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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

STUDY AND PROGNOSTIC ASSESSMENT OF CENOPOPULATIONS OF SOME RARE MEDICINAL PLANTS IN THE NORTHERN-EASTERN PART OF THE GREATER CAUCASUS

Speciality: 2417.01 – Botany

Field of science: Biology

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Baku – 2022

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INTRODUCTION

The actuality of the subject and degree of the study of the topic. In modern times, as a result of the negative impact of various natural and anthropogenic factors, the vegetation of planet has been severely degraded, large numbers of plant species have disappeared from the Earth, and tens of thousands of species are in danger of extinction. One of the main features of decreasing of biodiversity is that they cover more useful species of wild plants, including medicinal plants, and damage real and potential sources of raw materials and resources[1].

In recent years, the economic and social development of the regions of Azerbaijan has necessitated the construction of new land plots and the expansion of infrastructure. As a result of the influence of these factors, the number of rare species included in the second edition of the Red Book[2] of Azerbaijan has increased up to 300. Therefore, each of the researches on the study of rare and endangered plants of Azerbaijanflora, especially their useful, as well as medicinal species, is important and in essence, ultimately serves to protect biodiversity and organize its efficient use.

In this regard, the topic chosen for the study of the dissertation "Study and prognostic assessment of cenopopulations of some rare medicinal plants in the northern-eastern part of the Greater Caucasus" is quite relevant and serves to fulfill the tasks set by the state. At the same time, it was taken into account that in botany, information on the ecological and population characteristics of species, population size, structure, dynamics, adaptation and evolution was accepted as a fundamental objective in assessing the condition of species and solving practical problems in biological protection ofspecies.

Object and subject of the research. The object of research is 6 rare taxa: (*Galanthus alpinus* Sosn. var. *alpinus*, *Crocus speciosus* M. Bieb., *Iris reticulata* M. Bieb., *Platanthera chlorantha* (Cust.) Reichenb., *Ophrys sphegodes* subsp. *mammosa* (Desf.) Soó ex E.

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[1] Ibadullayeva, S.J. & Huseynova, I.M. An overview of the plant diversity of Azerbaijan Biodiversity, Conservation and Sustainability in Asia / M. Öztürk et al. (eds.), Biodiversity, Conservation and Sustainability in Asia. Springer Nature Switzerland AG, – 2021. Vol.1. – p. 431-478.

[2] Azərbaycan Respublikasının Qırmızı Kitabı. Nadir və nəsli kəsilməkdə olan bitki və göbələk növləri. İkinci nəşr / – Bakı: Şərq-Qərb, – 2013. – 676 s.

Nelson, *Ophrys apifera* Huds.). The subject of the study includes the identification of the status of these 6 rare species cenopopulations, the study of the morphometric and vitality structure of cenopopulations at different levels of climatic and anthropogenic impact, prognostic assessment of their current and future status.

The purpose and goals of the research. The purpose of the presented research is to study determination of the status of rare taxa cenopopulations which is distributed in the northern-eastern part of the Greater Caucasus and prognostic assessment of their condition under changing climate scenarios. In this regard, the following tasks have been set:

- Detection of cenopopulations and study of phytocenotic features of 6 rare taxa in Khizi, Siyazan, Shabran, Guba, Gusar, Khachmaz, Gobustan, Shamakhi and Ismayilli regions;
- Study periods and stages of ontogeny of the investigated species;
- Carrying out phenological observations of taxa for years and research of their flowering biology;
- Compilation of ontogenetic spectrum of identified cenopopulations and determination of demographic structure;
- Study of the morphometric and vitality structure of the studied cenopopulations;
- To study the ecological properties of taxa and determine their hemerobia properties;
- Development of a prognostic model of the potential distribution and future status of the studied taxa under the influence of climatic factors.

Methods of study. Classical and modern methods (route-recognostic, geobotanical, population-ontogenetic, statistic and mathematical-computer) were used during the research.

The main provisions of the dissertation:

1. *Galanthus alpinus* var. *alpinus*, *Platanthera chlorantha*, *Crocus speciosus*, *Iris reticulata*, *Ophrys sphegodes* subsp. *mammosa* and *Ophrys apifera* taxa are distributed in the northern-eastern part of the Greater Caucasus from the lowlands to the middle mountain range and participate in the formation of micro-associations in various cenoses.

2. The ontogenetic structure of cenopopulations of the studied

taxa is dominated by pregenerative and generative individuals, depending on the species, the life cycle of individuals varies from 3-4 periods and 6-9 stages, and the flowering period of a flower varies from 9 to 23 days.

3. According to the age (Δ) and efficiency (ω) indices of the demographic structure of cenopopulations, there is 58.8% of *G. alpinus* var. *alpinus* cenopopulations are transitional and mature type, 22-40% of other species are transitional, and according to *Q*, *Iq* and *IVC* indexes of vitality structure, 17 cenopopulations as a whole are flowering and only 7 are depressive. .

4. A mathematical computer model was developed and relevant prognosis were made for the potential development of the studied taxon populations and prognostic assessment of the area.

Scientific novelty of the research. For the first time, have been conducted population and phytocenological studies of rare and endangered taxa *Galanthus alpinus* var.*alpinus*, *Platanthera chlorantha*, *Crocus speciosus*, *Iris reticulata*, *Ophrys sphegodes* subsp. *mammosa*,*Ophrys apifera* in the northern-eastern part of the Greater Caucasus, and it has been determined that they are distributed from the lowlands to the middle mountain range and participate in the formation of microassociations in various cenoses.

The ontogenetic structure of the cenopopulations of these taxa was studied, and it was found that pregenerative individuals predominated for three species and generative individuals for the other three species. The ontogenesis of the species was studied, the periods and stages of their life cycle, the lifespan of a flower of the taxa under cultural conditions were determined.

The demographic structure of cenopopulations was assessed according to age (Δ) and efficiency (ω), vitality structure was assessed according to *Q*, *Iq* and *IVC* indices, and in this regard, their spectrum of distribution by types was determined.

Cluster analysis was conducted based on the average morphoparameters of individuals, the relationship of the environment suitable for their development to climatic conditions and soil types was determined, and it was found that there are significantly more individuals with larger morphological parameters and higher viability in those suitable conditions.

For the first time, a prognostic mathematical computer model of their potential development and distribution was developed based on the relationship of taxon populations to climatic factors, and its application resulted that there will be a reduction in the population of *P. chlorantha*, *C. speciosus*, *O. apifera*, but there is no serious threat to *I. reticulata*, *O. sphegodes* subsp. *mammosa* and *G. alpinus* var. *alpinus*.

Theoretical and practical importance of the research. The obtained information will be used to prepare a new edition of the Red Book of the Republic of Azerbaijan and the "Ontogenetic Atlas", to develop measures for the protection of studied taxa, also can be considered as a useful resource working in the field of botany and ecology, as well as teaching aids for university students, masters and doctoral students. The data of cenopopulations of these taxa discovered by us were included in the "Electronic database of populations of rare and endemic plants of Azerbaijan" created by the staff of the department "Phytosociology of ecosystems" of the Institute of Botany, ANAS.

Approbation and application. Materials related to the dissertation is presented in international conferences such as "State of the World's Plants" (London, 2017); "Study, preservation and rational use of the plant world of Eurasia" (Almaty, 2017); "I International Scientific Conference of Young Researchers" (Khirdalan, 2017); "Actual problems of modern natural sciences" (Ganja, 2017); "Principles and methods of biodiversity conservation" (Yoshkar-Ola, 2019); "Multidisciplinary approaches in solving modern problems of fundamental and applied sciences" (Baku, 2020); International "Current issues of biodiversity protection in protected areas" (Ufa, 2020) and local conferences such as "New challenges in botanical research" (Baku, 2018); "Innovations in Biology and Agriculture to Solve Global Challenges" (Baku, 2018); "The role of academician V.I. Ulyanishev in the development of mycological research in Azerbaijan" (Baku, 2018); "Innovation and Traditions in Modern Botany" (Baku, 2019).

