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Plant diversity in riverine wetlands of Armenia

Abstract

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The article presents the results of a detailed comparative floristic analysis of the floras of wetlands of the main river basins of Armenia. The taxonomic structure of the floras of individual basins and the ratio of life forms are considered, as well as a detailed chorological analysis is carried out. It is shown that, in general, the flora of the wetlands of Armenian river basins is mainly Holarctic, Circumboreal. The base of it constitute species are widely distributed in the north of Eurasia in the Postglacial period. A very large influence on the development of this flora had Ancient Mediterranean species survived the Ice Age in the more southern regions, in the Ancient Mediterranean. These species by their bio-ecological characteristics belong to hydro- and hygrophilous groups which are growing in wetlands in arid regions of the Earth. As for the features of the floras of separate river basins, they reflect the correct distribution of the territory of Armenia between Caucasian and Armeno-Iranian floristic province (between Circumboreal and Ancient Mediterranean subkingdoms of Holarctic floristic kingdom.

Key words: Flora of Armenia, river basins, floristic analysis, wetlands.

Introduction

Armenia is a Southern Caucasian republic, bordering with Georgia (in the North), Azerbaijan (in the East), Turkey (in the West and South-West), and Iran (in the South). It is a landlocked country with a total area of 29,740 km^2 (2,974,259 ha) with a total of 1479 km of border, at a distance of about 145 km from the Black Sea, 175 km from the Caspian Sea, 750 km from the Mediterranean Sea and 960 km from the Persian Gulf. It lies between 38°50’ and 41°18’ of northern latitude and between 43°27’ and 46°37’ eastern longitude, and measures 400 km along its main axis (north-west to south-east) and 200 km (east-west), with a narrow projection (Zangezur) in the south-east. Armenia is generally a mountainous country, having its lowest point of 375 m above sea level and culminating at 4095 m with an average altitude of 1850 m (76.5% of its territory is 1000-2500 m above sea level) (The The fifth National report to Convention on Biological Diversity 2014; Fayvush & Aleksanyan 2016).

The Republic of Armenia is located in the northeast of the Armenian Highlands on the border of the Caucasus and southwestern Asia. It covers over 10% of the Armenian plateau, which is 500 m higher than the neighboring Asia Minor and Iranian plateaus. Relatively recent volcanic activity on the Armenian plateau has resulted in large volcanic formations, and highlands consisting of a series of both small and large mountain massifs. A number of lakes (including Lakes Sevan, Van and Urmia) have also been formed as a result of tectonic activity in the Armenian plateau (Agroclimaticheskie resursy Armjanskoy SSR 1976; Zohrabyan 1979).

The ancient history of the origination and formation of flora and vegetation of Armenia, the diversity of natural conditions, the impact on them of various biotic and abiotic factors, the different geological history of individual parts of the republic led to a high degree of heterogeneity in its flora. The location of the country in the intersection of three bio-geographical provinces, diversity of climatic conditions and active geological processes have resulted in formation of diverse ecosystems and rich flora with high level of endemism. In the result, on the small territory of the country there are about 3800 species of vascular plants (half of the flora of the whole Caucasus), 142 from which are local narrow endemic species.

