

TRADITIONS AND
CONTEMPORANEITY IN THE
TAXONOMY AND SYSTEMATICS OF
THE FLORA OF THE CAUCASUS

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ТРАДИЦИИ И СОВРЕМЕННОСТЬ В
ТАКСОНОМИИ И СИСТЕМАТИКЕ
ФЛОРЫ КАВКАЗА

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<p>UOT UDC: 58.</p> <p>ORKID İD ORCID ID: 0000-0002-9958-766X</p> <p>Daxil oldu Received:02.06.2022</p> <p>Qəbul olundu Accepted:13.06.2022</p> <p>Redaktə etdi Edited by Prof. Dr. Maryam Seyidbeyli</p>	<p>Key words: plant systematics, taxonomy, flora, history, innovation methods, e-flora, Caucasus, Azerbaijan</p> <p>Summary</p> <p>The article deals with the problem of new and integrative approaches in evolutionary biology and systematics, as well as in biodiversity research. Of fundamental importance is the analysis of trends in taxonomy, the evolution of organisms, their forms and functions, historical and philosophical prerequisites, as well as inventory and management of biodiversity. The results of the development of ways and modern research in the field of phytodiversity in the Caucasus, including Azerbaijan, are discussed, the prospects for their development in the fundamental and applied direction using innovative approaches, ways to solve the problem of conservation of populations, species, communities and ecosystems are considered. Molecular-genetic methods of studying biological diversity, as well as the need to create an electronic flora, are also considered separately. It is emphasized that an important aspect of modern research is the identification of ecosystem activities aimed at ensuring the health of the environment, which is inextricably linked with the quality of the habitat and serves as the main indicator of sustainable development. An integrated approach ultimately makes it possible to identify vulnerable species, structure and their populations; by molecular identification to clarify the taxonomic status of the disputed species.</p> <p>Ключевые слова: систематика растений, таксономия, флора, история, инновационные методы, э-флора, Кавказ, Азербайджан</p> <p>Резюме</p> <p>В статье рассматривается проблема новых и интегративных подходов в эволюционной биологии и систематике, а также в исследованиях биоразнообразия. Фундаментальное значение имеет анализ тенденций в систематике, эволюции организмов, их форм и функций, исторических и философских предпосылок, а также инвентаризации и управления биоразнообразием. Обсуждаются результаты разработки путей и современных исследований в области фиторазнообразия на Кавказе, в том числе в Азербайджане, рассматриваются перспективы их развития в фундаментальном и прикладном направлении с использованием инновационных подходов, пути решения проблемы сохранения популяций, видов, сообществ и экосистем. Молекулярно-генетические методы изучения биологического разнообразия, а также необходимость создания электронной флоры также рассматриваются отдельно. Подчеркивается, что важным аспектом современных исследований является выявление экосистемной деятельности, направленной на обеспечение здоровья окружающей среды, которая неразрывно связана с качеством среды обитания и служит основным показателем устойчивого развития. Комплексный подход в конечном итоге позволяет идентифицировать уязвимые виды, структуру и их популяции; путем молекулярной идентификации уточнить таксономический статус спорных видов.</p>
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	<p>Açar sözlər: bitki sistematikas, taksonomiyası, flora, tarix, innovasiya üsulları, e-flora, Qafqaz, Azərbaycan</p> <p>Xülasə</p> <p>Məqalə təkamül biologiyası və sistematikasında, həmçinin biomüxtəlifliyin tədqiqatında yeni və integrativ yanaşmalar probleminə həsr olunmuşdur. Taksonomiyadakı tendensiyaların, orqanizmlərin təkamülünün, onların forma və funksiyalarının, tarixi və fəlsəfi ilkin şərtlərin, habelə biomüxtəlifliyin inventarlaşdırılması və idarə edilməsinin təhlili prinsiplik əhəmiyyət kəsb edir. Qafqazda, o cümlədən Azərbaycanda fitomüxtəliflik sahəsində yolların və müasir tədqiqatların işlənilib hazırlanmasının nəticələri müzakirə olunur, onların innovativ yanaşmalardan istifadə etməklə fundamental və tətbiqi istiqamətdə inkişaf perspektivləri, populyasiyaların qorunması probleminin həlli yolları, növlər, icmalar və ekosistemlər nəzərə alınır. Bioloji müxtəlifliyin öyrənilməsinin molekulyar-genetik üsulları, həmçinin elektron floranın yaradılması zərurəti də ayrıca nəzərdən keçirilir. Xüsusi vurğulanır ki, yaşayış mühitinin keyfiyyəti ilə ayrılmaz şəkildə bağlı olan və davamlı inkişafın əsas göstəricisi kimi çıxış edən ətraf mühitin sağlamlığının təmin edilməsinə yönəlmiş ekosistem fəaliyyətinin müəyyən edilməsi müasir tədqiqatların mühüm istiqamətidir. İntegrasiya edilmiş yanaşmanın həssas növləri, strukturu və onların populyasiyalarını müəyyən etməyə imkan verən amillər bunlardır; mübahisəli növlərin taksonomik statusunu aydınlaşdırmaq üçün molekulyar identifikasiya yolu.</p>
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Introduction

