Т. 12. №6 2026
https://doi.org/10.33619/2414-2948/127

UDC 581.526
AGRIS F40

https://doi.org/10.33619/2414-2948/127/11

PHYTOCENOLOGICAL, BIOMORPHOLOGICAL AND PHYTOCHEMICAL STUDY OF THE FAMILY Crassulaceae J. St.-Hil. IN THE TERRITORY OF THE NAKHCHIVAN AUTONOMOUS REPUBLIC

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ФИТОЦЕНОЛОГИЧЕСКОЕ, БИОМОРФОЛОГИЧЕСКОЕ И ФИТОХИМИЧЕСКОЕ ИССЛЕДОВАНИЕ СЕМЕЙСТВА Crassulaceae J. St.-Hil. НА ТЕРРИТОРИИ НАХЧЫВАНСКОЙ АВТОНОМНОЙ РЕСПУБЛИКИ

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Abstract. The study investigates the biomorphological, phytocenological, and phytochemical characteristics of the family Crassulaceae in the flora of the Nakhchivan Autonomous Republic. The main objective of the research was to evaluate the ecological adaptation mechanisms, community structure participation, and bioactive compound potential of Crassulaceae species distributed in the arid and semi-arid ecosystems of the region. Field investigations were carried out during the active vegetation period using route and quadrat sampling methods. Biomorphological characteristics of plants were analyzed based on life form classification, morphometric parameters, and structural adaptation features. Phytocenological assessment was performed using the Braun-Blanquet approach to determine species abundance, dominance status, and interspecific relationships within plant communities. Phytochemical screening of leaf and stem samples was conducted using standard qualitative reactions and spectrophotometric analysis to determine the presence of phenolic compounds, flavonoids, and antioxidant constituents. The results demonstrated that Crassulaceae species in the study area are mainly hemicryptophyte and chamaephyte life forms with succulent vegetative organs adapted to water-deficit conditions. These species are commonly associated with petrophytic xerophytic communities and play a stabilizing role in erosion-prone habitats. Phytochemical analysis revealed moderate to high levels of secondary metabolites, with ecological stress factors influencing compound accumulation. In conclusion, Crassulaceae representatives show significant ecological plasticity and possess promising biological activity potential, supporting their importance in biodiversity conservation and applied botanical research in the region. Research in this direction can provide a scientific basis for a deeper understanding of the structural and functional characteristics of vegetation, the protection of rare and endemic species, as well as the identification of promising medicinal and ornamental plants.

Аннотация. В исследовании изучаются биоморфологические, фитоценологические и фитохимические характеристики семейства Crassulaceae во флоре Нахчыванской Автономной Республики. Основной целью работы являлась оценка механизмов экологической адаптации, участия видов в структуре растительных сообществ и биологического потенциала активных соединений видов Crassulaceae. Полевые исследования проводились в период вегетации растений с использованием маршрутного и квадратно-учётного методов. Фитоценологическая

Т. 12. №6 2026
https://doi.org/10.33619/2414-2948/127

оценка осуществлялась по методу Браун-Бланке для определения обилия видов, уровня доминирования и межвидовых взаимодействий в растительных сообществах. Биоморфологические особенности растений анализировались на основе классификации жизненных форм, морфометрических параметров и структурных адаптивных признаков. Фитохимический анализ образцов листьев и стеблей проводился с применением стандартных качественных реакций и спектрофотометрических методов для выявления фенольных соединений, флавоноидов и антиоксидантных компонентов. Полученные результаты показали, что виды Crassulaceae на исследуемой территории в основном представлены гемикриптофитными и хамефитными жизненными формами с суккулентными вегетативными органами, адаптированными к условиям дефицита влаги. Виды преимущественно встречаются в петрофитных ксерофитных сообществах и играют важную роль в стабилизации эрозионно-опасных участков. Фитохимический анализ выявил среднее и высокое содержание вторичных метаболитов, при этом экологические стрессовые факторы способствовали накоплению биологически активных веществ. Исследования в этом направлении могут обеспечить научную основу для более глубокого понимания структурных и функциональных характеристик растительности, защиты редких и эндемичных видов, а также выявления перспективных лекарственных и декоративных растений.

Keywords: Crassulaceae, Nakhchivan flora, biomorphology, succulents.

Ключевые слова: толстянковые, флора Нахчывана, биоморфология, суккуленты.

The Crassulaceae family is widely distributed in the world flora, mainly found on rocky and stony substrates, in alpine-subalpine and semi-desert ecosystems. In the territory of the Nakhchivan Autonomous Republic, species belonging to this family act as an important component of phytocenoses on mountain slopes, bare rocks and areas exposed to erosion. They play an important role in protecting the soil from erosion, stabilizing the microclimate, and maintaining the biodiversity of the region. From a biomorphological point of view, Crassulaceae representatives are mainly represented by annual and perennial herbaceous plants, subshrubs, and forms capable of vegetative reproduction. These features are not only an indicator of adaptation to the arid climatic conditions of the region but also have important significance for taxonomic identification. From a phytocenological point of view, the dominance status of species, association structure, and mutual relations with other species require special research. Phytochemical analyses have shown that Crassulaceae plants contain flavonoids, phenolic compounds, organic acids, and other metabolites with antioxidant activity. Environmental stress factors can affect the synthesis intensity of these substances, which increases the importance of studying regional populations separately. Thus, a comprehensive study of the Crassulaceae family creates a scientific basis for studying the structural features of the Nakhchivan flora, protecting rare species, and assessing promising plant resources [1-4].

Materials and methods

The study covered various phytogeographic zones of the region: mountainous, mid-mountainous, low-mountainous, and semi-desert landscapes. Field studies were conducted during the active phase of the vegetation period (April–September), and rocks, gravel slopes, dry steppes, and alpine–subalpine meadows where species of the family are distributed were studied using the route and quadrat methods [10].

