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Vascular plants of Azerbaijan: a supplement for an updated checklist of pteridophytes and gymnosperms

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Abstract: An updated checklist of plant species increases knowledge about flora available for a given area and are fundamental to the public awareness and conservation of plant diversity. These kinds of achievements are closely linked to the implementation of Global Strategy for Plant Conservation Target 1. This paper provides a supplement for an updated nomenclatural checklist of the non-flowering vascular flora of Azerbaijan, one of the main plant diversity center in the Caucasus. Information on taxonomy and nomenclature of non-flowering vascular plants, an updated list of the accepted names and principal synonyms of the taxa of native and xenophyte plants known to occur in Azerbaijan are presented in the checklist. Their distribution and life form, rarity and endemic status are also quantitatively analyzed. It includes 115 species, 27 infraspecific taxa (subspecies and varieties) and 11 natural hybrids of native and naturalized non-flowering vascular plants of Azerbaijan belonging to 22 families and 50 genera. After the publication of the first volume of Flora of Azerbaijan about 50 new taxa were recorded as a result of studies by various researchers. The nomenclatural changes were done among 28 taxa according to recent phylogenetic and systematic investigations of relevant plant groups. An up to date nomenclatural checklist will be a key text to develop e-flora of Azerbaijan and is necessary for future systematics, ecology, physiology, ethnobotany and phytochemistry in Azerbaijan.

Key Words: *Azerbaijan, pteridophytes, gymnosperms, vascular plants, taxonomy*

INTRODUCTION

According to Target 1 of the 2011-2020 Global Strategy for Plant Conservation (GSPC) of the United Nations' Convention on Biological Diversity (CBD), one of the widely accessible Flora of all known plant species is a fundamental requirement for plant conservation. Additionally, a number of global initiatives have been established to promote the implementation of the GSPC and provides a baseline for the achievement and monitoring of other targets of the Strategy beyond 2020 [Miller, Ulate, 2017; Sharrock et al., 2018].

Since 2014 as a participating member of the World Flora Online Consortium, an international collaborative project that meets the goals of the GSPC Target 1, the Institute of Botany of the National Academy of Sciences of Azerbaijan has been purposefully working on the development of electronic flora of Azerbaijan. Within this purpose as a very first basis, a prerequisite of the floristic inventory of Azerbaijan is the need to develop online taxonomic resources and the mechanism for updating the online flora of Azerbaijan.

In the last decade, the checklist of diatomic algae (Bacillariophyta) of the continental reservoirs of Azerbaijan [Mukhtarova, Jafarova, 2020] and diversity and taxonomic structure of Cyanoprokaryota in the Azerbaijan sector of the Caspian Sea [Nuriyeva, 2019a, b] have been updated. These products that we envisage for the near future to publish in the online database. On the other hand, developing an up to date version of the checklists bryophytes and vascular plants for Azerbaijan are an ongoing projects of the Institute of Botany.

Historically, the first comprehensive floristic works to study the vegetation of Azerbaijan were conducted by A.A. Grossheim. He summarized all prior works and published first edition Flora Azerbaijan [1934-1936]. During the 1930s and 1960s, the vegetation of Azerbaijan was further studied by A.A. Grossheim, I.I. Karyagin, R. Rzazade, Y. Isayev, H. Gadirov, S. Aghajanov, R. Askerova and V. Hajiyev, where floristic work had turned to the monographic style, taxonomy had broadened into systematics and experimental taxonomy. A team of these enthusiastic botanists under the editorship of I.I. Karyagin was published the most complete 8 volumes of the Flora Azerbaijan [1950-1961] which remains in use today and is the indispensable reference of all botanists. The next steps over the years, several new botanical studies have been made by Azerbaijani researchers such as R. Askerova, V. Hajiyev, G. Akhundov, L. Prilipko, A. Askerov, etc. and foreign scientists.