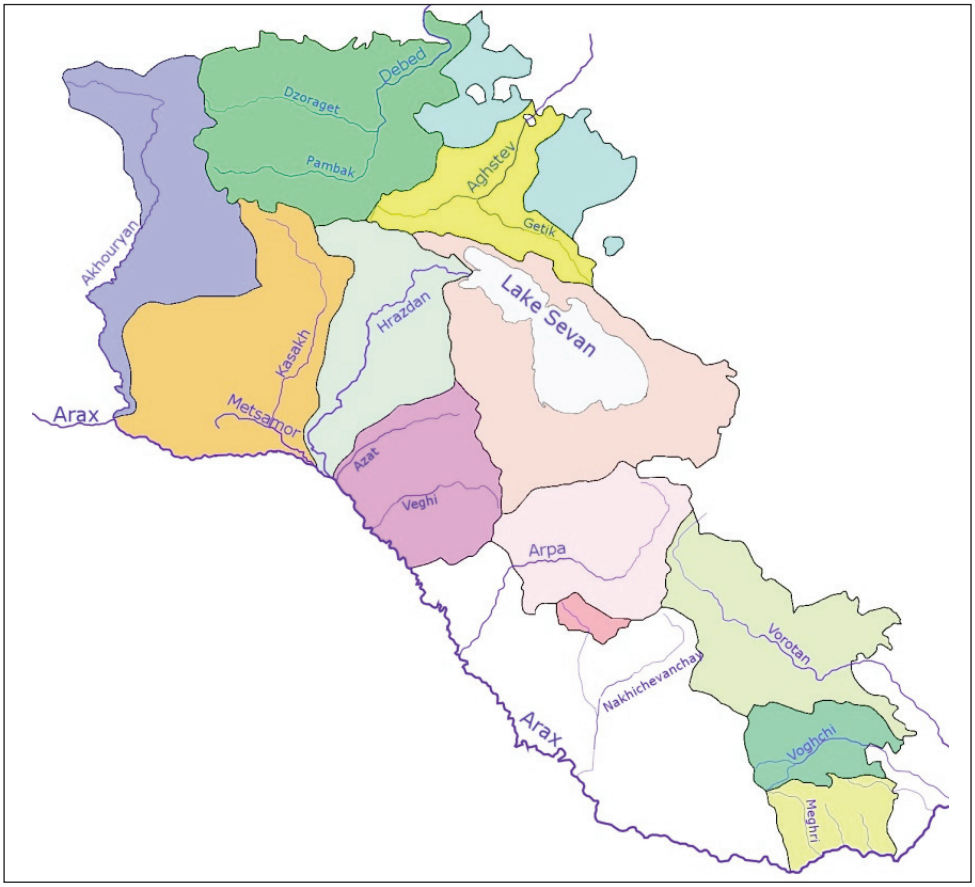
The diversity of landscapes and orography is an important determinant of Armenia's diverse vegetation. All main natural ecosystems of the Caucasus are presented in the country except moist subtropical ecosystems. The lower mountain belt (375–1200 m) is covered by semi-desert (or phryganoid) formations, gypsophilous or halophilous vegetation. There are salt marsh areas as well as the Transcaucasian sand desert. The middle and upper mountain belts (1200–2200 m) are characterized by various kinds of steppe and forest vegetation, meadow-steppes, shrub steppes and thorny cushion (tragacanth) vegetation. The altitudinal span of the forest belt varies from 500 to 1500 (2000) m depending of the region, and may be approaching to 2400 m when open park-like tree stands are included. The subalpine and alpine belts (2200–4000 m) are covered by tall-grass vegetation, meadows and carpets (Magakyan 1941; Takhtadjan 1941; Fayvush 2008). Flora of many types of vegetation has been studied by botanists of Armenia for decades (Manaseryan 1987; Fayvush 1992; Baloyan 1992; Aleksanyan 2012; etc.). A. Barsegyan (1990) conducted the study of the wetlands flora and vegetation of Armenia for many years. However, the water and coastal flora of the rivers of Armenia remained practically without specialists' attention. Considering that in the Lesser Caucasus the water and coastal vegetation served as a refugium for the conservation of many tertiary relic species during the Ice Age, and then served as the main ways and sources of their spread in Eurasia. We decided to pay attention to this flora and analyze it in detail, which can help in solving many questions of the origin and development of the flora of Armenia as a whole, and also to some extent assess the ways and directions of its transformation in connection with climate change and the impact of anthropogenic factor.

Climate and hydrology of Armenia

A wide range of climatic zones have been recorded within Armenia. The territory of Armenia is specific for strongly pronounced vertical alternation of six basic climate types - from dry subtropical up to severe alpine, and temperature contrasts. The average annual temperature ranges from -8°C in high-altitude mountainous regions (2,500 m and higher) to 12-14°C in low-traced valleys. Summer is temperate. In the lowlands the average air temperature in July and August reaches 24-26°C, and in the alpine belt the temperature does not exceed 10°C. The absolute maximum temperature is 43.7°C (recorded in Meghri in 2011). Winter is cold. January is the coldest month of winter with an average temperature of -6.7°C. The absolute minimum temperature, -42°C, was recorded in Paghakn and Ashocq in 1961. Winter is temperate in the northeastern and southeastern regions of the country. The country is located centrally in the sub-tropical zone, and thus is dominated by arid to semi-desert conditions. The altitudinal zonation adds diversity resulting from altitudinal clines. In general the climate is best characterized as dry continental, in some areas with an annual rhythm more or less similar to the Mediterranean one. The average annual precipitation in Armenia is 592 mm. The most arid regions are Ararat valley and Meghri region. The annual precipitation there is 200-250 mm. The highest annual precipitation, 800-1000 mm, is observed in high altitude mountainous regions. In Ararat valley, the average precipitation during summer does not exceed 32-36 mm. The significant part of the territory - over the 60% - receives less than 600 mm, 20 % - less than 400 mm, and on the bottom of the closed basins - only 200-300 mm. The most precipitation falls in the spring. Long-lasting snow cover exists in the mountains above 1300 m, where the annual snowfall could attain 2 m. In the northern part of Armenia humidity comes from the Black Sea in the west, in the southern part from the Caspian Sea in the east, the central part is in the rain shadow of mountain ridges the driest area (Third National communication on climate change under the United Nations Framework Convention on Climate change 2015).

