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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

INTRODUCTION OF SOME SPECIES OF THE FAMILY OF CACTUS (*CACTACEAE* JUSS.*)* IN CONDITIONS OF COVERED SOILSS IN ABSERON AND THE FORMATION OF THE GENE POOL

Specialty: 2417.01 - Botany

Field of research: Biology

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The work was performed out at the Department of "Biology and its teaching technology" of the faculty of Chemistry and Biology of the Azerbaijan State Pedagogical University, and some of it in the laboratory of "Plants grown in the conditions of covered soils" of the Central garden of ANAS.

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INTRODUCTION

Content of The Relevance of the topic and degree of development. In the modern world, the preservation of the global gene pool is one of the priorities of the modern stage of human development. Currently, there is a significant decrease in the area of vegetation with active and intensive use of natural resources. These processes are the result of global environmental changes, active anthropogenic impact, and inefficient use of plant resources. In this regard, one of the most effective ways to protect plant diversity is planting plants in Botanical gardens. The introduction of plants and the creation of a collection Fund is one of the most important stages of using promising plant species, especially in decorative floristry.

Tropical and subtropical plants are one of the key elements of landscaping of internal, industrial and public buildings, artistic and architectural design and improvement of working conditions. Currently, this problem is difficult to solve using existing varieties of ornamental plants. Therefore, to successfully solve this problem, it is necessary to use the plant resources of tropical and subtropical regions of the world's flora to get new promising introductions. This issue is the main strategic direction for the introduction of plants in regions with extreme natural conditions, including Absheron.

In this regard, it is particularly important to study the problems of optimizing the environment in which people live, including the internal environment in which they live and work.

It should be noted that of particular interest are the *Cactaceae* Juss. species, which are widely cultivated in most countries of the world. The species in this family are available in various shapes, highly decorative and original. However, at present, the *Cactaceae* Juss. species is not sufficiently found in ornamental plants grown in conditions of covered soilss in Azerbaijan. This is due to the fact that the gene pool of cactus species is limited and almost unknown.

Among the tropical and subtropical plants that have recently been studied in conditions of covered soilss in Absheron, Cactus family (*Cactusae* Juss.) has its place. Introduction, systematization,

taxonomy, bioecology, biomorphology, biology, and agrotechnology of growth and development this family has theoretical and practical significance. The species studied in this family are not only an ornamental plant, but also a valuable medicinal and nutritious herb.

Research in this area is also needed as part of the global strategy *"of the international Council for the conservation of Botanical gardens (BGCI-Botanic Gardens Conservation International)"*[1]. This program was adopted "*at the world summit on plant protection and sustainable development*"[2]. Under this program, each country must participate in a program to restore 5% of the world's endangered plant species.

The Botanical description, species diversity, geographical distribution, bioecological and biomorphological characteristics, phylogeny, systematics and taxonomy ofthe species of family of *Cactaceae*, as well as their introduction in Botanical gardens of many foreign countries is reflected in the works of *F. Buxbaum*[3], *C. Backeberg*[4], *W. Barthlott*[5], *E. Chichkanov*[6], and in Azerbaijan in those of *Sh.R. Babaev*[7], *Sh.N. Gasimov*[8] and others. Up to now, onlysome aspects of "*palinomorphology, molecular systematics,*

[1] https://www.bgci.org/russia/policy/

[2] www.un-documents.net/aconf199-20.pdf

[3] Buxbaum, F. Kakteen-Pflege biologisch richtig. Pflege, Zucht, Beschreibung der Gattungen - Stuttgart: Franckh. – 1959. - 224 s.

[4] Backeberg, C. Das Kakteenlexicon / C. Backeberg, Jena: - 1976. - 822 s

[5] Barthlott, W. Cacti. Botanical aspects, descriptions and cultivation. - Cheltenham: Stanley Thomas, - 1979. - 249 p.

[6] Chichkanova, Ye.S. Biomorphological features of Rebutia K. Schum. species in glasshouse conditions in the south-east of Ukraine. // Industrial botany Journal, - 2013. №13, - p. 305-311.

[7] Babaeva, Sh. Introduction of some types of succulents (prickly pear) from the family Cactaceae in the conditions of closed and open ground Absheron: / Abstract of diss. on sois. scientific step. Cand. biol. Sciences / - Baku, 1975. - 32 p.

[8] Gasimov Sh.N. Biomorphological featurea of Parodia Speg. species in glasshouse conditions in the Absherone./ Sh.N. Gasimov, D.N. Taxmazova // Proceedings of the central Botanical Garden, - 2015. vol. XIII, - p. 12-21.

molecular phylogenetics, phylogenetics, genotype, selection, morphological and genetic features, genitive development, growth form"[9,10,11,12] of certain species belonging to the *Cactaceae* family in Botanical gardens of foreign countries have been studied.

However, until recently, there has been no complex comprehensive study of cacti in Azerbaijan. Therefore, the study of biomorphological features, cultivation conditions, mechanisms of plant adaptation, seasonal development, morphogenesis and ontogenesis of *Cactaceae* representatives in the conditions of covered soils is relevant enough today.

Purpose and objectives of the study. The aim of the study is to compare and analyze the introduction of some *Cactaceae* species in the conditions of covered soilsin Absheron, their morphobiological characteristics, early stage of development, morphogenesis and ontogenesis of plants, developmental biology, natural and cultural conditions.

To achieve this goal, the following tasks are planned:

- the creation of species belonging to *Cactaceae* family in the conditions of covered soils in Absheron;

- to study the morphobiological characteristics of introduced species *Cactaceae* family;

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[9] Wallace, R.S. Molecular systematic study of the Cactaceae: using chloroplast DNA variation to elucidate cactus phylogeny // Bradleya - 1995, 13: - p. 1-12.

