and the Mediterranean region [5]. Seeds, leaves and roots of the

genus *Adonis* are poisonous to humans. The plant has numerous stamens, linear filaments, and single-seeded ovaries with permanent stigmas [6]. Plants of this genus have historically been traditionally used to for the treatment of edema in many peoples of the former Soviet Union. Extracts were first introduced into medicine as a cardiac stimulant in 1879 by the Russian physician N.O. Buhnov. Since then, species of this genus have been of great interest to people [7]. The chemical composition of *Adonis* is similar to other species, all organs of the plant contain the same glycosides [8], carbohydrates, coumarins, cardenolides, flavonoids, fatty oil and are used in scientific medicine as a cardiogenic agent and as a potential substitute for *Adonis vernalis* [9-11], are used similarly to *A. vernalis*, but have less pronounced therapeutic properties [9].

*A. wolgensis* is mainly found in southeastern Europe, Western Siberia and the far north of Central Asia (the Aral-Caspian and Balkhash regions) habitats. This species is common in steppe communities, very rarely in shrubs and on the edges of forests. The range of *A. wolgensis* occurs in the Caucasian ecoregion and is isolated. In this region, *A. wolgensis* has a disjunctive range, and is distributed in the northeast of Turkey, in Armenia (Sevan and Aparan floristic regions), in the extreme southeast of Azerbaijan (Zuvand, Talysh), in the north and northwest of Iran. The distribution of this species is limited to the above-mentioned territories. *A. wolgensis* was found in Shida Kartli, Gori municipality [12]. On the territory of Kazakhstan it is found in the following floristic areas: 1. Spurs of the Common Syrt, 2. Tobol-Ishim, 4. Semipalatinsk boron, 6. Caspian lowland, 10. Western and 11. Eastern Shallow Soil, 11a. Kark, 22. Altai [13].

In the flora of Kazakhstan genus *Adonis* is represented by 8 taxa, of which 5 species grow on the territory of the study region [13]. A.N. Kupriyanov in his abstract "Flora of the Kazakh shallow-slope zone" [14] gives 4 species: *Adonis parviflorus* Fisch., *A. vernalis* L., *A. villosa* Ledeb., *A. wolgensis*. In the *Adonis wolgensis* Steven ex DC. conspectus it is indicated for Akmola region, vicinities of Katarkol settlement and Ereimentau Mountains.

*A. wolgensis* Steven ex DC. belongs to sect. Adonanthe W.T. Wang, subsect. Amurenses (Poschkurl.) M.H. Hoffm., is of great interest in systematic, biological and resource relations.

The aim of the work is to study the distribution and density of *A. wolgensis* populations in Akmola region of Northern Kazakhstan, floristic characteristics and ontogenetic states of individuals.

### Experimental

The work was carried out on the basis of expeditionary studies conducted in 2021-2022 in the steppe areas of Akmola region. 6 populations of *A. wolgensis* were surveyed and described (Fig. 1).