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Since botanical names and ranks are changed as a result of systematic and nomenclatural researches, the accumulation and interpretation of data never cease. Therefore there was a need to provide the current classification and nomenclature of these plants readily accessible through the indexing of all names. Within this context *Vascular Plants of Azerbaijan* is intended to be the first complete synonymized checklist of the native, xenophytic and adventive vascular plants, with current classifications and nomenclature. The first volume of the Vascular Plants of Azerbaijan dealt with the complete list of the native and naturalized flora of nonflowering families, including lycopods and other fern-allies, as well as the gymnosperms [Salimov et al., 2019]. It brings together information from specimens deposited at Herbarium of the Institute of Botany (BAK) as well as many relevant publications.

Our goal in this paper is to provide a supplement of the in-depth analysis for an updated nomenclatural checklist of the nonflowering vascular plants that are known to occur in Azerbaijan, one of the main plant diversity center in the Caucasus. This way, any person who deals with Azerbaijan plants will find the abovementioned checklist useful.

MATERIAL AND METHODS

The studies conducted by the authors were based on extensive systematic literature review and herbarium work, including analysis of herbarium specimens deposited at the BAK.

During the preparation of the checklist, the 1st volume Flora of Azerbaijan [Karyagin, 1950] was consulted as an initial step to prepare a list of taxa that provides overall vision of all useful information for compiling the list. In addition to this preparatory, the floras [Tahtadzjan, 1954; Davis, 1965; Ketskhoveli, 1971; Azadi, 2017] and checklists [Czerepanov, 1995; Gagnidze, 2005; Caucasian Flora Conspectus, 2003; Murtazaliev, 2009] of the adjacent countries, as well as many taxonomic and floristic publications [Askerov, Bobrov, 1972a, b; Askerov 1977, 1983, 2001, 2016; Askerov et al., 2015, 2016; Farzaliyev, 2008; Ibrahimov, 2006; Imkhanitskaya, 1990, 2003; Kudrjashova, Popova, 2008; Mammadov, 2011; Prilipko, 1961; Qurbanov, Farzaliyev, 2013, 2017; Safarov, Farzaliyev, 2019; Talybov, 2001; Talybov, 2014] dealing with the Azerbaijan flora and existing information in the virtual herbarium and various online databases such as Euro+Med PlantBase [2019], GBIF, The flowering world [2019], IPNI [2019], The Biodiversity Heritage Library [BHL, 2019], Azerbaijan Plant Data Service [AZBIMM, 2019] have been utilized for the compilation of the detailed literature and brought numerous taxonomic and nomenclatural changes. We kept track of those data sources in order to verify the scientific names of accepted taxa and their synonyms, standard abbreviations of authors via checking the related protologue of each taxon comprehensively.

Abbreviations of the authors' names follow those proposed by R.K. Brummitt & C.E. Powell [1992]. For the entries, titles of periodicals with botanical content have been abbreviated according to the BPH-2 (comprising the second edition of Botanico-Periodicum-Huntianum. Pittsburgh) [Bridson et al., 2004]. Book titles have been abbreviated as in Stafleu & Cowan, TL-2 (Taxonomic Literature Second edition) [Stafleu, Cowan, 1976-1988].

The concept of families and genera adopted in the checklist corresponds to the classification of a liner sequence of extant families and genera of lycophytes and ferns [Christenhusz et al., 2011a], Pteridophyte Phylogeny Group of 2016 (PPG I), and the linear classification of existing gymnosperms [Christenhusz et al., 2011b] with some exceptions. The families here recorded with three parts of the numbers which represented by total genera as well as their total taxa number (including native and xenophyte species, subspecies, varieties and natural hybrids); the cosmopolite and endemic taxa to Azerbaijan [Solomon et al., 2013]; and the threatened species [Solomon et al., 2013; Red Book of Azerbaijan, 2013]. The life-form categories for the terrestrial and aquatic plant species have followed the systems of Raunkiaer [1934] and subsequent extensions by Ellenberg & Mueller-Dombois [1967]. The distribution data are also provided based on records from 20 botanical regions of Azerbaijan.