[10] Ritz, C.M. The molecular phylogeny of *Rebutia* (Cactaceae) and its allies demonstrates the influence of paleogeography on the evolution of South American mountain cacti / C.M., Ritz, L. Martins, R. Mecklenburg [et al.] // Am. J. Bot. – 2007. 94 (8), - p. 1321–1332.

[11]Kosenko, Ya.V. Palinomorphology of some representatives of the family Cactaceae (subfamilies Opuntioideae and Cereoideae)/Ya.V. Kosenko, V.M. Leunova//Bull. Mosk. test islands nature. Sep. Biol. - 2010. v. 115, No. 1, - p. 42 - 49.

[12] Chichkanova, Ye. S. Morphological and genetic features of the species of Rebutia K. Schum. genus of Cactaceae Juss. family and their f1 hybrids. / Ye.S. Chichkanova, A.E. Demkovich. // ScienceRise**,** - 2015, v. 8, n. 1(13), - p. 19-24.

- to study the biological features and life cycle of the early stages of ontogenesis of the speciesbeing studied;

- comparative biomorphological analysis of the species being studied in natural and cultivated conditions;

- to study the phenology, growth dynamics and development of the species being studied in cultivation conditions;

- to study the bioecological basis of introduced speciesCactaceae family;

- development of optimal agrotechnical cultivation of *Cactaceae* family in the conditions of covered soils.

Method of research. The methodology of comprehensive study of the species belonging to *Cactaceae* family is based on the principle of their complex study. The research used bioecological, biomorphological, phenological, biorhythmic development of the vegetative field of plants, scales for evaluating decorative properties and methods of mathematical statistical processing.

Main provisions to defend:

1. Biomorphological analysis of the development cycle of organs formed at the initial stage of ontogenesis determines the correlation between them and ecological factors.

2. Biomorphological analysis of juvenile plants during the initial development of new introductions in the conditions of covered soilsis a key indicator of their adaptive potential.

3. The study of biomorphology and phenolophytes of *Cactaceae* familyin the conditions of coverred soil is the basis for evaluating their biological and decorative quality.

Scientific novelty of the research. For the first time, a rich gene pool of 53 species belonging *Cactaceae* family was createdin the conditions of covered soils in Absheron, and a biomorphological analysis of these species was carried out under new environmental conditions, and the biological and bioecological foundations of virgin and generational periods were studied. The results obtained at this time made it possible to develop theoretical and practical bases for growing the studied species in the conditions of covered soils in Absheron. Morphogenesis, ontogenesis, life cycle, growth and

development dynamics, flowering and fruiting biology, and seed productivity of species studied during the virgin and generative periods were identified.

Phenological observations have shown that in the conditions of covered soils in Absheron, all 53 species studied in the *Cactaceae* family are in a generative development cycle, of which 48 species (90.57%) bear fruit, and 5 species (9.43%) bloom. Of the studied species, the largest number of fruits grows *Opuntia maxima* (38-40 pieces), as well as *Stenocactus vaupelianus* (2-3 pieces). It was found that the largest number of seeds (1600 pcs.) is contained in one fruit *Parodia erinacea*, and the smallest number of seeds (2-3 pcs.) - in one fruit *Peireskia aculeata*. The optimal temperature (+26-30^{0}C) for seed germination was determined in Absheron. The highest percentage of germination in the studied seeds is *Astrophytum myriostigma var. quadricostatum* 90.80±0.73%, 88.00±0.40% in *A. myriostigma*, and 86.00±2.79% in *Peireskia aculeata*, while the lowest percentage of germination, *R. minuscula var. senilis*, is observed in senils (25.00±0.51%) and in *Rebutia neocumingii* (29.01±0.45%). A correlation was found between the rate of development of leafy foliage and hypocotyl in the initial development of the first studied species. Thus, in developed hypocotylic plants of high density, it was generally found that leaf germination is poorly developed (*Cereus forbesii*), and in young hypocotyl there is a developed juicy leaf (*Peireskia aculeata*). Of the species studied for the first time, a full development cycle of 4-6 years was established for *Echinopsis mirabilis.* As a result of the development of bioecological bases of cultivation, it was found that the correct definition of environmental factors (humidity, temperature and light) is important for all stages of development of the studied species.

Theoretical and practical significance of the study. Taxonomic analysis and biomorphological study of the species belonging to *Cactaceae* family that were introduced and grown in the conditions of covered soils of the Central Botanical Garden confirm the need for additional research related to the systematic and

taxonomic problems of this family. The temperature, illumination, substrate, and humidity necessary for the successful introduction of representatives of *Cactaceae* family in the conditions of covered soils were determined. The obtained experimental data and revealing features of growth and development justify the prospect of growing species of *Cactaceae* family in greenhouse and hothouse conditions. Complex agrotechnical measures were developed for growing cacti from latent (seed) to generative periods.

Based on the scale of biological and decorative quality assessment, promising cactus species have been identified for use in landscaping indoor interiors and micro-landscape compositions in phytodesign. Data on seed morphology, early stages of ontogenesis, and comparative biomorphological analysis can be used in the taxonomy of *Cactaceae* family, as well as in the identification of representatives of Botanical gardens in this family. In addition, the information obtained can be used in courses on taxonomy, morphology and biology of cactus development for students and doctoral students, as well as in public awareness events.