19 scientific works (8 articles, 11 abstracts) were published related to the dissertation, 4 of them were included in international databases (Web of Science, Scopus, RSCI).

Organization in which the dissertation work is carried out.

Research was carried out at the Department of Phytosociology of ecosystems of the Institute of Botany, ANAS.

The structure and scope of the dissertation. The dissertation consists of an introduction, 7 chapters, a conclusion, suggestions and recommendations, a list of 211 used references and appendices, 230 pages. The main part is illustrated with 25 tables, 24 diagrams, 6 graphics, 20 pictures, 18 photos and14 maps. The dissertation consists of a total of 234342 characters, the introduction section with the title page and table of contents 18872 characters, Chapter I, literature review 24790, Chapter II, section of materials and methods 20966 characters, the experimental part of the dissertation 159489 (Chapter III 54693, Chapter IV 23120,Chapter V 41452, Chapter VI 23417, Chapter VII 16807), results 3998, recommendations 1949. The dissertation is completed with annexes (20 diagrams and 1 table) which are 21 pages and 2278 characters.

CHAPTER I
LITERATURE REVIEW

Section 1.1 of this chapter discusses the distribution and new classification of taxa in Azerbaijan and in the world. Section 1.2 deals with research on the study of cenopopulations of these species. Information on the status of populations of these taxa in the past and present in Azerbaijan and around the world is reflected. Section 1.3 provides extensive information on the chemical composition, medicinal, food, aromatic and decorative properties of studied taxa.

CHAPTER II
MATERIALS AND METHODS OF RESEARCH

2.1. Ecological features of the study areas

This section describes the topography and vegetation cover of the study areas[3]. At the same time, the annual temperature and the amount of precipitation of these regions were calculated from the

[3] İbadullayeva, S.C., Mustafayev A.B., Şirəliyeva G.Ş. Böyük Qafqazın yüksək dağlıq ərazilərinin bitkiliyinin təsnifatı // – Bakı: AMEA-nın Xəbərləri, Biologiya və tibb elmləri seriyası, – 2014. Cild 69, No3. – s. 58-64.

World Weather Online website[4], and shown in the form of diagrams. The type and chemical composition of soils are given according to A.H. Babayev[5].

2.2. Research material

The investigations were carried out in the period from 2017 to 2021 in expeditionary, stationary and laboratory conditions.

The object of study is belonging to 3 family (Amaryllidaceae J.St.-Hil., Iridaceae Juss., Orchidaceae Juss.), 5 genera (*Galanthus* L., *Iris* L., *Ophrys* L., *Platanthera* Rich., *Crocus* L.) and 6 taxa: *Galanthus alpinus* Sosn.var. *alpinus*, *Crocus speciosus* M.Bieb., *Iris reticulata*M. Bieb., *Platanthera chlorantha* (Cust.) Reichenb., *Ophrys sphegodes* subsp. *mammosa* (Desf.) Soó ex E. Nelson, *Ophrys apifera* Huds.

2.3. Research routes

The field researchs were conducted in 4 botanical-geographical (GC Guba part, GC east, Gobustan, Samur-Davachi lowland) and in 9 administrative districts, in forests, in meadows (Figure 1).

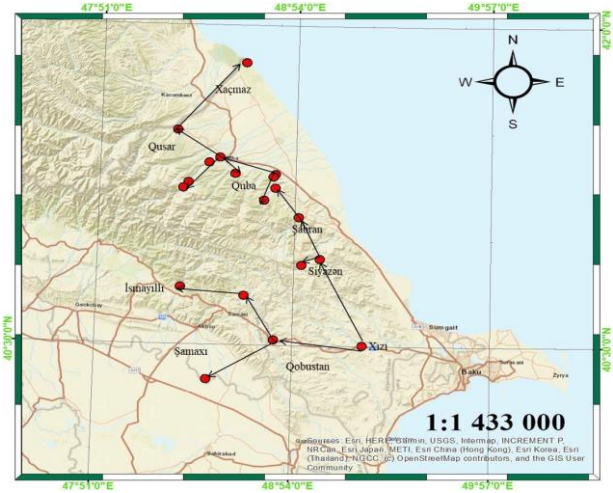

Figure 1. Routes of researchs

[4] https://www worldweatheronline.com

[5] Babayev, A.H. Torpaq keyfiyyətinin monitorinqi və ekoloji nəzarət / A.H.Babayev. – Bakı: Qanun nəşriyyatı, – 2011. – 263 s.

2.4. Methods of biological research

2.4.1. Route-recognostic and geobotanical methods.

The geobotanical description of the cenoses in which the taxa were studied was based on generally accepted methods in geobotany[6].

The Euro + Med Plantbase database[7] was used to determine the taxonomic status of Species involved in the cenosis.

2.4.2. Population-ontogenetic methods.

Observation of the developmental characteristics of a plant at the ontogenetic level under stationary conditions conducted by T.A. Rabotnov[8] and I.Q. Serebryakov[9] methods. Determination of stages conditions was done according to T.A. Rabotnov's scheme. During the study of the ontogenetic and demographic structure of cenopopulations were used the methods of T.A. Rabotnov and A.A. Uranov[10].

The type of cenopopulation was determined on the basis of the delta-omega (Δ-ω) classification of the normal population by A.A. Uranov and L.A. Zhivotovsky[11]. Morphometric analysis is carried out by selecting the appropriate parameters for each studied taxonindividually, as well as the study of the vitality structure of the cenopopulation conducted according to Y.A. Zlobin's methods[12]. The cenopopulation vitality index (*IVC*) was used to describe the viability of

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[6] Pedrotti, F. Plant and Vegetation Mapping (Geobotany Studies) / F.Pedrotti. – Berlin: Springer, – 2013. (5)3, – 275 p.

[7] http://ww2.bgbm.org/EuroPlusMed/ [accessed DATE].

[8] Работнов, Т.А. Жизненный цикл многолетних травянистых растений в луговых ценозах // Труды БИН АН СССР, сер. 3, Геоботаника. – вып. 6. –М., Л., 1950. – 7-204 с.

[9] Серебряков, И.Г. Морфология вегетативных органов высших растений / И.Г.Серебряков. – Москва: Современная Наука, – 1952. – 376 с.

[10] Уранов, А.А. Возрастной спектр фитопопуляций как функция времени энергетических волновых процессов // Биологические науки, – 1975. № 2. – с. 7 – 34.

[11] Животовский, Л.А. Онтогенетические состояния, эффективность и классификация популяций растений//Экология, – 2001. №1.– с.3-7.

[12] Злобин, Ю.А. Популяции редких видов растений: теоретические основы и методика изучения: монография. / Ю.А.Злобин, В.Г.Скляр, А.А.Клименко – Сумы: Университетская книга, –2013. – 439 с.

the population[13].

2.4.3. Phenological and ecological methods.

Phenological observations[14] were made on the individuals of the studied plants, the flowering biology is conducted according to the A.N. Ponomarev[15] method.

M.M. Ishmuratova's method was used for study the hemerobia properties of taxa[16].

The canonical correspondence analysis (CCA) was used to clarify the relationship between the distribution of the studied taxa, environmental reactions and environmental variability[17].

2.4.4. Statistical processing of data and compilation of electronic maps.

Statistical analysis was performed for each parameter. The error ($M \pm m$), the standard deviation (SD) was determined by the arithmetic mean. Hierarchical clustering was performed based on the average values of morphological parameters using Ward's Euclidean distance.

All statistical analyzes were performed in PAST 3.15[18], GraphPad Prism 7, STATISTICA[19] and Microsoft Excel 2010. The distribution maps of the research objects were conducted in ArcGIS 10.5 program.

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[13] Ишбирдин, А.Р., Ишмуратова, М.М. Адаптивный морфогенез и экологические стратегии выживания травянистых растений // Методы популяционной биологии: Материалы докл. VII Всерос. популяционного семинара, – Сыктывкар: Коми науч. центр Урал.отд-ния РАН, –2004. Ч. 2. –с.113 – 120.