For almost 30 years, there have been active discussions about taxonomic obstacles and the challenges this poses for solving the current biodiversity crisis caused by human activity (Engel et al., 2021). There is a constant large discrepancy between the reality of a particular biodiversity and our knowledge about it (Raposo M.A. et al., 2020). To clarify the problems of new and integrative approaches in evolutionary biology and systematics, as well as in biodiversity research of fundamental importance are the consideration of trends in taxonomy, the evolution of organisms in time and space, their forms and functions, historical and philosophical views, as well as inventory and management of biodiversity (Plant diversity between the Black and Caspian Seas, 2014) .

This includes assessing and managing the diversity of organisms on our planet, highlighting the history that led to this diversity, and understanding the mechanisms that shape the evolution of organisms (Plant Diversity in the Central Great Caucasus: A Quantitative Assessment., 2017). Biosystematics is the basis for all these topics, which require an accurate understanding of species as structural units of biodiversity. Currently, the need for sustainable conservation and management of biological diversity at the global level is widely recognized in society, but urgent measures must be taken to stop the loss of biodiversity (Convention on Biological Diversity. What is taxonomy? , 2016).

History of plant systematics and evolution of the Caucasus

An early synthesis of the historical situation shows that Russian Empire's expansion to the south with the cession of the North Caucasus to it after a long series of Russian-Persian and Russian-Turkish wars, ended with the annexation of the Ottoman province of Kars in 1878 (Plant diversity between the Black and Caspian Seas, 2014). The situation with the availability of research in the Caucasus improved during the 19th century. Hardly in any other region of the world over the past 200 years there have been so many flora as in the Caucasus. The first of them was “Flora of the Taurica-Caucasus”, published in 1808 by Friedrich August Baron

Marshal von Biberstein. Many botanists and plant collectors, including Christian von Steven, Karl Anton Meyer and Franz Ruprecht had close ties with the Imperial Russian Academy of Sciences in St. Petersburg and had the opportunity to travel around the region. Two other names deserve special mention. The versatile naturalist and geographer of plants Gustav Radde was the first botanist permanently residing in the Caucasus. In 1863, he founded the Natural History Museum in Tbilisi, serving as its director until 1903. Edmond Boissier, an independent scientist living in Geneva, has never visited the countries between the Black and Caspian Seas, but nevertheless published a monumental five-volume book "Oriental Flora" on the material of the herbarium, in which he examined the flora of the Caucasus with a special emphasis on botanical connections in southern directions.

