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## FLORA OF ARMENIA: ITS COMPOSITION, ANALYSIS AND RELATIONSHIPS

## ФЛОРА АРМЕНИИ: ЕЁ СОСТАВ, АНАЛИЗ И СВЯЗИ

The presented analysis clearly demonstrates that flora of Armenia is a highly complex heterogeneous and heterochronous entity. It is the result of in situ transformation of two ecologically opposite floras of the Paleogene age: of Laurasian ("flora of *Ginkgo*") and Gondwanan ("flora of *Welwitschia*") origins. Detailed analysis of species' ranges combined with the phylogenetic data allows tracing the branches of the mesophyllous Laurasian flora with the main contemporary centers of preservation in the Sino-Himalayan (southern branch) and Sino-Japanese (northern branch) choria. They entered our territory from opposite directions: the south-east and north respectively. Their closest centers of preservation are the Hyrcanian and Euxine provinces. The next wave of migration came from the arid center of Central Asia, also of Paleogene age. This floristic complex spread along the Circum-Hyrcanian arid track: across the deserts of Turania, North Caspian shore and Iran in the Upper Miocene. It penetrated the eastern Transcaucasia in the middle Pliocene. The Central Asian desert affiliations have Chenopodiaceae, *Nitraria*, *Zygophyllum*, *Euphorbia*, and others. In the Oligocene another Gondwanan element, of South African origin, riched Frontal Asia moving along the African arid track by way of Mediterranean. There was also a North African xeric element (Resedaceae, *Helianthemum*) and the Mediterranean element itself (*Asphodeline*, *Legousia*) that spread to the east. The next element of the flora is connected to the Cimmerian and Alpine orogeny and is of Laurasian (*Saxifraga*, *Gentiana*) or Gondwanan (Crassulaceae) origin. All the waves of migration diversified in situ to produce new lineages; some were more successful than the others, while older ones, persisted in the refugia mesophyllous ancient Lurasian (*Daphne mesereum*) forest species, become relictual. The closest affinities of the forest flora of Armenia are with the western Palearctic, the Submediterranean and Central European choria (many Rosaceae and Fabaceae). The great outburst of more recent speciation is an ongoing process in the Tethyan territory and here we have the richest genera with the younger Cenozoic lineages of the flora (Dipsacaceae, Brassicaceae, Apiaceae, etc.).

The majority of species of the flora of Armenia are native to the Ancient Mediterranean Subkingdom and are xerophyllized in the Coenozoic, mostly Neogene, derivatives of more ancient Laurasian element, or less abundant derivatives of the Gondwanan element. Among the petaloid monocots, most of the species of Asparagales: in *Asparagus*, *Asphodeline*, Hyacinthaceae, Iridaceae, Colchicaceae, and Smilacaceae had originated in the (Eastern) Mediterranean-Western-Asian (including Trans-Caucasus) secondary center of speciation and have Gondwanan ancestors. Diversification of some of them was connected to the Cimmerian and European orogeny (*Ornithogallum*), others, the older ones, tend to the remnants of the mesophytic Eastern-Mediterranean-Euxino-Hyrcanian chorioa (*Galanthus*), or have as well a few younger Coenozoic lineages, derivatives of that tertiary forest center (*Scilla*). The Tethyan xeromorphogenesis is perfectly expressed in the entire Alliaceae.

The species of Liliaceae, Orchidaceae, Melanthiaceae, and Convallariaceae belong to oligotypic genera that have ancient Laurasian roots and are relictual in Armenia. The majority of the Cyperales and Poales are either Laurasian or Tethyan with Laurasian roots; only a few belong to the Gondwanan element.

Among the dicots species of Boraginaceae, Rhamnaceae, Zygophyllaceae, Apocynaceae, *Haplophyllum*, *Jaubertia*, *Rubia*, *Lycium*, Lactuceae, and *Helichrisum* have Gondwanan roots.

The majority of largest genera and families have predominance of the Thetyan element. Most important are: Papaveraceae, Plumbaginaceae, Caryophyllaceae, Chenopodiaceae, a number of tribes in papilionoid Fabaceae, Brassicaceae, Boraginaceae, Lamiaceae, Apiaceae, Crassulaceae, and Fagaceae; eighty percent of the Asteraceae are endemic to the Ancient Mediterranean Subkingdom.

The Laurasian element is better expressed in Cyperaceae, Juncaceae, Poaceae, Ranunculaceae, Polygonaceae, Geraniaceae, Trifolieae, Viciae, Gentianaceae, Betulaceae, and Rubiaceae.

Some large polychorous and old families like Rosaceae, Fabaceae, Poaceae, and Scrophulariaceae have a mixture of different elements.

### Abstract

Flora of Armenia comprises some 3342 species of vascular plants in 823 genera of 130 families on a land area of ca 35,360 sq. km. Ten largest families have 2036 species (62% of all sp.). The largest genera are *Astragalus*, *Carex*, *Centaurea*, *Veronica*, *Allium*, *Silene*, and *Vicia*. Almost half of the flora is represented by the Ancient Mediterranean and one third by the Irano-Turanian geo-element. Some aspects of phytogeography of the Frontal Asian Subregion are discussed, as are some florogenetic concepts. Flora of Armenia comprises a mixture of Laurasian, Gondwanan and Tethyan historic elements with the prevalence of the Tethyan element in the Armeno-Atropateno-Zagrosian major part of the Republic. The three northernmost floristic districts belong to the Caucasian province of the Boreal Subkingdom and are on the southern edge of it. Here are obvious western Palearctic connections of the flora. The majority of species of Liliidae in the flora of Armenia had originated in the Eastern Mediterranean-Western Asian (including Trans-Caucasus) secondary center of speciation and have Gondwanan ancestors. Species of Liliaceae, Orchidaceae, Melanthiaceae, and Convallariaceae have oligotypic genera and reveal Laurasian connections of the flora. Among Dicots, Boraginaceae, Rhamnaceae, Zygophyllaceae, *Jaubertia* have Gondwanan roots. The majority of large genera and families have predominance of the Thetyan element. Most important are: Papaveraceae, Plumbaginaceae, Caryophyllaceae, Chenopodiaceae, Fabaceae, Brassicaceae, Boraginaceae, Lamiaceae, and Apiaceae. In the largest family Asteraceae 80% of species are endemic to Ancient Mediterranean. Laurasian element is better expressed in Cyperaceae, Poaceae, Ranunculaceae, Polygonaceae, Geraniaceae, *Trifolieae*, *Viciae*, Gentianaceae, and Rubiaceae. Some large and old families like Rosaceae, Fabaceae, Poaceae, and Scrophulariaceae have a mixture of different elements.

Situated in the Lesser Caucasus between latitudes 38°50' and 41°18'N and longitudes 43°27' and 46°37'E, the Republic of Armenia comprises a land area of 29800 km<sup>2</sup>. Species of ca 5360 km<sup>2</sup> adjacent territory of Nachichevan were also counted. Armenia is a landlocked country of mostly mountainous terrain with large portions covered by mountainous xerophytic vegetation and few forests (Saghatelyan, 1999). The climate is highland continental with hot dry summers and relatively cold winters. The land rises up to 4095 m on volcanic mount Aragatz, while the low point is below 375 m above sea-level.

### **Geographical setting**

Orographically the area represents folded ridges of the Lesser Caucasus, easternmost part of the Armenian Volcanic Highland (Dumitrashko, 1979), Ararat Valley, and to the east of the Valley, the Sub-Araks folded mountain ridges. Within 27 km of the western boundary of the Republic, the summit of the forestless volcano Ararat (5165 m) rises. The Armenian border lies along the river Araks to the east from Turkey and to the north from Iran, where several paleotropical desert species reach the northernmost edge of their distribution. Southward and eastward from Armenia the vast Iranian Highland is stretched, with hot deserts in the central part, bordered on the north by the Elburs mountain range with the highest summit for Western Asia the volcano Demavend (5671m). The northern slope of Elburs and the southern Caspian Sea shore are covered with the relictual Hyrcanian forests. The Iranian and Armenian Highlands, along with the adjoining parts of the Lesser Caucasus, represent a major arena of Cenozoic progressive xeromorphogenesis in many endemic Irano-Turanian genera, comprehensively listed by Takhtajan (1988). Another floristically important area in the Western Asian center of xerophilous diversification is the Anatolian Highland, which is situated to the west of the Armenian Highland. The boundary between the two Highlands is known as the Anatolian Diagonal (Davis, 1971). It coincides with the distributional limits for many species characteristic to several different floristic provinces. To the south of Armenia along the western Iranian boundary, the Zagros mountain range (peaks around 4300 m) is stretched. Its watershed also represents an important climatic and floristic barrier, creating rain shadow and preventing further migration of many Mediterranean species from its western slope to the east. Fewer representatives of that element can be found as far to the east as the Western Kopetdagh at the Khorassan-Turkmenian boundary.

### **Materials and methods**

The main method of this work was based on our previous detailed study of the flora of Armenia species' general distribution. As the flora in subject is complex, we attempted to reveal all the groups of species (geoelements) with similar generalized tracks. The aim was to test the hypothesis that floristic complexes (floras of particular biomes) are represented by ecologically similar geoelements which can have spatially, historically and genetically different roots. They are heterochronous and can reveal the tendencies in the formation and transformation of the floras and plant communities. We tried to compare our spatial data with the recently published phylogenetic data on different lineages.

The database and the checklist (not published yet) of the flora of Armenia were compiled mainly on the basis of the Herbaria of the Botanical Institute of Armenia (ERE) and Komarov Botanical Institute (LE), "Flora of Armenia" (Takhtajan, 1954–1995), "Flora of Yerevan" (Takhtajan & Fedorov, 1972), and "Flora of Caucasus" (Groszheim, 1939–1967). The main sources on general species' distributions were the "Floras" of Western and Central Asian countries, Europe and the former Soviet Union, which

are too numerous to list here. Most extensively used were "Flora SSSR" (1934–1960), "Flora of Turkey" (Davis, 1965–1989) and "Flora Iranica" (Rechinger, 1963–1999). Monographic treatments and distributional maps were used, whenever available. For the data on general distribution of the families we used "Flowering plants of the world" (Heywood, 1978), "Floristic regions of the world" (Takhtajan, 1988), and "The classification and geography of the monocotyledon subclasses ..." (Thorne, 2000). For the placement of Angiosperm families we mostly followed recent phylogenetic classification (Judd, Campbell, Kellogg, 2004 and Angiosperm Phylogeny Website, 2003). Personal field floristic, phytosociological and ecological observations, as well as consultations with the experts on some systematic groups and their publications (Gabrieljan, 1978, Barseghjan, 1981; Gabrieljan & Greuter, 1984, Oganessian, 1995; Oganessova, 1997 a,b, 1999) were very helpful. Methods of separation of different floristic elements (geographical, altitudinal, ecological, life forms etc.) were applied with subsequent biogeographic and florogenetic analysis.

### Phytogeography

Most of the above-mentioned territories belong to different provinces of the Irano-Turanian Region of the Tethyan (Ancient Mediterranean) Subkingdom, while the northern part of the republic belongs to the Caucasian province of the Boreal Subkingdom of Takhtajan's (1988) chorionomic system, which was accepted here as a fundamental starting scheme. For more than 3300 species known to grow in Armenia, we have developed a classification scheme of geographical elements (Saghatelyan, 1997a). We will consider here 38 geoelements (Table 1) or area-types from that scheme. They were named mainly as the choria in Takhtajan's (1988) chorionomic system, to which we will refer in the sequel. If not discussed specially, the boundaries of the choria are accepted as in Takhtajan's system. We will also refer to several following choria, as they were confirmed by the species of the flora of Armenia area configurations we have studied:

1) The Submediterranean s. str. region according to Meusel et al. (1965) with the Caucasian and Euxine provinces included in it (Maleev, 1938). It is in the boundaries of the Boreal Subkingdom of Takhtajan's system.

2) The Eurasian Steppe region of Lavrenko (1950), since the distribution of 178 species of the flora of Armenia embraces parts of the Eastern-Ancient Mediterranean and the Steppe region. We consider it as the eastern half of the Submediterranean s. lato region which corresponds to the southern part of the Boreal Subkingdom of Takhtajan's system.

3) The Central Asian subregion of the Irano-Turanian Region of Takhtajan is accepted according to Lavrenko (1965) and Kamelin (1973, 1979). It therefore includes desert territories only.