[14] Primack, R.B. Essentials of Conservation Biology // 6th ed. Sinauer Associates, Inc., Sunderland, United Sates.– 2006.

[15] Пономарёв, А.Н. Полевая геоботаника – Изучение цветенияи опыления растений: /А.Н.Пономарёв. – Москва: Наука, – т. 2. – 1960. – 9-18 с.

[16] Ишмуратова, М.М.Использование показателей гемеробии для оценки уязвимости некторых видов орхидей южного Урала и устойчивости растительных сообществ /М.М. Ишмуратова, А.Р. Ишбирдин, И.В. Суюндуков [и др.] // Биологический вестник, – 2003. № 7(7). – с. 33-36.

[17] Braak, C.J.F. Canonical correspondence analysis: a new eigenvector technique for multivariate direct gradient analysis // – Washington: Ecology, – 1986. № 67, – p. 1167-1179.

[18] Hammer, Ø., Harper, D.A.T., Ryan, P.D. PAST: Paleontological statistics software package for education and data analysis // Palaeontologia Electronica, – 2001. 4(1), – p. 9.

[19] http://www.statsoft.com.

2.5. Mathematical-computer methods.

Compilation of prognostic models. 19 bioclimate layers were obtained from the WorldClim database[20].

During the study, all models were performed using the MaxEnt algorithm[21] with a standard parameter. We calculated the Area Under the Curve (AUC) of the Receiver Operating characteristic Curve (ROC) for determining the accuracy of the resulting models.The MaxEnt results for further analysis and visualization are included in ArcGIS 10.5.1, and potential areas are grouped into five classes as follows: unfavorable (0-0.2), less favorable (0.2-0.4), relatively favorable (0.4-0.6), favorable (0.6-0.7), quite favorable (0.7-1.0)[22]. Model has developed for predicting the future distribution of species under the climate scenario CSIRO (Commonwealth Scientific and Industrial Research Organization).

CHAPTER III
ONTOGENETIC AND DEMOGRAPHIC STRUCTURE OF CENOPOPULATIONS OF STUDY TAXA

The condition of the investigated cenopopulations, their demographic structure, ontogenetic spectrum were studied, the reasons for the decrease were investigated, and suggestions on protection measures were put forward.

3.1. Study of cenopopulations of *Galanthus alpinus* Sosn. var. *alpinus.*

During the study were studied 17 cenopopulations and their condition of *G. alpinus* var. *alpinus* in Khizi (CP 1-2), Shabran (CP 3-4), Guba (CP 5-13) and Gusar (CP 14-17) regions. The ontogenetic structure of this taxon shows that all cenopopulations are normal.

[20] http://worldclim.org/version.

[21] Phillips, S.J., Anderson, R.P., Schapire, R.E. Maximum entropy modeling of species geographic distributions // Ecological Modellling, – 2006. 190, – p. 231-259.

[22] Qin, A. Maxent modeling for predicting impacts of climate change on the potential distribution of *Thuja sutchuenensis* Franch., an extremely endangered conifer from southwestern China / A.Qin, B.Liu, Q.Guo [et al.] // Global Ecology and Conservation, – 2017. 10, – p. 139-146.

However, CP 1-3, CP 5-7, CP 9-10, and CP 17 are incomplete due to the absence of subsenile and senile individuals.

According to the indices Δ and ω of demographic structure, CP 3, CP 11 are maturing, CP 1, CP 4, CP 8-9, CP 14-17 transition, and the rest are young type.

3.2. Study of cenopopulations of *Iris reticulata* M.Bieb.

During the study, 10 cenopopulations of *I. reticulata* were found in Khizi (CP 1-2), Shabran (CP 3), Guba (CP 4-7), Shamakhi (CP 8-9) and Gobustan (CP 10) regions, and their condition was studied[23]. The ontogenetic structure of the cenopopulations of *I. reticulata*in the study regions shows that all cenopopulations are normal. However, CP 1, CP 4, CP 5-6 are incomplete due to the absence of senile individuals.

According to the indices Δ and ω of demographic structure, CP 1, CP 2, CP 7 and CP 9 are transitions, and the rest are young type.

3.3. Study of cenopopulations of *Ophrys sphegodes* subsp. *mammosa* (Desf.) Soó ex E. Nelson.

9 cenopopulations of *O. sphegodes* subsp. *mammosa* were found in Khizi (CP 1-3), Siyazan (CP 4-5), Guba (CP 6), Gusar (CP 7), Khachmaz (CP 8) and Gobustan (CP 9) regions, and their condition was studied[24].

The ontogenetic structure of *O. sphegodes* subsp. *mammosa* cenopopulations shows that all cenopopulations are normal.

According to the indices Δ and ω of demographic structure, CP 7 and CP 9 cenopopulations are transitional, the remaining other cenopopulations are young type.

3.4. Study of cenopopulations of *Platanthera chlorantha* (Cust.) Reichenb.

During the study, cenopopulations of *P. chlorantha* were found

[23] Mursal, N., Mehdiyeva, N.P. Ontogenetic Structure of coenopopulations and variability of morphoparameters of *Iris reticulata* M.Bieb. // – Baku: Plant & Fungal Research, – 2018. Vol. 1, 1(38), – p. 52-61.

[24] Mursal, N., Mehdiyeva, N.P. Studies on the botanical and ecological aspects of a rare species *Ophrys caucasica* from Azerbaijan (Orchidaceae) //Academia Journal of Medicinal Plants, – 2019. 7(9), – p. 206-217.

in Khizi (CP 1), Siyazan (CP 2), Guba (CP 3-7), Gusar (CP 8-9), Shamakhi (CP 10-11) and Ismayilli (CP 12) regions. In total, 12 cenopopulations of this plant in those regions were studied and their condition was studied. The ontogenetic structure of the cenopopulations of *P. chlorantha* in the study area shows that all cenopopulations are normal.

According to the indices Δ and ω of demographic structure, CP 3, CP 6, CP 11 are transitional, and the rest are young type.

3.5. Study of cenopopulations of *Crocus speciosus* M.Bieb.

During the study period, 12 cenopopulations of *C. speciosus* were found in Khizi (CP 1-2), Siyazan (CP 3), Shabran (CP 4), Guba (CP 5-6), Khachmaz (CP 7-9), Shamakhi (CP 10), Gobustan (CP 11) and Ismayilli (CP 12) districts, the status of it was studied[25]. Analysis of the ontogenetic structure of the cenopopulations of *C. speciosus* shows that all cenopopulations are normal. However, CP 1, CP 10, CP 11 are incomplete due to the absence of senile individuals.

According to the indices Δ and ω of demographic structure, CP 5 and CP 8 are transitional, and the rest are young type.

3.6. Study of cenopopulations of *Ophrys apifera* Huds.

During the study, cenopopulations of *O. apifera* were found in Khizi (CP 6-8), Shabran (CP 1), Guba (CP 2) and Shamakhi (CP 3-5) regions. In general, 8 cenopopulations of this plant in those regions were studied and their condition was studied[26]. The ontogenetic structure of the cenopopulations of *O. apifera* in the study area shows that all cenopopulations are normal. However, CP 1, CP 2, CP 5, CP 6-7 are incomplete due to the absence of subsenile and senile individuals.

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[25] Мурсал, Н. Онтогенетическая структура ценопопуляций редкого вида *Crocus speciosus* (Iridaceae) в северо–восточной части большого Кавказа (Азербайджан) // – Дагестан: Ботанический Вестник северного Кавказа, – 2020. № 1, – с.46-58.

[26] Mursal, N. Current status of endangered species of *Ophrys oestrifera* M.Bieb. in the Greater Caucasus (Azerbaijan) // Материалы Всероссийской научно-практической конференции с международным участием «Актуальные вопросы охраны биоразнообразия на заповедных территориях», – Россия, Уфа: – 24–26 ноября, – 2020. – с.151-155.

According to the indices Δ and ω of demographic structure, CP 5 and CP 7 are mature, while other cenopopulations are young type.