Interrupted by the events of the First World War and the October Revolution, the study of the flora of the Caucasus resumed in the late 1920s. Although Leningrad (St. Petersburg) remained the main place of research, at the beginning of the Soviet era there were botanical institutes in Baku, Yerevan and Tbilisi, which became important research centers with their own herbariums. In Baku, Alexander Alfonsovich Grossheim (1888-1948) publishes Flora of the Caucasus (1939-1967), a continuation of the Criticism of the Flora of the Caucasus, begun in Dorpat (Tartu) by N.I. Kuznetsov. Grossheim also took responsibility for "Flora of Talysh" (1926) and "Flora of Azerbaijan", which were continued by I. Karyagin and his colleagues since 1950. Multi-volume national floras were also published in other centers: "Flora of Georgia" has been published since 1971 in the second edition edited by N.Ketskhoveli, G. Nakhutsrishvili and R.Gagnidze. The first botanical study to use the plant community approach was the Seyfriz study (1931) in the

Kazbegi area at the beginning of the twentieth century. The driving force behind the "Flora of Armenia" project, started in 1953 and completed in 2011, was A.L. Takhtajan. The authors of all the regional flora of the Caucasus relied on the "Flora of the USSR" (1934-1964), initiated by V. L. Komarov (1869-1945), which is one of the most important botanical publications of the last century. The English edition of this work made the botanical treasures of the former Soviet Empire accessible to anyone who does not speak Russian. Komarov considered morphological features to be extremely important, although now it is time to include morphological features (Shulkina T.V., 1993) in parallel with molecular data in studies aimed at building natural systems of different plant groups.

Systematics is an underappreciated biological discipline, which is mainly due to several misconceptions about taxonomy that are widespread in the scientific community. Among them are opinions that taxonomists study only morphology and provide only identification of samples that are used in other biological studies, such as molecular phylogeny, ecology or conservation biology. Meanwhile, taxonomy, like any other science, is based on clear concepts, as well as on the formulation and verification of hypotheses. This requires an integrated approach in which scientists benefit by working on the synthesis of the results of data obtained from morphology, bioacoustics, ecology, geography, molecular biology, chemistry, history and other diverse fields of research. In this sense, it is perhaps the most integrative of all biological disciplines (de Carvalho et al., 2007).

So, what is a "traditional taxonomy"? The Convention on Biological Diversity, 2016, states that "Taxonomy is the science of naming, describing and classifying organisms, including all plants, animals and microorganisms of the world." It is obvious

that progress in biological science is impossible without taxonomic efficiency (Kotov, 2016). Different names can be applied to one or more taxa depending on their classification, which, in turn, is the fruit of a scientific point of view and is formed as new knowledge accumulates. At the same time, the application of the same names to different taxa can be observed if the same taxon names are used without the idea of which organisms belong to the taxon. In addition, distinctions between taxa may be associated with the use of different concepts, or valuable information may be accompanied by anachronisms. Taxonomic treatment forms the traditional part of the problem by listing synonyms and sometimes by mentioning incorrect names. In some cases, a certain overview of the historical and modern treatment of the taxon is given.

Almost two million species of animals, plants and microorganisms have been named by taxonomists over the past 250 years. However, in the last 10-15 years there has been a deep crisis of taxonomy affecting traditional taxonomic science. There are serious disagreements on this issue (Lis, 2011), besides, manuscripts on traditional taxonomy are not popular with journals with a high impact factor. As it is known, traditional taxonomy has a powerful taxonomic tool based on deep and long-term studies of the taxonomic group by specialists by combining morphological and molecular phylogenetic studies (Adpagsop & Kuntner, 2007; Walter & Winterton, 2007). Unfortunately, we see that traditional taxonomy (even with the use of molecular methods) is rejected a priori by many publishers on the grounds that it is a descriptive science. This cannot be considered correct, because the accumulation of routine knowledge is a necessary step for further progress in any direction. At the same time, it is obvious to the traditional taxonomist that a strong phylogenetic evidence can only be found during a detailed analysis based on a

deep knowledge of morphology, and a good phylogenetic study requires a long-term study in order to best identify the object.