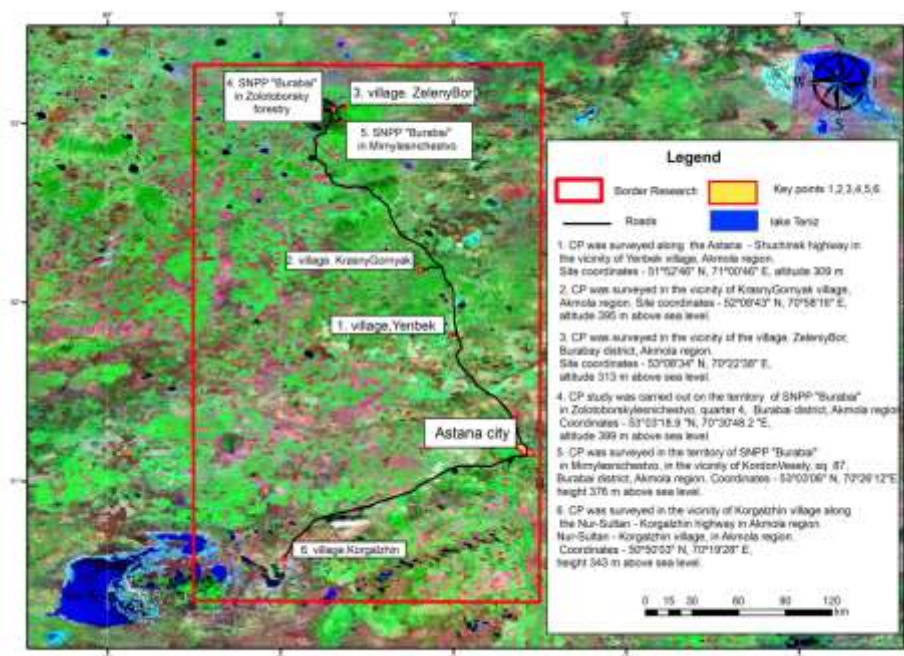


Figure 1. Map of studied population of *A. wolgensis*

The studies were carried out by detailed-route and cameral methods, geobotanical common methods were used to describe the objects. Ontogenetic age states were carried out according to the method of A. Rabotnov [15] and Smirnova [16]. The following classification of age groups was used to describe the age

groups: seedlings, juvenile, immature, virgin, young generative, mature generative, old generative, and senile individuals.

To study the ontogenetic structure and population size of *A. wolgensis*, plots with a high density of flowering individuals were selected with an area of 1 m<sup>2</sup>. In each population, 15 study plots were established: 10 × 10 m (100 m<sup>2</sup>). A total of 90 plots were counted. Characterization of age states was used according to A.P. Poshkurlat [4]. The ontogenetic spectrum was constructed according to the generally accepted methodology [15]. The type of cenopopulation was determined according to the classification of A.A. Uranov and O.V. Smirnova [16, 17].

All plant names are given according to the Plants of the World Online directory (POWO 2022) [18].

In addition to the materials of field studies, we used literature and materials from herbarium collections (AA) of the Institute of Botany and Phytointroduction and Astana Botanical Garden (Nur). Data on the distribution of *A. wolgensis* are fragmentary [19], special studies of the structure of cenopopulations (CP) of this region have not been conducted before.

Distribution map of *A. wolgensis* was obtained by ArcMap program.

### Results and discussion

The geographical, ecological and phytocenotic features of habitats, population characteristics and parameters of individuals were studied. Age composition was determined, total population size was calculated. As a result of floristic studies it was established that the cenoflora of *A. wolgensis* includes 119 species belonging to 28 families and 75 genera.

*A. wolgensis* is a perennial herbaceous, beautifully flowering plant, 5-25 cm tall, a species with a shrinking range. It grows among steppe grasses, in bushes, occasionally on forest edges and on forest lawns.

This plant has pale yellow flowers, oblong, narrow, narrowed at the ends, sometimes weakly toothed, 1-1.5 cm long and 0.5-1 cm wide; however, smaller than those of *Adonis vernalis*, 15-30 cm tall at the beginning of flowering, lengthening to 30-40 cm after flowering. The rhizome is erect, short, thick, with lace-like brownish-black roots. Stems solitary, with spreading branches; entire plant spreading-hairy, lower leaves brown, scaly, subsequent stem leaves twice pinnate, sessile, with 2 shortened lobes at the base; flowers 3.5-4.5 cm in diameter, petals 17-20 mm long and 6-7 mm wide; bracts globular or ovoid, sometimes drooping; fruits numerous, rounded, vaguely wrinkled, 3-4 mm long, ovoid, slightly wrinkled, pubescent, spout small, hooked downwardly bent. Nuts slightly wrinkled, hairy, about 4 mm long. The species blooms in late March-April, fruits in May-June [13]. It grows along the edges of birch forests and in mountain steppes (Fig. 2).



Figure 2. Period of flowering of *A. wolgensis* in the surrounding of village of Enbek, Akmola region

*A. wolgensis* is easier to cultivate than *A. vernalis*. Propagation is seed and vegetative – by rhizomes. In culture it blooms 6-8 years after sowing seeds, in separated years it gives self-seeding.

In nature grows singly or in small groups, natural reserves of the plant are quickly depleted. Obviously, in such a situation, studies of the peculiarities of biology, ecology and state of populations of this species in natural conditions are extremely important. Availability of such information is necessary for organization of works on preservation and increase of the number of its individuals and populations in the territories of their natural growth.

One of the most important features characterizing the state of a cenopopulation is ontogenetic structure [20], which is one of the existing features of a population. The side of structural organization provides the ability of a population system to self-maintenance and determines its sustainability. The analysis of the ontogenetic structure of plants provides insight into the future fate of species populations [21, 22].

