

ANNOTATION

dissertation for the degree of Doctor of Philosophy (PhD)
in the specialty "6D061300 - Geobotany"

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**«Assessment of the current state of populations of species of the genus
Dactylorhiza Necker ex Nevski from Kazakhstan Altai»**

General description of work. The work is devoted to the study of the species diversity of the genus *Dactylorhiza* Necker ex Nevski in the Kazakhstan Altai, the current state of the populations of these species, the floristic composition of coenopopulations and the development of measures for the conservation and protection of rare species.

Relevance of the research topic.

The genus *Dactylorhiza* belongs to one of the largest families of monocotyledonous plants – Orchidaceae Juss. Species of the genus *Dactylorhiza* are vulnerable and belong to rare and endangered plant species. In many countries, these species are included in the lists of protected species in accordance with the National Strategies for the Conservation of Biological Diversity.

Dactylorhiza is a taxonomically complex genus. Representatives of the genus are distinguished by high phenotypic variability, which often does not allow one to clearly distinguish between species even within the same coenopopulation or closely located communities. In the Flora of Kazakhstan (1956), the genus *Dactylorhiza* has 8 independent species, of which the Euro-Siberian *D. fuchsii* is listed in the Red Book of the Republic of Kazakhstan (2014) and is considered endangered. According to S.A. Abdulina (1999) the genus *Dactylorhiza* in the flora of Kazakhstan includes only 9 species. For the Kazakhstan Altai, 5 species are noted.

The development of measures for the conservation and protection of endangered species of the genus *Dactylorhiza* is not possible without studying the geography of populations, ecological confinement and floristic population plasticity of the species under study. Thus, the study of the current state of populations of species of the genus *Dactylorhiza* in Kazakhstan Altai has fundamental and practical interest, and is aimed at preserving the flora of Kazakhstan.

Purpose of the work: Population and ecological-biological study of the species of the genus *Dactylorhiza* in Kazakhstan Altai, the establishment of the species composition of the genus, the development of measures for their protection.

Research objectives:

1. Determination of localities of populations of species of the genus *Dactylorhiza* in Kazakhstan Altai.
2. Study of population characteristics of species of the genus *Dactylorhiza* in natural populations of Kazakhstan Altai.
3. Study of the geographical distribution and ecological characteristics of the species of the genus *Dactylorhiza* in Kazakhstan Altai. Mapping the localities of the studied populations of species of the genus *Dactylorhiza*.
4. Study of the genetic structure of populations of species of the genus *Dactylorhiza* using polymorphic microsatellite markers.

5. Development of scientific foundations (recommendations) for the preservation of the gene pool of species of the genus *Dactylorhiza*.

Objects of research: Natural populations of species of the genus *Dactylorhiza*, growing in various regions of the Kazakhstan Altai.

Subject of research: Representatives of the genus *Dactylorhiza*, floristic composition of coenopopulations and their geographical distribution.

Research methods:

In the course of the work, geobotanical, introduction, morphometric, molecular genetics and cartographic methods were used.

Scientific novelty of the research.

For the first time, on the basis of population-quantitative and ecological-biological studies, the species composition was clarified, the distribution and current state of populations of the genus *Dactylorhiza* of the Kazakhstan Altai were studied, the reasons for the rarity of the studied species were established, the identified species were ranked according to the degree of rarity, maps of their locations were drawn up, a permanent collection of *Dactylorhiza* was created and carried out their primary introduction in the Altai Botanical Garden, work has begun on the development of technology for growing them in culture.

The theoretical significance of the work.

For the first time, the modern species composition of the genus *Dactylorhiza* was specified for the Kazakhstan Altai.

The current state of populations of species of the genus *Dactylorhiza* has been studied, typical habitats have been established, the ecological optimum for species of the genus *Dactylorhiza* has been determined, and current habitats have been examined.

The floristic composition of coenopopulations has been established, and the floristic population plasticity of species of the genus *Dactylorhiza* has been studied.

The age range of populations and the degree of regeneration of coenopopulations of species of the genus *Dactylorhiza* were studied.

For the first time, the analysis of herbarium samples of the main repositories was carried out, as well as revision of species of the genus *Dactylorhiza* in the Herbarium Fund of the Institute of Botany and Phytointroduction (AA).