Approbation and application. The main results of the work were presented at XVIII Republican scientific conference "Doctoral students and young researchers" (Baku, 2013), "Current problems of modern biology and chemistry "(Ganja, 2014), and at III international mycological forum "Modern Mycology in Russia" (Moscow, 2015), at the 5th International scientific and practical conference "Actual problems of biological and chemical ecology" (Moscow, 2016), at III International Scientific Conference "Ecological Biosystems: Problems, Indications and Prediction" (Astrakhan, 2017), as well as at the Council's seminar of Azerbaijan State Pedagogical University.

Organization where the dissertation work is carried out. Most of the dissertation work was carried out at the Department of Biology and technology of its teaching of the Azerbaijan State Pedagogical University, and some of it was conducted in the laboratory “Plants grown in the conditions of covered soils” of the Central Botany garden of ANAS.

Published works. As a result of the research work carried out in 2013-2019, 16 scientific papers on the topic of the dissertation were published.

Structure and volume of the dissertation. Dissertation work consists of the introduction [11497 sign], presentation of results obtained from the literature review [Chapter 1 (25681 sign), Chapter 2 (17714 sign)], description of research materials and methods [Chapter 3 (3345 sign)] and their interpretation [Chapter 4 (27935 sign), Chapter 5 (13802 sign), Chapter 6 (25715 sign), Chapter 7 (67342 sign)], main conclusions (2374 sign), references 157 (21491 sign), appendices (1090 sign), and a list of abbreviations (691 sign). The dissertation consists of 179 pages (254934 sign), including 12 tables and 90 figures (including 43 in appendices).

CONTENT OF WORK

Literature review. The review part of the dissertation consists of 2 chapters.

Chapter 1. A systematic analysis of *Cactaceae* Juss. family, its general morphological features, history and study. This Chapter of the dissertation provides an overview of the chronological sequence of scientific research on taxonomy, general morphobiological characteristics, and the history of studies of *Cactaceae* introduction.

Chapter 2. Summary of important environmental factors of the natural conditions and the area of introductionof intact plants. This Chapter provides an overview of the environmental conditions of the species of *Cactaceae* family that were introduced to covered soils of Absheron, based on literature sources, as well as the climatic conditions of covered soils (greenhouse and hothouse) where the introductions are grown and the introductory regionin Absheron.

Chapter 3. Object and methods of research. The research was conducted in 2013-2018 at the Azerbaijan State Pedagogical University and the laboratory of vegetable plants at the Central

Botanical Academy of ANAS. The object of the study was 49 species and 4 variations of the family *Cactaceae*.

Specification of botanical names of the studied species it was carried out according to *Anderson E.F.*[13]*, Britton N.L., Rose J.N.*[14] and *ICSK*[15].

Phenological observations were made using the previous "*General methodology adopted by the Council of Botanical gardens of the USSR*"[16] and the methodology proposed by *S. Smirnov*[17]. When studying the phenological and morphological features of cactus species in the conditions of covered soils, 5-6 plants of each species were identified. At the same time, we studied the average growth statistics of annual plant sprouts and the beginning, length, width, vegetation period, flowering phases, flowering and fruiting of newly formed organs. Ontogenesis of cacti is given according to *A.A. Uranova*[18].

Annual growth of sprouts is studied by *M.N. Gaydazhi*'s[19] biorhythmic method of development of the vegetative field of plants.

According to literary sources, "*climatic and ecological featuresof natural habitats*"[20,21,22] were studied.

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[13] Anderson, E.F. The *Cactus* Family, - Pentland, Oregon: Timber Press, - 2001. - p. 262.

[14]Britton, N.L. The Cactaceae / N.L. Britton, J.N. Rose - // Washington: - 1919, Vol. 1, - 236 p.; - 1920, vol. 2, - 239 p.; - 1922, vol. 3, - 255 p.; - 1923, vol. 4, - 318 p.

[15] https://cactuslife.com/Articles/classification_ICSG.php

[16] Phenological Observation Methods in Botanical Gardens of the USSR. // Bulletin of the Central Botanical Garden of the Academy of Sciences of the USSR, - 1979, vol. 113, - pp. 3–8.

[17] Smirnova, E.S. Methodology for observing plants in interiors. // Bull. GBS AN USSR, - 1980. issue. 117, - p. 36–40.

[18] Uranov, A.A. Ontogenesis and age-specific structure of flowering plant population. / A.A. Uranov, – M.: Nauka, - 1975, - 139 p.

[19] Gaydarzhi, M.M., Biological Rhythms of Vegetative Sphere Development in Cactaceae Family Plants. / M.M. Gaydarzhi. – K.: Botanichnyi sad im. akad. O.V. Fomina Kyiv. un-tu (O.V. Fomin Botanical Garden of the Kyiv University), - 1995. – p. 42.

Life-formswere studied according to *I.Q. Serebryakov*'s[23] biomorphological classification.

Morphological features of seeds were described according tomethodology and terminology by *Ivanov, Dudik[24], A. Fedorov and others[25]*. During the morphological description of the seeds, reference was made to the terminology of *F. Buxbaum[26]*.

Comparative biomorphological characteristics of the species studied using"*decorative evaluation scale*"[27] in "*covered soils andnatural growing conditions*"[28,29,30,31,32] were carried out.

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[20] Agroclimatical world atlas. / I.A. Golzberg. - L.: Gidrometeoizdat,- 1972.-115 p.

[21] Vitvitsky, T.N. Climates of North America / T.N. Vitvitsky. - M.: State. Izv. Of geographical literature, - 1953. - 288 p.

[22] Climate Directory of South America / Ed. A.N. Lebedev. - L.: Gidrometeoizdat, - 1975. - 369 p.