4) The Eastern Asiatic region we consider sensu Wu (1998), who proposed to separate the Sino-Himalayan and the Sino-Japanese Subregions of the Eastern Asiatic Region by Takhtajan. This delineation was based on the florogenetic conclusion that the genera with a Sino-Japanese distribution pattern are usually historical elements

Table 1.

## Geographical elements of the flora Armenia

1.	Polichorous	58
2.	South Palearctic-Paleotropic	32
3.	Holarctic	128
4.	Palearctic	176 (74 western Palearctic)
5.	Euro-Siberian	276 {126 western (European)}
6.	Arcto-Montaine	18
7.	Pontian- Ancient-Mediterranean	178
8.	Submediterranean	241
9.	Asia Minor-(Balkan)-Caucasian	103
10.	Caucasian	195
11.	Eastern-Lesser-Caucasian	146
12.	Colchic-Caucasian	34
13.	Euxinian	43
14.	Euxino-Hyrcanian	34
15.	Hyrcanian	22
16.	Ancient Mediterranean large	62 (15 common with East Asia)
17.	Mediterranean-Frontal Asian	108 (36 East Medit.-Frontal Asian)
18.	Mediterranean-western-Frontal-Asian	170 (101 East Medit.-West Frontal Asian)
19.	Irano-Turanian large	49
20.	Frontal Asian large	213
21.	Middle Asia-Iranian	46
22.	Irano-Anatolian	30
23.	Armeno-Iranian	45
24.	Iranian	94
25.	Atropatenian	231 (66 North Atropatenian; 27 +East-Caucasus)
26.	Armenian	103
27.	Armeno-Atropatenian	88
28.	Atropateno-Kurdo-Zagrosian	46 (17 + Armenian)
29.	Atropateno-Chorasanian	5
30.	Anatolia-Atropatenian	73 (10 Anatol.-Arm.; 27 + Kurdo-Zagros)
31.	Turan-Circum-Hyrcanian	41 (17 Turanian)
32.	Turan-Armeno-Iranian	13
33.	Mesopotamian-Iranian	13
34.	Endemic	113-126
35.	Disjunctive	41
37.	Exotic	21
38.	Unidentified	24

from the ancient Laurasian flora, while the Sino-Himalayan genera are mixed with several neoendemic elements derived from Laurasian, Tethyan and Gondwanan elements, especially of Tethyan origin. The latter belong to such families as Lamiaceae, Apiaceae, Brassicaceae, Boraginaceae and Dipsacaceae. Our data on the flora of Armenia greatly corroborate this conclusion.

5) The eastern limits of the Frontal Asian subregion are well delineated by the Near-Himalayan chorion of Popov (1927, 1963), since it serves as the eastern limit for

many largely Frontal Asian species.

We consider the Frontal Asian subregion as divided in two groups of provinces:

1) The Turkestanian-Irano-Anatolian group of mountain provinces of Western Asia (Kamelin, 1979).

2) The Turano-Irano-Mesopotamian group of desert provinces of Western Asia.

6) We delineated the Armeno-Atropateno-Zagrosian province of group 1 (Saghatelyan, 1997a), to which belongs the major part of Armenia. It represents the western half of the Takhtajan's Armeno-Iranian province. There is also an exclave of the Turanian province of group 2 in Southern Armenia and Nachitchevan along the valley of the river Araks.

7) We consider the Caucasian Diagonal (Saghatelyan, 1994 : 316, 1997 : 31) that stretches from Dagestan south-westward to the Plato Kars, and runs parallel to the Anatolian Diagonal, to be the tentative demarcation line. It separates western and northern parts of the Caucasus Isthmus that are essentially Submediterranean (Boreal subkingdom) from its southern and eastern part that belongs to the Frontal Asian subregion (Tethyan subkingdom).

Being orographically and tectonically bound to the Western Asian structures, and consistently representing the Irano-Turanian Region, Armenia, in its smaller northern part, belongs to the southernmost edge of the Caucasian floristic province of the Boreal Subkingdom. Thus, the floristic treatment here will be dealing with the boundary between two chorua of higher rank, the two Subkingdoms of the Holarctic Kingdom.

The Caucasian province embraces the mountain system of the Greater Caucasus (with the peak of Elbrus, 5633 m) and the intermountain depression between the Greater and Lesser Caucasus. It is a part of the European Oro-Mediterranean belt, and they share the same floristic history (see surveys of Mai, 1991; Manchester, 1999; Hably et al., 2000). The southern boundary of the Caucasian Province has been a subject of discussion in the literature on the Caucasian flora and vegetation (Grossheim, 1936, Takhtajan, 1941, Magakyan, 1938, 1941, 1947; Gabrielyan & Elenevskiy, 1965; Fajvush, 1986, 1987). Our quantitative analysis (Saghatelyan, 1997a, b) allows us to determine this boundary along the southern borders of the Upper Achurjan, Lori, and Ijevan floristic districts of Armenia (Fig. 1).

Two other floristic centers in the proximity to Armenia, the Euxine province on the Black Sea shore and the Hyrcanian province on the southern Caspian Sea shore, to the north of the Elburs mountains watershed, are important Tertiary refuges. They are remnants of two mesophyllous Tertiary forest floras: the Euxine province represents the northern branch of the Laurasian (warm) temperate flora and the Hyrcanian province represents the Tethyan notophyllous mountain flora, or the southern branch of the Laurasian flora. The Hyrcanian province has essential floristic connections to the Western Himalayan province, although the northern Laurasian temperate and Hyrcano-Euxinian elements are strongly expressed there. For example, for one of the renowned Hyrcanian endemics *Gleditsia caspia* Desf., the Sino-Himalayan connections were suggested. *Gleditsia* (Schnabel et al., 2003) most likely evolved in the Eastern Asia in Eocene and had a widespread Asian distribution from Eastern China to the Caucasus by Pliocene.



Fig. 1. Map of the floristic regions of Armenia (after Takhtajan, 1954).

1 – Upper Achurjan; 2 – Shirak; 3 – Aragatz; 4 – Lori; 5 – Ijevan; 6 – Aparan; 7 – Sevan; 8 – Gegham; 9 – Yerevan; 10 – Darelegis; 11 – Zangezur; 12 – Meghri; 13 – Nachichevan.

*Parrotia persica* C.A. Mey., another dominant Hyrcanian species, is close to the monotypic western Himalayan genus *Parrotiopsis* of the same tribe Hamamelididae (Li et al., 1999). Other species like *Pyrus boissierana* Buhse of the basal sect. *Pashia* had probably similar pathways of distribution; its closest relative *P. pashia* Buch. & Ham. belongs to the Himalayan-SE Asian assemblage of subtropical monsoon oak forests (Menitski, 1984). The same was inferred for *Acer velutinum* Boiss. (Takhtajan, 1988) and some other Hyrcanian species. They all are paleorelics of the ancestral subtropical humid mountain forests of the Ancient Mediterranean, now confined to several small humid refuges disjunctly distributed on the territory from the Atlas Mountains to West Himalaya.

### Main concepts

We follow here the ideas of the school of florogenetics founded by M. Popov (1927, 1941, 1963, and 1983) who had developed the concept of two genetically and ecologically different floras of the North-subtropical latitudes of the Old World. According to this concept, a mesophyllous subtropical forest flora, which Popov named "flora of *Ginkgo*" in 1927, was largely distributed in the subtropical zone of the northern hemisphere in the Tertiary (Paleogene). Its contemporary main region of preservation lies in China, Japan (except the North), most of the Himalaya, and the Southeastern United States. There are also several relictual islands covered by that flora in the Moroccan Atlas, Cilicia, Colchis-Lazistan, Hyrcania, and Kafiristan, where we find representatives of the floristic complex of the "flora of *Ginkgo*". According to R. Kamelin (1973), the more ecological, rather than systematic concept of the "flora of *Ginkgo*" joins together ecologically different Poltavian and Turgayan flora elements of Kryshfovich (1928).

There was also a quite different arid xerophilous paleoflora in the Paleogene of the Ancient Mediterranean, which "originated from South Africa, or rather the Gondwanaland" which was named "flora of *Welwitschia*" by Popov. It is distributed, according to the author of the concept, mainly in the ancient (Paleogene) Central Asian mainland, never covered by Tethys Sea (chiefly Mongolia and Eastern Tjan-Schan). Its representatives are found today in different arid parts of the Irano-Turania and are systematically very isolated.

More recent works also state that in the Tertiary the central portion of China was dominated by an arid zone that stretched from the eastern coast northwest to the present area of Tibet, hosting savanna vegetation (see surveys of Axelrod, Al-Shehbaz, Raven, 1996; Tiffney & Manchester, 2001).

Nevski (1937) further divided the flora elements of Popov. The "flora of *Welwitschia*" element was divided into: original Ancient Mediterranean and Gondwana-Mediterranean, or the "flora of *Welwitschia*" element *sensu str.* The "flora of *Ginkgo*" element was divided into: Mediterranean-Holarctic (xerophylic derivatives of the Holarctic migrants), Arcto-Tertiary, and Boreal.

Popov (1941) described three stages of the transformation of subtropical forests of the "flora of *Ginkgo*" to xeric forests of the Ancient Mediterranean: the stage of *Juglans*, the stage of *Quercus*, and the stage of *Juniperus–Pistacia*. Most importantly, he developed a concept of autochthonous flora of the Ancient Mediterranean (Tethyan flora) of the Neogene age. Its most peculiar systematic groups had been revealed and analyzed by him biogeographically.

These ideas were largely and deeply developed in the works of Kamelin (1973, 1979, 1987, and 1990). On the example of the flora of the Mountain Middle Asia, Kamelin describes the following three main paleofloristic complexes of the Tethyan Subkingdom:

- 1) The complex of subtropical coastal forests of the Ancient Mediterranean with most of the dominants (*Platanus*, *Datisca*, *Ziziphus*, *Vitex*, *Populus* subg. *Turanga*, *Eleagnus*, *Ficus*) directly connected to tropical ancestors.

2) The complex of mainly oak forests since the Upper Cretaceous – Paleogene which the author calls "Preshibliak" (*Dryophyllum*, *Quercus*, *Castanopsis*). By the time of the Upper Paleogene they were transformed to oak forests with dominants close to contemporary ones, oaks from the sections *Cerris* and *Ilex*. Many Ancient Mediterranean woody Rosaceae (*Pyrus*, *Amygdalus*, *Crataegus*) and Fabaceae (*Colutea*, *Sophora*, *Genista*), species of *Rhamnus*, *Celtis*, *Pistacia*, *Fraxinus* (sect. *Ornus*), *Acer* (sect. *Pubescentia*, *Monspessulana*), *Rhus*, *Cotinus*, *Carpinus*, *Punica*, *Ficus*, *Paliurus*, *Juniperus*, as well as a number of Mediterranean species (*Nerium oleander*, *Viburnum* gr. *Tinus*, etc.), belong to this complex.

3) The complex of temperate mesophyllous mountain forests with *Juglans regia* L., species of *Berberis*, *Spiraea*, *Sorbus*, *Cotoneaster*, *Crataegus*, *Rosa*, *Prunus*, *Caragana*, *Lonicera*, *Jasminum*, *Euonimus*, and *Vitis*. The closest similarity of this complex to the floras of central and northern part of SW China, SW and West Iran and parts of SW Himalaya was emphasized. These forests were considered to be sister to more northern "Turgayan" ones.

The concept of "Turgayan flora" of the Old World created by Kryshstofovich (1928) is used here only in an ecological sense, as explained by Zhilin (1989 : 288): "In the very wide sense it reflects a zonal ecological similarity among floras of different territories as they evolved into a temperate flora during the middle of the Tertiary Period". The author states that the Miocene floras of Cis-Caucasus have only a few species in common with Turgayan floras of west Kazakhstan, whereas all of the Miocene extra-tropical floras of the northern hemisphere are extraordinarily alike at the generic level. This illustrates that they evolved from the single floristic Holarctic pool.

### History of the flora of Armenia

Most territory of the contemporary Caucasian Isthmus, except for a few islands, was under the shallow sea during the Mesozoic. These islands were occupied by paleotropical-paratropical paleoflora which was ecologically of the Poltava type (Kryshstofovich, 1928, 1955, Zhilin, 1989).

For the Upper Cretaceous of Darelegis, Armenia, for example, the following species are known (Takhtajan, 1974): *Comptonia yakovlevii*, *Myrica zenkeri*, *Widdringtonites reichii*, *Sequoia reichenbachii*, *Agathis borealis*, *Araucaria angusta*, *Populus daralagensis* (subgenus *Turanga*). There were no members of Fagaceae.