Life cycle duration and reproductive characteristics are the main indicators of the ontogenetic state of a species. The ratio of the number of individuals of different age states allows determining the viability of cenopopulations. The biological peculiarities of the species under study include short period and average seed germination. Assessment of the vital state of *A. wolgensis* cenopopulations showed that plants in cenopopulations are flowering and fruiting. Adults for this species have an optimal height of the aboveground part [23, 24].

Below a characterization of *A. wolgensis* cenopopulations (CP) is given.

1 CP was surveyed along the Astana – Shuchinsk highway in the vicinity of Yenbek village, Akmola region. Site coordinates – 51°52'46" N, 71°00'46" E, altitude 309 m above sea level (Fig. 1). *A. wolgensis* is a part of steppe-grass-grass communities. The dominant species in the phytocenosis are *Festuca valesiaca*, *Stipa pennata*, *Limonium gmelinii*. Steppe xerophytic species often occur in the community: *Artemisia campestris*, *A. glauca*, *A. sericea*, *Glycyrrhiza glabra*, *Agropyron pectinatum*, *Galium verum*. Total projective coverage is 85%. Saline steppe chernozem soils.

Juvenile sprouts were absent in the cenopopulation, which is probably connected with sodden grass cover, as the vegetation cover was dominated by species of the *Poaceae* family. Species of this family prevent seed germination due to high density of rhizomes.

2 CP was surveyed in the vicinity of Krasny Gorniyak village, Akmola region. Site coordinates – 52°08'43" N, 70°58'16" E, altitude 395 m above sea level (Fig. 1). The species is a member of shrub-grass-grass communities. The dominant species in the phytocenosis are *Stipa capillata*, *Spiraea hypericifolia*, *Festuca valesiaca*, *Poa transbaicalica*. Among minor species *Achillea millefolium*, *Potentilla virgata*, *Allium lineare*, *Artemisia sericea*, *Phlomis tuberosa*, *Galium verum*, *Fragaria viridis*. Cenopopulations are subjected to anthropogenic impact in the form of cattle grazing. Adonis population is degrading, as young specimens and seedlings are damaged and die due to trampling by cattle. The total projective cover is 65%.

3 CP was surveyed in the vicinity of the village. Zeleniy Bor, Burabay district, Akmola region. Site coordinates – 53°08'34" N, 70°22'38" E, altitude 313 m above sea level (Fig. 1). The *A. wolgensis* population is a part of steppe-grass-grass communities. The community is dominated by the following species: *Stipa capillata*, *S. zaleskii*, *Festuca valesiaca*, *Pulsatilla flavescens*. Xerophytic species often occur in the community: *Carex humilis*, *Potentilla virgata*, *P. bifurca*, *Alyssum desertorum*, *Orostachys spinosa*, *Artemisia glauca*, *Thymus pulegioides subsp. pannonicus*, *Antennaria dioica*. The total projective coverage is 55%. Populations of *A. wolgensis* occur in the form of microphytocenoses of 500-700 m<sup>2</sup>, mainly on gentle slopes of hills or on tops. Participation of *A. wolgensis* in the herbage is 25-40%, the largest number of adult generative individuals is present, almost all of them flowered this summer and formed fruits (only 1.8 % were temporarily non-flowering), no sub-senile and senile plants were found. In 40 % of plants shoots branched up to the third order. Juvenile plants accounted for 15.5 %. No seedlings were found.

4 CP was carried out on the territory of SNPP “Burabai” in Zolotoborskylesnichestvo, quarter 4, Burabai district, Akmola region. Coordinates – 53°03'18.9 "N, 70°30'48.2 "E, altitude 399 m above sea level (Fig. 1). The species is a part of mixed grass sparse birch colony forests and intercolumnar steppe areas. The tree stand is formed by *Betula pendula* with insignificant inclusion of *Populus tremula*. The herbaceous layer is dominated by mesoxerophytic grasses: *Calamagrostis epigeios*, *Festuca valesiaca*, *Poa pratensis*, *Elymus repens*. Among herbs *Artemisia sericea*, *Filipendula vulgaris*, *Inula salicina*, *Fragaria vesca*, *Thalictrum simplex*, *Phlomis tuberosa*, *Rubus saxatilis*, *Lathyrus pratensis*, *Vicia cracca*, *Geranium pratense*, *Allium obliquum* frequently met. *A. wolgensis* is scattered over the territory of the population, renewal is satisfactory. The cenopopulation contains the largest number of adult generative and juvenile individuals.