Armenia has extremely limited water resources. The rivers of Armenia are the confluents of the large rivers in Southern Caucasus – the Araks and Kura (Baghdasaryan & Gabrielyan 1962; Gabrielyan 1986).

The river network is rather dense, including 9,500 small and medium rivers, from which 215 rivers are longer than 10 km. The total length of rivers is 25 thousand km. The longest rivers are: Akhuryan (186 km), Araks (158 km), Debed (154 km), Hrazdan (141 km), and Vorotan (119 km) (Resources of USSR's waters, 1973). The density of the river network varies significantly across the country (0-2.5 km/km^2). The irregularity of river flow distribution (both annually and multi-annually) is typical for the rivers of Armenia. The average annual flow of surface waters is about 6.8 billion m^3. These rivers are mainly fed by snowmelt, rain and underground waters. Extensive flooding occurs in spring as a result of runoff from snow melt and heavy rainfall. Overall, the flow in rivers totals 7 km^3, however this may fall to 5 km^3 at some times. Main river basins of Armenia are represented in the map 1.



Map 1. Rivers and river basins of Armenia.

Materials and methods

Results of our own long-term studies of Armenia's flora and vegetation served as material for this study, as well we used literature and herbarium data from the Institute of Botany of the National Academy of Sciences of Armenia (ERE).

We selected 10 major river basins of Armenia (Map 1), flowing in all 11 administrative and 12 floristic regions of Armenia (Tamanyan & Fayvush, 2009) for this study. Both floristic list in general and lists by basins and floristic regions were analyzed.

The classical methods of phyto-geographical analysis proposed in the works of Tolmachev (1974), Kamelin (1973), Schmidt (1984), Yurtsev (1987) were used in our investigation.

The classifications of plant life forms proposed by Raunkiaer (1934; 1937) and Serebryakov (1962; 1964) were used for the bio-morphological analysis.

Numerous literary sources (mainly "floras", "manuals" and maps of areals) were used to conduct the chorological analysis. N. Portenyer's scheme (2000), somehow adapted by us to the conditions of Armenia was used in determining the geographic elements for our analysis.

For comparison of the species lists of the studied basins Stugren-Radulescu coefficients (P_{sr}) of the coexistence were calculated.

$$P_{sr} = \frac{(x+y-z)}{(x+y+z)}$$

where X - is the number of species encountered in the first flora, but absent in the second; Y - is the number of species encountered in the second flora, but absent in the first; Z - is the number of species encountered in both floras.

This coefficient varies in the range from -1 to +1 and in the interval from -1 to 0 indicates coexistence, and from 0 to +1 - on the difference of floras (Schmidt 1984).

Then using the "maximum correlation path" method a dendrite and correlation galaxies were constructed (Schmidt 1984).

The above mentioned methods were widely used in phyto-geographical and floristic studies in the Caucasus and in many other regions of the former Soviet Union. They are the basis of the theory of the "flora" not as a simple list of taxa, but as a system (Tolmachev 1974; Kamelin 1973; Yurtsev 1987; etc.). These methods have been widely used by us and other researchers in the study of the flora of Armenia, and therefore we have dwelled on them in this study, in spite of the fact that at present there are other methods of comparative research.

