ANNOTATION

of the dissertation for the degree Doctor of Philosophy (PhD)
in the educational program «8D05108 - Geobotany»

Kairanova Gulzat Kanatkyzy

on the topic: **"Assessment of the current state of cenopopulations of the plant *Zygophyllum fabago* L. in the conditions of the Ile-Balkhash region"**

General characteristics of the work. The dissertation is devoted to a comprehensive assessment of the current state of the coenopopulations of *Zygophyllum fabago* L. distributed in the Ile-Balkhash region of Kazakhstan. The study involved geobotanical, anatomical, soil, and phytochemical analyses aimed at determining the ecological conditions and biological properties of the species. The obtained results are intended to form a scientific basis for the rational use and conservation of *Zygophyllum fabago* L.

Relevance of the research. Currently, there is a significant global increase in interest in the use of medicinal plants in medicine. Preparations derived from medicinal plants contain high levels of phenolic compounds, flavonoids, alkaloids, saponins, vitamins, and other biologically active substances. These compounds exhibit a wide range of pharmacological effects, including anti-inflammatory, antioxidant, immunomodulatory, and other important properties. Therefore, the study of medicinal plants and the identification of biologically active substances in their composition are highly relevant in modern pharmacology. Phyto preparations have a mild effect on the human body and are economically advantageous. Consequently, medicinal plants play an important role in disease prevention and in long-term therapeutic applications.

In recent years, more than 50,000 plant species have been used in traditional medicine, and this number continues to increase annually. With the advancement of medical research, the range of diseases is expanding, and the demand for safe and natural substances is growing. For Kazakhstan, this represents a strategic opportunity: the country's rich flora and diverse geographical conditions (desert, steppe, forest-steppe, and high-mountain regions) create favorable environments for the development of plants with unique phytochemical compositions. In this regard, the priority directions of domestic pharmaceutical science and production include the identification of new plant resources, the isolation of biologically active compounds, and the development of affordable Phyto preparations.

According to the literature, at least 230 species of natural flora of Kazakhstan are used in official medicine; 29 species are included in the State Pharmacopoeia, including important representatives from various plant families. However, considering endemic plants, many species remain insufficiently studied: the phytochemical composition of approximately 450 endemic taxa has not been fully characterized, and the range of currently utilized medicinal species remains limited. Therefore, proving the safety and efficacy of Phyto preparations and standardizing raw plant materials are key tasks of domestic pharmaceutical science.

According to international studies, approximately 80% of the world's population uses plant-based medicines to some extent; about 40% of modern

pharmaceutical drugs are directly or indirectly derived from plants. Of the more than 350,000 vascular plant species worldwide, nearly 50,000 are believed to possess medicinal properties. These data highlight the importance of rational use of natural resources and the conservation of biodiversity. Unfortunately, according to the International Union for Conservation of Nature (IUCN), approximately 15,000 plant species are threatened with extinction; insufficient control and unsystematic harvesting of medicinal plants lead to population decline. In this context, implementing conservation measures both in natural habitats (reserves, national parks, specially protected areas) and under ex situ conditions (botanical gardens, collections, seed banks), including the introduction of geographic information systems and digital monitoring, is highly relevant.

The theoretical significance of the research lies in explaining the phytochemical adaptations of semi-desert flora representatives, the influence of biogeographical factors on the accumulation of biologically active compounds (BACs), and the relationship between extraction conditions and biological response. The practical significance consists of the preliminary investigation of natural antioxidants and antimicrobial agents, as well as extracts with potential anticancer properties, forming a basis for standardized phytochemical raw materials. This direction contributes to reducing the raw material dependence of local pharmaceutical production and to creating high-value Phyto preparations.

The regional characteristics of Kazakhstan support the planning of medicinal plant resource use. For example, in East Kazakhstan, Zhetysu, and the Ile-Balkhash region, species rich in essential oils and phenolic compounds are frequently found. One promising medicinal species is *Zygophyllum fabago* L. This plant grows in desert and semi-desert ecosystems, is adapted to saline and clay soils, performs an anti-erosion ecological function, and is used in traditional medicine as an anti-inflammatory, diuretic, and wound-healing agent.