5 CP was surveyed in the territory of SNPP “Burabai” in Mirnylesnichestvo, in the vicinity of Kordon Vesely, sq. 87, Burabai district, Akmola region. Coordinates – 53°03'06" N, 70°26'12" E, height 376 m above sea level (Fig. 1). The species is a part of pine-birch herbaceous forests. The tree stand is formed by *Betula*

pendula and *Pinus sylvestris*. The herbaceous tier is relatively species-poor, dominated by xeromesophytic vegetation – *Calamagrostis epigeios*, *Equisetum sylvaticum*, *Pyrola rotundifolia*, *Poa nemoralis*, *Rubus saxatilis*, *Geranium pratense*, *Melica nutans*, *Orthilia secunda*, *Phlomis tuberosa*. *Adonis* population of normal type, seed renewal is noted.

A high number of adult generative individuals were observed in the cenopopulation, the presence of juvenile and mature generative ontogenetic states indicates mature, established and stable populations.

6 CP was surveyed in the vicinity of Korgalzhin village along the Astana – Korgalzhin highway in Akmola region. Nur-Sultan – Korgalzhin village, in Akmola region. Coordinates – 50°50'03" N, 70°19'28" E, height 343 m above sea level (Fig. 1). The species is a part of grass-stipa-wormwood steppes (*Stipa sarillata*, *S. zaleskii*, *Festuca valesiaca*, *Artemisia glauca*, *A. frigida*, *A. commutata*). The community often contains xerophytes such as: *Achillea millefolium*, *Galium verum*, *Pulsatilla uralensis*, *Eryngium planum*, *Artemisia sericea*, *Potentilla virgata*, *Ranunculus repens*. The relief of the site is leveled, soils are steppe chernozems. The population is of normal type, good seed renewal is observed, the number of young individuals varies within 3-6 pcs/m<sup>2</sup>.

A high number of adult generative individuals were observed in the cenopopulation, which indicates the ecological plasticity of the cenopopulation. The presence of juvenile and mature generative ontogenetic states indicates maturity, formation and stability. In the floristic environment of *A. wolgensis* there are the following rare and protected plants of Akmola region: *Iris sibirica*, *Tulipa schrenkii*.

As a result of analyzing the age composition of the effective size of the studied cenopopulations of *A. wolgensis*, it was noted that most of them are full-members, as evidenced by the presence of juvenile individuals, with small deviations of CPs belong to normal. The exception is CP1 and CP2 located in a depression along the highway on saline soils, where we noted incomplete CPs associated with a small number of senile individuals. A large number of young vegetative individuals was noted. We managed to identify seedlings only in CP 2.

### Conclusion

Thus, the condition of the studied 6 cenopopulations of *A. wolgensis* was studied. They are in satisfactory condition, which is provided by vegetative and seed reproduction methods. The cenopopulations not or slightly affected by anthropogenic impact are characterized by the ontogenetic spectrum, in which the absolute maximum falls on the age states of the pre-generative period. In terms of vitality, they are medium thriving and are not located in a protected area. Grazing in cenopopulations leads to a decrease in plant vitality, suppression of seed reproduction.

Ontogenetically, CPs are close and mainly centered on young generative individuals, indicating that they are capable of self-renewal, are mature or transitional in mature. The evaluation of the gene pool status of the studied CPs of *A. wolgensis* is satisfactory. They are depressed with a medium degree of depression. The populations need urgent measures for their conservation and population recovery. It is necessary to prohibit the collection of raw materials, develop methods of cultivation in culture, organize reproduction of the species in commercial quantities, and strengthen protection measures in the places where the species grows.

In the long term, it is necessary to continue monitoring of price populations and careful counting of individuals of this species in order to develop and improve measures aimed at ensuring the conservation, protection and reproduction of this red-listed species.

### Acknowledgements

Research work was carried out on the basis of the project No AP15473108 of the Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan.