Anatolia, Iran, Afghanistan, Himalaya, and Tibet were parts of the Cimmerian land, constituted from several large blocks that were separated in the Triassic from the Eastern Gondwana (Scotese, 2004). These blocks drifted into the Tethys Ocean toward Siberia in the Jurassic and their impact with Laurasia started the Cimmerian orogeny, including the ancestral Caucasus Mountains. In the Cenozoic, the collision of India with Eurasia shepherded northward the many remnant Asian blocks that became Iran, Afghanistan, Central Asia, Tibet, and Himalaya. A long island, known in literature as Jafetida, was formed on the place of the Greater Caucasus in the Paleocene, and was inhabited at that time by the paratropical paleotropical flora, mostly of evergreen Fagaceae, *Myrica* and other angiosperms (Nakhutsrishvili, 1999).

There were several other small islands on the Caucasian Isthmus covered by the paratropical flora of the evergreen sclerophyllous broad-leaved and mixed mesophytic type with the abundance of Lauraceae, evergreen Fagaceae, palms, and very few conifers. This was alternated by subtropical and even sclerophyllous vegetation on different elevations. A completely subtropical paleoflora was found in North Armenia from the Eocene. It included *Ocotea*, *Comptonia*, *Daphnogene*, and *Castanopsis* (Zhilin, Gabrielyan, 1999).

The floras of the contemporary Euxine and Caucasian provinces show strong ancient Western Palearctic (Paleo-European) connections. Later in the Tertiary they had experienced the temperate influence of the Turgayan flora, including the Asian migrants to the west along the northern Tethyan coastline from the territory of today's Sino-Japanese subregion of the Eastern Asiatic region.

Up until the late Oligocene no communication existed between the European archipelago and Asia (Rügl & Steininger, 1984). The penetration of Laurasian temperate species to the Caucasus and the islands of Transcaucasia, where the flora of Poltava type dominated, may have occurred not earlier than in the late Eocene, after the Turgay strait desiccation, followed by the formation of the Mediterranean orogenetic band at the Eocene-Oligocene boundary. This uplift caused the emergence of the main part of Europe and the Caucasus Isthmus from water. The Caucasian biota experienced a great influence of the Laurasian temperate flora in the Oligocene (Grossheim, 1936, 1946; Gabrieljan, Takhtajan, Sarkisjan, 1958; Gokchtuni, 1974, 1976, 1977, 1982, 1987; Doluchanov, 1989; Grigorjan, Gabrieljan, 1994). Many conifers and deciduous woody species penetrated then from the north.

Farther to the west, on the Balkan Peninsula, a very rich Western Rodopi paleoflora (Palamarev & al., 2000) of late Eocene to Early Oligocene age reveals a similar tendency as on the Caucasian Isthmus: the transition from ancient notophyllous paleotropical evergreen forest flora to the mixed mesophytic or microphyllous broad-leaved evergreen sclerophyllous forest flora. Most importantly, the authors describe in the Western Rodopi paleovegetation the sclerophyllous shrub paleocenosis with species of *Acacia*, *Pistacia*, *Ziziphus*, and *Ceratonia*. On the basis of this core paleocenosis, with the addition or vicariance of other genera in different parts of the Ancient Mediterranean, diversification of the indigenous Tethyan communities of mountain xerophytes had started: formations of *Juniperus*, shibliak, phryganoids, and cushion plant steppes.

The uplifting Sino-Himalayan subregion of the Eastern Asiatic Region was an important source of species origin, diversification, preservation, and dispersal to the west along the uplifting mountain ranges on the northern Tethys seashore. Many of the widespread genera (*Gentiana*, *Pedicularis*, *Primula*) are extremely diverse in the southwestern China and the Himalayas, and their species richness often drastically decreases eastward (Qian, 2002). Thus, beginning from the Late Eocene, the process of differentiation of autochthonous flora and vegetation of the Ancient Mediterranean had started.

Major orogenetic events created a great variety of environments; gradual aridization of climate and seismic activity accelerated processes of speciation followed by

species dispersal within ecologically diverse Tethyan territory. This process was accompanied by simultaneous differentiation of paleo-communities and by their arrangement along the abiotic gradients to different altitudinal belts in situ in a rich diversity of ecomiches hosted by the uplifting mountains. During cold and arid periods of the Pleistocene, this resulted in intensive outbursts of speciation especially in the xerophytic and montane native genera which contributed to the inequity in the numbers of species in different genera of the contemporary flora of Armenia (Table 2). To the contrary, some regions of preservation of ancient woody flora, like Eastern Asiatic, are known to have exceptionally large numbers of endemic genera which are mostly monotypic and oligotypic (Wu, 1998). Another famous ancient region of Mediterranean type climate with predominance of shrubs and perennial herbs, Cape Region (Goldblatt & Manning, 2002), has more than 20% of the flora in the ten largest genera and one of the highest ratios of species per genus in the world. In Armenia, the ten largest genera comprise 13.8% of the flora, or 457 species. Many younger genera or sections in today's Irano-Turanian region are polymorphous, and sometimes enormous, like *Astragalus* and *Centaurea* in the Western Asia, *Cousinia*, *Ferula*, *Nepeta* in Iran-Middle Asia, *Acantholimon* in the Irano-Turanian Region, or *Allium* in the whole Ancient Mediterranean and south-western United States.

Thus the history of the flora of Armenia, being a part of the history of the Tethyan Subkingdom as a whole, is intricate.

Table 2.

## Polymorphic and medium genera of the flora Armenia

<i>Astragalus</i>	112
<i>Carex</i>	69
<i>Centaurea</i>	43
<i>Veronica</i>	38
<i>Allium</i>	36
<i>Silene</i> , <i>Vicia</i>	34
<i>Galium</i> , <i>Ranunculus</i>	31
<i>Verbascum</i>	29
<i>Euphorbia</i>	28
<i>Rosa</i>	27
<i>Trifolium</i>	26
<i>Scrophularia</i>	24
<i>Potentilla</i>	23
<i>Gagea</i>	22
<i>Campanula</i> , <i>Cirsium</i> , <i>Alchemilla</i>	21
<i>Cerastium</i> , <i>Polygonum</i> , <i>Onobrychis</i> , <i>Stipa</i>	20
<i>Geranium</i> , <i>Salvia</i> , <i>Cousinia</i> , <i>Erysimum</i>	19
<i>Festuca</i> , <i>Tragopogon</i>	18
<i>Dianthus</i> , <i>Nepeta</i> , <i>Trigonella</i>	17
<i>Acantholimon</i> , <i>Alyssum</i> , <i>Poa</i>	16
<i>Sedum</i> , <i>Pyrus</i> , <i>Viola</i> , <i>Stachys</i> , <i>Scorzonera</i> , <i>Senecio</i> , <i>Tanacetum</i>	15

## Taxonomic and geographic analysis of the flora of Armenia

### Numbers of species

The number of vascular plant species in the flora of Armenia is about 3342 in the territory of ca. 35360 sq km. Due to the frequent changes in taxonomic status, all numbers must be regarded as tentative. For the adjacent Republic of Georgia ca 4400 species are known from the more than doubled territory of 69700 sq km (Ketzkhoveli & Gagnidze, 1971–2001). The Flora of Turkey (Davis, 1965–1989) includes 8650 species of vascular plants (ca 2.5 times more than flora of Armenia) on the land area of 780000 sq km (22 times more than that of Armenia). The Middle Asian floras are richer or of comparable size.

The California floristic province has 4452 species of vascular plants (Raven, Axelrod, 1995) on the area of about 324000 sq km (10 times larger than Armenia). For the flora Texas 4834 species are known (Kartesz & Meacham, 2005) on the territory of 751000 sq km (21 times larger than Armenia).

One of the world's richest, the Cape flora has 8920 species on the land area of ca 90000 sq km (Goldblatt & Manning, 2002). This is almost the same proportion of ca 100 species per 1 sq km as in Armenia, although the level of endemism in the Cape is unprecedented. The ancient forest region of Qinling Mountains of North China which is 5° south from the latitude of Armenia, covers an area of 76500 sq km (2.1 times larger than Armenia) and has a flora of ca 3125 species (Ying & Boufford, 1998).

This comparison reveals the richness of the flora of Armenia, even among subtropical floras, though the number of endemics is small: 126 species and only a few of them are paleoendemics. The low rate of endemism is due to a very small land area of the flora and its relatively young age. The high number of species can be explained not only by the geographical position of the country on the crossroads of migration waves from many different directions, complicated history, and a wide altitudinal range, but also by its proximity to several important centers of contemporary speciation. However, the number of species endemic to different subprovinces and provinces that meet on the territory of Armenia is more substantial. There is no generic endemism in Armenia. Thus the high number of species and the low number of endemics in Armenia are not only due to the nature of the flora itself, but also to its administrative, rather than natural delineation. Because of that, the analysis of its flora should be considered as a sampling of a floristic situation (Yurtsev, Kamelin, 1987).

### Important genera and chorionomy

Polymorphic genera of the flora are discussed in Saghatelyan (1997b) and can be observed here in Table 2. Smaller, but characteristic genera of the flora are also listed in Table 2, in its lower part. Floristic proportions of different floristic districts of Armenia (Tables 3.1, 3.2, 3.3) reveal important genera of the 2 provinces they belong to. The first three districts in the table, Upper Achurjan, Lori, and Ijevan are samples of the Caucasian province. All the rest belong to the Armeno-Atropateno-Zagrosian

province of the group of Mountain provinces of Western Asia. However, floras of the districts Aparan, Sevan, Gegham, and Zangezur experience influence of the Caucasian province at the upper mountain belts. In general, most true to the Atropatenian Subprovince districts are Nachichevan, Yerevan, Darelegis and Meghri. Atropatenian with some Caucasian features is Zangezur. Eastern part of the forestless Armenian Volcanic Highland represented by Shirak and Aragatz districts belongs to the Armenian Subprovince. Within the boundaries of the Armenian Subprovince are also the Aparan and Sevan districts; they experience some Caucasian influence in the higher elevations and Atropatenian influence in the lower elevations (the latter is especially true for Sevan).

#### Important families

The ten largest families of the flora contain 2043 species (61% of all sp.) in 469 genera (57% of all genera). Eleven families of middle size total 576 species in 138 genera.

The familial composition is not only typical to the North Subtropical-Temperate floras of the Old World, but also has some similarities with those of the New World.

Table 3.1.

Polymorphic genera of the floristic districts of Armenia

Upper Achurjan 660 sp.		Lori 1083 sp.		Ijevan 1322 sp.		Shirak 891 sp.		Aragatz 778 sp.	
Carex	15	Carex	34	Carex	28	Astragalus	30	Astragalus	20
Astragalus	11	Astragalus	18	Vicia	22	Centaurea	17	Veronica	19
Trifolium	10	Veronica	16	Astragalus	20	Verbascum	12	Carex	15
Senecio	10	Ranunculus	12	Veronica	17	Allium	12	Potentilla	11
Allium	9	Silene	12	Allium	16	Trifolium	11	Trifolium	11
Silene	8	Trifolium	12	Trifolium	15	Artemisia	10	Scrophularia	10
Poa	8	Galium	12	Ranunculus	13	Poa	10	Ranunculus	10
Tanacetum	8	Polygonum	11	Silene	13	Stipa	10	Centaurea	9
Sedum	7	Geranium	11	Orobanche	13	Silene	9	Galium	9
Galium	7	Centaurea	11	Alchimilla	12	Dianthus	9	Tanacetum	8
Verbascum	7	Scrophularia	10	Onobrychis	11	Euphorbia	9	Gagea	8
Veronica	7	Campanula	10	Lathyrus	11	Veronica	9	Festuca	8
Scrophularia	7	Sedum	9	Cirsium	11	Campanula	9	Sedum	8
Linaria	7	Euphorbia	9	Geranium	11	Potentilla	8	Salvia	8
Campanula	7	Cirsium	9	Galium	11	Galium	8	Cirsium	8
Centaurea	7	Senecio	9	Rubus	10	Nepeta	8	Allium	8
Inula	7	Gagea	9	Sedum	10	Salvia	8	Verbascum	7
Artemisia	7	Alchimilla	9	Campanula	10	Cirsium	8	Nepeta	7
		Vicia	9	Euphorbia	10	Inula	8	Poa	7
		Hieracium	9	Dianthus	9	Tanacetum	8	Alopecurus	7
		Nepeta	9	Poa	9				
		Poa	9	Potentilla	9				
				Stachys	9				
				Salvia	9				

We will compare it with the familial spectrum of the flora Texas (Table 4), obtained from the "Synthesis of the North American flora" (Kartesz & Meacham, 2005). All the counts were obtained for only native species. Texas, which is 5° south from the latitude of Armenia, has more subtropical flora. It has more sclerophyllous and evergreen woody plants, like *Quercus virginiana* Mill., *Arbutus xalapensis* Kunth, *Sophora secundiflora* (Ortega) Lag. ex DC., and many others. It also is characterized by relatively good representation of tropical and subtropical genera like fabaceous *Acacia*, *Prosopis*, *Mimosa*, *Cesalpinia*, *Proboscidea*, several Bignoniaceae etc. The flora of Armenia is more divergent, has none of the listed genera, and only a few immediate connections to the Paleotropical flora. There are only a few evergreen species of dicots like *Quercus infectoria* Olivier subsp. *boissieri* (Reut.) O. Schwarz, a few Thymelaeaceae and Ericaceae, and several woody Fabaceae like *Colutea*, *Caragana grandiflora* (Bieb.) DC., *Halimodendron halodendron* (Lam.) Fisch. ex DC., and *Cercis griffithii* Boiss. in Armenia. Very typical for Western Asia are shrubby cushion-plant species of *Astragalus* sect. *Tragacantha*, *Onobrychis cornuta* (L.) Desf., Plumbaginaceae (*Acantholimon*), Caryophyllaceae (*Gypsophyla*), and others.