According to the ontogenetic structure of cenopopulations, the predominance of pregenerative individuals is recorded in *P. chlorantha* (50.86%), *I. reticulata* (48.07%) and *C. speciosus* (49.78%), while the largest number of generative individuals is in *O. sphegodes* subsp. *mammosa* (49.93%), *O. apifera* (49.84%) and *G. alpinus* var. *alpinus* (49.52%). Based on age (Δ) and efficiency (ω) indices, it was determined that 58.82% of cenopopulations of *G. alpinus*var. *alpinus* are transitional and mature type, *I. reticulata, C. speciosus, P. chlorantha, O. sphegodes* subsp. *mammosa* and *O. apifera* taxa, respectively; 17%; 25%; 22% are transitional.

CHAPTER IV
ONTOGENESIS OF STUDIED RARE TAXONS

Knowing the developmental characteristics of plants from the initial stage of ontogeny, as well as phenological observations provide a favorable basis for managing future reproduction processes. Thus, the ontogenetic periods and stages in the large life cycle of each taxa were studied, and the dimensions and descriptions of the morphological parameters of individuals in each ontogenetic age period were given.

4.1. The ontogenesis of *Galanthus alpinus* var. *alpinus*

According to the results of the investigations 4 periods (latent, pregenerative, generative, and postgenerative) and 9 ontogenetic age states (sprouts, juvenile, immature, virginil, young generative, mature generative, old generative, subsenile, senile) were detected in the large life cycle of this taxon[27] (Figure 2).

[27] Mursal, N. A case study for coenopopulations of a rare species *Galanthus alpinus* (Amaryllidaceae) in the Greater Caucasus (Azerbaijan) // – Грозный: Грозненский естественно-научный бюллетень», – 2020. Vol 5, №1(19), – p. 59-67.

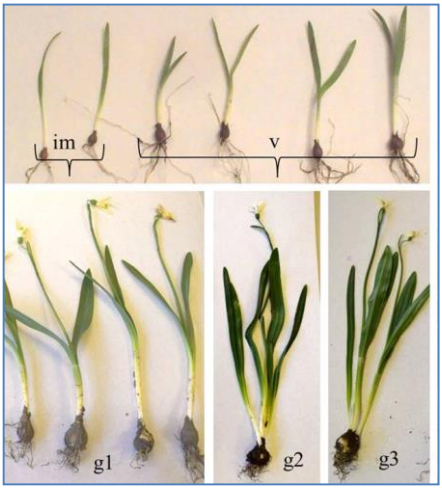


Figure 2. Ontogenetic states of *Galanthus alpinus* Sosn. var. *Alpinus*

4.2. Ontogenesis of *Iris reticulata* M.Bieb.

In the ontogenesis of *Iris reticulata* 4 periods and 6 ontogenetic age states (juvenile, immature, virginil, young generative, mature generative, old generative) were studied (Figure 3).

Figure 3. Ontogenetic states of *Iris reticulata* M.Bieb.

4.3. Ontogenesis of *Crocus speciosus* M.Bieb.

In the ontogenesis of this taxon, we studied 4 periods and 8 ontogenetic age states (juvenile, immature, virginil, young generative, mature generative, old generative, subsenile, senile) (Figure 4).

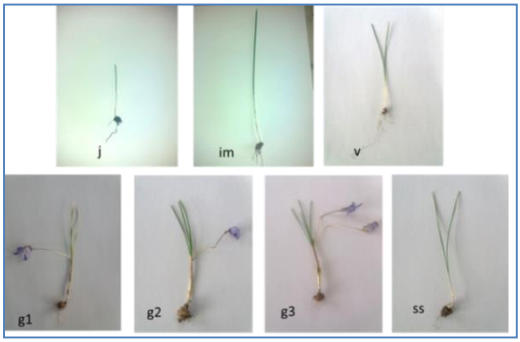


Figure 4. Ontogenesis of *Crocus speciosus* M. Bieb.

4.4. Ontogenesis of *Platanthera chlorantha* (Cust.) Reichenb.

As a result of research, 4 periods and 8 ontogenetic age states (juvenile, immature, virginil, young generative, mature generative, old generative, subsenile, senile) were studied in the ontogenesis of *P. chlorantha* (Figure 5).

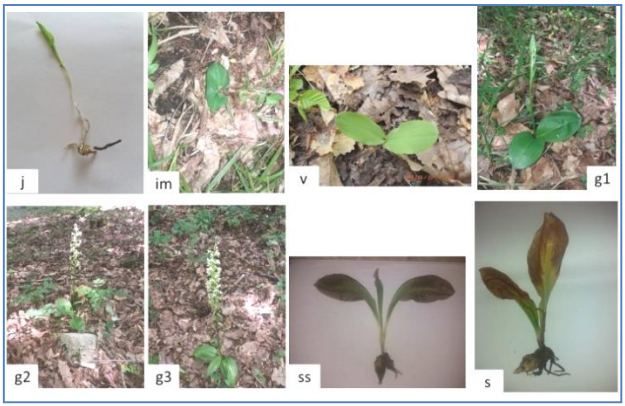


Figure 5. Ontogenesis of *Platanthera chlorantha* (Cust.) Reichenb.

4.5. The ontogenesis of *Ophrys sphegodes* subsp. *mammosa* (Desf.) Soó ex E. Nelson

In the ontogenesis of the this taxon, we have studied 3 periods (latent, pregenerative, generative) and 6 ontogenetic age states (juvenile, immature, virginil, young generative, mature generative, old generative) (Figure 6).

Figure 6. Ontogenesis*Ophrys sphegodes* subsp. *mammosa* (Desf.) Soó ex E. Nelson

4.6. Ontogenesis of *Ophrys apifera* Huds.

In the ontogenesis of *O. apifera*, 3 periods and 6 ontogenetic age states (juvenile, immature, virginil, young generative, maturegenerative, old generative) were studied (Figure 7).

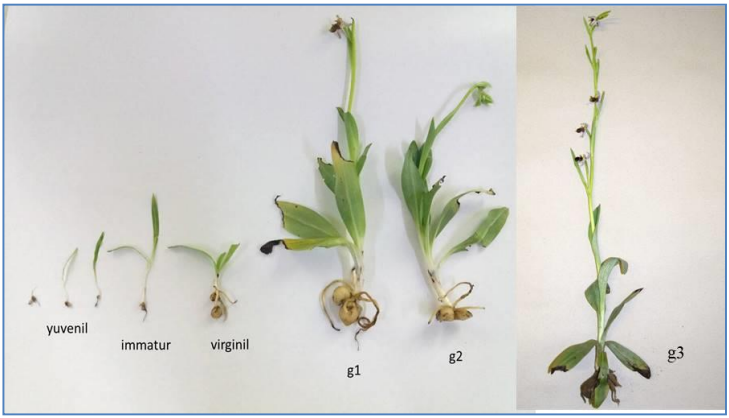


Figure 7. Ontogenetic states of *Ophrys apifera* Huds.

The study of flowering biology of the taxa under culture condition showed that the life of 1 flower of the plant is: for *G. alpinus* var. *alpinus* (17-23), *I. reticulata*(12-13), *C. speciosus* (19-20), *P. chlorantha* (9-11), *O. sphegodes* subsp. *mammosa* (4-15) days, *O. apifera* (14-22) days.

CHAPTER V
MORPHOMETRIC AND VITALITY STRUCTURE OF CENOPOPULATIONS OF STUDIED TAXA

5.1. Morphometric and vitality structure of *Galanthus alpinus* Sosn. var. *alpinus* cenopopulations

Morphometric and vitality structure was studied in the cenopopulations of alpine snowdrop found around Ispik (CP 1), Nugadi (CP 2), around Dagli (CP 6), around Girizdahna (CP 7) of Guba region, around Zeyva village of Shabran region (CP 3), around Gizilgazma village of Khizi region (CP 4), in the forests (CP 5) around Piral village of Gusar region (Table 1). The following morphoparameters of generative individuals in cenopopulations were selected for morphometric and vitality analyzes: leaf length and width, flower shootlength, petal length and width.