### References

- 1 Красная книга Казахстана. — Т. 2: Растения. — Астана: ТОО «АртPrint XXI», 2014. — 452 с.
- 2 Nishikawa T. *Adonis* / T. Nishikawa, Y. Kadota // In: K. Iwatsuki K. et al. (eds). Flora of Japan. VII. — Tokyo: Kodansha, 2006. — P. 287-288.
- 3 Ren Y. Floral development in *Adonideae* (*Ranunculaceae*) / Y. Ren, H.L. Chang, X.H. Tian, P. Song, P.K. Endress // Flora. — 2009. — Vol. 204. — P. 506-517.
- 4 Пошкурлат А.П. Род горичвет – *Adonis* L. Систематика, распространение, биология / А.П. Пошкурлат. — М.: Наука, 2000. — 199 с.

- 5 Ghorbani N. Pollen morphology of some *Adonis* L. species (*Ranunculaceae*) From Iran / N. Ghorbani et al. // Journal Bot. — 2008. — Vol. 14 (2). — P. 165-170.
- 6 Hirsch H. High genetic diversity declines towards the geographic range periphery of *Adonis vernalis*, a Eurasian dry grassland plant / H. Hirsch, V. Wagner, J. Danihelka, E. Ruprecht, P. Sánchez-Gomez, M. Seifert et al. // Plant Biol. — 2015. — Vol. 17. — P. 1233–1241. <https://doi.org/10.1111/plb.12362>
- 7 Shang X. The Genus *Adonis* as an Important Cardiac Folk Medicine: A Review of the Ethnobotany, Phytochemistry and Pharmacology / X. Shang, X. Miao, F. Yang, C. Wang, B. Li, W. Wang, H. Pan, X. Guo, Y. Zhang, J. Zhang // Front. Pharmacol. — 2019. — Vol. 10. — P. 25. <https://doi.org/10.3389/fphar.2019.00025>
- 8 Yatsyuk V.Y. Cardenoloids of *Adonis wolgensis* / V.Y. Yatsyuk, N.F. Komissarenko, É.V. Gella // Chemistry of Natural Compounds. — 1976. — Vol. 12, No. 5. — P. 607–607.
- 9 Растительные ресурсы СССР. Цветущие растения, их химический состав, применение: Сем. *Magnoliaceae-Limoniaceae*. — Л.: Наука, 1984. — 460 с.
- 10 Strokova N.P. Change in the glycoside content in the aboveground shoots of the spring horticulture (*Adonis vernalis* L.) during a large development cycle and according to phenophases II / N.P. Strokova // Biol. sciences. — 1971. — No. 12. — P. 70-73.
- 11 Грудзинская Л.М. Аннотированный список лекарственных растений Казахстана: Справоч. изд. / Л.М. Грудзинская, Н.Г. Гемеджиева, Н.В. Нелина, Ж.Ж. Каржаубекова. — Алматы, 2014. — 200 с.
- 12 Lachashvili N. *Adonis wolgensis* Steven — New species for flora of Georgia / N. Lachashvili, N. Eradze // Bulletin of the Georgian National Academy of Sciences. — 2017. — Vol. 11 (4). — P. 95-99.
- 13 Флора Казахстана. — Алма-Ата: Наука, 1961. — С. 130.
- 14 Куприянов А.Н. Конспект флоры Казахского мелкосопочника / А.Н. Куприянов. — Новосибирск, 2020. — С. 53.
- 15 Работнов Т.А. Определение возрастного состава популяций видов в сообществе / Т.А. Работнов // Полевая геоботаника. — М.–Л.: Изд-во АН СССР, 1964. — С. 132–145.
- 16 Смирнова О.В. Критерии выделения возрастных состояний и особенности хода онтогенеза у растений разных биоморф / О.В. Смирнова, Л.Б. Заугольнова, Н.А. Торопова, Л.Д. Фаликов // Ценопопуляции растений (основные понятия и структура). — М.: Наука, 1976. — С. 14–44.
- 17 Уранов А.А. Возрастной спектр фитоценопопуляций как функция времени и энергетических процессов / А.А. Уранов // Биол. науки. — 1975. — № 2. — С. 7–34.
- 18 POWO. Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. — [Electronic resource]. — 2022. — Access mode: <http://www.plantsoftheworldonline.org/>
- 19 Султангазина Г.Ж. Редкие флористические комплексы природного парка «Бурабай» / Г.Ж. Султангазина, Б. Амантайқызы // Материалы Респ. науч.-теор. конф. «Сейфуллинские чтения–13: сохраняя традиции, создавая будущее». — Костанай, 2017. — Т. I. — Ч. 6. — С. 164–166.
- 20 Смирнова Е. Б. Состояние популяций *Adonis wolgensis* DC. в Балашовском районе Саратовской области / Е.Б. Смирнова // Науч. тр. Присур. гос. природ. заповедн. — 2015. — Т. 30. № 1. — С. 238–240.
- 21 Заугольнова Л.Б. Структура популяций семенных растений и проблемы их мониторинга: автореф. дис. ... д-ра биол. наук / Л.Б. Заугольникова. — СПб., 1994. — 70 с.
- 22 Жукова Л.А. Популяционная жизнь луговых растений / Л.А. Жукова. — Йошкар-Ола, 1995. — 223 с.
- 23 Шапаренко И.Е. Распространение, ценоотическая характеристика и состояние ценопопуляций *Adonis vernalis* L. на территории бассейна реки Ворсклы / И.Е. Шапаренко // Междунар. журн. эксперим. обр. — 2013. — № 10–1. — С. 111–117.
- 24 Султангазина Г.Ж. Структура популяций *Adonis wolgensis* Stev. Северного Казахстана / Г.Ж. Султангазина, А.Н. Куприянов, О.А. Куприянов // Материалы V Междунар. конф. «Проблемы промышленной ботаники индустриально развитых регионов». — Кемерово, 2018. — С. 109–118.