The presented provisions confirm the need for in-depth study of drought-resistant species such as *Zygophyllum fabago* L., including the assessment of the state of natural coenopopulations, determination of resource potential, scientific justification of harvesting periods and volumes, as well as preclinical evaluation of safety and efficacy. The rational use of the floristic diversity of Kazakhstan will contribute to strengthening public health through the development of new phytopreparations that meet modern medical requirements.

Research object: The species *Zygophyllum fabago* L., belonging to the family *Zygophyllaceae* R.Br., occurring in three natural populations of the Ile-Balkhash region.

Research aim: To comprehensively investigate the current state of the coenopopulations of the promising plant species *Zygophyllum fabago* L., growing in the Ile-Balkhash region of Kazakhstan, using botanical and phytochemical methods, and to assess their present condition based on the obtained results.

Research objectives:

1. To identify populations of the medicinal plant *Zygophyllum fabago* L. in the Ile-Balkhash region and provide their geobotanical characterization.

2. To assess the growth conditions of the coenopopulations of *Zygophyllum fabago* L.
3. To determine the comparative anatomical features of the vegetative organs of *Zygophyllum fabago* L.
4. To provide a morphological description of the soil environment of the populations of *Zygophyllum fabago* L.
5. To determine the composition of biologically active compounds in *Zygophyllum fabago* L.
6. To determine the overall composition of biologically active compounds and the level of biological activity in extractive preparations obtained from *Zygophyllum fabago* L. using different extraction methods.

Research methods. In the course of the study, geobotanical and morphological-anatomical investigations were conducted. In addition, the physicochemical properties of the soil were determined using standardized laboratory methods. Phytochemical analyses included extraction with various solvents, and antioxidant, antimicrobial, and cytotoxic activities were evaluated using modern biochemical methods.

Scientific Novelty. Populations of *Zygophyllum fabago* L. were identified in the Ile-Balkhash region, and their geobotanical characteristics were described. An analysis of the floristic composition of the habitats where *Zygophyllum fabago* L. occurs was carried out. For the first time, the anatomical features of the aboveground and underground vegetative organs of *Zygophyllum fabago* L. were comparatively studied within three populations of the Ile-Balkhash region, and structural adaptations of the vegetative organs were identified. Soil profiles were established for all three populations, and their morphological and genetic horizons were described. Based on samples taken from each horizon, a comprehensive study of the physical and chemical properties of the soil was conducted. Phytochemical analysis of extracts obtained from the aboveground and underground organs of *Zygophyllum fabago* L. revealed the presence of phenolic compounds, flavonoids, and saponins. Antioxidant, antimicrobial, and cytotoxic studies demonstrated that the biological activity is directly associated with the composition of these metabolites.

The data obtained from these comprehensive studies made it possible to assess the current state and the ecological and biological characteristics of *Zygophyllum fabago* L.

Scientific and practical significance of the research. Based on the comprehensive study of populations of *Zygophyllum fabago* L. growing in the Ile-Balkhash region of the Republic of Kazakhstan, a scientifically grounded assessment of their current state was provided.

Seeds collected from *Zygophyllum fabago* L. populations in the Ile-Balkhash region were transferred, for the purpose of preserving the species' gene pool, to the "Seed Bank of the Natural Flora of Kazakhstan" laboratory of the Republican State Enterprise on the Right of Economic Management "Institute of Botany and Phytointroduction" under the Committee of Forestry and Wildlife of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan.

Determination of the phytochemical composition of the aboveground and underground organs of Kazakhstani populations of *Zygophyllum fabago* L. revealed the presence of valuable and biologically active compounds. The research results confirmed the biological activity of phenolic, flavonoid, and saponin compounds and contribute to understanding their structural characteristics and mechanisms of action.