The correct understanding of the biodiversity of the Caucasus was hindered by the obvious discrepancy between the systematic groups (the so-called Anglo-Saxon version and the Oriental school "Oriental") and scientific communities describing and studying local biodiversity. For a long time, it was difficult for Western taxonomists to study local Caucasian species in detail due to limited contacts with local experts and inadequate access to local taxonomic resources. A paradoxical situation has been developing in the Caucasus for 70 years, when the majority of taxonomic treatments published in the local literature in the local language made it difficult to determine the appropriate type of speciation and endemism and therefore was most often ignored or perceived as additions to the species synonymy by Western taxonomists. As a result, despite the high level of endemism in the Caucasus, unfortunately, there is still a lack of accurate assessment of the richness of biodiversity for many taxonomic groups. Despite the successes achieved in recent years in the development of new directions of botanical science, there is still a discrepancy between systematic traditions among many taxonomic groups, causing incompatible taxonomic assessments of Caucasian species. It also needs to be underscored that the field of plant taxonomy is a good example where digitization has already created a much improved research environment (Borsh T., Berendson W., Dalcin E. etc., 2020)

Modern approaches to taxonomic problems

In general, it is obvious that the occurrence of interspecific morphological differences is inextricably linked with changes in the processes of development and, consequently, with changes in its adaptive properties. Therefore, first of all, it is necessary

to find out what genetic changes underlie the morphological evolution of plants. Thus, in the direction of evolutionary genetics of development, using data from taxonomy, comparative plant morphology, developmental genetics and molecular phylogenetic analysis of genes responsible for the processes of morphogenesis, genetic mechanisms that may underlie the morphological evolution of plants are being studied (Doebley J. 1998). Changes in the structure of genes controlling taxonomic traits identified in the analysis of molecular phylogeny and their relationship with morphological changes serve as a valuable tool in molecular phylogenetic studies to assess their role in morphological evolution (Thijssen G., Becker A., Di Rosa A., etc. 2000)

It is also important to note that a significant part of the alpha taxonomy is performed by amateurs from developing countries who are insufficiently trained, but nevertheless the traditional taxonomy is potentially strong enough to be adequately represented among other fields of science. Unfortunately, the traditional taxonomists themselves are partly responsible for the situation, as they prefer to publish articles in some national or local journals or collections that are not represented in international reference databases. And when good articles are published in local publications with limited access, taxonomists themselves marginalize their discipline (De Carvalho et al. 2007, 2009). Most often, the community of traditional taxonomists refers to some researchers from Eastern Europe and the former Soviet Union, which was separated from the rest of the world by the "Iron Curtain". Many good taxonomists from the Soviet Union, Poland, Slovakia and other countries found it easier to publish their articles, more often in national languages in national collections, rather than in Western journals. This is also typical for scientists in this field from the Caucasus and Azerbaijan,

and, unfortunately, partially preserved after the collapse of the Soviet bloc. What should be done to improve the situation? First of all, taxonomists should make efforts to publish their manuscripts in journals with a higher rating. There are illustrative examples of such publications for Caucasus (Elmira Maharramova et al., 2017; Rashad A. Salimov, Gerald Parolly & Thomas Borsch. 2021, etc.). Recent articles have been published in the best WOS journals, and taxonomy, as a discipline, receives two to three times more citations in this case. Unfortunately, local, mostly young taxonomists trained abroad, are unfairly criticized by old taxonomists of the Soviet period. But even aggressive criticism from them can be useful because it reflects the position of a wider audience. The traditional taxonomy currently needs to be adapted.

So, there is no doubt about the importance of the traditional taxonomy that is used to define species. At the same time, molecular and other methods are necessary to confirm the traditional findings of species. Thus, traditional taxonomy is the main and very important part of these studies, which, in turn, requires the use of alternative methods of species identification using the latest technologies. In any case, morphology is used as the first tool in taxonomy, the first step to identify unknown species following the principles of taxonomy. There is no doubt that other tools like molecular taxonomy (DNA barcoding) are also important for clarifying the reliability of the species identification process, especially with a complex of taxonomic problems. I.e., integration of morphological and molecular approaches is necessary. Molecular methods are used to confirm taxonomic results, especially to identify hidden species or to separate species that are morphologically similar to each other. Unfortunately, it must be admitted that molecular methods are difficult to access and

expensive for scientists in developing countries.

Databases correspond to large floristic developments. The appearance of databases in taxonomy and floristic, which are descriptive sciences operating with large volumes of data, is one of the main directions of their development, an important step in the translation of the original data array to computer media. However, the modern information system strengthens attempts to unify data from various sources. Admittedly, the risk of conceptual instability increases with the number of different sources of information, and therefore the possibility of flexible decentralized use of the information system, the creation of special tools and interfaces for communication between remote users is being considered.