[23]Serebryakov, I.G. Ecological plant morphology: Life forms of angiosperms and conifers / I.G. Serebryakov. - M.: Higher school, - 1962, - 378 p.

[24] Ivanova, I.A. To the methodology for the description of carpathological signs of seeds / I.A. Ivanova, N.M. Dudik. // Compilation of plant identifiers for fruits and seeds. - Kiev: Science. Dumka, - 1974, - p. 43-54.

[25]Fedorov, A.A. Atlas of Higher Plants Descriptive Morphology. / A.A. Fedorov, M.E. Kirpichnikov, Z.T. Artyushenko. // - L.: Nauka, - 1979. – 296 p.

[26] Buxbaum, F. Grundlagen und Methoden Einer Erneuerung der Systematik der Hoheren Pflanzen. Die Forderung dynamischer Systematik im Bereiche der Blutenpflanzen. // - 1953. The Quarterly Review of Biol. 28: 3: - p. 294-294.

[27] Glihov A.Z. Decorative and biological parameters of Rebutia K. Schum. species, family Cactaceae Juss. / A.Z. Glihov, N.A. Bagrikova, E.S. Chichkanova. // Bulletin of TvSU, series "Biology and Ecology", - 2017, №2, - p. 188-199.

[28] Gornitskaya, I.P. Theoretical Background of Tropical and Subtropical Plants Introduction, / I.P. Gornitskaya, L.P. Tkachuk. - Donetsk: Donechchina, - 2008, - 348 p.

[29] Fedorov, A.A. Atlas of Higher Plants Descriptive Morphology. / A.A. Fedorov, M.E. Kirpichnikov, Z.T. Artyushenko. // - L.: Nauka, - 1979. – 296 p.

[30] Britton, N.L. The Cactaceae / N.L. Britton, J.N. Rose - // Washington: - 1919, Vol. 1, - 236 p.; - 1920, vol. 2, - 239 p.; - 1922, vol. 3, - 255 p.; - 1923, vol. 4, - 318 p.

[31] Buxbaum, F. Grundlagen und Methoden Einer Erneuerung der Systematik der Hoheren Pflanzen. Die Forderung dynamischer Systematik im Bereiche der Blutenpflanzen. // - 1953. The Quarterly Review of Biol. 28: 3: - p. 294-294.

Latin names of pathogenic fungi and names of authors at the time of writing taxa are given in accordance with CABI "*Index Fungorum*"[33].

Mathematical statistical processing of research results was carried out on the basis of the *G.F. Lakin*'s [34] methodology.

Experimental part. This part of the dissertation consists of 5 chapters.

Chapter IV. Morphobiological characteristics of species *Cactaceae* Juss. family introduced into covered soils. This Chapter gives a brief morphological characteristic of species of *Cactaceae*family introduced into the covered soils in Absheron.

Chapter V Ontogenesis of *Cactaceae* family plants in the conditions of covered soils. Some *Cactaceae* species studied in this Chapter provide an overview of the characteristics of early stages of ontogenesis, morphogenesis of new organs, and growth and development dynamics.

Studies have shown that species belonging to different subfamilies of the *Cactaceae* family (*Peireskioideae, Opuntioideae, Cereoideae*) (*P. aculeata, Op. maxima, Op. engelmannii, Op. humifusa, C. forbesii, M. crucigera, M. violaceus, P. mammulosa* var. "*Orthacanthus*", *P. erinacea, A. capricorne, Ech. mirabilis*) have a number of features of individual development. Representatives of the *Peireskioideae* subfamily are similar to other plantations of the dwarf class. Thus, they are also characterized by thin hypocotia (*Peireskia aculeata*: length 27.00±0.56 mm, thickness 1.90±0.03 mm), large lobed leaves (length 2.42±0.11 mm, width 1.12±0.10 mm) and have the first true leaf with stems.

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[32] Nyffeler, R.A farewell to dated ideas and concepts – molecular phylogenetics and a revised suprageneric classifica-tion of the family *Cactaceae* / R. Nyffeler, U.A. Eggli // Schumannia. – 2010. Vol. 6, - P. 109–149.

[33] http://www.speciesfungorum.org/Names/Names.asp

[34] Lakin, G.F. Biometry / G.F. Lakin. - M .: Higher. School, - 1980. - 293 p.

It was found that the life span of *Peireskia aculeata* seeds grown in the conditions of covered soils in Absheron is 60-62 days. The first germination takes place in 10-12 days after sowing.

Seedlings of species belonging to *Opuntioideae* subfamily have more succulent lobed leaves (length 1.52±0.13 mm, width 0.75±0.14 mm) and a concentrated hippocotal compared to *Peireskia aculeata* (for example, *Opuntia maxima* - length 15.13±0, and width 0.75±0.14 mm). The life span of *Op. maximum* leaf is 169 days. The first sprouts appear 36 days after sowing.

The seeds of other types *Op. engelmannii* and *Op. humifusa* of *Opuntioideae* germinate 9-10 days after sowing. 8-9 days after germination, the buds are formed. In other types of this subfamily, the appearance of hypocoty occurs simultaneously with sprouts (Fig. 1; 2). On the first day, the seed size ranges from 0.9 mm to 1.3 cm.