Results and discussion

Floristic patterns

As a result of our research it was established that the water and coastal flora of the main rivers of Armenia includes 268 species of vascular plants from 62 families and 138 genera. *Poaceae* family is the most abundant in the investigated flora, 44 species of which reflects the well-expressed boreal line of our flora. The second place in the spectrum of the largest families of the studied flora occupies also the predominantly boreal family *Cyperaceae* - 18 species. Taking into consideration the ecology of most species of this family, usually confined to wetland habitats, it is quite natural. Third place in the spectrum occupies *Fabaceae* family (17 species) underlining the Mediterranean component of the flora of river basins in Armenia. The same number of species contains the family *Salicaceae* (12 species belong to the genus *Salix*). Armenia in general is characterized by the richness of the diversity of this genus - 14 species, while their majority is confined to the riverine woody ecosystems. The following families in the spectrum are *Rosaceae* (13 species), reflecting the Caucasian line of the flora, and *Potamogetonaceae* (11 species), in which exclusively aquatic plant species are represented. The originality of the spectrum of the families is expressed in the seventh place of the largest family in Armenia and Holarctic - *Asteraceae* (8 species). In Armenia, the greatest diversity of the species of this family is concentrated in arid ecosystems - steppes, semi-deserts, woodlands.

Table 1 shows the species richness of the flora of separate river basins in Armenia.

Species richness (S_{AP}) per region ranged from a minimum of 126 (Akhuryan river basin) to a maximum of 205 (Azat, Vedi river basin) and averaged 158 species. If we analyze species richness per square kilometer in all floristic regions, the richest flora is in Meghri river basin and the lowest - in Hrazdan.

As can be seen from Table 1, the flora of the basins of the rivers Azat and Vedi is the most abundant. This wealth could be probably explained by the fact that both rivers originate in the alpine belt of the Geghama Range and flow into the Araks River in the lower mountain belt at an altitude of less than 800 m above sea level. Moreover, in addition to the high altitude amplitude, a significant part of the river beds passes along the arid lower belt of the Yerevan floristic region, due to which their flora includes numerous species that are not characteristic of other floristic regions. There are fewer species in the floras of the basins of Hrazdan (including Kasakh and Metsamor) and Debed rivers. These basins also have a fairly large altitude, length and the fact that most of them pass in the richest floristically middle and lower mountain belts. The fact that these two belts are the richest floristically, is clearly seen from Fig. 1, which shows the distribution of all species on altitudinal belts. In Fig. 2 it is also shown that the flora of the Yerevan floristic region is the richest.

At first glance, when considering the bio-morphological spectrum of the flora, the complete predominance of perennial grasses or cryptophytes seems strange (Figs. 3, 4). It would seem that the role of tree and shrub forms should be much higher, as it is manifested in coastal floras of more Southern arid and tropical regions. However, in the flora of Armenia as a whole (as in the whole Holarctic) and in most of the separate types of vegetation, herbaceous perennials fully prevail, which is especially characteristic of highland, arid and semi-humid floras.

When considering the chorological spectrum (Fig. 5) of the flora, the complete predominance in its composition of species with a very wide range (polychoric) and species associated with the Holarctic kingdom (160 species) is immediately evident. One third less species are associated with the area of the Ancient Mediterranean (97 species). Such a distribution of species can be considered quite normal, since Armenia is located at the junction of the Armeno-Iranian and Caucasian provinces of A. Takhtadjyan (1978), and accordingly at the junction of the Boreal and Ancient Mediterranean subkingdoms of the Holarctic Kingdom.

Table 1. Species richness of the flora of separate river basins in Armenia

River basin	Floristic region	Area (km^2)	Number of species
Arpa	Darelegis	2306	154
Vorotan	North and South Zangezur	2476	144
Voghchi	South Zangezur	1341	138
Meghri	Meghri	664	137
Akhouryan	Upper-Akhuryan and Shirak	2784	126
Debed	Idjevan	3895	181
Rivers of Sevan basin	Sevan and Areguni	4750	167
Hrasdan, Kasakh, Metsamor	Aparan and Yerevan	6285	186
Aghstev	Idjevan	2480	144
Azat, Vedi	Yerevan	1950	205