Since 2010, the management of the Institute of Botany of Azerbaijan National Academy of Sciences (ANAS) has been responsible for maintaining the representation of our science in international reference databases. Thanks to the efforts of the management of the Institute of Botany, the inclusion of Azerbaijani flora species in modern databases, such as Tropicos, Euromed, etc., was initiated. The Institute of Botany is one of the Participating Members of the World Flora Online Project from 2014 (Borsch T., Berendson W., Dalcin E. et al, 2020). However the online project “Flora of Azerbaijan” (through the website www.tropicos.org) started in 2018 within the World Flora Online. The checklist with the accepted scientific names and synonyms of vascular seedless plants, gymnosperms and monocots, and part of work on dicots has been built. Some of which have been published in the form of published books (Rashad A. Salimov, Parvana Kh. Garakhani, S. Aliyeva, 2019, Rashad A. Salimov, Vugar N. Karimov, Parvana Kh. Garakhani, Zenfira S. Aliyeva, 2020, A.S.Zernov, Sh.N. Mirzayeva. 2021, Valida

Alizade, Naiba Mehdiyeva, Vugar Karimov, Aida Ibrahimova, 2019 etc.) evaluated by Western experts as pioneering not only for Azerbaijan, but also for the entire Caucasus. This proves that new forms of taxonomic information can exist and even be very successful. Admittedly, lower citation rates in taxonomy also reflect numerous and diverse taxonomic databases, the creation of which requires a lot of time and effort, although they do not properly provide references to their authors and to taxonomy as a direction of biological research. In order to demonstrate why taxonomy is so important for modern biology and human society, it requires not only the hard work and enthusiasm of taxonomists, but also their active participation.

Analysis of the situation explains a lot: we are hardly and rather slowly getting rid of the stereotypes of the last century, when the traditional classical approach was the only one in almost all countries of the post-Soviet space and became universal for many years. Unfortunately, it is difficult to fit new concepts and approaches into the scale of the old academic science, which are inaccessible to the old generation of scientists. Meanwhile, time inexorably dictates its own: the educational and scientific process should be built according to modern challenges and a high level of knowledge, relying on young advanced personnel. Only this creates an opportunity for integration into the international scientific community, which is important for raising the level of science development in the country.

Flora of the Caucasus in the XXI century

There is a widespread opinion that the Caucasus is one of the most beautiful regions in the world. Not only local patriots love this place, but also visitors admire the beauty of the region. Wonderful mountains with snow-capped peaks, subalpine and alpine meadows with unusual flowers and mountain rivers with

crystal clear water - all this is very impressive. The nature of the Caucasus is extremely rich, and there is a historical explanation for this fact. The fact is that the Caucasus is one of the three regions of the Northern Hemisphere that have survived since the glacial periods of the Pleistocene. These are: 1) the Handuan and Quinling Mountains in south-central China, 2) the southeastern United States, and 3) western Eurasia (Mediterranean), including the Caucasus (Raven, 2013, Borsch, 2014). That is why the flora of the Caucasus is very rich - it is 6,300 species of vascular plants with a large number of endemics - 2,790 species. (Red List of the Endemics of the Caucasus, 2013). This means that more than two and a half thousand species are found only in the Caucasus and nowhere else. The Caucasus is the first and only area on the territory of the former Soviet Union recognized as a "biodiversity hotspot" among 25 other areas around the world.

The nature of the Caucasus has been studied in detail, but in fact each region was considered separately, and not separately from the entire region. The reason for this approach was the political isolation of a significant part of the Caucasus, which used to belong to the empire of the Soviet Union. Currently, the Komarov Botanical Institute has started publishing *Conspectus Florae Caucasi* (2003), which covers three countries of the South Caucasus (Armenia, Azerbaijan, Georgia) and the northern part of the region belonging to Russia. The lack of a general analysis was the reason that the Caucasus was not represented in *Flora Europaea* and in the *Med-Checklist*, which described vascular plants of Mediterranean countries. A few years ago, the geographical position of the Caucasus was the subject of discussion – whether the Caucasus is part of Europe or should be included in Asia. The recent publication of a new geographical map confirmed that the Caucasus is part of Europe (Bohn et al., 2003, 2007). The new edition of *Flora of Europe* (if any) should

include Caucasian plants. Caucasian botanists should become active members of the world botanical community.