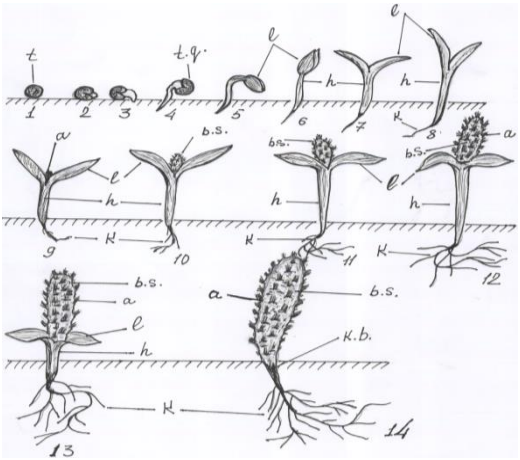

Figure 1. Graphic description of seed germination and formation of juvenile plants of *Op. engelmannii*:
1- seed, 2- edema, 3-4- hypocotyl formation, 5-8- lobed leaf development, 9- formation of the firstareola, 10-13- formation and formation of the first segment, 14- juvenile plants.
t- seeds, h- hypocotyl, t.q.- bark seeds, l- lobed leaves, a - areola, b.s.- the first segment, k.b.- the root of the stem, k- the root.

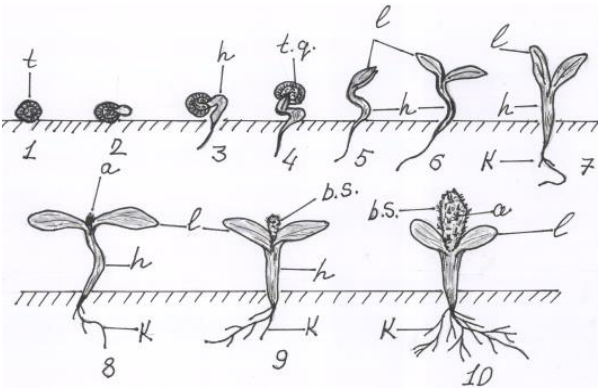

Figure 2. Graphic description of the germination of *Op. humifusa* and the formation of juvenile plants:
1- seed, 2- the swelling of the seeds, 3-4- the formation of hypocotyls, 5-7- development of lobed leaves, 8- formation of the first areol, 9- formation and emergence of the first segment, 10- juvenile plants.
t- seeds, h- hypocotyl, t.q.- bark seeds, l- leaf, a- areol, b.s.- the first segment, k- the root.

Hypocotyl in *Op. engelmannii* and *Op. humifusa* species has cylindrical form. Thus, the upper part of the hypocotyl is compacted, and the lower part is thinner. The color of the hypocotyl is white with a light greenish tinge, yellowish-red above and red below. The main stem develops from the upper part of the hypocotyl. The main stem sprouts 7-8 days after emergence.

The studied species of the genus *Opuntia* usually have 2 lobed leaves, but sometimes there may be 3 or 4 (for example, *Op. humifusa*).

Two or three days after the first stem emerges, the lobed leaf begins to grow and does not exceed 1-2 mm in width and 4-5 mm in length. In both species (*Op. engelmannia*, *Op. humifus*), the lobed leaves have a convex shape with a solid edge, on which there is a waxy layer. The front side of the paw leaf is olive, the opposite side is orange-pink.

After about 10 days, a barely visible furrow is formed at the site of the ends of the leaves. From the depth of the furrow, a top bud develops, which subsequently becomes a segment. In the top bud there is a petty areol consisting of a bristly hair and a fetus leaf. The second segment will appear next spring. Drying leaves lasts a long time. For example, in the genus *Op. humifusa*, lobed leaf dryness occurs within 4-5 months. During this time, the process of growth and development of plants, the appearance of new segments, the growth of roots occurs intensively. Thus, the emergence of new segments, as well as the growth of previously formed roots, continues. At the same time, the growth of new segments, as well as the diversification of previously formed rootscontinues.

In the plants of *Cereoideae* subfamily, the size of the seedlings is smaller than in other subfamilies, and their hypocotyls are very concentrated (for example, the hypocotyl in *Cereus forbesii*, length 2.83±0.03 mm, thickness 3.03±0.02 mm). In them, the shape of the lobed leaf is bubble or in the form of icelike cone (Fig. 3). Even in the germination of *Mamillaria*, *Melocactus*, *Parodia*, and *Astrophytum* species, it is almost impossible to distinguish the lobed leaf from the hypocotyl.

Studies of seedlings of the genus *Parodia* have shown that their sproutshas a long elliptical shape. Rarely it was observed in balloon-shaped forms with well-developed thick hypocotyls and short lobed leaves. The lobed leaves of the studied species are very short, and the protrusions with areol at the top are clearly visible.

In the plantsof *Cereoideae* subfamily, life expectancy of the lobed leaf (depending on species) ranges from 23 to 165 days.

Studies have revealed a relationship between the lobed leaf and hypocotyl. For example, if a lobed leaf is thicken and plays a key role as a spare organ, then the hypocotyl in the seed is thinned, and vice versa, when there is a thicken hypocotyl in germination, then an undeveloped lobed leaf is observed.

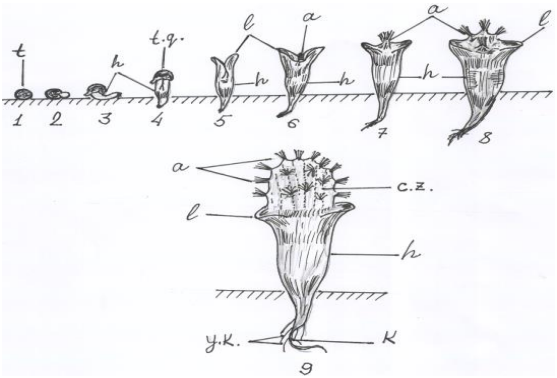

Figure 3. Graphic description of the germination of *Cereus forbesii* and the formation of juvenile plants:
1- seed, 2- seed swelling, 3-4- hypocotyl formation, 5- lobed leaf development, 6-7- emergence of the first areol, 8- formation of areol, 9- formation of juvenile plants.
t- seed, h- hypocotyl, t. q.- seed bark, l- lobed leaves, a- areol, c.z.- formation of a young shoot, k- root, y.k- lateral roots.