RESULTS AND DISCUSSION

There are 22 families, 50 genera, 115 species, 27 infraspecific taxa and 11 natural hybrids of native and naturalized non-flowering vascular plants from Azerbaijan in the checklist (Fig. 1). With the current knowledge, there are 37 species, 1 subspecies and 1 hybrids of non-native vascular plants (xenophytes), belonging to 19 genera and 5 families (Table 1).

When analyzing the diversity of families at the genus level the 10 most genus-rich families have at least two genera and together include 38 genera, which account for 76% of the total genus richness. of the non-flowering vascular flora of Azerbaijan (Fig. 2).

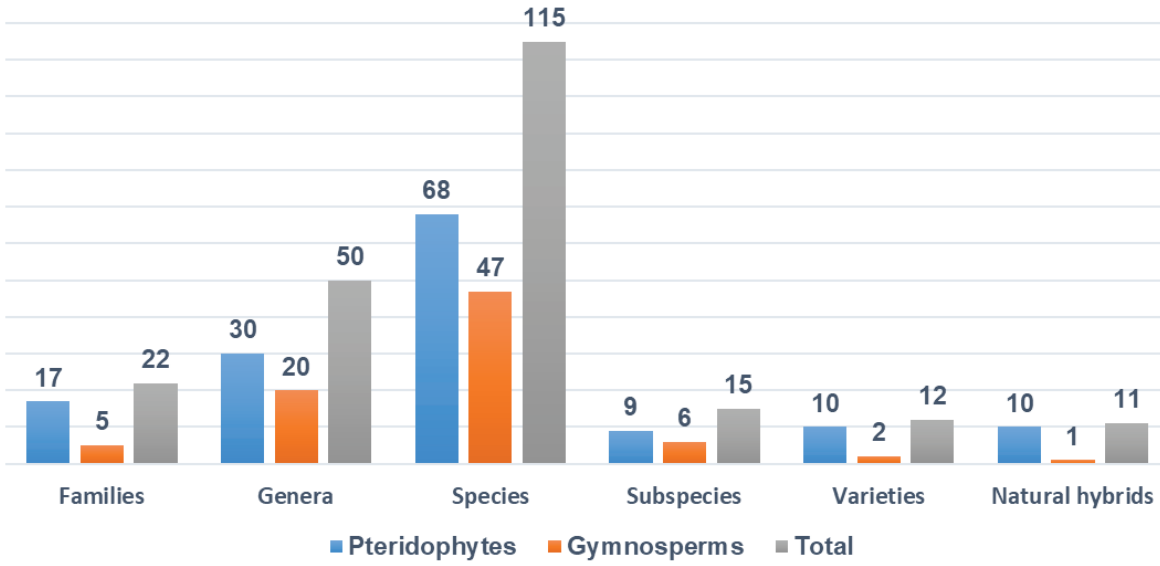

Figure 1. Total taxa number of families, genera, species, subspecies, varieties and natural hybrids.

Table 1. The total genera and infraspecific taxa number within the families.