This is especially true for Azerbaijan, largely because it is the most plant-rich country in the Caucasus. It's relatively rich flora of at least about 5000 species of vascular plants that represent 64% of the total species known for the Caucasus. The flora of the country is of great interest to any botanists, including ethno botanists and gardeners (Ali-zade V., Shulkina T., 2018). The Caucasian flora is an excellent source of new food and medicinal plants, as well as new ornamental plants. As you know, the Caucasus was one of the major centers of economic development (Vavilov, 1958-1964). Thus, many important food plants were brought from the Caucasus, such as cereal species, rye, peas, Colchian flax, most types of pears, oriental apple, medlar, dogwood, cherry and plum. Some of the ancestral species and their relatives still grow in the wild, and they are of great interest to agricultural practitioners for future hybridization work. Most countries of the world continue to expand floristic research and value botanical catalogs as valuable national resources. Flora is published not only in English, but also in the relevant national languages. Modern "Flora" should be a product of collective labor. Its writing has always been an interconnected and collaborative process, in which various sources of information on the distribution areas of organisms are collected, global general knowledge of experts on geography, taxonomy, morphology and other characteristic features of plants are taken into account. In parallel with the latest advances in computer science and communication technologies, these processes have been optimized and accelerated in recent decades. An important step in this direction was the transition from data collection to structuring them in text form, where data on discoveries, observations and descriptions of plants are

entered into an electronic database after appropriate processing, and thus, using all the possibilities, it becomes possible to improve networks.

Back in the 1980s, the electronics of floral information significantly expanded in the West. Nevertheless, there has been no significant progress in the collection, registration, provision of information flows, their inclusion in the central database and processing for publication in the flora lists. In particular, the constant review of data from distribution maps and plant lists by specialists took a lot of time, since at that time the technologies of dynamic synthesis, analysis and publication of data did not yet exist or were very weak.

The situation changed significantly in the 1990s with the creation and rapid expansion of the World Wide Web. Since that time, it has become possible to create and operate various dynamic electronic databases of plants by end users. At the same time, experts were able to use and update a specific version to view and add data. Thus, the new versions, called the term "electronic Flora", began to provide much broader opportunities than the traditional "Flora" on paper. On the one hand, the world Wide Web offers an ideal platform for presenting general information (for example, maps of the distribution of individual plant groups) in relation to basic information (collections of observations and samples) in accordance with certain criteria. On the other hand, e-Flora users can make comments or suggestions on floral information by e-mail or directly to a special system, which means that a high-quality, constantly updated information base will be available. Thus, electronic maps are not only digitization of their respective printed versions, but also interactive information systems with powerful search and navigation capabilities.

In recent years, the number of "flora" in the worldwide web has increased due to the

availability of a more efficient technical infrastructure. They are also focused on larger phytogeography areas. But, at least as a result of constant climatic changes and intense human impact on nature, the distribution of plants is constantly changing rapidly. Thus, in the future, the development and optimization of floral communication and information platforms for creating constantly updated realistic images of plant diversity will come to the fore.

The classic "Flora" in book format is increasingly losing out to professionally stored electronic databases with limited Internet resources. "E-Flora", unlike printed ones, provides interactive search and navigation functions and is convenient for multitasking information processing. Updates related to floral information can be added to the system by any user in real time. At the same time, it is already clear that the acceleration of the process of scientific research of various contents is accompanied by a shortage of highly qualified specialists. It is obvious that in order to achieve success in this direction in the coming years, it is necessary to educate young researchers as highly qualified botanists, increase their knowledge and skills at the modern level.