Representatives of the *Cactaceae* family have different periods of ontogenesis. In the genus *Parodia*, the trunk develops rapidly, and after 9-10 months the plant goes from the juvenile phase to the immature one, and from the third to the fourth year of development enters the generative cycle. Their great life cycle lasts from 13 to 19 years.

The large life cycle of *Echinopsis mirabilis* species was studied during the study period. Thus, the full cycle of this species lasts 4-6 years, depending on environmental factors and cultivation conditions. This allowed us to learn about the large life cycle of this species.

In the conditions of covered soils, the main stages of ontogenetic development of *Ech. mirabilis* are the following:

Latent period. The fruit is dry, length 4.03±0.02 cm, width 0.62±0.03 cm. When the fruit ripens, it cracks and at this time remains of the flower on its stem.There are 3±1 fruits per plant and

145±2 seeds per a fruit. Seeds are oval, grey, spotted, opaque, superficial, with a surface of 1.43±0.03 mm, a width of 1.54±0.02 mm and without a dormant period.

The Virginal period. For this, the type of surface germination is characteristic. The hypocotyl is green. The lobed leaves are weakly developed in the form of bubbles. The emergence of the first thorns coincides with the beginning of the juvenile age. Juvenile plant retains its lobed leaf. The lobed leaf life span is 23±3 days.

For an immature plant, dry lobed leaves are characteristic. During this period, there is an intensive growth of vegetative mass. The epidermis of the bodyvirginal plantis brown-green. The color of the spikes varies from light brown to dark brown. Virginal period lasts for two years.

The Generative period. The height of the trunk of generative plant is 6.4±0.41 cm, and the diameter is 1.6±0.03 cm. The flowers are fragrant, white and open at night. Flowers are 7.43±0.30 cm in length. Blooms in June and July. Bears fruit. Seeds are formed by self-pollination. Fruits ripen in August and September. The generative period lasts three to four years.

Thus, the species of *Ech. mirabilis* can be used as a model object for studying the features of the large life cycle of *Cactaceae* family plants.

Dynamics of growth and development of cacti. One of the key indicators of successful introduction of plants is their ability to bloom and bear fruit in new conditions. Species of the *Cactaceae* family studied in the conditions of covered soils in Absheron reach the generative stage of development. This is a key indicator of the successful use of the studied species in the conditions of covered soils in Absheron.

In the annual cycle, *Cactaceae* plants grow vegetative organs (February-March), active growth (April-June), germination (February-August), flowering (February-October), short-term summer dormant (July-August), slow autumn growth (August-October), mandatory winter dormant (November-January) was observed. All the species of *Cactaceae* family studied in the

conditions of covered soils in Absheron have reached the generative stage of development.

Representatives of the family are polycarp plants. In the plants of *Astrophytum, Echinocereus, Echinopsis, Gymnocalycium, Mamillaria, Opuntia, Parodia, Rebutia*species and others in the Absheron greenhouse and hothouse are observed flowring every year. For a general assessment of the seasonal rhythm of plant growth and development, the duration of flowering of different species and species during the year was determined: autumn-winter flowering (October-December); winter flowering (January-February); winter-spring flowering (January-March); spring flowering (March-April); spring-summer flowering (May-August); summer-autumn flowering (August-October).

In plants of the genus *Mamillaria, Rebutia, Parodia, Turbinicarpus,* the seeds are formed by self-pollination. In the species of *Astrophytum, Cleistocactus, Echinocereus, Echinopsis,* etc. artificial pollination should be carried out for seed formation in species.

Cactus fruits are berry, fleshy, semi-aromatic and dry. White, yellow, pink and red fleshy fruits are typical for plants of the genus *Echinocereus, Mamillaria, Melocactus, Opuntia* and *Schlumbergera*. For some species of *Gymnocalycium, Echinopsis,* the fruits are half fleshy. Plants of the genus *Parodia, Notocactus, Turbinicarpus* are arid.

During the research of the seed productivity of some species of *Mamillaria, Melocactus, Parodia, Rebutia,* and others was studied.

Studies have shown that *Op. maxima* produces the largest number of fruits (38-40 fruits) on a single plant and the smallest number of fruits (2 or 3 fruits) on a single *St. vaupelianus* plant. The largest number of seeds (1,600 seeds) is contained in a single fruit of the species *P. erinacea,* and the smallest number of seeds (2, sometimes 3) is contained in a single fruit of *Peireskia aculeata*.

During the study period, the influence of temperature and light on the phenological phases of development of the studied species of

the genus *Parodia* and the annual growth of sprouts (diameter and height) was studied.

Of the studied *Parodia* species, early vegetation was observed in *P. mammulosa* and *P. erinacea.* At the next stage, the generative phase of development began in may in *P. mammulosa* and *P. erinacea.* In the studied species of this genus, the species *P. magnifica* is at the first place due to the length of the flowering period. At the same time, the *P. erinacea* species blooms for a long time, with a flowering period of 5 days.

Dominant ones of sprouts of the studied species of the genus *Parodia* have been identified and found out in accordance with the indicators annual growth rate.As a result of the studies it was determined that, in the species *P. erinacea, P. mammulosa* var. "*Orthacanthus*", *P. concinna* var. *tabularis,* the sprouts mainly increased heights, in those of *P. mammulosa, P. magnifica* and *P. Erinacea* increased their diameter.

