ABSTRACT

to the dissertation of **Musina Maral Elubekovna**, submitted for the degree of **Doctor of Philosophy (PhD)** in the educational program **8D05108 – Geobotany**

Assessment of the Current State of Populations of the Medicinal Species *Calligonum leucocladum* (Schrenk) Bunge in South-Eastern Kazakhstan

General Characteristics of the Study: This dissertation research is devoted to a comprehensive assessment of the current state of cenopopulations of the medicinal plant *Calligonum leucocladum* (Schrenk) Bunge naturally growing in the South-Eastern region of Kazakhstan. The study examined the distribution range and population structure of the species, its ecological and cenotic condition, including a comparative analysis of changes in green vegetation cover over the last ten years using the Normalized Difference Vegetation Index (NDVI). In addition, the physicochemical properties of soils in the plant's habitats were investigated, and the phytochemical composition of the species was analyzed. Indicators of genetic diversity were studied, and the stability of populations and their level of adaptation to environmental conditions were assessed. The research results are aimed at developing scientific foundations and recommendations for the conservation of medicinal plant biodiversity, their sustainable use, and protection.

Relevance of the Research Topic: The flora of South-Eastern Kazakhstan is rich and diverse, with medicinal plants occupying a special place within it. One of these species is *C. leucocladum*, which is of significant biological and pharmacological importance. However, in recent years, natural populations of this species have declined considerably due to anthropogenic pressure, climate change, and excessive exploitation of natural resources. Therefore, a comprehensive study of the cenopopulation status of *C. leucocladum* represents an urgent scientific task.

The investigation of the ecological condition and distribution range of *C. leucocladum* plays an important role in biodiversity conservation. Within the framework of this study, changes in vegetation cover over the past decade were analyzed using NDVI data, allowing the identification of plant growth conditions and its role within ecosystems. These indicators provide insight into the ecological status of the species and enable assessment of its resilience. Furthermore, the physicochemical properties of the soils in which the plant grows were examined, clarifying its ecological requirements.

Phytochemical analysis was aimed at identifying the composition of bioactive compounds in *C. leucocladum* and determining their pharmacological significance. The active substances found in the plant provide

a basis for expanding its potential applications in medical and pharmaceutical fields. In addition, genetic studies examined the structure and diversity of plant plastids, enabling assessment of genetic stability and adaptive capacity.

The results of this research are intended to develop scientific recommendations and methodologies for the conservation, sustainable use, and protection of medicinal plant biodiversity. These findings contribute to improving Kazakhstan's bioresource conservation policy and provide a foundation for strategic decision-making in nature conservation and the effective utilization of pharmacological potential.

Object of the Research: The object of the study is the current state of natural populations of the medicinal species *C. leucocladum* growing under natural conditions in the South-Eastern region of Kazakhstan. The research comprehensively examined the species' distribution range, population structure, ecological and cenotic condition, physicochemical properties of soils, phytochemical composition, and genetic diversity. These parameters were used to assess population stability and address issues related to biodiversity conservation and sustainable use.

Subject of the Research: The structure of natural populations of *C. leucocladum* in South-Eastern Kazakhstan, their ecological adaptation, biomorphological characteristics, soil properties of their habitats, phytochemical composition, and plastid-level genetic diversity.

Aim of the Study: To assess the current state of populations of the medicinal species *C. leucocladum* (Schrenk) Bunge in South-Eastern Kazakhstan.

Objectives of the Study

1. To conduct a comprehensive study of the natural coenopopulations of the medicinal species *C. leucocladum* and to provide a versatile evaluation and description of their eco-coenotic conditions.
2. To determine the population structure, age spectrum, and morpho-biological characteristics of the *C. leucocladum* species.
3. To monitor the state of *C. leucocladum* populations based on the Normalized Difference Vegetation Index (NDVI) and to evaluate the physico-chemical properties of the ecotope soil.
4. To identify the main bioactive compounds and analyze the genomic structure of the *C. leucocladum* plant.

Scientific Novelty: For the first time, a comprehensive study of natural populations of the medicinal species *C. leucocladum* in South-Eastern Kazakhstan was conducted. The research determined the ecological and cenotic status of populations, biomorphological traits, and adaptive features of the species, as well as the dynamics of vegetation cover based on NDVI data over the past decade.

Additionally, for the first time, the physicochemical properties and compositional characteristics of soils in habitats of *C. leucocladum* were described. Phytochemical studies identified biologically active compounds in the plant.

Genetic research revealed plastid DNA-level genetic diversity of *C. leucocladum* and identified features of genetic structure among natural populations. These results made it possible to assess the species' adaptive capacity and genetic resilience.

Theoretical and Practical Significance: The research results expand the theoretical knowledge base regarding the ecological, morphological, phytochemical, and genetic characteristics of natural populations of *C. leucocladum*, contributing to botany, ecology, and sustainable use of plant resources. The findings provide scientific foundations for understanding population structure, adaptive strategies, ecosystem roles, and environmental responses of the species.