It should be noted that in the field of comprehensive study of the higher plants of the Azerbaijani flora, the role of Academician A.A. Grossheim is invaluable, and his achievements are reflected in 3 volumes of "Flora of Azerbaijan" (1934-1936), 7 volumes of "Flora of the Caucasus" (1939-1967), "Flora of Talysh" (1926). The study of the vegetation of Azerbaijan in the 1930s-1960s, along with A.A.Grossheim, I.I.Karyagin, R.Rzazade, Ya.Isaev, H.Gadirov, S.Agazhanov, R.Askerova, was continued by V.Hajiyev, H.Akhundov, L.Prilipko and others. The 8-volume "Flora of Azerbaijan", prepared and published by scientists of the Institute of Botany in 1950-1961 under the guidance and

scientific editorship of the outstanding Russian scientist in the field of plant systematics in Azerbaijan I.I. Karyagin, is a completed fundamental work. This work is still used today and is an invaluable source of information for all botanists.

During the years of independence, Azerbaijani botanists made a number of attempts to prepare a new edition of the flora of Azerbaijan, which was processed and expanded in the national language, but many years of work was unsuccessful due to the lack of scientists' access to world databases and nomenclature changes in the names of a number of taxa. This proves once again that, as systematic and nomenclatural research continues, the repeated collection and revision of data as a result of changes in botanical names and colors never ends. Therefore, it became necessary to provide an easy update of the existing classification and nomenclature of these plants by indexing all botanical names and creating electronic systems.

Since 2014, the Institute of Botany, which is an equal member of the "online Consortium of World Flora", has been carrying out purposeful work on the preparation of the "e-flora" of Azerbaijan. As part of this goal, together with the Missouri Botanical Garden of the USA as the basis for the inventory of the flora of Azerbaijan tropicos.org The development of a mechanism for updating taxonomic resources and online flora of Azerbaijan in the web database has begun.

Biodiversity and ecosystems Investigations in Azerbaijan

For a long time, the taxonomic status of many of the taxa, especially Rosaceae Juss. (Sorbus L., Pyrus L., Rubus L., Rosa L.), Fabaceae Lindl. (Leguminosae Juss.) (Genista L.) and others was not recognized in European taxonomy due to taxonomic differences between species in Europe, the Caucasus and Russia. There are many locally described

species in the Caucasus for many genera of plants that are under global threat of decline (Red List of the Endemics of the Caucasus, 2014). For example, the Caucasian countries are home to many local pear species, Pyrus, some of which belong to endangered endemics that require the development of a special conservation strategy in the wild. Their exact number in the region is unknown due to unresolved taxonomy, although here is the center of the greatest diversity for this very economically important genus.

Since the beginning of the XXI century, the research activities of the botanists of the Caucasus have been aimed at implementing the "Regional Strategy for Plant Conservation for 2012-2020" (<http://www.mobot.org/MOBOT>), including the creation of a comprehensive scheme of the ecosystems of the Caucasus as a basis for the sound conservation of species and their habitats in situ; studying the impact of climate change on species and ecosystems; conducting taxonomic studies of plants; identifying alien plants; assessments of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). It should be noted that for the first time the past, current and future trends in the development of ecosystems and biodiversity of the salt lakes of Europe and Central Asia was made analysis by IPBES experts (Egor Zadereev et al., 2020). This allowed to establish the current state of the species diversity of algae common also in the Caspian Sea, identifying of factors leading to a reduction in species richness and the disappearance of endemic species, as well as assess and predict of the impact on the development of biodiversity and ecosystem services.

The mission of the Caucasian IUCN group, including the Azerbaijani RLA group, whose permanent head was the author of this article, was to contribute to the expansion of modern knowledge about the taxonomy and

ecology of species in the Caucasus and to promote their long-term conservation. During 2010-2020. A significant contribution was made to the implementation of the Caucasus Plants Initiative, including the knowledge of indigenous and local peoples, the expansion of innovations and practices related to plant resources to support the traditional use of sustainable livelihoods, local food security and health. This helped to create the basis for schemes for the sustainable use of wild plant resources, preserving traditional knowledge about the interaction of man and nature. In addition, the data collected during 2017-2020 were published. data for 200 regional assessments in the Red List of Endangered Species in the SIS IUCN database, which will contribute to the conservation of these species, as well as associated habitats, and further plant species will have to be evaluated and reassessed based on field studies of rare plant populations, as well as to identify threatened ecosystems and assess the degree of risk in the Caucasus countries (Red List of the Endemics of the Caucasus, 2014).