Families	Genera	Native				Xenophytes			Endemic, non-endemic	Threatened
		Species	Subspecies	Varieties	Natural hybrids	Species	Subspecies	Hybrids		
PTERIDOPHYTES										
Aspleniaceae Newman	1	7	4	1						
Athyriaceae Alston	1	1		2						
Cystopteridaceae Shmakov	2	3	1							
Dennstaedtiaceae Lotsy	1	1	1							
Dryopteridaceae Herter	2	19	2	4	9				5, 29	1
Equisetaceae Michx. ex DC.	1	7			1					1
Lycopodiaceae P.Beauv.	1	1								1
Marsileaceae Mirb.	1	2								
Ophioglossaceae Martinov	3	4								
Onocleaceae Pic.Serm.	1	1								
Osmundaceae Martinov	1	1								
Polypodiaceae J.Presl & C.Presl	1	3	1	3						
Pteridaceae E.D.M.Kirchn.	6	8								1
Salviniaceae Martinov	2	2								
Selaginellaceae Willk.	1	1								
Thelypteridaceae Ching ex Pic.Serm.	3	3								
Woodsiaceae Herter	2	4							1, 3	
GYMNOSPERMS										
Cupressaceae Gray	12	3	3	1		19		1		
Ephedraceae Dumort.	1	5	2			1				
Ginkgoaceae Engl.	1					1				
Pinaceae Spreng. ex F. Rudolphi	4	1		1		15	1		1, 17	
Taxaceae Gray	2	1				1				
Total	50	78	14	12	10	37	1	1	7, 146	4