From a practical perspective, the results can be applied to planning conservation measures, sustainable use, and restoration of medicinal plant resources. Phytochemical data may serve as a basis for evaluating the quality of natural raw materials used for pharmacological purposes and for developing new medicinal products. In addition, the potential for conserving the species in natural habitats or cultivating it under controlled conditions, considering soil and climatic factors, was assessed.

Genetic diversity data provide insight into evolutionary potential, adaptive capacity, and genetic connectivity among populations of *C. leucocladum*, playing an important role in developing strategies for conserving the gene pool of rare and valuable plant species.

Main Provisions Submitted for Defense

1. For the first time, the extent and current state of natural populations of *C. leucocladum* in South-Eastern Kazakhstan were comprehensively assessed.
2. Based on ecological and cenotic characteristics and NDVI data, changes in vegetation cover over the past ten years were identified, serving as indicators of population degradation.
3. Biomorphological parameters and adaptive strategies of the species were determined, demonstrating its ability to adapt to various environmental conditions.
4. The physicochemical properties of soils in *C. leucocladum* habitats were studied, and relationships between the plant and its environment were established.
5. Phytochemical studies identified biologically active compounds and assessed their pharmacological potential, while genetic analysis revealed

plastid-level diversity and evaluated genetic differentiation and resilience among populations.

Personal Contribution of the Dissertator to the Implementation of the Results of the Scientific Research Work Recommended for Defense: All stages of the research work—from field expeditionary work to laboratory analyses and the examination of scientific results—were carried out with the direct participation and independent execution of the dissertator.

The dissertator, on a scientific basis, pre-selected the research object in the South-East Kazakhstan region and, based on cartographic and geobotanical data, taking into account the natural and climatic features of the region, determined the distribution area of the *C. leucocladum* plant. Having established field routes over several seasons, he conducted comprehensive studies on the cenopopulation in order to study the distribution structure and density of natural populations. During the research, biomorphological indicators of the plants—such as height, branching nature, leaf shape, and flowering phase—were measured and prepared for statistical processing.

The dissertation analyzed the NDVI (Normalized Difference Vegetation Index) over the last 10 years through remote sensing and geographic information systems. With the help of these methods, the state of the green cover and its change in the studied area were determined quantitatively, and the ecological state of the plant was fully described.

During the study of the physico-chemical properties of the soil, the dissertator collected soil samples from each population site and conducted a comprehensive laboratory analysis of pH, salt, organic substances, and structural features.

Within the framework of phytochemical studies, the dissertator independently carried out laboratory preparation work such as obtaining extracts from plant materials, drying, grinding, and extraction. The identification and quantitative analysis of bioactive compounds (phenols, flavonoids, tannins, etc.) were conducted using chromatography and spectrophotometry methods.

In genetic studies, the dissertator independently performed the work of isolating DNA from samples, conducting molecular analyses at the plastid level, comparing the obtained data through molecular markers, and evaluating genetic diversity. He fully participated in laboratory work and carried out the analysis and scientific interpretation of the results.

Furthermore, the research conducted at Istanbul University includes, as the dissertator's personal contribution, the collection of biomaterials from three populations of the *C. leucocladum* species, organizing the sequencing of chloroplast genomes, and performing laboratory work to obtain high-quality genomic data, as well as processing the obtained genomic data and participating in comparative analysis. The dissertator actively contributed to

conducting phylogenetic analysis, interpreting results, and making scientific conclusions. During the research, he independently executed the main results justifying the scientific novelty of the work and participated in the full cycle of field and laboratory research. He systematized the collected data and prepared tables and graphs for their analysis. These data are an important tool in the scientific justification of strategies for preserving the said plant population, rational use of bioresources, and restoration. In addition, he actively participated in scientific articles and reports at conferences, contributing directly to the publication of the results as one of the main authors.

Approbation of the Work: The main results of the dissertation work were reported and discussed at international and republican scientific conferences, symposia, and seminars. In particular: The main scientific results of the dissertation work were tested at scientific events of international and republican levels. The research results were published as two articles in journals indexed in the Scopus / Web of Science (Q1) database. One article was published in a republican journal recommended by the Committee for Ensuring Quality in the Field of Education of the Ministry of Education and Science of the Republic of Kazakhstan. In addition, two dissertations (abstracts) were presented in the materials of International Scientific Conferences. Thus, the scientific results of the work were tested in the scientific community through publication in reputable publications and discussion at international conferences.

Structure of the Dissertation: The dissertation consists of 186 pages, an introduction, a review of domestic and foreign literature, objects and methods of research, research results and their discussion, a conclusion section, and a list of 181 used literature references, 29 tables, and 33 figures.