The number of endemic species in Texas is 326, ca. 3 times more than in Armenia, which is due to its much bigger territory.

Table 3.2.

Polymorphic genera of the floristic districts of Armenia.

Gegham 758 sp.	Yerevan 1682 sp.	Darelegis 1448 sp.	Zangezur 1669 sp.	Meghri 1564 sp.					
Astragalus	22	Astragalus	53	Astragalus	41	Astragalus	42	Astragalus	30
Veronica	14	Orobancha	24	Centaurea	22	Carex	34	Trifolium	24
Galium	12	Carex	21	Silene	18	Allium	23	Vicia	22
Scrophularia	12	Veronica	20	Allium	18	Vicia	22	Allium	20
Trifolium	11	Centaurea	20	Carex	18	Veronica	20	Silene	19
Campanula	11	Euphorbia	19	Veronica	17	Silene	20	Veronica	19
Festuca	10	Allium	19	Ranunculus	15	Orobancha	20	Verbascum	18
Poa	10	Silene	17	Galium	15	Ranunculus	19	Scrophularia	18
Silene	9	Verbascum	16	Gagea	15	Trifolium	19	Trigonella	16
Carex	9	Tragopogon	14	Campanula	15	Geranium	18	Cirsium	15
Ranunculus	8	Vicia	13	Salvia	14	Centaurea	17	Orobancha	14
Onobrychis	8	Galium	13	Trifolium	14	Rosa	13	Campanula	14
Gentiana	8	Scrophularia	13	Scrophularia	13	Cirzium	13	Centaurea	13
Nepeta	8	Cuscuta	13	Cirzium	13	Poa	13	Gagea	13
Cirsium	8	Gagea	13	Onobrychis	12	Campanula	13	Galium	13
Alyssum	7	Trifolium	12	Verbascum	12	Onobrychis	12	Pyrus	12
Hieracium	7	Valerianella	12	Polygonum	11	Verbascum	12	Sedum	12
Gagea	7	Scorzonera	12	Aethionema	11	Euphorbia	12	Euphorbia	12
Allium	7	Stipa	12	Tragopogon	11	Viola	11	Rosa	12
		Ranunculus	11			Epilobium	11	Papaver	11
		Atriplex	11			Galium	11	Nepeta	11
		Salsola	11			Salvia	11	Salvia	11
		Aethionema	11			Scrophularia	11	Carex	11
		Poa	11			Potentilla	11	Tragopogon	11

The first three places in both floras are occupied by the largest cosmopolitan contemporary families Asteraceae, Poaceae, and Fabaceae. Together their species comprise 30% of the flora of Armenia and 31% of the flora of Texas. The Asteraceae family in Texas has 1.4% more species than in Armenia and is a very prominent family in the open landscapes. The flora Texas has 1% more species of Poaceae than the flora of Armenia, because the grasses dominate the major biome, prairies. This is also related to the more southern location, floristic connections with South America, and a better contribution of subtropical grasses to the flora of Texas than to the flora of Armenia.

Next, the 4<sup>th</sup> largest family in Armenia, Brassicaceae, comprises 5.8% of the flora and reveals its specific Ancient Mediterranean nature, where this family has the largest center of speciation. It has 2.9% more species in Armenia than in Texas. Brassicaceae in Texas (93 native and 40 exotic species) is at 9<sup>th</sup> place with many genera being common to both floras. However, there are several peculiar genera, like western American *Lesquerella* or *Nerisyrenia*, not represented in the flora of Armenia.

Table 3.3.

Polymorphic genera of the floristic districts of Armenia

Aparan 1081 sp.		Sevan 1464 sp.		Nachichevan 1573 sp.	
Veronica	20	Astragalus	37	Astragalus	74
Silene	18	Carex	38	Silene	28
Onobrychis	18	Silene	21	Galium	21
Carex	17	Veronica	21	Vicia	19
Astragalus	15	Ranunculus	19	Verbascum	18
Centaurea	15	Centaurea	17	Ranunculus	16
Trifolium	13	Potentilla	16	Salvia	16
Campanula	12	Trifolium	16	Veronica	16
Allium	12	Galium	16	Orobanche	16
Cirsium	11	Alchimilla	15	Rosa	15
Dianthus	10	Onobrychis	14	Erysimum	15
Rosa	10	Allium	14	Scrophularia	15
Galium	10	Polygonum	13	Salsola	14
Senecio	10	Euphorbia	13	Polygonum	14
Gagea	10	Scrophularia	13	Trigonella	14
Poa	9	Senecio	13	Allium	14
Ranunculus	9	Nepeta	12	Trifolium	13
Vicia	9	Campanula	12	Euphorbia	13
Hieracium	9	Dianthus	11	Dianthus, Potentilla	12
		Sedum	11	Sedum, Alyssum	12
		Vicia	11	Aethionema, Gagea	12
		Geranium	11	Delphinium, Papaver	10
		Hieracium	11	Cerastium, Acantholimon	10
		Cirsium	11	Alchimilla, Nepeta, Stachys	10
		Stipa	11	Tragopogon, Stipa	10

At 4<sup>th</sup> place in Texas is mainly northern temperate family Cyperaceae, well represented in Eastern Texas. In overall arid Armenia, this, usually large in North and temperate Holarctic spectra family, is only at 10<sup>th</sup> place and has 2.5% less species than Texas.

At 5<sup>th</sup> place in Armenia is Rosaceae, typical to the middle and high altitude mountain biomes of Northern Hemisphere. Polymorphism of Rosaceae in Armenia is mainly the Western Palearctic and Ancient Mediterranean feature of its flora. Unlike more specialized families like Asteraceae, Boraginaceae, Scrophulariaceae, and partially Lamiaceae, all of which, in Texas, have generic composition essentially different from that of Armenia, the more primitive family Rosaceae has many same genera in Texas as in the Old World. This fact points to their northern Laurasian routs of dispersal via North Atlantic land bridge (NALB) and/or Bering land bridge (BLB) and probability of the origin from common tropical ancestors for many lineages. Besides, flora Texas has several of many western American rosaceous genera: *Fallugia*, *Cercocarpus*, *Holodiscus*, *Purshia*, *Vauquelinia*, and *Petrophyton* and one eastern American genus *Gillenia* (Kalkman, 2003, Kartesz & Meacham, 2005). Not only most other genera of Rosaceae in both floras have wide distribution in the Holarctic, but several species are the same. Unlike the rich in Rosaceae floras of the western and eastern United States

Table 4.

Polymorphic families of the flora Armenia and Texas

Armenia / Total:3342 Family	Species / % of the flora	Genera	Texas / Total:4648 Family	Species / % of the flora	Genera
Asteraceae	415 / 12.4%	94	Asteraceae	640 / 3.8%	176
Poaceae	300 / 9 %	96	Poaceae	469 / 10%	107
Fabaceae	294 / 8.8%	30	Fabaceae	329 / 7%	69
Brassicaceae	195 / 5.8%	64	Cyperaceae	295 / 5.6%	17
Rosaceae	163 / 4.9%	27	Euphorbiaceae	142 / 3%	17
Caryophyllaceae	152 / 4.5%	28	Lamiaceae	106 / 2.3%	21
Lamiaceae	151 / 4.5%	34	Scrophulariaceae	101 / 2.2%	28
Scrophulariaceae	140 / 4.2%	20	Boraginaceae	98 / 2.2%	19
Apiaceae	130 / 3.9%	61	Borag./Hydrophyll.	(66 / 32)	13 / 6
Cyperaceae	103 / 3.1%	15	Rosaceae	94 / 2%	21
Ranunculaceae	82 / 2.5%	17	Cactaceae	94 / 2%	20
Boraginaceae	75 / 2.5%	32	Brassicaceae	93 / 2%	48
Rubiaceae	49 / 1.5%	8	Malvaceae	79 / 1.7%	27
Orchidaceae	44 / 1.3%	6	Onagraceae	70 / 1.5%	7
Polygonaceae	42 / 1.3%	18	Solanaceae	64 / 1.4%	14
Liliaceae	37 / 1.1%	4	Apiaceae	64 / 1.4%	32
Euphorbiaceae	36 / 1%	4	Rubiaceae	56 / 1.2%	15
Alliaceae	35 / 1%	2	Orchidaceae	54 / 1.2%	20
			Polygonaceae	52 / 1.1%	6
			Verbenaceae	51 / 1.1%	15
			Convolvulaceae	48 / 1%	12

in overall flat and low Texas Rosaceae is only at the 11<sup>th</sup> place. There is some speciation activity in the genera *Crataegus*, *Rosa*, *Prunus*, which reveals the warm temperate period of the mid Tertiary (see Manchester, 1999; Tiffney & Manchester, 2001) common to the history of both floras.

At 5<sup>th</sup> place in the Texas spectrum is Euphorbiaceae. This family is 3.1 times (by 2%) richer in the flora of Texas. Prominence of the generic and species composition of Euphorbiaceae in Texas and the essential degree of endemism in it illustrate its floristic connections to the Topical/Subtropical Central & South America. Some examples are *Jatropha dioica* Sesse ex Cerv. and *Euphorbia antisiphilitica* Zucc. in West Texas. The number of genera in Texas is 19 vs 4 in Armenia where Euphorbiaceae is at 17<sup>th</sup> place. It represents secondary Ancient Mediterranean center of speciation in the widespread genus *Euphorbia* (11<sup>th</sup> largest genus of the flora) and Central Asian-Iranian center of speciation in *Andrachne*. For the tribe *Euphorbieae* was hypothesized an African origin before the breakup of Gondwanaland (Steinmann & Porter, 2002) and for its clade containing *Euphorbia*, an ancient dispersal event to Laurasia.

At 6<sup>th</sup> place of the flora of Armenia spectrum is Caryophyllaceae, as its territory is a part of the major center of differentiation and endemism of the family in the Mediterranean and Western Asian floras. Thus the Caryophyllaceae here have a very essential representation of the Western Asian element. In Armenia caryophyllaceous lineages of the Tethyan origin predominate whereas in Texas this family includes mostly ubiquitous temperate taxa and is not polymorphic, yielding the leadership to the most prominent branch of the American Caryophyllidae, Cactaceae.

The next two large families Lamiaceae and Scrophulariaceae are at 7<sup>th</sup> and 8<sup>th</sup> place in Armenia and 6<sup>th</sup> and 7<sup>th</sup> place in Texas, respectively. Lamiaceae essentially represent an Ancient Mediterranean element of the flora of Armenia; species confined to the Tethyan subkingdom comprise 85% of all mints in Armenia. Several species have a wider range in the Holarctic, being spread recently to North America as weeds. Lamiaceae in Texas, along with a few same as in the Old World genera, has also several exclusively American genera. Some of them are *Monarda*, *Agastache*, *Brazoria*, *Hedeoma*, *Hyptis*, *Trichostema*; and *Leonotis*. There is an important center of differentiation of the large genus *Salvia* in Mexico which extends to SW Texas; *Salvia* is also very important in the Middle-Western Asian region.