For the first time, the intra- and interpopulation diversity of species of the genus *Dactylorhiza* was studied on the basis of microsatellite markers.

The morphometric structure of flowers of species of the genus *Dactylorhiza* of Kazakhstan Altai, as the main taxonomic feature in the identification of species, has been studied.

For the first time, a taxonomic key was compiled according to the dichotomous principle of determining the species of the genus *Dactylorhiza* for the Kazakhstan Altai.

The practical value of the research.

New data have been obtained on the distribution of rare and endangered species of *Dactylorhiza* in the Kazakhstan Altai.

Schematic maps of the ranges and distribution of species of the genus *Dactylorhiza* in the Kazakhstan Altai have been compiled.

Passports of species of the genus *Dactylorhiza* of the Kazakhstan Altai have been compiled.

Herbarium sheets of the studied genus and closely related species were collected, designed and transferred to the Herbarium collection of the Institute of Botany and Phytointroduction (AA) – 87 herbarium sheets, to the Herbarium collection of the University of Gdansk (UGDA) – 18 sheets.

A permanent collection of living plants of the genus *Dactylorhiza* has been created in the collection site of the department of natural flora of the Altai Botanical Garden. Primary introduction studies have been carried out.

Guidelines for the protection and conservation of species of the genus *Dactylorhiza* in the Kazakhstan Altai have been published.

The main provisions for the defense:

1. The genus *Dactylorhiza* in Kazakhstan Altai is represented by four species: *D. fuchsii*, *D. incarnata*, *D. salina* and *D. maculata*.

2. In the Kazakh Altai, the species *D. fuchsii* is represented by 4 main populations, 12 coenopopulations and a coenoflora consisting of 251 species; *D. incarnata* is represented by 4 populations, 13 coenopopulations, and a coenoflora consisting of 117 species; *D. salina* is represented by 2 populations, 2 coenopopulations, and a coenoflora consisting of 72 species; species *D. maculata* – 1 coenopopulation and coenoflora of 33 species.

3. In the initial *ex-situ* introduction tests, the highest plasticity and good adaptability were shown by *D. incarnata* specimens.

4. The morphometric structure of a flower can serve as the main effective taxonomic character in identifying the species of the genus *Dactylorhiza* in the Kazakhstan Altai.

5. In the medium term (2041-2060), according to ENM forecast, *D. incarnata* and *D. maculata* species may not be found in Kazakhstan, *D. salina* and *D. fuchsii* can significantly reduce their ranges.

Key research findings and conclusions:

As a result of the study, four species of the genus *Dactylorhiza* were found in the study area, from the *Dactylorhiza* section: *D. incarnata* (L.) Soo and *D. salina* (Turcz. ex Lindl.) Soo from the *Dactylorhiza* subsection, as well as *D. fuchsii* (Druce) Soo and *D. maculata* (L.) Soo from the subsection *Maculatae* (Parl.) Aver.

It was found that in the Kazakhstan Altai *D. fuchsii* is represented by 4 main populations and 12 coenopopulations; *D. incarnata* is represented by 4 populations and 13 coenopopulations; *D. salina* is represented by 2 populations and 2 coenopopulations; *D. maculata* – 1 coenopopulation.

Flora of *D. incarnata* populations in Kazakhstan Altai includes 117 species belonging to 30 families and 80 genera. The floristic population similarity of the studied populations varies within the range of 9–27%. The ecological optimum of the species falls on the southeastern slopes with diffused lighting and moderate wind impact. The surveyed populations require protection and long-term monitoring of the demographic structure.

Flora of *D. fuchsii* populations in Kazakhstan Altai includes 251 species belonging to 49 families and 155 genera. The coenoecotypes occupy wet meadows,

edges of birch and mixed forests, river and stream valleys, in areas with stable moisture and rich humus substrate. The floristic population similarity of the studied populations varies within 12–24%. The assessment of the renewal of coenopopulations indicates a high degree of selectivity and low ecological plasticity of the species. It has been established that the ecological optimum of the species falls on the edges of mixed and dark coniferous forests, under the canopy of high shrubs, as well as along the valleys of mountain streams on moss.