Table 1

Indicators of the vitality structure of cenopopulations of the studied taxa

CP	The proportion of individuals in the classes of vitality, %			Quality index (*Q*)	Flowering or depressive degree (*Iq*)	Vitality Index (*IVC*)	Vitality type
	a	b	c				
CP 1	0.13	0.61	0.26	0.37	1.42	0.21	Flowering
CP 2	0.33	0.19	0.48	0.26	0.54	0.20	Depressive
CP 3	0.17	0.55	0.28	0.36	1.28	0.14	Flowering
CP 4	0.34	0.26	0.39	0.3	0.77	0.15	Depressive
CP 5	0.26	0.48	0.26	0.37	1.42	0.14	Flowering
CP 6	0.26	0.32	0.42	0.29	0.69	0.15	Depressive
CP 7	0.32	0.42	0.26	0.37	1.42	0.14	Flowering

5.2. Morphometric and vitality structure of *Iris reticulata* M.Bieb. cenopopulations

The morphometric and vitality structure was studied in the grassy slopes in the direction of Gedik (CP 1), Isnov (CP 2), Uchkun-Kupchal

(CP 3) villages of Guba region, Altiagaj-Angilan (CP 4) villages of Khizi region, Chukhuryurd-Nagarakhana (CP 5) village of Shamakhi region (Table 2). The following morphoparameters of generative individuals in cenopopulations were selected for morphometric and vitality analysis: leaf length and width, flower shoot length, petal length and width, bulb length and width, length and number of root.

Table 2

Indicators of the vitality structure of cenopopulations of the studied taxa

CP	The proportion of individuals in the classes of vitality, %			Quality index (*Q*)	Flowering or depressive degree (*Iq*)	Vitality Index (*IVC*)	Vitality type
	a	b	c				
CP 1	0.23	0.42	0.35	0.32	0.92	0.21	Depressive
CP 2	0.17	0.55	0.28	0.36	1.28	0.14	Flowering
CP 3	0.14	0.54	0.32	0.34	0.11	0.79	Depressive
CP 4	0.14	0.5	0.36	0.32	0,89	0.92	Depressive
CP 5	0.26	0.48	0.26	0.37	1.42	0.14	Flowering
CP 6	0.18	0.51	0.31	0.34	1.11	0.46	Flowering

5.3. Morphometric and vitality structure of *Crocus speciosus* M.Bieb. cenopopulations

Morphometric and vitality structure was studied in the forests around Gizilgazma village of Khizi region (CP 1 and CP 2), sown areas in Gedik village of Guba region (CP 3), around Girizdahna village (CP 7), around Khudat city (CP 4), in Yalama forest (CP 5), in the forests around Samurchay village (CP 6) of Khachmaz region (Table 3). The following morphoparameters of generative individuals in cenopopulations were selected for morphometric and vitality analyzes: length and width of the flower shoot, length and width of the petal.

Table 3

Indicators of the vitality structure of cenopopulations of the studied taxa

CP	The proportion of individuals in the classes of vitality, %			Quality index (*Q*)	Flowering or depressive degree (*Iq*)	Vitality Index (*IVC*)	Vitality type
	a	b	c				
CP 1	0.14	0.5	0.36	0.32	0.88	0.94	Depressive
CP 2	0.14	0.5	0.36	0.32	0.88	0.79	Depressive
CP 3	0.32	0.54	0.14	0.43	3.07	0.98	Flowering
CP 4	0.28	0.48	0.24	0.38	1.58	0.46	Flowering
CP 5	0.25	0.61	0.14	0.43	3.07	0.21	Flowering
CP 6	0.36	0.5	0.14	0.43	3.07	0.19	Flowering
CP 7	0.23	0.42	0.35	0.32	0.92	0.21	Depressive

5.4. Morphometric and vitality structure of *Platanthera chlorantha* (Cust.) Reichenb. cenopopulations

Morphometric and vitality structure was studied in Ispik (CP 1), Nugadi villages of Guba region (CP 2), Piral village of Gusar (CP 3), Gizilgazma village of Khizi (CP 4), Galaalti village of Siyazan region (CP 5), in the forests (CP 7) around Archiman village of Shamakhi region (CP 6), around Ismayilli-Shamakhi road (CP 7)[28] (Table 4). The following morphoparameters of generative individuals in cenopopulations were selected for morphometric and vitality analysis: leaf length and width, flower shoot length and width, number of flowers, and number of veins in the leaf.

[28] Mursal, N., Mehdiyeva, N.P., Ibrahimova, A.G. Population status and ecology of *Platanthera chlorantha* (Orchidaceae) in the Greater Caucasus (Azerbaijan) // – Mordovia: Nature Conservation Research, (Suppl.1), – 2020. – p. 114-124.

Table 4

Indicators of the vitality structure of cenopopulations of the studied taxa

CP	The proportion of individuals in the classes of vitality, %			Quality index (*Q*)	Flowering or depressive degree (*Iq*)	Vitality Index (*IVC*)	Vitality type
	a	b	c				
CP 1	0.22	0.56	0.22	0.39	1.74	0.14	Flowering
CP 2	0.22	0.67	0.11	0.44	4.04	0.20	Flowering
CP 3	0.11	0.67	0.22	0.39	1.77	0.14	Flowering
CP 4	0.26	0.48	0.26	0.37	1.42	0.14	Flowering
CP 5	0.17	0.55	0.28	0.36	1.28	0.14	Flowering
CP 6	0.32	0.42	0.26	0.37	1.42	0.14	Flowering
CP 7	0.29	0.40	0.31	0.34	1.11	5.50	Flowering

5.5. The morphometric and vitality structure of *Ophrys sphegodes* subsp. *mammosa* (Desf.) Soó ex E. Nelson. cenopopulations

Morphometric and vitality analysis has been studied in Altiagaj settlement of Khizi region (CP 1), Yalama village of Khachmaz region (CP 2), Piral village of Gusar region (CP 3), Galaalti village of Siyazan region (CP 4) (Table 5).The following morphoparameters of generative individuals in cenopopulations were selected for morphometric and vitality analysis: stem width, number of leaves, leaf length and width, flower shoot length, number of flowers, bud length and width, number of leaf veins.

Table 5

Indicators of the vitality structure of cenopopulations of the studied taxa

CP	The proportion of individuals in the classes of vitality, %			Quality index (*Q*)	Flowering or depressive degree (*Iq*)	Vitality Index (*IVC*)	Vitality type
	a	b	c				
CP 1	0.31	0.45	0.24	0.38	1.58	0.46	Flowering
CP 2	0.31	0.42	0.27	0.36	1.35	0.21	Flowering
CP 3	0.18	0.51	0.31	0.34	1.11	0.14	Flowering
CP 4	0.22	0.32	0.46	0.27	0.59	0.15	Depressive

5.6. The morphometric and vitality structure of *Ophrys apifera* Huds. cenopopulations

Morphometric and vitalitystructure has been studied in Altiagaj settlement of Khizi (CP 1), Zeyva village of Shabran (CP 2), Ispik village of Guba (CP 3), Gizmeydan village of Shamakhi region (CP4) (Table 6). The following morphoparameters of generative individuals in cenopopulations were selected for morphometric and vitality structure analysis: flower shootlength, flower group length, flower shoot width, leaf length and width, number of flowers, leaf veins, bud length and width.

Table 6

Indicators of the vitality structure of cenopopulations of the studied taxa

CP	The proportion of individuals in the classes of vitality, %			Quality index (*Q*)	Flowering or depressive degree (*Iq*)	Vitality Index (*IVC*)	Vitality type
	a	b	c				
CP 1	0.2	0.52	0.28	0.36	1.28	1.26	Flowering
CP 2	0.32	0.36	0.32	0.34	1.06	0.13	Flowering
CP 3	0.14	0.54	0.32	0.34	0.11	0.79	Depressive
CP 4	0.29	0.42	0.29	0.35	1.22	0.13	Flowering

The results of cluster analysis based on the average values of morphoparameters of individuals in cenopopulation show that favorable conditions for *O. sphegodes* subsp. *mammosa* are mainly low-moisture areas and alkaline, alluvial-meadow-forest-type soils, for *O. apifera* – acidic, mostly dry soils, for *P. chlorantha* – temperate, warm and humid climate, mountain-brown soils, for *I. reticulata* – alkaline, mostly dry soils, for *G. alpinus* var. *alpinus* – a soil of abundant moisture, acidic environment, mountain-brown type. In such environments, the morphological parameters of individuals are large and their viability is high.