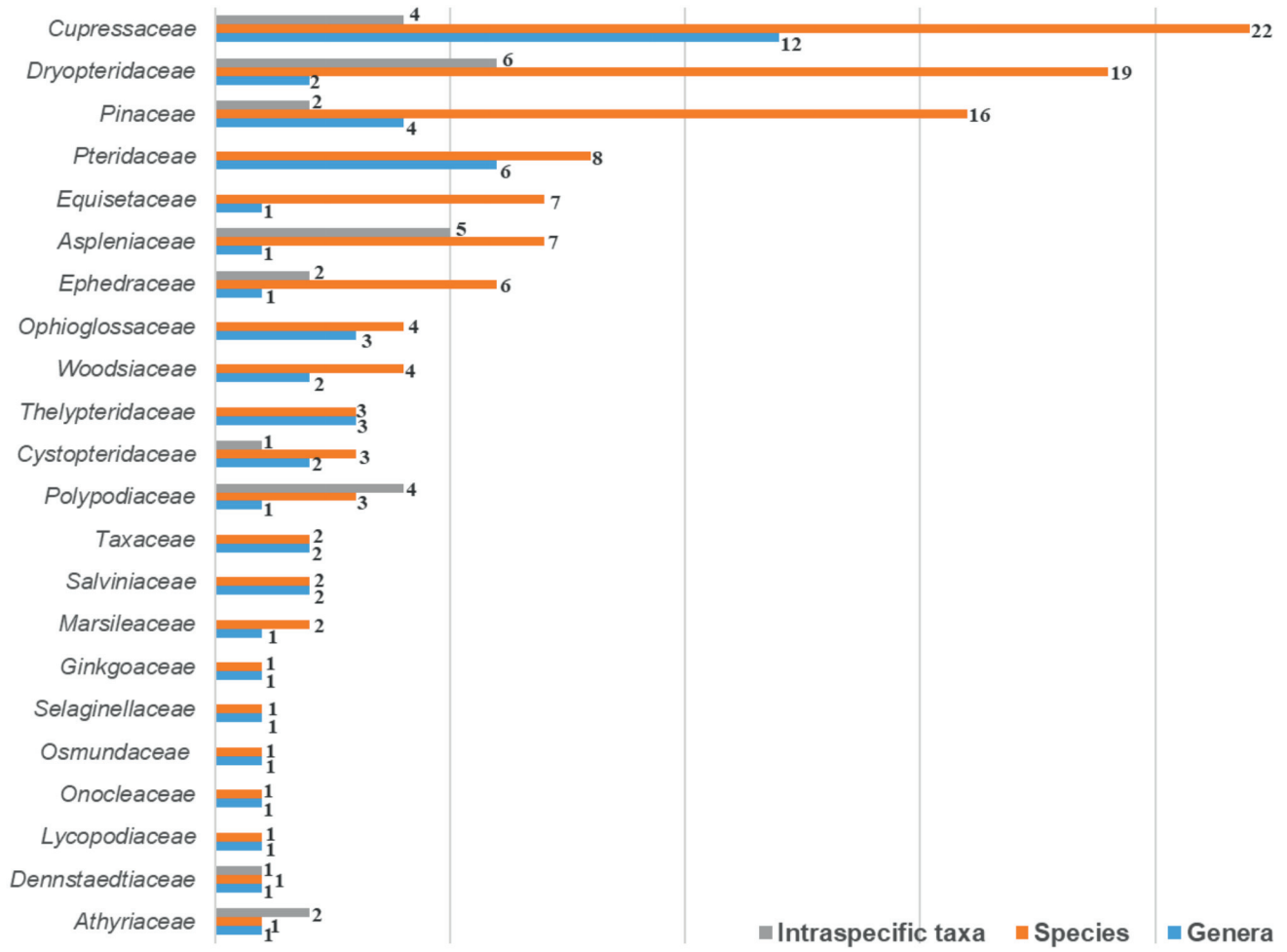

Figure 2. The ranking of species-rich families of non-flowering vascular flora.

The most genus-rich families within gymnosperms are Cupressaceae and Pinaceae, with 12 and 4 genera, respectively, and among pteridophytes are Pteridaceae, Ophioglossaceae and Thelypteridaceae with 6 genera and 3 genera each, respectively. The most 9 species-rich families together include 93 species representing 80.9% of all non-flowering species of Azerbaijan. In another hand, there are 7 families with only one species each, 3 families with two species each, and 3 families with three species each.

In view of climatic and geographic diverse conditions, mainly mountain parts and mesophilic plant association of forests of the Greater and Lesser Caucasus as well as Talysh represents biodiversity centres for non-flowering vascular plants (Table 2, Fig. 3). Among them, the Lankaran lowlands and Western Greater Caucasus stand out in terms of species diversity followed by the Northern Lesser Caucasus, the Quba part of the Greater Caucasus, and the Mountain part of Lankaran. The high species-rich for Absheron is mostly due to large datasets from introduced and cultivated gymnosperms used in landscape design and botanical gardens.

By comparing different regions of Azerbaijan, the most species-poor regions are Samur-Devechi and Caspian lowlands, Bozgir plateau and Lankaran-Mugan with less than 6 species (Table 2).

According to present knowledge, the families in the richest in the endemic taxa in the non-flowering vascular plants of Azerbaijan are Dryopteridaceae, with five species, followed by Woodsiaceae and Pinaceae with one species each. Among these species *Dryopteris raddeana* (Fomin) Fomin, *D. talyschensis* (Askerov & A.E.Bobrov) Askerov & Aktcay, *Polystichum kadyrovii* A.Askerov & A.Bobrov, and *Pinus eldarica* Medw. are national endemics, whereas *Dryopteris oreades* Fomin, *Polystichum woronowii* Fomin, *Woodsia fragilis* (Trevis.) T. Moore are endemics of Caucasus.

Each non-flowering vascular plant species occurring in Azerbaijan were analyzed in regard to plant response to unfavorable conditions and classified into

Table 2. The total taxa number (including families, genera, species, subspecies, varieties and hybrids) of non-flowering vascular plants in each botanical-geographical region of Azerbaijan (from 1 to 20 indicated in the figure 3).

№	Botanical-geographical region	Families	Genera	Species	Subspecies	Varieties	Hybrids
1	Samur-Devechi lowlands	4	4	5	1		
2	Caspian lowlands	4	4	6			2
3	Guba part of the Greater Caucasus	16	21	37	8	2	4
4	Eastern (AZ) Greater Caucasus	11	13	15	5		1
5	Western (AZ) Greater Caucasus	18	31	51	4	4	1
6	Alazan-Ayrichay valley	10	13	15	1		3
7	Bozgir plateau	4	4	5	3		
8	Gobustan	9	10	17	4		1
9	Absheron	8	26	50	3		2
10	Kur plain	8	10	11	2		1
11	Kur-Araz lowland	10	10	16	3		
12	Northern (AZ) Lesser Caucasus	15	26	47	8	2	1
13	Central (AZ) Lesser Caucasus	14	19	31	6		
14	Southern (AZ) Lesser Caucasus	11	14	21	4		
15	Mountain part of Nakhchivan	9	13	18	6		
16	Nakhchivan plain	9	11	16	3		
17	Lankaran Mugan	1	1	1			
18	Mountain part of Lankaran	14	18	37	6	3	6
19	Lankaran lowlands	19	32	55	5	6	8
20	Diabar	9	10	15	4		1