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### Ақмола облысы бойынша *Adonis wolgensis* ценопопуляцияларын және онтогенетикалық құрылымын зерттеу

Мақалада Солтүстік Қазақстанда, оның ішінде Ақмола облысында сирек кездесетін дәрілік өсімдік *Adonis wolgensis* Steven ex DC. (*Ranunculaceae*) алты ценопопуляциясын зерттеу нәтижелері келтірілген. Өсімдікке экологиялық-фитоценоздық сипаттама берілген және ценопопуляциялардың онтогенетикалық құрылымы зерттелген. Зерттелетін аймақта *Adonis wolgensis* далалық шөптесін өсімдіктерде, бұталы жерлерде, кейде орман жиегінде және орман көгалдарында өсетіні анықталды. Жалпы зерттелген *Adonis wolgensis* ценопопуляцияларының жағдайы қанағаттанарлық. Жас спектрлерін талдау көрсеткендей, антропогендік әсерге ұшырамайтын немесе аз ұшыраған ценопопуляциялар спектрмен сипатталады, онда абсолютті максимум прегенеративті кезеңнің жас жағдайларына сәйкес келеді. Төрт ценопопуляцияда дарактардың едәуір бөлігі жас генеративті күйде болады, бұл олардың өзін-өзі

қалпына келтіру қабілеттілігін көрсетеді. Бұл зерттелетін аумақтардың өсімдіктер қауымдастығында түрдің тұрақтылығын қамтамасыз етеді. Екі ценопопуляцияның жағдайы деградациялық деп бағаланған, оларды сақтау және олардың санын қалпына келтіру үшін шұғыл шаралар қабылдау қажет. Ценопопуляцияларда мал жаю өсімдік тіршілігінің төмендеуіне және тұқымның көбеюінің тежелуіне әкеледі. Түрді сақтау үшін мал жаюды шектеу, шикізат жинауға тыйым салу, өсімдіні өсіру әдістерін әзірлеу, түрдің өнеркәсіптік көлемде көбеюін ұйымдастыру, қорғау шараларын күшейту қажет. Алынған нәтижелер Солтүстік Қазақстандағы түрдің жай-күйі туралы жаңа мәліметтер алуға мүмкіндік береді және оны одан әрі сақтап, іске жаратуға болады.

*Кілт сөздер:* *Adonis wolgensis*, ценопопуляция, онтогенетикалық құрылым, сирек, Ақмола облысы.