CHAPTER VI
HEMEROBIA AND ECOLOGICAL CHARACTERISTICS OF STUDIED TAXA

6.1. Assessment of hemerobia properties of plant communities which included in study taxa

Based on the hemerobia assessment of the taxa, it was determined that *G. alpinus* var. *alpinus* and *C. speciosus* – oligomezohemerob, *I. reticulata*, *O. apifera* and *O.sphegodes* subsp. *mammosa* – are mesohemerob and *P. chlorantha* is oligohemerob. Thus, the *P. chlorantha* is highly sensitive to anthropogenic influences, and the percentage of anthropotolerant species in the cenoses which it includes is lower than other species (27%)[29] (Figure 8).

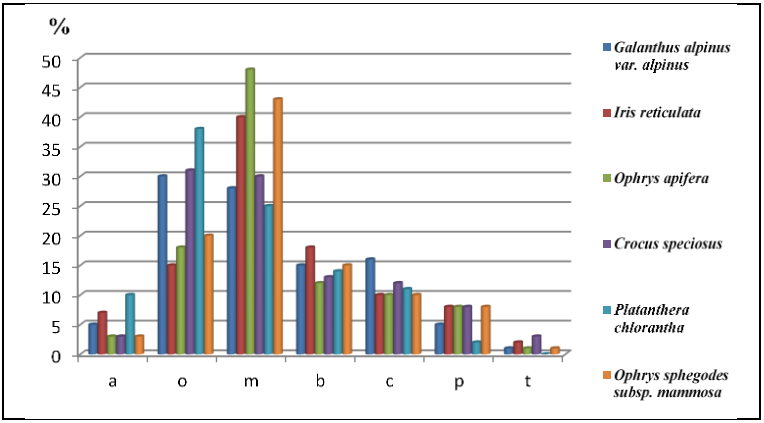


Figure 8. Hemerobia spectrum of plant communities participating with studied taxa (Absis–a-o-m-b-c-p-t fraction of hemerobia; Ordinate – level of hemerobia)

6.2. Influence of altitude and ecological factors on the studied taxa

The results of the regressive analysis showed that there is increase in the number of individuals in cenopopulations of *G. alpinus*

[29]Mürsəl, N., Mehdiyeva, N.P. Quba rayonunda nadir növlərin senopopulyasiyalarının ekoloji–fitosenotik və demoqrafik xüsusiyyətləri. // – Baku:Azerbaijan Journal of Botany.– 2020. 1(2), – 64-72 s.

var. *alpinus* (64-8293), *O. oestrifera* (16-124) and *I. reticulata* (48-516), but there is a decrease of *C. speciosus* (1809-39), *O. sphegodes* subsp. *mammosa* (549-25) and *P. chlorantha* (160-34).

6.3. Canonical correspondence analysis of studied taxa (CCA)

A canonical correspondence analysis was performed to clarify the relationship between the distribution of the taxa studied, environmental reactions and environmental variability.

During the study, *P. chlorantha* were recorded by us from 588 m a.s.l to 1043 m. The areas where it grows are mainly beech-hornbeam forests. Along with this taxon, other orchid species have been observed in the cenosis. CCA analysis was performed for this and other species (Figure 9):

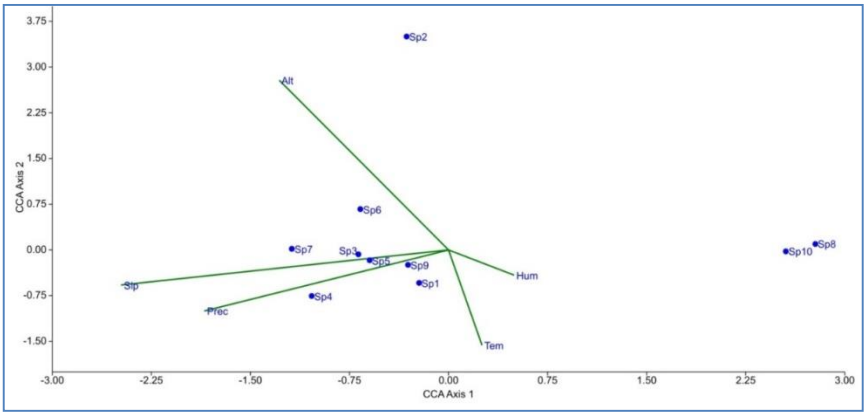


Figure 9. Ordinance diagram of the canonical correspondence analysis (CCA) of orchid species in the north-eastern part of the Greater Caucasus. Environmental factors (Alt – altitude, Slp – slope exposure, Tem – temperature, Prec – amount of precipitation, Hum – humidity)

Platanthera chlorantha (CP1), *Ophrys sphegodes* subsp. *mammosa* (CP2), *Ophrys apifera* (CP3), *Epipactis palustris* (L.) Crantz (CP4), *Neottia nidus-avis* (L.) Rich. (CP5), *Limodorum abortivum* (L.) Sw. (CP6), *Neottia ovata* (L.) Bluff & Fingerh. (CP7), *Himanthoglossum formossum* (Steven) K.Koch (CP8), *Orchis purpurea* Huds. (CP9), *Dactylorhiza romana* subsp. *georgica*(Klinge) Soó ex Renz & Taubenheim (CP10). The specific value for CCA axis 1 was

64.11% and for CCA axis 2 – 16.21%.

One more species located considerably separately was *Ophrys sphegodes* subsp. *mammosa*. Obviously, this orchid is confined to the highest altitudes and lowest temperature in the Great Caucasus. Other seven species are almost not distinguishable according to the analysed environmental factors. Of them, *P. chlorantha*, *O. apifera*, *O. purpurea*, *N. nidus-avis* and *N. ovata*formed almost undivided group.

There is *G. alpinus* var. *alpinus* were mainly found by us at altitudes of 588 m a.s.l. to 1397 m. The areas where it grows are mainly beech-hornbeam forests. Along with this species, other species most commonly found in the cenosis were also included in the CCA analysis: *G. alpinus* var.*alpinus*, *I. reticulata*, *C.speciosus*. The specific value for CCA axis 1 was 73.98% and for CCA axis 2 it was 26.02% (Figure 10).

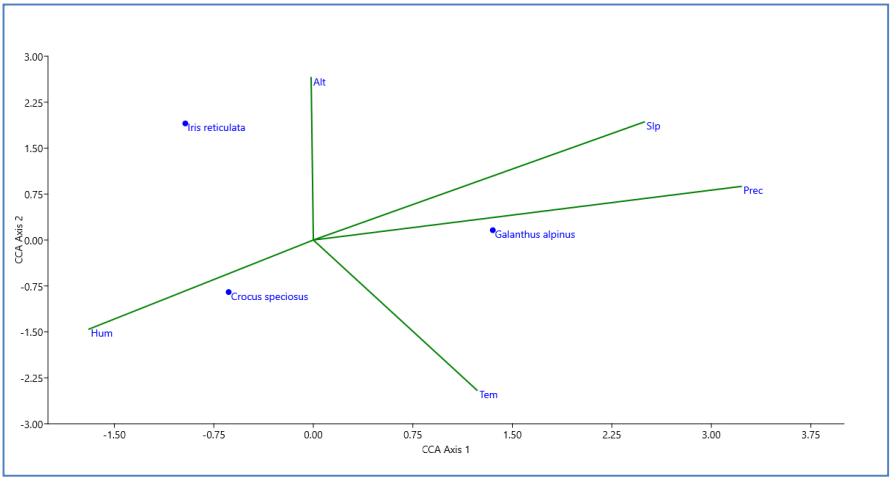


Figure 10. Ordination diagram of canonical correspondence analysis (CCA) of *Galanthus alpinus* var. *alpinus*, *Iris reticulata*, *Crocus speciosus* in the north-eastern part of the Greater Caucasus. Environmental factors (Alt – altitude, Slp – slope exposure, Tem – temperature, Prec – amount of precipitation, Hum – humidity).