Mainly north temperate-subtropical family Scrophulariaceae is better represented (by 2.1%) in the flora of Armenia. Here are a large genus *Verbascum*, with the main center of diversification in West Asia, and mostly temperate genera *Veronica*, *Scrophularia*, and *Linaria*. Scrophulariaceae in Texas are mostly American and very different from those in Armenia. Common for the two floras are only the genera *Linaria*, *Verbascum*, *Veronica*, *Scrophularia*, namely their temperate widespread species native to the Old World.

At 9<sup>th</sup> place in the Armenia spectrum is Apiaceae, a very polymorphic family in the Ancient Mediterranean, which comprises ca 3.9% of the flora. In Texas this family includes only 1.4% of the flora and is not prominent (12<sup>th</sup> place).

The 8<sup>th</sup> family in Texas, Boraginaceae, includes an exclusively American group

*Hydrophyloideae*, and because of that is even larger in the Texas spectrum than Scrophulariaceae. Some polymorphic genera from the section *Eritricheae* – *Cryptantha*, *Plagiobothrys*, and *Amsinckia* – are also western American. High levels of endemism in these genera in the Californian flora (Raven, Axelrod, 1995) make Boraginaceae a very prominent family there. The majority of other genera of *Eritricheae* are Eastern-Central Asian (Ge-lin et al., 1995). In the flora of Armenia, the most interesting isolated xeric species belong to the genera with disjunctive distribution of the Afro-Asian section *Cynoglosseae*. In Texas, *Cynoglosseae* are represented by only 2 species of wide distribution. The family Boraginaceae in Armenia is not large (at 11<sup>th</sup> place), but is a very peculiar Irano-Turanian group.

At 9<sup>th</sup> place in the Texas spectrum are florogenetically opposite families Rosaceae and Cactaceae (2% each). The former has 2.9% more species in Armenia, while the latter is very important in Texas and absent in Armenia.

The 11<sup>th</sup> family in Texas is Malvaceae, with mostly Neotropical connections and only a few widely distributed species native to the Old World. In Armenia, Malvaceae is not very polymorphic, with a moderate rate of endemism. More southern and closer to Africa, the flora of Israel (Feinbrun Dothan & Danin, 1991) has more native species of Malvaceae.

Most of the remaining families of both spectra reveal peculiarities of the floras in comparison. The Onagraceae, Verbenaceae, Solanaceae, and Convolvulaceae have American lineages in Texas and are not in the Armenian spectrum. For example, the Solanaceae in Armenia are synantropic, except *Lycium*, which is a component of ancient desert littoral hygrophyte and hydrohalophyte communities with Paleotropical affinities. Flora of Israel (Feinbrun Dothan, & Danin, 1991), which is more closely related to the Paleotropic kingdom, has a better representation of Solanaceae. Besides many synantropic solanaceous species, there are some native species from the genera *Withania*, *Mandragora*, and *Lycium*. Liliaceae and Alliaceae instead are polymorphic in Armenia and represent temperate Palearctic and Tethyan features of its flora.

Thus the first ten largest families in the spectra of Armenia and Texas have some similarities, whereas the remaining families of the spectra reveal more peculiarities of the floras. Latitudinal connections across the Northern Hemisphere are stronger in the north temperate groups than in the north subtropical groups. Flora Texas has much more bonds with that of Central/South America, than Armenia with Africa.

#### Geographical elements of the flora of Armenia

Quantitative correlations of geographical elements of the flora are represented in the Table 1.

Combining the geoelements in the Table 1 we can observe more general proportions of the flora. The total numbers of species restricted in their distribution within the frames of each of the three Subdominions of the Holarctic kingdom are as follows:

Holarctic	643 species,	21%
Submediterranean s. l.	892 species,	29%
Ancient Mediterranean	1519 species	50%

Without any doubt we can only compare the numbers of temperate Holarctic, mostly Palearctic, species and the Ancient Mediterranean ones. This reveals the more than double contribution of the autochthonous Ancient Mediterranean element to the flora. Out of 892 species which are Submediterranean s.l., 375 species are Caucasian endemics. The Armeno-Atropateno-Zagrosian province has 473 species in the flora, of which 236 species are Atropatenian endemics and 191 species are Armenian endemics. Integrating all species of the flora confined to the Irano-Turanian region, we get 1104 species, almost one third of the flora of Armenia. This number is large mostly due to the native Frontal Asian species.

#### Altitudinal range

Vertical distribution of the species in the flora is illustrated by Table 5 and following proportions. There are 386 species confined to the plains (Ararat valley), 853 species grow mostly at piedmonts, while low and middle mountain belts have the richest flora and count respectively 1626 and 2111 species. Diversity decreases gradually in the higher elevations: high mountains comprise a flora of 1158 species; while at sub-alpine and alpine altitudes can survive only 471 and 356 species respectively.

#### Angiosperm orders best represented in the flora of Armenia

We will discuss the taxonomic structure of the flora of Armenia with families arranged according to the Angiosperm Phylogeny Group (APG II, 2003) classification. Tribal delineation is accepted either as in Takhtajan (1997) or as in APG.

There are only 38 species of Pteridophyta in the flora Armenia (Gabrieljan & Greuter, 1984).

The extant gymnosperms are even fewer: one species of pine and European yew in the small refuges of pine and shady beech forests respectively. Five species of *Juniperus* are of Submediterranean and Frontal Asian chorotypes and dominate different formations of juniper woodlands. Two-three species of *Ephedra* dominate several xeric formations.

There are no extant members of Laurales, Magnoliales or Piperales in the flora.

Nymphaeaceae has only 3 species: a Euro-Mediterranean *Nymphaea alba* L., a European *N. candida* J. & C. Presl, and a Palearctic *Nuphar lutea* (L.) Smith. Ceratophyllaceae has 2 Palearctic species of *Ceratophyllum* in the flora.

#### Monocots

**Orders Acorales and Alismatales** include 22 widely distributed hydrophytic species. There are five relictual in the flora species of Araceae: two species of European, one Submediterranean, and two of Western Asian (*Arum rupicola* Boiss.) range.

**Order Asparagales** (162 sp.) is best represented among the monocots.

**Alliaceae** (35 sp.) has the largest genus among the monocots *Allium* (34 sp.) and a remarkable Atropateno-Zagrosian chasmophyte species *Nectaroscordum tripe-*

*dale* (Trautv.) Grossh. The latter is one of the 6 species of the endemic Ancient Mediterranean genus. The species of *Allium* represent various centers of speciation of the Ancient Mediterranean, the main territory of diversification of Alliaceae. Some of them are Eastern-Mediterranean-Western-Asian (*A. myrianthum* Boiss.) or Caucasian (*A. kunthianum* Vved.). Others have their ranges across the group of Mountain provinces of Western Asia (*A. callidictyon* C.A. Mey. ex Kunth, *A. rubellum* Bieb.). Most peculiar are Atropatenian chasmophyte *Allium materculae* Bordz. of the Ancient Mediterranean subgenus *Melanocrommyum* and *A. paradoxum* (Bieb.) G. Don, an isolated forest species of disjunctly distributed Mediterranean-Hyrcanian sect. *Briseis*. Only 4 species of the Alliaceae have a larger area that extends into the Pontian Steppe province.

Amaryllidaceae (5 sp.) has 2 relictual genera in the flora. Its world wide center of diversity and most suggestive place of origin is southern Africa (Proches et al., 2006). Our species evolved in the eastern Mediterranean-Euxino-Hyrcanian secondary center of the family. There are 3 species of *Galanthus* in Armenia: 2 of them are Hyrcanian (*G. transcausicus* Fomin), one is a local Iberian endemic of Hyrcanian connections (*G. alpinus* Sosn.). More humid adjacent country Georgia has 10 species of *Galanthus*. The Caucasus is referred to as the likely area of origin for the Galantheae (Meerow & al., 2006). For the ancestor of *Galanthus* the authors suggested that it was isolated in the Caucasus. The genus has a mostly Euxino-Hyrcanian distribution in the Caucasian Isthmus which points to its old age. The second genus, *Sternbergia* is in sister relationships with *Narcissus* and has Mediterranean affinities. It has two very rare in Armenia, but abundant in Karabach (Flora of Armenia, 2001), Eastern-Mediterranean-Western-Frontal-Asian species (*S. fischeriana* (Herb.) Roem).

Asparagaceae (4 sp.) reveals South African connections of the flora and has 4 species of the Ancient Mediterranean secondary center of speciation in *Asparagus* (*A. persicus* Baker). Two of them exceed into adjacent temperate Eurasia, the Pontian Steppe province (*A. verticillatus* L.) and middle Europe, while *A. breslerianus* Schult. fil. is a Turanian species of saline deserts. The genus originated in southern Africa and the Eurasian species originated from a southern African progenitor that radiated rapidly to adapt to dry environment (Fukuda et al., 2005).

Asphodelaceae (5 sp.), a Gondwanan family, with 157 species in South Africa (Goldblatt & Manning, 2002), has only two genera in Armenia. There are three species of the Mediterranean genus *Asphodeline*: a Mediterranean *A. taurica* (Pall.) Endl. and an Atropatenian *A. dendroides* Woronow by their range. The other Ancient Mediterranean genus *Eremurus* has one Western Asian species *E. spectabilis* Bieb. of montane cushion plant formations. The genus is close to Hemerocallidaceae (Chase & al., 2000) and has Eastern Asian connections.

Convallariaceae (6 sp.) represents a Laurasian mesophyllous forest flora element with 6 species of the temperate genus *Polygonatum* (*P. verticillatum* (L.) All.).

Hyacinthaceae (30 sp.) has more species in the flora. They belong to the strictly northern hemisphere tribe *Hyacintheae* (Manning et al., 2004). Seven species of *Scilla* reveal a complex pattern. An Euxinian *S. winogradowii* Sosn., an Armenian *S. armena*

Grossh., and an Euxino-Hyrcanian *S. monanthos* C. Koch represent local speciation which followed the dispersal from the Mediterranean region. All of them are restricted to mesophyllous communities of sub-alpine or alpine belts. There are also xerophyllised in the low mountains *S. hohenackeri* Fisch. & Mey. (Hyrcanian) and two Atropatenian species: *S. atropatana* Grossh. (in hammada) and *S. mischtschenkoana* Grossh. (in rock crevices). Only one species *S. siberica* A.H. Haworth extends to the Eastern European province. It is a vicariate of the Lesser Caucasian species, *S. caucasica* Mischz. In the flora of Israel (Feinbrun-Dothan & Danin, 1991) one finds an analogous picture: there are three species of *Scilla* of Mediterranean, and one of Irano-Turanian range.

Species' ranges of the *Ornithogalum* (10 sp.) in general can be defined as Oro-Mediterranean-Eastern-Mediterranean-Western Asian (*O. sigmoideum* Freyn & Synt. area outline can illustrate this type). There is some local speciation activity in this genus in the Armenian, Caucasian and Euxinian choria, which are more connected to the Mediterranean region; only one high mountain species, *O. schelkownikovii* Grossh. has an Atropateno-Kurdistanian range. To compare, the flora of Israel (Feinbrun-Dothan & Danin, 1991) has 10 species of *Ornithogalum*. Four of them are Mediterranean, three others Mediterranean-Irano-Turanian (2 of which are common with the flora of Armenia), one Irano-Turanian, and one Irano-Turanian-Sacharo-Arabian species. All of this, along with the absence of the genus in Middle Asia and Himalaya, points at its dispersal from South Africa along the arid track. Besides, Mediterranean species of *Ornithogalum* are embedded within southern African or sub-Saharan groups of species (Manning et al., 2004; Proches, 2006), and for them, more than one migration to the Mediterranean is suggested.

The genus *Bellevalia* (7 sp.) has mainly Eastern-Caucasian-Armeno-Iranian and especially Atropatenian species such as *B. longistila* (Mischz.) Grossh., *B. paradoxa* Boiss., and only two more species of a wider range. In Israel there are 12 species of *Bellevalia*: four of them are Mediterranean, five are Irano-Turanian-Sacharo-Arabian, and one Oro-Mediterranean. This is similar to the one of the *Ornithogallum* Irano-Turanian pattern. The last genus of the family, *Muscari* (7 sp.) includes the Caucasian, Lesser Caucasian and Western Asian species with one exceeding into the Pontian Steppe province.

For Hyacinthaceae, it was suggested that it had originated and evolved either in South Africa (Pfosser & Speta, 1999) or in South America with a following massive radiation in southern Africa (Proches et al., 2006). It has 285 species there. Thus, for this group the arid track (south Africa-east Africa-Mediterranean-Western Asia) route of dispersal is obvious. It might be dated by Early and Middle Miocene when an intermittent corridor between Arabia and Asia Minor permitted a series of migration waves between the adjoining continents (Rugl & Steiniger, 1984), no more than 20 Myr ago, which explains the low diversity of the family in Western Asia. The adjacent flora of Turkey thought has more bulbous species than Armenia or Israel due to its larger and diverse territory.