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## Изучение ценопопуляций и онтогенетической структуры *Adonis wolgensis* в Акмолинской области

В статье представлены результаты изучения шести ценопопуляций редкого лекарственного растения *Adonis wolgensis* Steven ex. DC. (Ranunculaceae) в Акмолинской области Северного Казахстана. Дана эколого-фитоценотическая характеристика, и изучена онтогенетическая структура ценопопуляций. Установлено, что в исследуемом регионе *Adonis wolgensis* произрастает среди степного разнотравья, в зарослях кустарников, изредка по опушкам лесов и на лесных лужайках. В целом, состояние изученных ценопопуляций *Adonis wolgensis* удовлетворительное. Анализ возрастных спектров показал, что ценопопуляции, не подвергающиеся или слабо подвергающиеся антропогенному воздействию, характеризуются спектром, в котором абсолютный максимум приходится на возрастные состояния прегенеративного периода. В четырех ценопопуляциях значительная часть особей находится в молодом генеративном состоянии, что указывает на их способность к самовозобновлению. Это обеспечивает стабильность вида в растительных сообществах исследуемых территорий. Состояние двух ценопопуляций оценивается как деградирующее, они нуждаются в принятии срочных мер по их сохранению и восстановлению численности. Выпас скота в ценопопуляциях приводит к снижению жизнеспособности растений и подавлению семенного размножения. Для сохранения вида необходимо ограничить выпас скота, запретить сбор сырья, разработать методы выращивания в культуре, организовать воспроизводство вида в промышленных объемах, усилить меры охраны. Полученные результаты позволили получить новые сведения о состоянии вида в Северном Казахстане и служат надежной основой для его дальнейшего сохранения.

*Ключевые слова:* *Adonis*, флора Казахстана, редкий вид, сохранение биоразнообразия, Северный Казахстан, состояние ценопопуляций.

## References

- 1 (2014). *Krasnaia kniga Kazakhstana. Tom 2: Rasteniia [The red book of Kazakhstan. Vol. 2 Plants]*. Astana: «ArtPrint XXI» Ltd [in Russian].
- 2 Nishikawa, T. et al. (2006). *Adonis*. In: K. Iwatsuki K. et al. (eds). *Flora of Japan. VII*. Tokyo: Kodansha, 287-288.
- 3 Ren, Y., Chang, H.L., Tian, X.H., Song, P., & Endress, P.K. (2009). Floral development in *Adonideae* (Ranunculaceae). *Flora*, 204; 506-517.
- 4 Poshkurlat, A.P. (2000). *Rod goritsvet — Adonis L. Sistematika, rasprostranenie, biologiiia [Genus goritsvet – Adonis L. Systematic, spreading, biology]*. Moscow: Nauka [in Russian].
- 5 Ghorbani, N. et al. (2008). Pollen morphology of some *Adonis L.* species (Ranunculaceae) From Iran. *Journal Bot.*, 14 (2); 165-170.
- 6 Hirsch, H., Wagner, V., Danihelka, J., Ruprecht, E., Sánchez-Gomez, P., Seifert, M. et al. (2015). High genetic diversity declines towards the geographic range periphery of *Adonis vernalis*, a Eurasian dry grassland plant. *Plant Biol.*, 17; 1233–1241. <https://doi.org/10.1111/plb.12362>
- 7 Shang, X., Miao, X., Yang, F., Wang, C., Li, B., Wang, W., Pan, H., Guo, X., Zhang, Y., & Zhang, J. (2019). The Genus *Adonis* as an Important Cardiac Folk Medicine: A Review of the Ethnobotany, Phytochemistry and Pharmacology. *Front. Pharmacol.*, 10; 25. <https://doi.org/10.3389/fphar.2019.00025>
- 8 Yatsyuk, V.Y., Komissarenko, N.F., & Gella, É.V. (1976). Cardenoloids of *Adonis wolgensis*. *Chemistry of Natural Compounds*, 12(5); 607–607.
- 9 (1984). *Rastitelnye resursy SSSR. Tsvetushchie rasteniia, ikh khimicheskii sostav, primeneniie: Sem. Magnoliaceae-Limoniaceae [Plant resources of USSR. Flowering plants, their chemical composition, using Family Magnoliaceae-Limoniaceae]*. Leningrad: Nauka [in Russian].