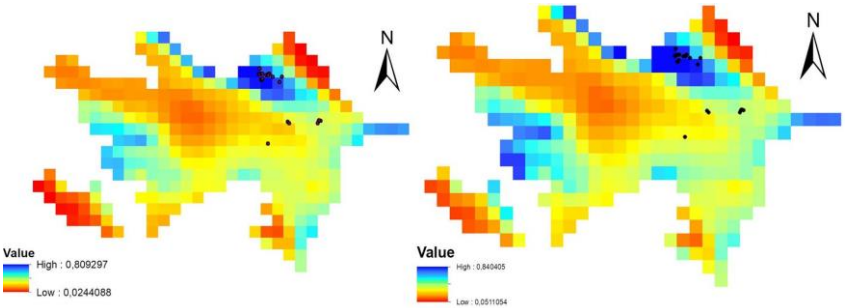
Based on the results of CCA analysis, *I. reticulata* was separated from the main group. It is clear that this is due to the low humidity and low slope of the area where the taxa grows, while individuals of this taxon prefer high altitudes and low temperatures in the Greater Caucasus. The alpine snowdrop responds more to rain and prefers moist places. Although the beautiful saffron plant is sensitive to the amount of moisture, they do not prefer the slope exposure.

CHAPTER VII
PROGNOSTIC MODEL OF POTENTIAL DISTRIBUTION OF STUDIED TAXA UNDER THE INFLUENCE OF CLIMATE FACTORS

In order to determine whether there is a close relationship between the studied taxa and climate variability, a map of their potential distribution for the current period was developed, as well as future favorable dynamic spatial-temporal areas under the climate scenario were assessed.

7.1. Prognostic model of potential distribution of *Galanthus alpinus* Sosn. var. *alpinus*

The model of the alpine snowdropis compiledand it showed a highly predictive presentation with AUC indicators. Thus, these indicators were 0.982 in the model conducted for the current period, and 0.973 in the model conducted under the climate scenario.

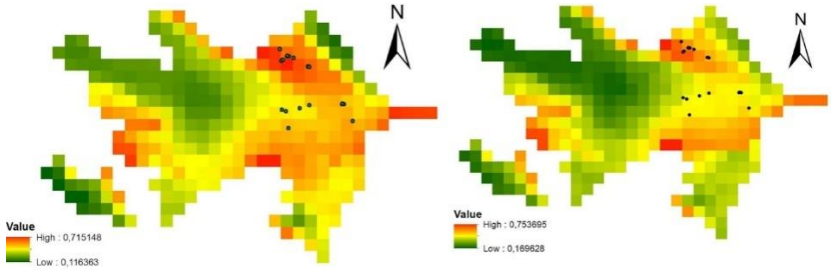


A B

Figure 11. Map of potential distribution of *Galanthus alpinus* Sosn. var. *alpinus* in the current period (A) and under the climatic scenario (B)

7.2. Prognostic model of the potential distribution of *Platanthera chlorantha* (Cust.) Reichenb.

The model of *P. chlorantha* showed a highly predictive presentation with AUC. Thus, these indicators were 0.993 in the model conducted for the current period, and 0.985 in the model conducted under the climate scenario.

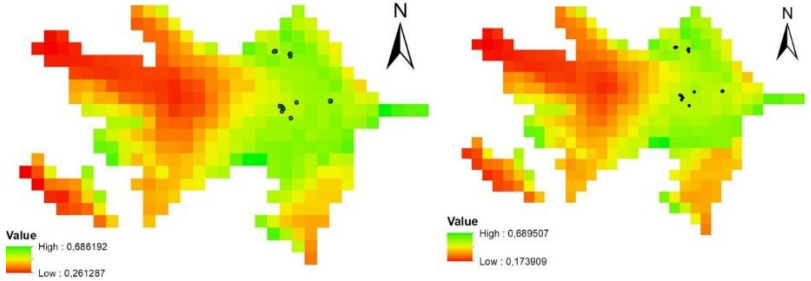


A B

Figure 12. Map of the potential distribution of *Platanthera chlorantha* (Cust.) Reichenb. in the current period (A) and under the climate scenario (B)

7.3. Prognostic model of the potential distribution of *Iris reticulata* M.Bieb.

I. reticulata model showed a highly predictive presentation with AUC. In the model conducted for the current period, it was 0.962, and in the model conducted under the climate scenario 0.955.

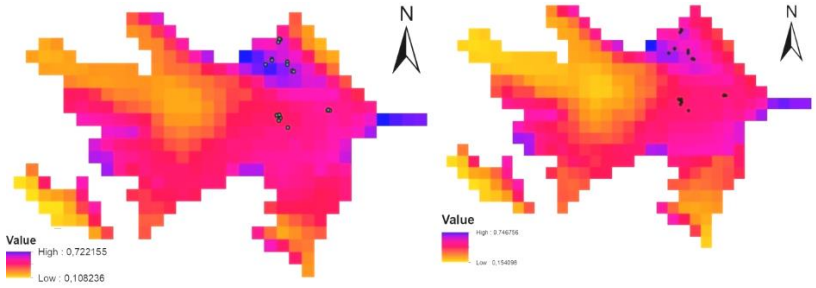


A B

Figure 13. Map of the potential distribution of *Iris reticulata* M. Bieb. in the current period (A) and under the climate scenario (B)

7.4. Prognostic model of the potential distribution of *Crocus speciosus* M. Bieb.

The model of the beautiful saffron showed a highly predicative presentation with AUC. These indicators were 0.971 in the model for the current period and 0.965 in the model conducted under the climate scenario.

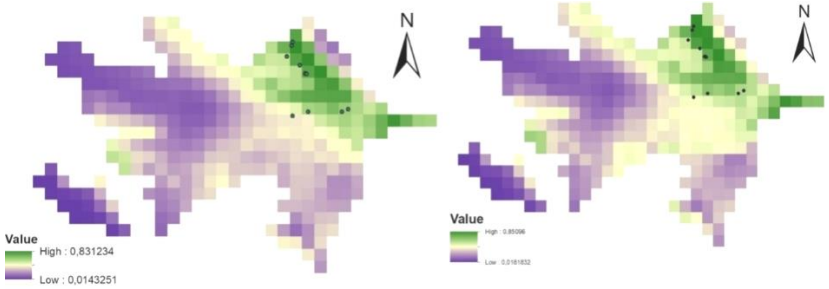


A B

Figure 14. Map of the potential distribution of *Crocus speciosus* M. Bieb. in the current period (A) and under the climate scenario (B)

7.5. A prognostic model of the potential distribution of *Ophrys sphegodes* subsp. *mammosa* (Desf.) Soó ex E. Nelson.

The AUC of the early spider eyebrow orchid model showed a highly predictive presentation. These indicators were 0.984 in the model for the current period and 0.972 in the model conducted under the climate scenario.

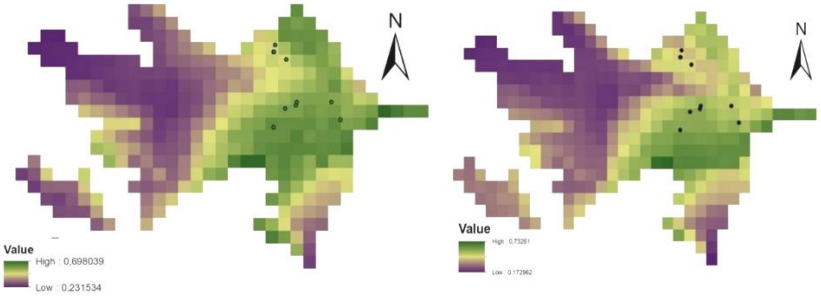


A B

Figure 15. Map of potential distribution of *Ophrys sphegodes* subsp. *mammosa* (Desf.) Soó ex E. Nelson in the current period (A) and under the climatic scenario (B)

7.6. Prognostic model of the potential distribution of *Ophrys apifera* Huds.

The AUC of the bee orchid plant model showed a highly predicative presentation. Thus, these indicators were 0.993 in the model conducted for the current period, and 0.987 in the model conducted under the climate scenario[30].