The study of biomorphological features of the studied species of the genus *Parodia,* in particular, the measurement of the annual growth of sprouts, the study of their phenorhythm allows you to choose the most promising types of work on phytodesign of interiors in the future.

Chapter VI. Comparative biomorphology of some species of *Cactaceae* Juss. family under natural and covered conditions. This Chapter presents the results of a comparative analysis of the biomorphological characteristics and phenology of the studied species under conditions of natural growth and cultivation of the studied species.

The study of plant evolutionary forms, their formation and transformation, patterns of ontogenesis and morphogenesis at different levels of plant development, biomorphological analysis of the organism and morphological structure is of great scientific and practical importance. In this regard, the comparative biomorphological study of morphological features in cultivated conditions with morphological signs of natural growth of the studied species and the results of phenological observations allowed them to

evaluate the decorative properties of these plants. According to the results, these species, which have a full cycle of development, are very promising for growing in the condition of covered soils in Absheron (greenhouse, hothouse, indoor interiors).

Chapter VII. Bioecological bases of cultivation of the investigated species in the condition of covered soils. This Chapter of the dissertation presents the preparation of substrates for growing cacti, methods of reproduction (seeds, vegetative), pests, diseases and measures to combat them, as well as the results obtained during this time.

The main task of growing cacti in the environment of the Central Botanical garden is to choose the optimal mode that takes into account all stages of growth and development. Thus, certain microclimate conditions (temperature, lighting, relative humidity, optimal substrate composition) were established for growing cactus species in greenhouses and hothouses.

Substrate for growing cacti. The choice of substrate is an important factor when growing cascade species. For mass cultivation of cacti, the following substrates were used: grassy soil, foliage, irritated sand or fine gravel, peat, burnt manure, charcoal, and brick scrap. According to the results, cacti grow better on substrates that absorb all the softness, water and air.

Reproduction of cacti. Reproduction of cactus is carried out in two main ways: by seeds and vegetative.

Reproduction by seeds. The seeds for the experiment were obtained from plants grown in the collection of the MNS, and from different countries of the world.

Seeds of a cactus differ from each other in size, shape and structure. *Peireskia aculeata* seeds are the largest, and *Parodia erinacea* seeds are the smallest. *Peireskioideae* seeds among these subfamilies - black, rough, smooth bark; *Opuntioideae* seeds are light brown, compressed and very strong bark (hence, sometimes the surface of the bark is mechanically cracked to sprout seeds); *Cereoideae* seeds are black, dark or light brown, gray, its bark is rough.

The data obtained from the study of the morphology of the seeds can be used for the identification of cactus species.

During the study, the ability to grow freshly harvested seeds of 21 species (Table 1) and the formation of primary seeds was studied.

Studies have shown that the highest percentage of germination in the studied seeds is *Astrophytum myriostigma* var. *quadricostatum* has 90.80±0.73%, *A myriostigma* 88.00±0.40% and *Peireskia aculeata* with 86.00±2.79%, and the lowest percentage of germination – *R. minuscula var. senilis* was observed (25.00±0.51%) and in *Rebutia neocumingii* (29.01±0.45%).

In most of the studied plant species, this occurs four days after the first planting. The seed germination period is 10-13 days. Mass seed germination is observed approximately 8-19 days after sowing, depending on the species.

The effect of different temperatures on the germination ability of freshly harvested seeds of six species was investigated during the study period: *A. myriostigma, M. crucigera, M. violaceus, P. magnifica, R. neocumingii, St. vaupelianus.*

The evidence obtained shows that the optimal temperature for germination of seeds of *Cactaceae* family is +26-30^{0}C. Seed germination lasts 4-5 days at temperatures below +26^{0}C, and the number of seedlings decreases by 2-2.5 times. Sprout growth slows down to temperatures below +18^{0}C. Also, germination of seeds decreases by 2-3 times at temperatures above +30^{0}C.

Depending on the storage period and seed germination conditions. In the experiment, the dependence of seed germination of nine plant species on time and storage conditions was studied. Experiments have shown that the less seeds are stored after harvest, the higher the rate of germination. Thus, the results show a link between survival and seed germination of some cactus species.

Vegetative reproduction. Segments and lateral shoots were used for vegetative reproduction of cacti. Representatives of the Cactus family differ in the rooting process depending on the growing conditions, that is, the temperature of the soil and air, the composition of the soil and humidity. To clarify the temperature of the soil and air,

Table 1. Indicators of seed germination of some species *Cactaceae* family in the condition of covered soils

№	Name of the species	Time for sowing	Germination	Mass germination
1	2	3	4	5
1.	*Astrophytum capricorne*	18.VIII	22.VIII	26.VIII
2.	*A. myriostigma var. quadricostatum*	18.VIII	28.VIII	01.IX
3.	*Cleitocactus smaragdiflorus*	19.VIII	27.VIII	01.IX
4.	*Echinopsis mirabilis*	19.VIII	25.VIII	27.VIII
5.	*Ech. oxygona*	19.VIII	27.VIII	02.IX
6.	*Gymnocalycium gibbosum*	18.VIII	27.VIII	31.VIII
7.	*Mammillaria crucigera*	24.VIII	31.VIII	06.IX
8.	*Melocactus violaceus*	18.VIII	26.VIII	30.VIII
9.	*Notocactus magnificus*	17.VIII	26.VIII	31.VIII
10.	*Opuntia engelmannii*	18.VIII	05.IX	07.IX
11.	*Op. humifusa*	18.VIII	03.IX	07.IX
12.	*Op. stricta*	17.VIII	03.IX	05.IX
13.	*Op. phaeacantha*	18.VIII	06.IX	08.IX
14.	*Parodia erinacea*	17.VIII	26.VIII	30.VIII
15.	*P. magnifica*	17.VIII	25.VIII	31.VIII
16.	*Rebutia minuscula var. senilis*	24.VIII	07.IX	11.IX
17.	*R. neocumingii*	24.VIII	31.VIII	05.IX
18.	*Stenocactus phyllacanthus*	19.VIII	25.VIII	28.VIII
19.	*St. vaupelianus*	19.VIII	25.VIII	28.VIII
20.	*St. crispatus*	19.VIII	25.VIII	27.VIII
21.	*Turbinicarpus gautii*	19.VIII	25.VIII	29.VIII