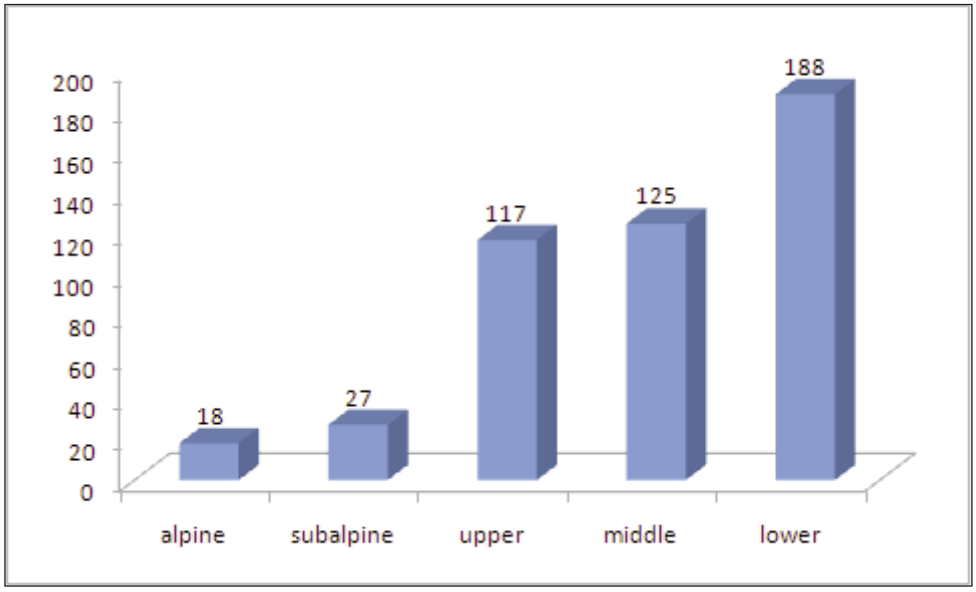


Fig. 1. Number of species in different mountain belts.

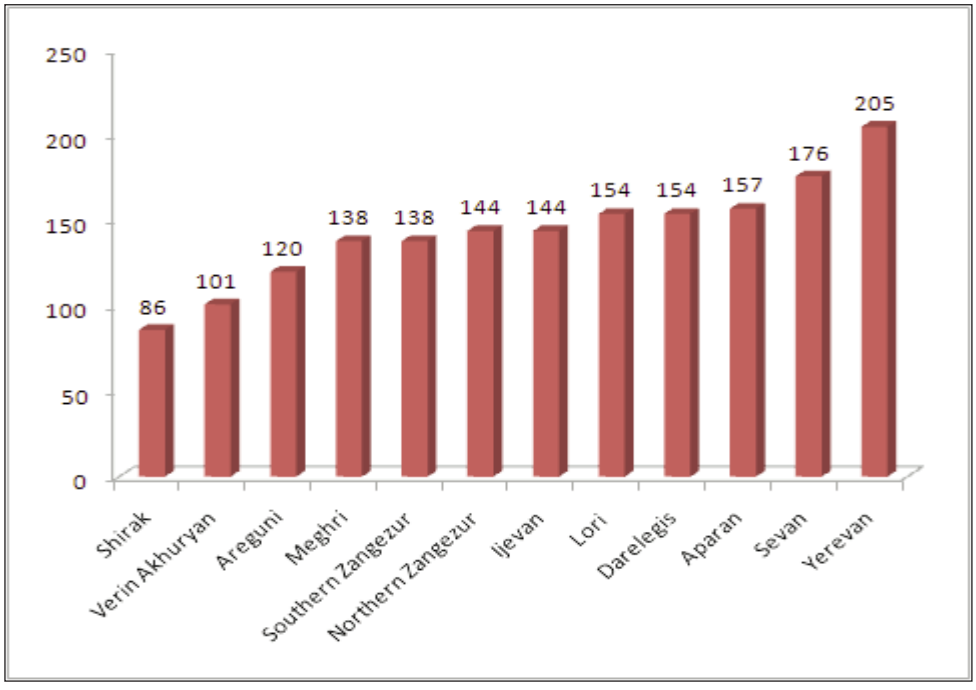


Fig. 2. Number of species in floristic regions.