- 10 Strokova, N.P. (1971). Change in the glycoside content in the aboveground shoots of the spring horticulture (*Adonis vernalis* L.) during a large development cycle and according to phenophases II. *Biol. sciences*, 12; 70-73.
- 11 Grudzinskaia, L.M., Gemejjeva, N.G., Nelina, N.V., & Karzhaubekova, Zh.Zh. (2014). *Annotirovannyi spisok lekarstvennykh rastenii Kazakhstana* [Annotated lists of medicinal plants of Kazakhstan]. Almaty [in Russian].
- 12 Lachashvili, N., & Eradze, N. (2017). *Adonis wolgensis* Steven – *New species for flora of Georgia*. *Bulletin of the Georgian National Academy of Sciences*, 11 (4); 95-99.
- 13 (1961). *Flora Kazakhstana* [Flora of Kazakhstan]. Alma-Ata: Nauka, 130 [in Russian].
- 14 Kupriianov, A.N. (2020). *Konspekt flory Kazakhskogo melkosopohnika* [Conspectus of flora of Kazakh upland]. Novosibirsk, 53 [in Russian].
- 15 Rabotnov, T.A. (1964). Opredelenie vozrastnogo sostava populiatsii vidov v soobshchestve [Determining the age composition of species populations in a community]. *Polevaia geobotanika – Field geobotany*. Moscow–Leningrad: Izdatelstvo AN SSSR, 132–145 [in Russian].
- 16 Smirnova, O.V., Zaugolnova, L.B., Toropova, N.A., & Falikov, L.D. (1976). Kriterii vydeleniia vozrastnykh sostoianii i osobennosti khoda ontogeneza u rastenii raznykh biomorf [Criteria for distinguishing age states and peculiarities of ontogenesis in plants of different biomorphs]. *Tsenopopuliatsii rastenii (osnovnye poniatii i struktura) — Plant cenopopulations (basic concepts and structure)*. Moscow: Nauka, 14–44 [in Russian].
- 17 Uranov, A.A. (1975). Vozrastnoi spektr fitosenopopuliatsii kak funktsiia vremeni i energeticheskikh protsessov [Age spectrum of phytocenopopulations as a function of time and energy processes]. *Biologicheskie nauki – Biol. science*, 2, 7–34 [in Russian].
- 18 (2022). *POWO. Plants of the World Online. Facilitated by the Royal Botanic Gardens*, Kew. Retrieved from <http://www.plantsoftheworldonline.org/>
- 19 Sultangazina, G.Zh., & Amantaikyzy, B. (2017). Redkie floristicheskie komplekсы prirodnogo parka «Burabai» [Rare floristic complexes of the Burabai Nature Park]. *Materialy Respublikanskoi nauchno-teoreticheskoi konferentsii «Seifullinskie chtenia–13: sokhraniia traditsii, sozdavaia budushchee» — Materials of the Republican scientific-theoretical conference “Seifullin’s readings – 13: preserving traditions, creating the future”*. Kostanay, I (6); 164–166 [in Russian].
- 20 Smirnova, E.B. (2015). Sostoianie populiatsii *Adonis wolgensis* DC. v Balashovskom raione Saratovskoi oblasti [Status of *Adonis wolgensis* DC. populations in Balashov district of Saratov region]. *Nauchnye trudy Prisurskogo gosudarstvennogo prirodnogo zapovednika — Scientific works of the Prisursky State Nature Reserve*, 30 (1), 238–240 [in Russian].
- 21 Zaugolnova, L.B. (1994). Struktura populiatsii semennykh rastenii i problemy ikh monitoringa [Population structure of seed plants and problems of their monitoring]. *Extended abstract of Doctor’s thesis*. Saint Petersburg [in Russian].
- 22 Zhukova, L.A. (1995). Populiatsionnaia zhizn lugovykh rastenii [Population life of grassland plants]. Ioshkar-Ola [in Russian].
- 23 Shaparenko, I.E. (2013). Rasprostranenie, tsenoticheskaiia kharakteristika i sostoianie tsenopopuliatsii *Adonis vernalis* L. na territorii basseina reki Vorskly [Distribution, cenotic characterization and state of *Adonis vernalis* L. cenopopulations on the territory of the Vorskla River basin]. *Mezhdunarodnyi zhurnal eksperimentalnogo obrazovaniia — International Journal of Experiential Education*, 10-1, 111–117 [in Russian].
- 24 Sultangazina, G.Zh., Kupriianov, A.N., & Kupriianov, O.A. (2018). Struktura populiatsii *Adonis wolgensis* Stev. Severnogo Kazakhstana [Population structure of *Adonis wolgensis* Stev. of Northern Kazakhstan]. *Materialy V Mezhdunarodnoi konferentsii «Problemy promyshlennoi botaniki industrialno-razvitykh regionov» — Proceedings of V International Conference Problems of Industrial Botany of Industrialized Regions*. Kemerovo, 109–118 [in Russian].