The biodiversity studies in Azerbaijan conducted at the Institute of Botany of ANAS deserve special attention in this aspect. Considering that an important criterion for assessing the conservation status is the state and number of populations of rare and endangered species, the project "Populations of rare and endangered species of Azerbaijan flora" was implemented during 2017-2020. New populations of species listed in the 2nd edition of the Red Book of Plants of Azerbaijan (2013) were discovered, as well as rare species new to the country. Monitoring of the structure and dynamics of populations in order to predict the viability of populations of rare plant species and the development of adequate conservation measures made it possible to assess the state of 218 natural populations of 60 rare species of medicinal, essential oil and ornamental plants growing in

various habitats of the Greater and Lesser Caucasus in Azerbaijan. "ex situ" (*Aquilegia colchica*, *Dianthus ketzkhovelli*, *D. azkurensis*, *Pulsatilla georgica*, *Gymnospermium smirnovii*). Based on these studies, the staff of the Institute of Botany of ANAS later published a monograph "Plants of the Greater Caucasus (Azerbaijan)" (Ali-zade V.M., Mehdiyeva N.P. et al. (2019), as well as "Vascular plants of Azerbaijan: nomenclature list of non-flowering (2019) and monocotyledon (2020) plants" (Salimov R.A et al, respectively published in two books).

With the help of computer modeling, the vulnerability of two rare ecosystems of Azerbaijan to the predicted climate change was assessed, as a result of which a forecast of their possible changes was made. Although taxonomic studies of the flora of Azerbaijan continued in subsequent years and new taxa were described, the intensity of botanical research decreased due to the spread of COVID-19 restrictions. Within the framework of the project "Development of tools for the conservation of plant diversity in the South Caucasus" on the basis of a Memorandum signed between the Botanical Garden and the Botanical Museum Berlin-Dahl (BGBM, Germany) and the Institute of Botany of ANAS, modern research continued in 2018-2020 to determine the phylogenetic development of selected model plant genera (*Scutellaria* L., *Pyrus* L. and *Calligonum* L.). The aim of a recent study of the diversity and evolution of *Scutellaria* (Lamiaceae) in Azerbaijan and neighboring countries is to understand the phylogenetic relationships in *Scutellaria* in order to gain insight into the evolution of Caucasian species and to assess species boundaries. (Salimov et al, 2021).

To assess risks and assess the impact on natural ecosystems, experts from the Institute of Botany participated in the preparation of the IPBES report on the regional assessment of biodiversity and ecosystem

services for Europe and Central Asia (2018). Prof. Dr. Valida Ali-zade participated as a Lead Author for chapter 3 ‘Status, trends and future dynamics of biodiversity and ecosystems underpinning nature’s contributions to people’ in the ECA assessment, particularly in the sections regarding the Caucasus and Central Asia regions. Dr. Rashad Salimov participated as a Contributing Author for chapter3 in the ECA assessment and as Young Fellow expert for chapter2 ‘Status and Trends – Drivers of Change, Nature and Nature’s Contributions to People’ in the global assessment. in

At the same time, during 2012-2020, within the framework of the target of the Institute of Botany, Azerbaijan National Academy of Sciences, two projects were carried out in collaboration with the Millennium Seed Bank, Kew (UK): “Saving the Flora of the Caucasus: Azerbaijan wild species collecting” and “Global Tree Seed Bank Project”. The key goal was to maintain

the regional genetic variability of endangered plants by collecting seeds and preserving natural populations. Both projects focused on the collection and storage of seeds of priority species in the country, especially the rarest, endangered and useful species.

This article is written with the hope of creating a basis for future botanical work in the Caucasus. The data collected here also represent Azerbaijan's contribution to regional biodiversity assessments in the context of IPBES (International Platform on Biodiversity and Ecosystem Services).

There is no doubt that more extensive research and comparative work in the field of evolutionary biology and ecology in the future will benefit from these studies by assessing past and present changes in biodiversity in the region, which can help in developing a policy for the conservation of nature of this amazing corner of the Earth.

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