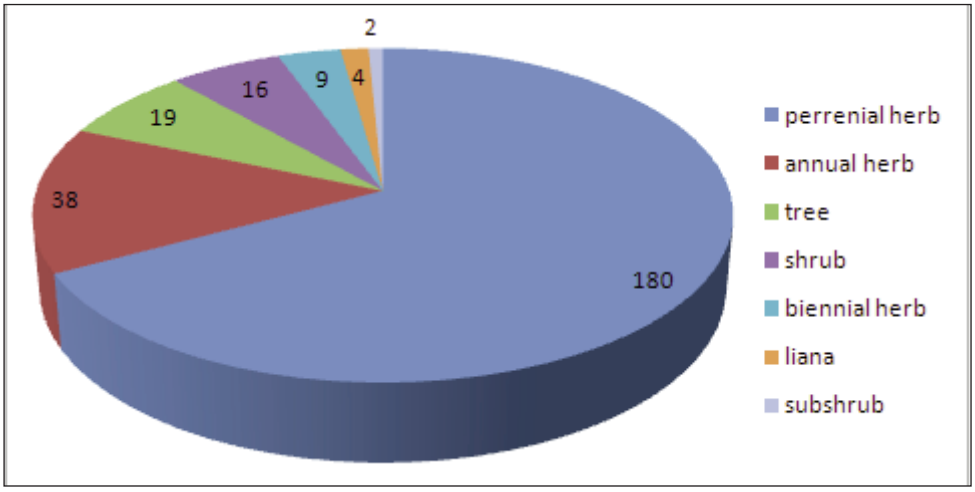


Fig. 3. Bioforms by Serebryakov.

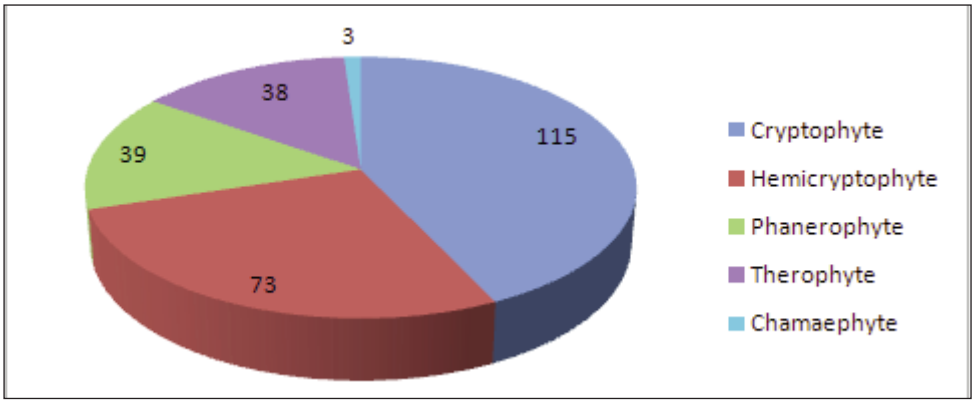


Fig. 4. Bioforms by Raunkier.

Similarity and difference

We tried to identify the similarities and differences between the floras of the separate river basins, since they are mostly located in different floristic regions, belonging to different floristic provinces and sub-kingdoms (Takhtadjan 1978; Tamanyan & Fayvush 2009). It should be pointed out at once that only 45 (17%) species found in all the studied basins, and 29 (11%) species growing in only one basin. 9 species are registered only in Meghri river basin, their area of distribution lies mainly to the south of Armenia (*Erianthus ravennae, Imperata cylindrica*, etc.).

We compared the lists of species of each basin and calculated the Stugren-Radulescu similarity coefficient (Table 2). Based on these data, the dendrite (Fig. 6) and correlation galaxies (Fig. 7) were constructed by the method of the maximum correlation path.

When considering the constructed dendrite, a) the maximum connection between the basins of the Aghstev and Debed rivers is immediately evident, and b) the smallest similarity with other basins of the Meghri, Voghji and Akhuryan rivers. In general, these indicators are fairly well explained by the geographical and phyto-geographical location of these basins. The rivers Agstev and Debed run along parallel canyons and are located almost entirely in one floristic region of Armenia - Idjevan. The Meghri river basin is located in the extreme south of Armenia in the Meghri floristic region, the flora of which is experiencing the strongest impact of the arid flora of the Atropatene subprovince of the Armeno-Iranian province (Takhtadjan 1978). The Voghchi River flows in the South Zangezur floristic region, whose flora, on the one hand, is mesophilous in nature and is under the influence of the Caucasian flora, on the other - there is also a strong influence of the Atropatene subprovince. The Akhuryan River flows in the northwest of Armenia in the Upper-Akhuryan and Shirak floristic regions and is most strongly influenced by the Armenian sub-province of the Armeno-Iranian province.