Iridaceae (25 sp.) has 767 species in South Africa and suggestive southern African origin (Goldblatt, 1978, Proches et al., 2006). The species of this family in Armenia have a similar pattern to the one described above. Two species of *Crocus* and 7 species of *Gladiolus* of the flora represent secondary Eastern-Mediterranean-Western Asian (*C. adamii* J. Gay) and Caucasian (*Gladiolus caucasicus* Herb.) centers of speciation. The genus *Iris* (16 sp.) has its own minor eastern-Caucasian-Irano-Anatolian center of diversification, underlined from the North by the Caucasian Diagonal. This center has 12 stenochorous endemic species, mostly from the group *Oncocyclus* (*I. paradoxa* Stev., *I. elegantissima* Sosn.), one Hyrcanian, one Caucasian, and 2 species exceeding into the Euro-Siberian territory.

Ixioliriaceae (1 sp.) is a mostly Irano-Turanian family, usually included into Amaryllidaceae. The western-Frontal-Asian species *Ixiolirion montanum* (Labill.) Herb. is frequently found in different open communities of *Paliureta-Junipereta* formations at the low-middle altitudes.

Orchidaceae (44 sp.) illustrates a Laurasian pattern of species distribution. Many have wide ranges in the Palearctic, temperate Europe or Euro-Mediterranean like *Anacamptis pyramidalis* (L.) L.C.M. Richard. Caucasian endemism is not significant. There are a few endemics in the humid refuges of the mesophyllous Tertiary flora: the Euxine (*Orchis stevenii* Reichenb. fil.), Caucasian (*Ophrys caucasica* Woronow ex Grossh.), and Eastern Mediterranean-Western Frontal Asian mountains (*Dactylorhiza iberica* (Bieb.) Soy).

**Order Dioscoreales** (1 sp.) has only one relictual Mediterranean species in the flora, which is of the Tethyan floristic complex with Gondwanan connections, *Tamus communis* L.

**Order Liliales** (53 sp.) is well represented in the flora and includes 4 families.

Colchicaceae (14 sp.) is a Gondwanan family. It is strongly represented in Africa (Vinnersten & Bremer, 2001) and its two genera in Armenia, *Merendera* and *Colchicum* have Mediterranean-South African connections. *Merendera* has seven species of the Eastern-Mediterranean-Western Asian center (*M. sobolifera* Fisch. & Mey.). There are five endemics of different Western Asian provinces in *Colchicum* (*C. szovitsii* Fisch. & Mey.), one Caucasian, and one Euxinian species. *Colchicum* in the flora of Israel (10 sp.) has seven Mediterranean, two Irano-Turanian, and a Sacharo-Arabian species. For *Androcymbium*, a genus very close to *Colchicum* (Vinnersten & Reeves, 2003), similar affinities of western Mediterranean and southern African species and a pattern of distribution along the arid track were revealed (Caujapá-Castells et al., 2001).

Liliaceae (40 sp.) is restricted to the Northern Hemisphere and is well expressed in West Asia, Himalaya and East Asia. It represents a historical ancient Laurasian element and its Western Asian xerophyllized derivatives in the flora. An Ancient Mediterranean genus *Gagea* contributes 25 species to the flora with the prevalence of Western Asian species of comparatively wide ranges like *G. tenuifolia* (Boiss.) Fomin. The genus *Gagea* includes several Caucasian and Asia Minor-Caucasian endemic species (*G. chanae* Grossh., *G. anisanthos* C. Koch). It also has two temperate European species and one species common with the Pontian Steppe province. Of

seven species of the genus *Tulipa*, five are stenochorous Armeno-Iranian endemics (*T. confusa* Gabrieljan, *T. florenskyi* Woronow); only 2 species have wider ranges: a Euro-Mediterranean *T. sylvestris* L. and an Eastern Mediterranean-Submediterranean-Pontian *T. biflora* Pall. The genus *Fritillaria* has 5 stenochorous species, while *Lilium* has only 2 rare mesophyllous western Asian forest species.

Melanthiaceae (1 sp.), restricted to the Northern Hemisphere, is represented by a mesophyllous relictual Laurasian montaine species *Veratrum album* L.

Smilacaceae (1 sp.) has a rare relictual in Armenia Eastern Mediterranean species *Smilax excelsa* L. with Gondwanan connections.

Thus, the majority species of Liliidae sensu Thorne (2000) of the flora of Armenia had originated in the Eastern Mediterranean-Western Asian (including Caucasus) secondary center of speciation and have Gondwanan ancestors. Some of them, whose ancestors had spread along the mountains of Eastern Africa, reveal connections to the subtropical flora of the South Africa (Goldblatt, 1978, 2002; Jürgens, 1997). In the relatively species-rich genera of the Liliidae of the flora, species of Tethyan origin prevail. Oligotypic genera, whose species have persisted in the exclaves of the Eastern Mediterranean flora on the Caucasian Isthmus, point to the Laurasian or Gondwanan connections of the flora.

### Commelinoids

Order Poales has 415 species in the flora of Armenia.

Juncaceae (17 sp.) and Cyperaceae (103 sp.) are represented mainly by hydro- and hygromesophytic species of temperate and cold regions of the Northern Hemisphere.

Juncaceae, with 12 species of *Juncus* and 5 species of *Luzula*, have Holarctic or Palearctic distribution. There are 2 Arcto-Mountain species of *Luzula* and only one stenochorous Asia Minor-Caucasian species, *L. stenophylla* Steud.

Cyperaceae (103 sp.) has one large genus *Carex* (65 sp.) and several small genera. Most of the species are of large Holarctic, Palearctic, or Atlantic-Mediterranean coastal ranges. There are also several tropic-subtropical (*Cyperus rotundus* L.) species. Many species of *Carex* have Submediterranean (*C. brevicollis* DC.) or Palearctic (*C. vesicaria* L.) ranges, while only 7 species are Ancient Mediterranean (*C. diluta* Bieb.).

Poaceae (300 sp.) is at second place in the spectrum.

The majority of grasses have wide species' ranges in the Holarctic, Palearctic, or the Pontian Steppe province and Ancient Mediterranean. A few tropical genera are represented by subtropical species like *Aeluropus littoralis* (Gouan) Parl., *Arthraxon langsdorfii* (Trin.) Hochst., and *Cynodon dactylon* (L.) Pers. There are several Ancient Mediterranean-Eastern Asian species of shibliak communities like *Bothriochloa ischaemum* (L.) Keng. and 12 southern Palearctic-Paleotropical species in the littoral communities along the river Araks, like *Imperata cylindrica* (L.) Beauv., *Pennisetum orientale* Rich., *Erianthus ravennae* (L.) Beauv. *Stipagrostis plumosa* Munro and *Schismus barbatus* (L.) Thell. belong to the genera centered in South Africa. The largest genera are *Stipa* (20 sp.), with the species ranges in Western

Asian, Pontian or Submediterranean territory, and *Festuca* (18 sp.) of mostly north temperate distribution.

Local Frontal Asian speciation is expressed in the genera *Triticum* (3 endemic Atropatenian sp.), *Secale* (Armeno-Atropatenian *S. vavilovii* Grossh.), and *Aegilops* (*A. persica* Boiss.). The Armenian Highland is known as homeland for several varieties of cultivated grasses of major importance.

## Eudicots

### Order Ranunculales (119 sp.).

Berberidaceae (4 sp.) of the flora is connected to the Sino-Himalayan Subregion. It has one European and two West Asian species of *Berberis* and one isolated West Asian species *Leontice armeniaca* Bñl., a component of a very original gypsum desert complex with *Colutea komarovii* Takht. and *Salsola nodulosa* Iljin.

Papaveraceae (21 sp.), a classical example of the Madro-Tethyan group, contributes three genera very typical to the Tethyan flora. Most archaic tribe, *Chelidoniae* has one Euro-Siberian species of *Chelidonium* and three species of mostly Ancient Mediterranean genus *Glaucium*. In Papavereae, the best represented tribe in Armenia, there are two species of endemic Tethyan genus *Roemeria* and 14 species of *Papaver*. Sister group of relationship of *Roemeria* to *Papaver* sect. *Agremonidium* were well supported (Kadereit et al., 1997). All species of *Papaver* in the flora except one are Ancient Mediterranean. Madrean-Sonoran Papaveraceae is also very diverse (Raven & Axelrod, 1995) and has more endemic species than that in the Tethyan center. Most archaic types however belong to the smaller Eastern Asian center of diversification of Papaveraceae (Kamelin, 1973). Phylogenetic analysis of *Papaver* s. l. (Kadereit et al., 1997) states that *Papaver* arose polyphyletically from within a paraphyletic Eurasian *Meconopsis* in response to Tertiary climatic aridification.

Fumariaceae (9 sp.) has 2 genera in the flora, *Fumaria* with 4 species of wide temperate ranges and *Corydalis* (5 sp.). Each of the species of *Corydalis* is endemic to different mountainous ranges separating the Armenian, Iranian, and Caucasian Highlands. There is one species of a disjunctive range: *C. marschalliana* (Pall. ex Willd.) Pers.

Ranunculaceae (82 sp.), similar to the two families above, belongs to the North temperate Laurasian element and its xerophyllized Tethyan derivatives. The latter seem to have originated in the vast territory of the Ancient Mediterranean on the basis of the East to West migrants from the Eastern Asiatic Region along the northern Tethys Sea. This was possible for the Caucasian Isthmus in the late Pleistocene.

Species of *Aconitum*, *Trollius*, *Actaea*, *Anemone*, *Pulsatilla*, *Ficaria*, *Ranunculus* (31 sp.), and *Thalictrum*, typical to humid and cold North temperate regions, are components of the montane temperate forests, sub-alpine, and alpine meadows in Armenia. They are found in the more humid Caucasian, Euxine, Hyrcanian, or Armenian provinces, where each of them usually has one or two endemic species. There is one exception: a very isolated xerophytic Iranian gypsophyte *Thalictrum sultanabadense* Stapf.

The majorities of species of the more progressive tribe *Delphinieae* in *Consolida*, *Nigella*, and *Delphinium* are found in the arid communities of mountain xerophytes and have Western Asian ranges. The species' ranges of *Adonis* and *Caltha* are similar, while *Delphinium* has a small center of diversification in Armeno-Atropaneno-Zagrosian province (*D. szowitsianum* Boiss.) and a very large one in the flora of China (173 sp.).

### Core Eudicots

#### **Order Caryophyllales** (321 sp.).

Almost all species of Amaranthaceae (incl. Chenopodiaceae) (87 sp.) in Armenia prominently represent the desert xerohalophytic and littoral hydrohalophytic floristic complex of the Irano-Turanian region. The geography of Chenopodiaceae reveals close affinities of the Armenian deserts to the ancient deserts of Central Asia and the deserts of Iran. The majority of ancestral species probably spread to Transcaucasia from Central Asia and the Turanian province during the northern Caspian Sea regression in the Late Miocene. During that period, in Pontian time, as a consequence of the Mediterranean desiccation, the Paratethys began to split up into isolated "land-locked seas" (Rugl & Steininger, 1984). In the beginning of the middle Pliocene there was a sharp decline in the level of the Caspian Sea to 500 m below sea level (Dumitrashko, 1977). Its reservoir was no larger than the Aral Sea and aridisation of climate in the Caspian basin was very intense; the climate was of desert or semidesert type. It is reasonable to assume that an extensive migration of the Turanian desert species to eastern Transcaucasia and Ararat valley occurred during this time as well.

There are 10 out of 30 genera of Chenopodiaceae sensu Takhtajan endemic to Irano-Turanian deserts in the flora of Armenia. They are represented by species endemic to one or another subprovince of the Group of West Asian desert provinces. Most of the genera in the flora are of subfamily *Salsoloideae* with many endemic and subendemic Atropatenian, Iranian, Circum-Hyrcanian and widely Turanian species of *Salsola*, *Halanthium*, *Noaea*, *Seidlitzia*, and *Girgensohnia*. The geographical analysis unequivocally points to their Central Asian connections. This is corroborated by the results of a phylogenetic analysis of *Salsoleae* (Pyankov et al., 2001). The authors reconstruct an origin of *Salsoleae* in Central Asia, from where species of *Salsoleae* dispersed to Europe, Africa, and Mongolia. The *Chenopodioideae* and *Salicornioideae* include species with mostly wide subtropical-temperate ranges in the Palearctic, but there are also species of several endemic Irano-Turanian genera (like *Kalidium* and *Halostachys*).