their influence on the formation of roots in seedlings, 9 species of cacti were seedlinged in all three conditions. At temperatures of +10-12^{0}C and +12-13^{0}C, cactus species had root formationin 30

days, root formation of seedlings was 50% and the root formation, at the air temperature +15-18^{0}C and soil temperature +18-20^{0}C was 60% in 31 days, with air temperature +19-22^{0}C and soil temperature +21-23^{0}C 70% for 17 days, at air temperature +22-28^{0}C and soil temperature +22-29^{0}C for 14 days 100% of root formation was recorded.

Pests, diseases and measures to control them. Pests and diseases of cactus varieties grown in the condition of covered soils were studied and measures were developed to combat them. Successful pest and disease control is important for timely detection of harmful organisms, accurate determination of species composition, degree of damage, development of corrective measures and correct identification of the causes of diseases. The best way to protect cacti from various diseases and pests is proper cultivation and care. The main pests of these plants are powdery cucumbers, seaweed, spider webs, spider mites, sperm, pelvis, root mites, nematodes. Pathogens are wet and dry rot, photosis, alternariosis, helminthosporiosis, rhizoctoniosis, rust, fusarium, anthracnose, phytophthora, bacteria, and viral mosaic. Entomological and phytopathological studies of the studied plants were conducted monthly, and twice a month in spring and autumn.

Optimal mode of agrotechnical care for cacti. The main factors that ensure normal growth and flowering of cacti in the condition of covered soils are the degree of illumination, temperature, irrigation, and substrate content. Soil often plays a crucial role in growing plants, meaning it not only nourishes the plant, but also regulates the temperature, humidity, and air of the entire underground part of the plant.

Using the *Cactaceae* species in interior landscaping. This section discusses the prospect of using the *Cactaceae* family for landscaping interiors, as well as agrotechnics for the development and cultivation of micro landscapes. At the same time, the role and use of the family in the educational and enlightenment activities of students and students is noted.

The use of a cactus collection in educational and enlightenment activities. The collection, made up of representatives of the *Cactaceae* family, can be actively used in educational and enlightenment work. Thus, it can be part of practical education of some parts of botany (systematics, geography, morphology, conservation of plant biodiversity), as well as the practical application of their use in the greening of Interior and phytodesign works during the educational excursions of students and school students in greenhouses and hothouses.

CONCLUSION

1. For the first time, morphogenesis, bioecological and comparative biomorphological research of the early stages of ontogenesis, agrotechnical research was conducted, and a collection of 49 species and 4 variations of *Cactaceae* Juss. family was created in the conditions of covered soils in Absheron, agrotechnical research, and internal gardening.

2. In the conditionsof covered soils in Absheron, all 53 species of studied *Cactaceae* family reach the generative stage of development. Of these, 48 species (90.57%) bloom and bear fruit, and 5 species (9.43%), (*Astrophytum capricorne A. myriostigma*, *A. myriostigma* var. *quadricostatum*, *Cleistocactus smaragdiflorus*, *Schlumbergera truncate*) only blossom.

3. As a result of phenological observations of cacti in the conditions of covered soils in Absheron, the duration of various phenophases were determined: the beginning of growth - February-March, active growth - April-June, short-term summerdormant - July-August, slow autumn growth - August-October, mandatory winter dormant occurs in November-January.

4. It was found that in contrast to other representatives of the *Cactaceae* family, *Echinopsis mirabilis* is characterized by a shorter life span - 4-6 years.

5. As a result of the conducted research, it was found that most fruits (38-40 fruit) are formed in one plant of the species *Opuntia*

maxima, and fewest fruits (2 or 3 fruit) are formed in one plant of the species *Stenocactus vaupelianus*. There are most seeds (1600 seeds) in one plant of the *Parodia erinacea*, fewest seeds (2 sometimes 3 seeds) in one plant of the *Peireskia aculeata* species.

6. The results show that the optimal temperature for sprouting *Cactaceae* family seeds is +26-30^{0}C. Seed germination lasts 4-5 days at a temperature below +26^{0}C, and the number of seedlings decreases by 2-2.5 times. The growth of sprouts slows down to a temperature below +18°C. also, seed germination is reduced by 2-3 times at a temperature above +30^{0}C.

7. Studies have shown that the highest percentage of germination in the studied seeds is *Astrophytum myriostigma* var. *quadricostatum* has 90.80±0.73%, *A. myriostigma* 88.00±0.40% and *Peireskia aculeata* 86.8±2.79%, and the lowest percentage of germination is in *R. minuscula.* In *Senils* (25.00±0.51%) and in *Rebutia neocumingii* (29,01±0,45%) was observed.

8. The dependence between the degree of development of the lobed leaf and the hypocotyl of the sprout has been found: In germination with advanced hippocotus, the lobed leaf usually develops poorly (*Cereus forbesii),* in germination with thin hippocotus the lobed leaf is developed and succulant (*Peireskia aculeata*).

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