Attention is also drawn to the relatively high similarity of the floras of the river basins of Central Armenia. At the same time, if the floras of the rivers Hrazdan and Azat are rather close to each other, especially since the rivers Azat and Vedi completely, and Hrazdan for the most part flow through the Yerevan floristic region. Floras of the rivers of the Lake Sevan basin, Arpa, and especially Vorotan, differ markedly less similarity between themselves.

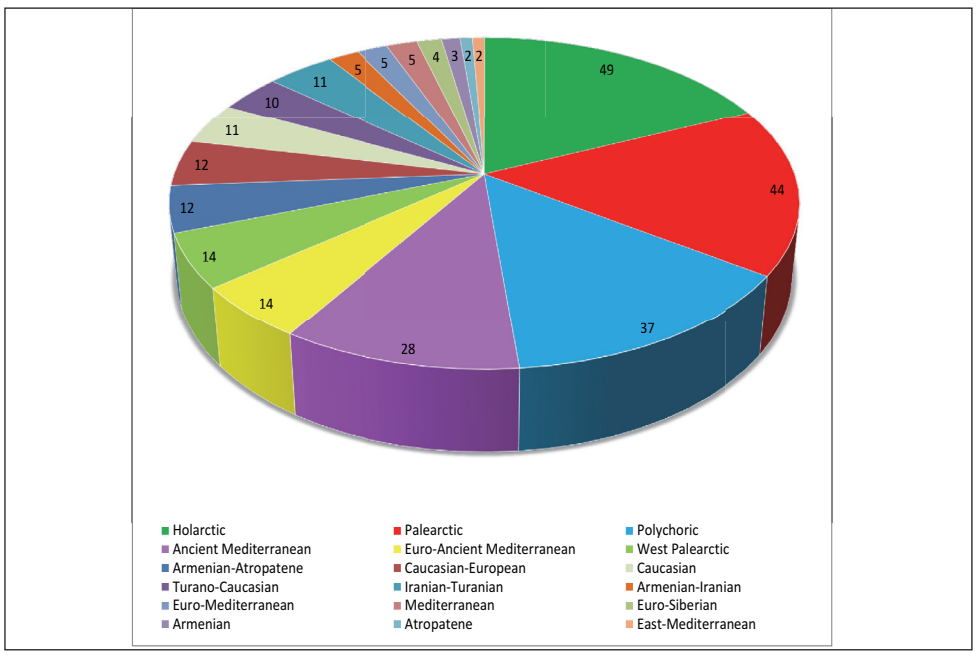


Fig. 5. Chorological range of investigated flora.

Thus, the Galaxies are distinguished, including “Debed-Agstev-Razdan-Sevan-Azat-Arpa” and “Debed-Agstev-Razdan-Sevan-Azat-Arpa-Vorotan”. The floras of other basins are more original and less similar to floras of these basins.

Table 2. The Stugren-Radulescu similarity coefficients (Psr) between the floras of separate river basins.

	Arpa	Vorotan	Voghchi	Meghri	Akhuryan	Debed	Sevan	Hrasdan	Aghstev
Vorotan	-0.22								
Voghchi	-0.11	-0.2							
Meghri	-0.04	0	-0.11						
Akhuryan	-0.11	-0.11	0.36	0.26					
Debed	-0.07	-0.13	-0.07	0.15	-0.07				
Sevan	-0.15	-0.11	0.08	0.24	-0.16	-0.25			
Hrasdan	-0.25	-0.08	-0.03	0.15	-0.06	-0.29	-0.39		
Aghstev	-0.05	-0.16	-0.17	0.07	0.02	-0.62	-0.02	-0.07	
Azat	-0.28	-0.12	-0.08	0	0	-0.22	-0.23	-0.51	-0.04