C. Raunkiaer's life-form categories modified by H. Ellenberg & D. Mueller-Dombois. From the evaluation of all these taxa, 152 of species and infraspecific taxa perennate, whereas only 1 species is an annual plant (Fig. 4). The overall spectrum of pteridophytes of Azerbaijan correlates very well with the general climatic conditions of the country. Nearly 60% of all non-flowering vascular plants represent the life-form of hemicryptophyte and geophyte. The predominance of woody plants (phanerophytes (50 taxa) and chamaephytes (5 taxa)) recorded among gymnosperms.

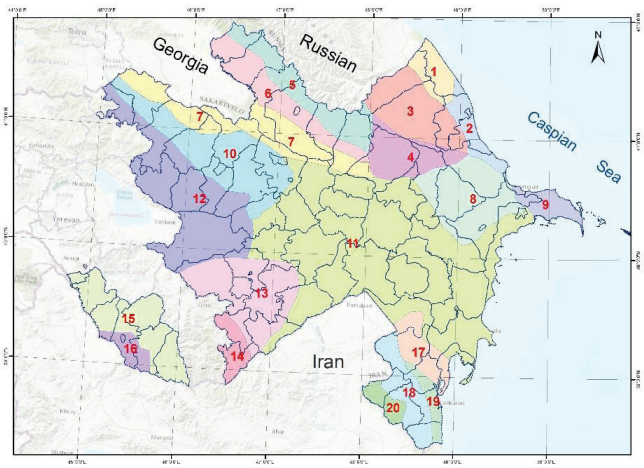

Figure 3. The botanical geographical division of Azerbaijan after Prilipko, 1960 [Salimov et al., 2018]

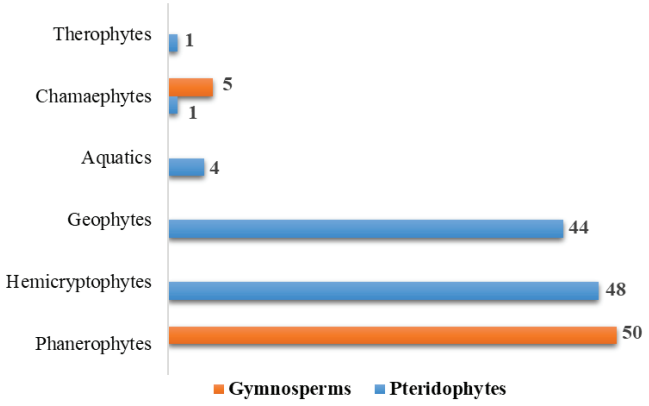

Figure 4. Plant life-form categories represented among the non-flowering vascular plants of Azerbaijan.