Flora of *D. salina* populations in Kazakhstan Altai includes 72 species belonging to 26 families and 61 genera. The similarity of the species composition of populations is 8%. Populations form the eastern part of the Kazakh species range. In ecological terms, the habitat of the species is represented by flooded steppe meadows, with noticeable salinity.

The population of *D. maculata* occupies a limited localized territory in a relief depression in a flooded forb meadow under a willow canopy. The environmental conditions are close to optimal: diffused lighting, good humidification and protection from wind exposure. The discovered location needs constant protection.

The analysis carried out by ENM shows that the spread of *Dactylorhiza* in Kazakhstan will be significantly hampered by global warming. *D. fuchsii* will react slightly differently, and its range may increase throughout the country, although global changes indicate a decrease in its occurrence in general. It is possible that two species will not be found in Kazakhstan in the future: *D. incarnata* and *D. maculata*. The range of *D. salina* will be significantly reduced.

As a result of the initial introduction of species of the genus *Dactylorhiza* in the Altai Botanical Garden, a stable collection of the genus *Dactylorhiza* was obtained. The species *D. incarnata* proved to be more plastic and adaptable to the cultivation conditions, the indicators of the length of the inflorescence, the number of flowers per one inflorescence, the length and width of the basal leaves increased significantly. *D. salina* reduced all parameters except for the number of flowers per inflorescence. Due to the high nutrient richness of the soil, the number of flowers per inflorescence increased in all 4 species. And the indicator of plant height, due to the receipt of more sunlight, also decreased in all species.

Ten SSR markers developed for the genus *Dactylorhiza* were tested in this study. It was found that all markers are informative (PIC <0.5), the KSSR-04 marker is considered to be highly informative and KSSR-22 is considered to be uninformative.

The essential metric features of the flower were revealed to distinguish four closely related species: *D. incarnata*, *D. fuchsii*, *D. maculata*, *D. salina*. The obtained data on the morphometry of the flower structure can serve as the main character in the taxonomy of the genus *Dactylorhiza* in the Kazakhstan part of the Altai mountainous country and in Kazakhstan as a whole.

A dichotomous key has been compiled for the species identification of the genus *Dactylorhiza* in the Kazakhstan Altai.

Certification of species was carried out to preserve the studied populations.

Personal contribution of the author. The author personally established the species composition of the genus *Dactylorhiza*, analyzed the current state of the

populations, and compiled species passports that would improve the conservation of populations of rare species. The author has determined the floristic composition of each population, and compiled a taxonomic key to determine it. The author has created a permanent introduced collection of living plants in the exposition of the Altai Botanical Garden. The articles were written with co-authors, with the personal contribution of the author being the main one.

Connection with the plan of the main scientific works. The dissertation work was carried out within the framework of the AR05133868 project "Study of the distribution and current state of populations of species of the Orchid family of Kazakhstan Altai and their introduction in the Altai Botanical Garden" grant funding for 2018 – 2020 and project "Development of scientific and practical foundations and innovative approaches to plant introduction in natural zones of Western and Eastern Kazakhstan for rational and effective use" of the Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan for 2021–2022.

Approbation of work. The materials of the dissertation were reported and discussed: at the International Conference: "International Orchid Conference for Young Scientists", Spala, Poland, 2019; at the Republican Conference "Science and Business", Almaty, 2019; at the XIX International Scientific and Practical Conference "Problems of Botany of Southern Siberia and Mongolia" Barnaul, Russia, 2020; at the VII International Scientific Conference "Farabi Alemi", Almaty, Kazakhstan, 2020; at the VIII International Scientific Conference "Farabi Alemi", Almaty, Kazakhstan, 2021; at the XX International Scientific and Practical Conference "Problems of Botany of Southern Siberia and Mongolia" Barnaul, Russia, 2021.

Publications. The main content of the dissertation is reflected in 16 printed works, including 2 articles in an international peer-reviewed journal with an impact factor, cited in Scopus and Web of Knowledge; 5 articles from the list of publications recommended by committee for the publication of the main results of scientific activity, 8 articles and abstracts in the materials of international and republican conferences; 1 methodological recommendation for the conservation of populations.

The structure of the thesis. The thesis is presented on 147 pages and consists of designations, introduction, review of literature, materials and methods, results and discussion, conclusion and list of used sources from 252 titles; contains 25 tables, 42 figures and 8 appendices.