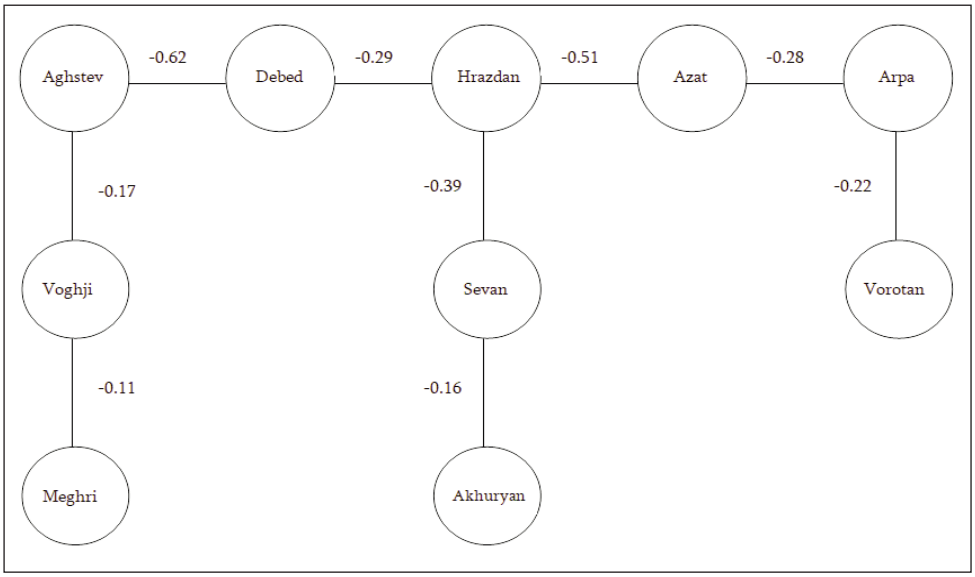


Fig. 6. Dendrite of maximum similarity between the studied river basins.

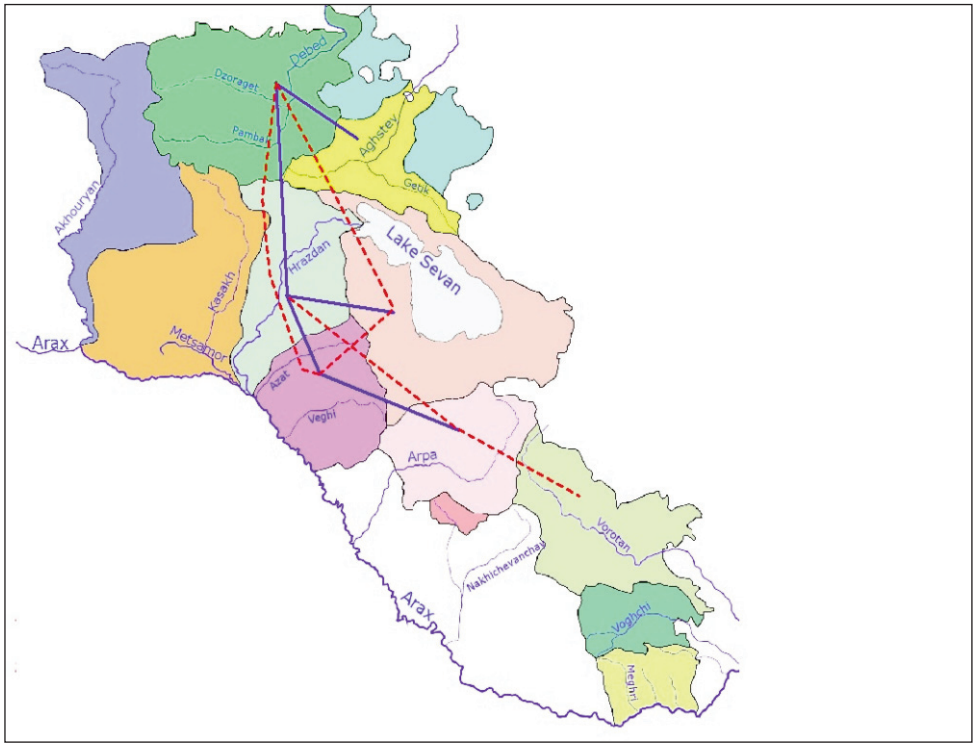


Fig. 7. Correlation galaxies
Solid line - Psr < -0.28
Dash line - Psr < -0.22

Conclusion

Thus, analyzing the floras of Armenia's major river basins it can be concluded that this flora is mainly Holarctic, Circumboreal. The base of it constitute species widely distributed in the north of Eurasia in the Postglacial period. In addition, a very large influence on the development of this flora had Ancient Mediterranean species survived the Ice Age in the more southern regions, in the Ancient Mediterranean. These species by their bio-ecological characteristics belong to hydro- and hygrophilous groups which are growing in wetlands in arid regions of the Earth.

As for the features of the floras of separate river basins, they reflect the correct distribution of the territory of Armenia between Caucasian and Armeno-Iranian floristic province (between Circumboreal and Ancient Mediterranean subkingdoms of Holarctic floristic kingdom.

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