According to the obtained data, ethanol and ethyl acetate extracts of *Zygophyllum fabago* L. demonstrated high antioxidant and cytotoxic activity. The ethanol extract showed the highest DPPH radical scavenging capacity, whereas the ethyl acetate extract exhibited pronounced activity against K562 leukemia cells. In addition, these extracts demonstrated strong antimicrobial activity against the pathogenic microorganisms *Escherichia coli* and *Candida albicans*, representing a novel finding not previously reported in earlier studies.

Main provisions submitted for defense:

1. The results of geobotanical studies of the populations of the medicinal plant *Zygophyllum fabago* L. identified in the Ile-Balkhash region of Kazakhstan.
2. The results of the analysis of the floristic composition of plant communities containing the promising medicinal species *Zygophyllum fabago* L. in the Ile-Balkhash region of Kazakhstan.
3. The results of anatomical studies of the aboveground and underground vegetative organs of *Zygophyllum fabago* L., selected as the research object.
4. The results of soil studies conducted in the habitats of *Zygophyllum fabago* L. populations.
5. The results of phytochemical studies of biologically active compounds accumulated in the vegetative organs of the medicinal plant *Zygophyllum fabago* L.
6. The results of studies on the overall composition of biologically active compounds and the level of biological activity in extractive preparations obtained from *Zygophyllum fabago* L. using different extraction methods.

Author's personal contribution. The author of the dissertation research defined the object and conceptual framework of the study and specified its main aim and objectives. The author also planned the stages of the experimental work and actively participated in the systematization, processing, and analysis of the obtained results, making a personal contribution at all stages of the research.

Approbation of the research. The results of the dissertation research were presented and published at six international scientific conferences:

- International Scientific and Practical Conference "Problems of Desertification of the Territory of the Republic of Kazakhstan and Ways to Solve Them," dedicated to the 80th anniversary of Candidate of Biological Sciences, Associate Professor Abibulla Ametuly Ametov (Almaty, Kazakhstan, 2023).
- International Conference of Students and Young Scientists "From Experience to Project," dedicated to the 90th anniversary of Al-Farabi Kazakh National University (Almaty, Kazakhstan, 2024).
- Proceedings of the International Scientific and Practical Conference of Young Scientists dedicated to the 130th anniversary of Academician Nikolai

Vasilyevich Pavlov, titled “The Ideas of N.V. Pavlov through the Eyes of a New Generation of Botanists” (Almaty, Kazakhstan, 2024).

- International Scientific Conference of Students and Young Scientists “Farabi Alemi” (Almaty, Kazakhstan, 2024).
- International Scientific Conference of Students and Young Scientists “Farabi Alemi” (Almaty, Kazakhstan, 2025).
- International Conference “Biodiversity and Sustainable Development” (Almaty, Kazakhstan, 2025).

Publications. The research findings have been published in 10 scientific works, including 2 articles indexed in the international Web of Science and Scopus databases Q2 (SJR - 0.375), Q3 (SJR - 0.158), 2 articles published in scientific journals recommended by the Committee for Quality Assurance of the Ministry of Science and Higher Education of the Republic of Kazakhstan, and 6 abstracts published in the proceedings of international scientific conferences. Based on the research results, Utility Model Patent №11833, entitled "Method for Obtaining an Extract Based on *Zygophyllum fabago* L.", was granted. In 2023, as part of her doctoral research, Gulzat Kairanova was awarded the national "Tauelsizdik Urpaqtary" grant in the Science category, organized by the Ministry of Culture and Information of the Republic of Kazakhstan, for the project entitled "Biological Profile and Bioactive Potential of the Medicinal Plant *Zygophyllum fabago* L.".

Structure of the dissertation. The dissertation consists of 153 pages and includes an introduction, a literature review, sections on the research object and methods, research results, their discussion, and conclusions. It contains a list of 196 references. In addition, it includes 32 tables, 24 figures, 10 formulas, and 4 appendices.