Caryophyllaceae (152 sp.) has principal centers of diversification in the Mediterranean, West Asia, Himalaya, and West China. The majority of the Caryophyllaceae is restricted to the Ancient Mediterranean Subkingdom. It includes xerophytic species of a number of small young endemic Tethyan genera: *Scleranthus*, *Bufonia*, *Telephium*, *Queria*, *Herniaria*, and *Paronychia*. There are 5 species endemic to the Atropatenian and Iranian subprovinces in the endemic xeric Irano-Turanian genera *Allorchusa* and *Acanthophyllum* (a genus of 50 sp. total). Some of Caryophyllaceae like *Gypsophyla aretioides* Boiss. or *Paronychia kurdica* Boiss., are extreme xerophytes of a highly specialized habitus. Most species of *Arenaria* and *Minuartia*

are endemic to different subprovinces of the Irano-Anatolian territory with 2–3 species of Euro-Siberian ranges. The largest genera *Silene* (34 sp.), *Dianthus* (17 sp.), and *Gypsophila* (13 sp.) reveal a similar arrangement of chorotypes. These genera have rich West Asian or West-Central Asian (*Gypsophila*) lineages and a few Euro-Siberian species each. Besides that, in *Silene* there are 5 Euro-Siberian species. Temperate and boreal genera like *Stellaria* and *Sagina* have fewer species in Armenia; only *Cerastium* has 20 species. They grow in the mesophytic montane meadows at higher altitudes. Some of them have mighty centers in the Eastern Asiatic Region. Flora China (Flora of China, 2001) for example counts 110 species of *Silene*, 64 species of *Stellaria*, and 102 species of *Arenaria*. Old World origin and two waves of dispersal in the Holarctic, in the Miocene and the Quaternary, were suggested for *Cerastium* (Scheen et al., 2004).

Plumbaginaceae (31 sp.) is very peculiar for the flora of the West Asian group of Mountain provinces. All 15 species of the sub-endemic Irano-Turanian genus *Acantholimon* (120 sp. total) in Armenia are endemic to different provinces and subprovinces of that group. Among them are Armenian (*A. calvertii* Boiss.), Atropatenian (*A. sahenticum* Boiss. & Buhse), Anatolia-Atropateno-Zagrosian (*A. caryophyllaceum* Boiss.), and Atropateno-Chorasanian (*A. avenaceum* Bunge) species. The species' ranges of *Limonium* and *Psylliostachys* circumscribe the Western Asian group of desert provinces.

Polygonaceae (42 sp.). The majority of species' ranges in *Rumex* and *Polygonum* are widely Palearctic; only several species are Tethyan (*Polygonum paronychioides* C.A. Mey., *P. luzuloides* Jaub. & Spach). Two small shrubby Irano-Turanian genera, *Atraphaxis* and *Calligonum* are dominants of some xeric (psammophytic *Calligonum polygonoides* L.) and phryganoid (*Atraphaxis spinosa* L.) formations.

Tamaricaceae (9 sp.), a family of subtropical deserts and semideserts of the Old World has two species of an Irano-Turanian-Sacharo-Arabian genus *Reaumuria*, five species of *Tamarix* and one species of *Myricaria*. Most of them are hydrohalophytes of Irano-Turanian litorales with secondary distribution in other temperate deserts.

**Order Saxifragales** (48 sp.) in two families: Crassulaceae and Saxifragaceae.

Almost all 20 species' ranges of Crassulaceae are in the mountains of the Mediterranean-western Frontal Asian and Submediterranean regions. Endemism of Crassulaceae in the western part of Western Asia is related to the vegetation of Submediterranean type. Here are Euxino-Hyrcanian (*Sedum oppositifolium* Sims, *S. gracile* C.A. Mey.), Asia Minor-Caucasian (*S. tenellum* Bieb.), and Caucasian (*S. pilosum* Bieb.) petrophytes and chasmohytes. The species' ranges of *Rosularia* reveal several Eastern Mediterranean floristic refuges across the south Anatolia-Atropateno-Kurdo-Zagrosian mountains (*Rosularia persica* (Boiss.) Berger, *R. elymaitica* (Boiss. & Hausskn.) Berger). While members of Crassulaceae are highly abundant and diverse in East Asia and Himalaya, with 121 species of *Sedum* in the flora of China (Kunjun et al., 2001), distribution pattern of species of the *Sedoideae*, best represented in Armenia, reveals western (mostly Oro-Mediterranean) connections of the flora of Armenia. This pattern is characteristic of Laurasian diversification related

to the Alpine orogeny. Recent phylogenetic studies (Mort et al., 2001) state that Crassulaceae appears to have arisen in southern Africa, from where the family spread northward into the Mediterranean region; from there the family spread to Asia/East Europe and North Europe.

Saxifragaceae (11 sp.) is a Laurasian group with 222 species in the flora of China. In Armenia it includes Euro-Mediterranean (*Saxifraga adscendes* L.), Arcto-Alpian (*S. hirculus* L.), and Sub-Mediterranean (*S. moschata* Wulf.) species. There are several species of the Euxine-Caucasian center of speciation, which is a part of the Oro-Mediterranean floristic belt (*S. cartilaginea* Willd.).

## Rosids

### Order Geraniales

#### Geraniaceae (26 sp.)

The species of *Geranium* (19 sp.) have mostly wide ranges in the western Palearctic, Europe or Euro-Mediterranean (*G. rotundifolium* L.). Several species are sub-endemics of the Caucasian (*G. platypetalum* Fisch. & Mey.) or Hyrcanian (*G. ruprechtii* (Woronow) Grossh.) provinces, which reveals a typical pattern of mesophytic Laurasian element. More xerophytic species of *Erodium* (7 sp.) have more southern ranges in the western half of the Ancient Mediterranean and the Pontian territory. Two of them are endemics of the Armenian subprovince (*Erodium armenum* Woronow and *E. sosnowskianum* Fedorov).

#### Order Myrtales (26 sp.).

Lythraceae (8 sp.) and Onagraceae (18 sp.) have either adventive or hygrophite species of a wide range. *Punica granatum* L. is a rare relictual "preshibliak" species of an eastern Mediterranean-Frontal Asian chorotype.

#### Order Zygophyllales

Zygophyllaceae (3 sp.). A genus of desert and semidesert areas of the Old World, *Zygophyllum* has two species in the flora and is the brightest example of the "flora of *Welwitschia*". *Z. atriplicoides* Fisch. & Mey., an Atropateno-Chorasanian species, dominates in the most interesting xeric shrub and subshrub formations. The species belongs to a group *Atriplicifolia* distributed from South Iranto Balujistan and Fergan valley (Popov, 1927). *Z. fabago* Thunb. represents a widely Central Asian subgenus *Fabago* (22 sp. total) centered in Jungaria. According to Popov, the deserts of Mongolia and Jungaria have an older flora than those of Frontal Asia. Not only have the Central Asian deserts some genera common with South and North Africa, SW Australia and America, but they have some unique groups, like subgen. *Fabago* of *Zygophyllum*.

#### Order Malpigiales

Euphorbiaceae (36 sp., Frontal Asian, some West Palearctic), Linaceae (11 sp., South Palearctic, Pontian-Ancient-Mediterranean), Violaceae (15 sp., Laurasian), Salicaceae (8 sp., Palearctic), Hypericaceae (12; Palearctic, Frontal Asian).

### Eurosids I

Eurosids I are best represented in Armenia and comprise 23% (604 sp.) of the flora. The largest orders are Fabales and Rosales.

**Order Fabales** includes 302 species in Fabaceae (294 sp.) and Polygalaceae (8 sp.).

Best represented are papilionoid genera of the Astragalean, Vicioid and Hedi-saroid clades of the Hologalegina (Wojciechowski et al., 2000). Some herbaceous and cushion plant genera of Fabaceae are very large. Among them there are seven large and middle sized genera, which include 234 out of 294 species of the family. Legumes had diversified during the Early Tertiary (Herendeen et al., 1992) to become cosmopolitan. For papilionoid crown clades, the age range of 40 to 59 Mya was suggested (Wojciechowski, Lavin, and Sanderson, 2004). The largest genus, *Astragalus* (112 sp.) is number one in any Irano-Turanian spectra. More than 80% of its species are stenochorous, and  $\frac{3}{4}$  of them are confined to the Armeno-Atropateno-Zagrosian province. Atropatenian endemics are most numerous, while the rest of the species of *Astragalus* are of Armenian, Anatolian, or Caucasian chorotypes.

Well represented among Fabaceae are Ancient Mediterranean sections of the tribes *Galegeae*, *Trifolieae*, *Hedysareae*, and *Vicieae*. The species of *Argyrolubium*, *Genista*, *Lens*, *Trigonella*, and *Medicago* reveal Mediterranean-Western Asian connections of the flora of Armenia, while the species of *Melilotus*, *Trifolium*, *Coronilla*, *Lathyrus*, and *Vicia* are of wide Laurasian range.

The species of *Vicia* (34 sp.) have different ranges in the western part of temperate and Mediterranean Palearctic. The rate of endemism in Armenia is low and mostly of a Laurasian flora character. The endemics are either of Euxino-Hyrcanian (*V. crocea* (Desf.) Fritsch), high mountain Armeno-Atropatenian (*V. variegata* Willd.), Asia Minor-Caucasian (*V. alpestris* Stev.), or Balkan-Asia Minor-Caucasian (*V. cracca* Labill.) origin. The species of *Trifolium* (26 sp.) have similar ranges. However, it has more Mediterranean species than *Vicia*. Both genera reveal western Palearctic affinities of the flora. To the contrary, in *Colutea*, *Caragana*, *Halimodendron*, *Asrtagalus*, *Hedysarum*, *Onobrychis*, *Alchagi*, and *Cicer* the eastern Ancient Mediterranean species prevail. They dominate a core floristic complex of autochthonous mountain xerophyte's formations, like cushion *Astragalus* species and *Onobrychis cornuta* (L.) Desv. A very peculiar local endemic *Colutea komarovii* (Saghatelyan, 1981) and *Halimodendron halodendron* (Pall.) Voss dominate Turano-Iranian desert formations of gypsophytes and psammophytes.

**Order Fagales** (14 sp.). All of them play important role in the plant cover. The only Frontal Asian species of Juglandaceae, *Juglans regia* L. is a Laurasian relict, co-dominant in the hornbeam-oak forests.

Fagaceae has six species in Armenia. Two of them are relictual: an eastern Mediterranean-Euxino-Hyrcanian *Fagus orientalis* Lipsky and a Mediterranean-western Frontal Asian *Castanea sativa* Mill. All four species of *Quercus* are stenochorous in West Asian. They dominate major forest types at the middle and high mountain belts (*Q. iberica* Steven and *Q. macranthera* Fisch. & Mey. ex Hohen.

respectively). An Atropateno-Zagrosian shrubby oak *Quercus araxina* (Trautv.) Grossh. dominates most xeric oak formation. The Fagaceae of the flora have Eastern Asian and Mediterranean affinities (Menitski, 1984).

Betulaceae, on the contrary, is northern North temperate and has only two species in Armenia: a Euro-Siberian *Betula pendula* Roth in subalpine belt and an Asia Minor-Caucasian *B. litwinowii* Doluch. found only in the northern districts, but better preserved in Georgia. The latter is a component of Eu-Caucasian birch-rhododendron formations (Doluchanov, 1989; Nakhutsrishvili, 1999).

**Order Rosales** (190 sp.) includes Rosaceae (163 sp.), Rhamnaceae (8 sp.), Ulmaceae (5 sp.), Elaeagnaceae (3 sp.), Urticaceae (7 sp.), Cannabaceae (2 sp.), and Moraceae (2 sp.).