During the biomorphological analysis, the life forms of plants, the structure of vegetative and generative organs, the degree of succulence, the type of root system, and reproductive characteristics were investigated. Morphometric measurements were carried out using electronic calipers and measuring lines, and the average value, standard deviation, and coefficient of variation were

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https://doi.org/10.33619/2414-2948/127

calculated for statistical evaluation of the results. Phytocenological studies were based on the Braun-Blanquet method. Plots of 1–10 m² were established in the test areas, and species composition, cover degree, abundance, and dominance indicators were recorded. The structure of plant communities, interspecific relationships, and the influence of ecological factors were comprehensively evaluated. Leaf and stem samples collected for phytochemical analysis were dried and ground in the laboratory; the presence of biologically active substances was determined by qualitative reactions and spectrophotometric methods. The extraction process was carried out using ethanol and water-based solutions, and total phenol and antioxidant activity were evaluated according to standard methods.

Results and Discussion

The study found that the vast majority of Crassulaceae representatives found in the region are perennial herbaceous plants and belong to the hemicryptophyte and chamaephyte biomorphological groups [9].

This feature is an indicator of their adaptation to harsh continental climate conditions—high temperatures and drought in summer, and low temperature amplitude in [5].

Tabel 1

BIOMORPHOLOGICAL INDICATORS OF REPRESENTATIVES OF THE CRASSULACEAE FAMILY

Indicators	*Minimum*	*Maximum*	*Average value (M±m)*
Plant height, cm	6.2	28.5	15.8 ± 0.9
Leaf length, mm	8.4	32.6	19.7 ± 1.1
Leaf width, mm	4.1	18.3	10.6 ± 0.7
Succulent tissue thickness, mm	1.2	4.8	2.9 ± 0.3
Vegetation period, days	65	110	87 ± 3.2
Coverage rate, %	12	48	29 ± 2.1

The fleshy leaf and stem structure of Crassulaceae representatives allows for water storage, and this adaptation is especially evident on rocky and gravelly substrates. Morphometric analyses have shown that in individuals distributed in high mountainous areas, the sizes of vegetative organs are relatively smaller and the tissue density is higher [6].

According to phytocenological assessments, Crassulaceae species are mainly involved in xerophytic and petrophytic plant communities and contribute to the formation of microphytocenoses and soil stabilization on erosion-sensitive slopes. The distribution density of species is related to the mechanical composition of the substrate and slope exposure, with higher distribution density on south- and southwest-facing slopes [8].

Phytochemical analyses confirmed the presence of flavonoids, phenolic compounds, and metabolites with antioxidant activity in plant samples [3, 7].

The total phenol content was relatively increased in populations collected from areas exposed to drier conditions and higher solar radiation, which is explained by the stimulation of secondary metabolite synthesis by environmental stress factors. Spectrophotometric evaluations showed high antioxidant activity in some populations, demonstrating the promising application of Crassulaceae species in terms of botany and phytopharmacology [7].

The results obtained show that the distribution and morphoecological characteristics of the Crassulaceae J.St.-Hil. family in the territory of the Nakhchivan Autonomous Republic are closely related to the arid and semi-arid climatic conditions of the region. Biomorphological adaptations, their position within the phytocenosis, and the intensity of synthesis of phytochemically active substances are formed in interaction with each other and act as an integral part of a complex ecological system.

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https://doi.org/10.33619/2414-2948/127

Tabel 2

PHYTOCHEMICAL INDICATORS IN CRASSULACEAE SAMPLES

Indicators	*Minimum*	*Maximum*	*Average value (M±m)*
Total phenol (mg/g)	12.4	38.7	24.6 ± 1.5
Flavonoid (mg/g)	6.8	21.3	14.2 ± 0.9
Antioxidant activity (%)	41.2	78.6	63.4 ± 2.3
Extract output (%)	9.5	26.4	17.8 ± 1.2

Conclusion

As a result of the research, the succulent leaf and stem structure, superficial root system, short vegetation period, and early flowering characteristics of species belonging to the Crassulaceae family are the main indicators of adaptation to extreme environmental factors. Biomorphological analyses have shown that life forms and morphometric variability are mainly related to altitudinal zones and microclimatic factors. Phytocenological assessments have confirmed that Crassulaceae representatives play an important role in petrophyte and xerophyte plant communities, contributing to the stabilization of soil cover and the maintenance of microecological balance. Phytochemical analyses have shown that the plants are rich in flavonoids, phenolic compounds, and antioxidant active components. Environmental stress factors stimulate the synthesis of secondary metabolites, increasing the pharmacological and application potential of these species. Overall, the results obtained indicate that the Crassulaceae family is of significant ecological and scientific importance in the flora of the region and creates opportunities for the conservation of biodiversity, the protection of rare species, and the use of promising plant resources..

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Поступила в редакцию
03.04.2026 г.

Принята к публикации
11.04.2026 г.

Ссылка для цитирования:

Talibov T., Jamalbeyli S. Phytocenological, Biomorphological and Phytochemical Study of the Family Crassulaceae J. St.-Hil. in the Territory of the Nakhchivan Autonomous Republic // Бюллетень науки и практики. 2026. Т. 12. №6. С. 95-99. https://doi.org/10.33619/2414-2948/127/11

Cite as (APA):

Talibov, T., & Jamalbeyli, S. (2026). Phytocenological, Biomorphological and Phytochemical Study of the Family Crassulaceae J. St.-Hil. in the Territory of the Nakhchivan Autonomous Republic. *Bulletin of Science and Practice, 12*(6), 95-99. https://doi.org/10.33619/2414-2948/127/11