A B

Figure 16. Map of the potential distribution of *Ophrys apifera* Huds. in the current period (A) and under the climate scenario (B)

Based on the prognostic model developed for the first time, it was determined that strong climate change effects and loss of favorable areas will occur in the future for *P. chlorantha*, *C. speciosus*, *O. apifera*, but there is no danger of these factors for *I. reticulata*, *O. sphegodes* subsp. *mammosa* and *G. alpinus* var. *alpinus*.

RESULTS

1. For the first time population and phytocenological investigations of 6 rare and endangered *G. alpinus* var. *alpinus*, *P. chlorantha*, *C. speciosus*, *I. reticulata*, *O.sphegodes* subsp. *mammosa* and *O. apifera* taxa have been conducted in the north-eastern part of the Greater Caucasus and it has been established that they are spreading in different vegetation types form lowlands to the middle mountain zone and take part in formation different microassociations

[30] Mursal, N., Mehdiyeva, N.P. Maxent modeling for predicting the potential habitat and future distribution of a rare species *Ophrys apifera* Huds. in the Greater Caucasus (Azerbaijan) // – Mordovia: Proceedings of the Mordovia State Nature Reserve, – 2021, Vol.27, – p. 3-12.

(*Scilla siberica+Primula acaulis+Galanthus alpinus* var. *alpinus, Tulipa biebersteiniana+Iris reticulata+Crocus speciosus, Cephalanthera grandiflora+Ophrys sphegodes* subsp. *mammosa+Platanthera chlorantha, Anacamptis pyramidalis+Ornithogalum pyrenaicum+Ophrys apifera*) in different cenoses.

2. Pregenerative individuals of *P. chlorantha* (50.86%), *I. reticulata* (48.07%) and *C. speciosus* (49.78%) are dominated in the ontogenetic structure of their cenopopulations, but *O. sphegodes* subsp. *mammosa* (49.93%), *O. apifera* (49.84%) and *G. alpinus* var.*alpinus* (49.52%) cenopopulations are dominated by generative individuals. Based on age (Δ) and efficiency (ω) indices, it was determined that 58.82% of cenopopulations of *G. alpinus* var. *alpinus* are transitional and mature type, *I. reticulata*, *C. speciosus*, *P. chlorantha*, *O. sphegodes* subsp.*mammosa* and *O. apifera*, respectively; 17%; 25%; 22% are transitional.
3. The ontogenesis of the studied taxa has been investigated and it has been determined that their life cycle is: *G. alpinus* var. *alpinus* – 4 periods, 9 states; *I. reticulata* – 4 periods, 6 states; *C. speciosus* and *P. chlorantha* – 4 periods, 8 states; *O. sphegodes* subsp. *mammosa* and *O. apifera* – 3 periods, 6 states. The study of flowering biology of the taxa under culture condition showed that the life of 1 flower of the plant is: for *G. alpinus* var. *alpinus* (17-23), for *I. reticulata* (12-13), for *C. speciosus* (19-20), for *P. chlorantha* (9-11), for *O. sphegodes* subsp. *mammosa* (4-15) days, for *O. apifera* (14-22) days.
4. Based on the assessment of the *Q, Iq* and *IVC* indices of the vitality structure of the studied taxa populations, it was determined that all 7 cenopopulations of *P. chlorantha* are flowering type, *G. alpinus* var. *alpinus* and *C. speciosus* – 4 flowering, 3 depressive, *I. reticulata* – 3 flowering, 3 depressive, *O. sphegodes* subsp. *mammosa* and *O. apifera* – 3 flowering, 1 depressive type.
5. The results of cluster analysis based on the average values of morphoparameters of individuals in cenopopulation show that favorable conditions for *O. sphegodes* subsp. *mammosa* are mainly low-moisture areas and alkaline, alluvial-meadow-forest-type soils, for *O. apifera* – acidic, mostly dry soils, for *P. chlorantha* – temperate, warm and humid climate, mountain-brown soils, for *I. reticulata* – alkaline, mostly dry soils, for *G. alpinus* var. *alpinus* – a soil of abundant moisture, acidic environment, mountain-brown

type In such environments, the morphological parameters of individuals are large and their viability is high.

6. The results of the regressive analysis showed that there is increase in the number of individuals in cenopopulations of *G. alpinus* var. *alpinus* (64-8293), *O. oestrifera* (16-124) and *I. reticulata* (48-516), but there is a decrease of *C. speciosus* (1809-39), *O. sphegodes* subsp. *mammosa* (549-25) and *P. chlorantha* (160-34). Based on the hemerobia assessment of the taxa, it was determined that *G. alpinus* var. *alpinus* and *C.speciosus* – oligomezohemerob, *I. reticulata*, *O. apifera* and *O. sphegodes* subsp. *mammosa*– mesohemerob and *P. chlorantha* – oligohemerob.
7. For the first time, a prognostic mathematical computer model was developed of their potential and future distribution based on the relationship of taxon populations to climatic factors. Based on the prognostic model developed for the first time, it was determined that strong climate change effects and loss of favorable areas will occur in the future for *P. chlorantha*, *C. speciosus*, *O. apifera*, but there is no danger of these factors for *I. reticulata*, *O. sphegodes* subsp. *mammosa* and *G. alpinus* var. *alpinus*.

SUGGESTIONS AND RECOMMENDATIONS

1. Reaffirmation of the rarity and endangerment of the species studied in the course of the dissertation work, given that cenopopulations of some species are depressed,necessary measures should be taken to protect them *in-situ*, including the entering of these species in the next edition of the Red Book of Azerbaijan.
2. When planning and carrying out economic and infrastructure works in these areas by the relevant agencies, it should be taken into account that plants are rare and endangered, and the threats to them should be minimized.
3. Local executive authorities, local residents, employees of recreation areas, as well as tourists should be informed about the irreparable damage to nature as a result of the collection of plants, especially popularly called "Xarı bülbül" and became a symbol of Bright Victory in the Patriotic War of Azerbaijan – *Ophrys sphegodes* subsp. *mammosa* və *O. apifera*, and explained to them the inadmissibility of it. For this purpose, various educational boards,

posters, etc. visual aids can be prepared and distributed.

4. The external beauty of the studied species, as well as the fact that their flowering period lasts up to about 25 days, there are good prospects for their use in decorative floriculture. To this end, depending on the degree of danger, they can be propagated in experimental fields and gradually introduced into crop rotation.
5. The current interest in herbal medicines, as well as the fact that the studied species have different therapeutic properties, they have good prospects as an object of pharmacological research. These species can be propagated in experimental fields to obtain research materials.
6. The materials of the dissertation can be used as a tool in the teaching of botany at the bachelor's and master's levels, especially in the study of theoretical, practical features of research, evaluation and protection of medicinal, rare and endangered plants.

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The defence will be held on 15 March 2022 at 11^{00} atthe meeting of Dissertation council ED 1.26 of Supreme Attestation Comission under the (registration number of the dissertation council) President of the Republic of Azerbaijan operating at the Institute of Botany of Azerbaijan National Academy of Sciences.

Adress: Badamdar highway 40, AZ 1004, Baku, Azerbaijan.

The dissertation is available at the library of the Institute of Botany of the Azerbaijan National Academy of Sciences.

The electron version of the dissertation and its abstract is available on the official website the of Institute of Botany of Azerbaijan National Academy of Sciences (https://botany.az/).

Abstract was sent to the required addresses on 15 february 2022

Signed for print: 11.02.2022

Paper format: 60x84$^{1/16}$

Volume: 37732

Number of hard copies: 20