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Azərbaycanın vaskulyar (damarlı) bitkiləri: qıjıkimilərin və çılpaqtoxumluların yenilənmiş məlumat siyahısına əlavə

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Bitki növlərinin yenilənmiş məlumat siyahısı, müəyyən regionda mövcud olan flora haqqında bilikləri genişləndirməklə ictimaiyyəti məlumatlandırmaq və bitki müxtəlifliyini qorunmasının fundamental əsasını təşkil edir. Bu cür nailiyyətlər Bitkilərin Qorunmasının Qlobal Strategiyası Hədəf 1-in həyata keçirilməsi ilə sıx bağlıdır. Bu məqalədə Qafqazdakı fitomüxtəlifliyin əsas mərkəzlərindən biri olan Azərbaycanın çiçəksiz vaskulyar (damarlı) bitkilərinin yenilənmiş nomenklatur məlumat siyahısına əlavələr verilmişdir. Məlumat siyahısı, Azərbaycan florasında rast gəlinən çiçəksiz vaskulyar (damarlı) bitkilərin taksonomiyası və nomenklaturası, təbii və ksenofit bitkilərin qəbul edilmiş adların və sinonimlərinin yenilənmiş siyahısına dair informasiyaları ehtiva edir. Bundan əlavə, onların botaniki-coğrafi rayonlar üzrə paylanması və həyat formaları, nadirlik və endemizm statusu təhlil edilmişdir. Məlumat siyahısına Azərbaycanın təbii və ksenofit çiçəksiz vaskulyar (damarlı) bitkilərinin 22 fəsiləyə və 50 cinsə aid olan 115 növ, 27 növdaxili taksa (yarımnöv və variasiya) və 11 təbii hibridləri daxildir. "Azərbaycan Florası"nın I cildi nəşr olunduqdan sonra müxtəlif tədqiqatçılar tərəfindən 50-yə yaxın yeni taksonun (növ, yarımnöv və variasiya) əlavə olunduğu müəyyən edilmişdir. Müvafiq bitki qruplarının son filogenetik və sistematik tədqiqatlarına əsasən, 28 taksonun arasında nomenklatura dəyişiklikləri edilmişdir. Müasir

nomenklatura məlumat siyahısı Azərbaycanın elektron florasının hazırlanması üçün əsas mətnə çevriləcək və gələcək taksonomik, ekoloji, fizioloji, etnobotanik və fitokimyəvi tədqiqatlar üçün zəruridir.
Açar sözlər: *Azərbaycan, qıjıkimilər, çılpaqtoxumlular, vaskulyar (damarlı) bitkilər, taksonomiya*

Сосудистые растения Азербайджана: дополнения к обновленному списку птеридофитов и голосеменных

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Обновленный контрольный список видов растений расширяет знания о флоре определенного региона и имеет фундаментальное значение для информирования общественности и сохранения разнообразия растений. Достижения такого рода тесно связаны с реализацией Глобальной стратегии по сохранению растений (задача 1). В данной статье представлены дополнения к обновленному номенклатурному контрольному списку нецветковых сосудистых растений Азербайджана, одного из основных центров фиторазнообразия на Кавказе. Информация о таксономии и номенклатуре сосудистых нецветковых растений, обновленный список принятых названий и основных синонимов таксонов местных и ксенофитных растений, известных в Азербайджане, представлены в контрольном списке. Кроме того приведет количественный анализ их распределения и жизненных форм, редкость и эндемический статус. Он включает 115 видов, 27 внутривидовых таксонов (подвидов и вариаций) и 11 природных гибридов нативных и натурализованных нецветковых сосудистых растений Азербайджана, принадлежащих к 22 семействам и 50 родам. Было установлено, что после публикации 1 тома “Флора Азербайджана” различными исследователями в него были внесены сведения приблизительно о 50 новых таксонах (видах, подвидах и вариациях). До и после публикации I тома Флоры Азербайджана были обнаружены новые сведения о 50 новых таксонах (видах, подвидах и вариациях) различных исследователей. Согласно недавним филогенетическим и систематическим исследованиям соответствующих групп растений среди 28 таксонов были сделаны номенклатурные изменения. Современный номенклатурный список необходим для развития будущей систематики, экологии, физиологии, этноботаники и фитохимии в Азербайджане и станет ключевым основой для развития электронной флоры Азербайджана.
Ключевые слова: *Азербайджан, птеридофиты, голосеменные, сосудистые растения, таксономия*