Rosaceae (163 sp.) is the 5<sup>th</sup> largest family in Armenia with the wide species' ranges in the Palearctic, especially in the western Palearctic. The species of *Rosa*, *Rubus*, *Fragaria*, *Geum*, and *Filipendula* reveal the temperate European and Submediterranean connections of the flora. Eastern Irano-Turanian and Pontian connections have the species of *Cotoneaster* and *Spiraea*. North temperate genus *Potentilla* is best represented in the mesophyllous centers of the Caucasian Isthmus: the Caucasian, Euxine, and Hyrcanian provinces. The genus *Alchemilla* illustrates a typical high mountain dispersion of the Laurasian element, with many Greater Caucasian species and several endemic species in the mountains of the Colchic Subprovince, Hyrcania, and the Lesser Caucasus. On the contrary, polymorphism of the East Asian-Tethyan genus *Pyrus* (15 sp.) especially to the east and south of the Caucasian Diagonal is a subtropical Ancient Mediterranean feature of the flora. The species of *Sorbus* (12 sp.) and *Crataegus* (12 sp.) have their ranges in the different choria of West Asia, Euxine, Caucasian, and East Caucasian choria as well as one to three species of a temperate European range. Thus, some Rosaceae, of the quercetal complex, genetically bind temperate forests of Armenia with those of the western Palearctic (*Sorbus*), while others with Submediterranean shrub communities (*Rosa*, western; *Cotoneaster*, eastern) or Ancient Mediterranean xeric shrub communities (*Pyrus*, *Amygdalus*, *Cerasus*, *Crataegus*). Genera *Sorbus* (Gabrielyan, 1978), *Cotoneaster* (Kalkman, 2004), *Potentilla*, and *Rubus* have large centers of diversification and endemism in the Sino-Himalayan Subprovince of East Asia. The species of *Sorbus* in Armenia, for example, probably represent both branches of "flora of *Ginkgo*". Most of them are derivatives of its northern, European, or Submediterranean branch, while species like *S. graeca* Lodd. ex Steud., *S. luristanica* (Bornm.) Schonbeck-Temesy, and *S. tamamschjanae* Gabrieljan have West Himalayan and Middle Asian connections and may be derivatives of the southern branch of "flora of *Ginkgo*".

The rest of the Rosaceae reveal connections to the temperate Palearctic and the closest centers of high montane endemism: the Greater Caucasus, Colchis and the Armenian Highland.

Rhamnaceae (8 sp.) has major dominants of secondary xeric shrub communities of Tethyan origin: *Paliurus spina-christi* Mill. and two species of *Rhamnus*. *R. pallasii* Fisch. & Mey. has close species in the eastern Hyrcanian, Pamiro-Alayan and

Hindukush-Himalayan choria (Kamelin, 1979). They all are of an Ancient Mediterranean subsect. *Petrophilae* Grubov, while a Euro-Siberian species of the subsect. *Rhamnus*, *R. cathartica* L., has north temperate affinities with Sino-Japanese and Dauro-Manchzhurian species. There are two relictual species in the flora of Armenia: *Rhamnus microcarpa* Mill. (Euxinian) and *Ziziphus jujuba* Mill. (littoral Eastern-Mediterranean-Eastern Asian disjunctive). A phylogenetic study (Richardson et al., 2000) states, that *Ziziphus* and *Paliurus* make up a strongly supported tribe *Paliureae* with a predominantly southern hemisphere distribution and possibly of Gondwanan origin. This corroborates a hypothesis of a Gondwanan origin for major dominants of xeric shrub and semishrub communities.

## Eurosids II

**Order Brassicales** (202 sp.) in Armenia includes three families, Brassicaceae (195 sp.), Resedaceae (5 sp.), Capparaceae (2 sp.).

Brassicaceae (195 sp.) has its important centers of diversification in the Irano-Turanian region with ca. 150 genera, 900 species, 530 endemic (Appel & Al-Shehbaz, 2003), and the Mediterranean. Armenia has 7 of many endemic Irano-Turanian genera (see: Takhtajan, 1988 : 136). High generic and species polymorphism is congruent with the comparatively recent age of the whole family (Koch et al., 2003) and the taxa native to the Irano-Turanian region. Among medium sized genera of the flora are *Erysimum* (19 sp.), *Alyssum* (16 sp.), *Aethionema* (14 sp.), *Isatis* (13 sp.), *Thlaspi*, and *Lepidium* (11 sp. each) with most species' ranges in the Ancient Mediterranean. Many genera in the tribes *Alysseae*, *Hesperideae*, and others are endemic to different provinces of the Ancient Mediterranean or the Caucasus. Very peculiar of the Caucasian endemic genera are *Coluteocarpus*, *Sobolevskia*, *Didymophysa*, and *Peltariopsis*.

Resedaceae (4 sp.) is especially well represented in the deserts and semideserts of the Ancient Mediterranean-Sacharo-Sindian territory with the center in north and north-east Africa. There are four species in the xeric subshrub communities of Armenia. Two of them are of a Euro-Ancient Mediterranean chorotype (*Reseda lutea* L.); two others are of an Iranian (*R. microcarpa* Mill. Arq. and *R. globulosa* Fisch. & Mey.) chorotype.

Capparaceae (2 sp.), a tropical/subtropical family has only one species each of *Capparis* and *Cleome* in Armenia. Both genera have numerous sections confined to the Old and the New World. It is interesting, that *Capparis* of the Old world lacks close paleotropical allies (Kers, 2003).

**Order Malvales** (37 sp.) includes 3 families.

Cistaceae (8 sp.), a family with the strongest concentration around the Mediterranean area dated back to Upper Miocene (Arrington & Kubitzki, 2003) has 7 species of mostly Ancient Mediterranean genus *Helianthemum* and one Mediterranean species, *Fumana procumbens* Gren. & Godr. They all are phryganoid species and have Mediterranean-Frontal-Asian ranges.

Malvaceae (22 sp.), a primarily tropical family, has mostly weedy species. Frontal

Asian lineages have only *Alcea* (8 sp., 7 of them Armeno-Iranian) and *Malvalthaea transcaucasica* (Sosn.) Iljin. They are all shibliak-phryganoid species. The species' ranges of *Althaea* (4 sp.) are widely Ancient Mediterranean.

Thymelaeaceae (7 sp.), a primarily tropical and subtropical family, has several relict mountain mesophytes like Euro-West-Siberian *Daphne mesereum* L. or Colchis-Caucasian *D. glomerata* Lam. The genera *Thymelaea*, *Diarthron* and *Stelleropsis* have a single species each within Tethyan territory. Divergence and radiation of their Ancient Mediterranean lineages was dated by Middle and Upper Miocene (Galicia-Herbada, 2006).

Order Sapindales (17 sp.) has dominants in the communities of deciduous forests and shibliak that mostly belong to the "Preshibliak" complex. Among them are a few relicts, like *Cotynus coggygia* Scop. (Tethyan), *Biebersteinia multifida* DC. (Tethyan), and *Acer hyrcanum* Fish. & Mey. (Hyrcanian).

Anacardiaceae has only 3 "shibliak" species in the flora, *Rhus coriaria* L., *Cotinus coggygia*, and *Pistacia atlantica* Desf. with West Himalayan-SW-Central China connections. These species are of an Ancient Mediterranean or + Submediterranean (*Rhus coriaria* L.) chorotype and have diminishing regional populations in Armenia.

Biebersteiniaceae (1 sp.) is a very distinct family of only 5 isolated species with vague systematic position (Liu & al., 2001) and disjunctive distribution in the eastern half of the Ancient Mediterranean region. There is one species, *Biebersteinia multifida* in the Atropatenian districts of Armenia. It is confined to hammada and lowland limestone phryganoid communities. Its distribution outline delineates South Anatolian-Iran-Middle Asia-North Afghanistan low mountains of the Irano-Turania. The rest of the species of *Biebersteinia* are distributed as follows: in Tibet, in the north-western China (also close to the Central Asia), in Greece and the Anatolian province. It has been suggested (Kamelin, 1998) that the genus is very old, since the Paleogene, and that it included more species then.

Rutaceae (5 sp.). This largely tropical family has only four Atropatenian xerophytes of a very rich in Iran and Middle Asia genus *Haplophyllum* and one Caucasian species of *Dictamnus* in Armenia.

Sapindaceae (6 sp.). The species of the only genus *Acer* represent Laurasian historic element and are components of mesophyllous quercetal forest communities and their derivatives. They are endemics of different forest choria on the Caucasian isthmus (Euxinian, Euxino-Hyrcanian, Hyrcanian, and East-Caucasian).

Nitrariaceae (3 sp.) are desert xerohalophytes: a south Irano-Turanian *Tetradiclis tenella* Litw., an Ancient Mediterranean *Peganum harmala* L., and a littoral hydrohalophyte of Irano-Turanian-West Central Asian desert range, extending to Sacharo-Arabia, *Nitraria schoberi* L. All three species are only found in true Atropatenian districts of Armenia. The genus *Nitraria* is of an ancient Central Asian arid center (Popov, 1927).

### Euasterids

Both Cornales and Ericales have their greatest centers of contemporary diversity in China and the Himalayas and represent a Laurasian element of the flora.

**Cornales** (3 sp.) has Laurasian relicts: a submediterranean *Cornus mas* L. and Euxino-Hyrcanian *Swida* (2 sp.).

**Ericales.** Represent Lurasian montaine element, relictual in Armenia.

*Diospiros lotus* L. of Ebenaceae and 3 species of Ericaceae: *Rhododendron caucasicum* Pall. and two Holarctic species of *Vaccinium*, are found in only true Caucasian districts of North Armenia.

Primulaceae (28 sp.). *Primula* and *Androsace* are typical examples of Eurasian montane group diversified during alpine orogeny with more than half of the species in the Sino-Himalayan chorion. Most of the species' ranges of the flora of Armenia are disjunctive in different mountain systems of the Palearctic.

### Euasterids I

Boraginaceae (75 sp.) has very remarkable xerophytes from the largest in the family secondary herbaceous tribe *Boraginoideae* concentrated in the Ancient Mediterranean. The diversification of primarily woody tropical taxa is dated by the Mid Cretaceous (Gottschling et al. 2004) with the herbaceous *Hydrophyloideae* and *Boraginoideae* separating 59–56 mya. "Flora of *Welwitschia*" roots were suggested (Popov 1927, 1963) for the genera *Rindera* (1 sp.), *Onosma* (7 sp.), *Cynoglossum* (3 sp.) and other *Boraginoideae*. To the contrary, the species' ranges of *Myosotis* (14 sp.), *Lithospermum* (4 sp.), and *Pulmonaria* have a typical Laurasian flora pattern. The remaining genera have Eastern-Mediterranean-Western Asian (*Arnebia*, *Alkanna*, and *Moltkia*), Submediterranean s. l. (*Echium*, *Nonnea*, *Lappula*), or widely Ancient Mediterranean (*Anchusa*) species' ranges. Several stenochorous species' ranges (*Rindera lanata* (Lam.) Bunge, *Onosma microcarpa* Stev. ex DC.) are typical for the whole group of Western Asian Mountain provinces, while those like an Atropatenian *O. gracilis* Trautv. delineate different provinces of that group. Eastern Frontal Asian species: *Caccinia macranthera* (Banks & Soland.) Brand, *Solenanthus stamineus* (Desf.) Wettst., *S. circinnatus* Ledeb., and *Rochelia cardiosepala* Bunge are most isolated and interesting and tend to the ancient Central Asian arid center. Mostly tropical and warm temperate tribe *Heliotropoideae* has only 8 widely distributed species of *Heliotropium* in the flora.

**Order Gentianales** (76 sp.) has 3 families in the flora.

The Gentianaceae (17 sp.) are of the north temperate tribe *Gentianoideae* and belong to the Sino-Himalayan branch of Laurasian element. They mostly tend to the high mountain-alpine belts and have "true" Laurasian mountain, often disjunctive distribution: Euro-West Siberian, Oro-Mediterranean (*Gentiana ciliata* L.), Caucasian (*G. caucasea* Lodd. ex Sims), or Asia Minor-Caucasian. The genus *Gentiana* has 248 sp. in China (2/3 species of the genus) and 147 sp. in Himalaya. There are 3 Irano-Turanian species of *Swertia* (*S. longifolia* Boiss.) in Armenia, while 150 sp. of *Swertia* (half of the genus) are known in China, and 53 sp. in Himalaya.

Apocynaceae (8 sp.), as a mostly tropical family, has only a few species of warm temperate ranges in Armenia. Interesting are two relictual Mediterranean-Frontal Asian species, *Periploca graeca* L. and *Cynanchum acutum* L.

Rubiaceae (49 sp.), a mostly tropical family, has one large temperate genus *Galium* (31 sp.) in the flora. Many species of *Asperula* and *Galium* have wide ranges in the Palearctic and grow in the mesophyllous forests and meadows. Among 31 species of *Galium*, 17 belong to the Tethyan element (*Galium decaisnei* Boiss.). One genus is endemic for the Irano-Turanian (*Leptunis*), and another for the Ancient Mediterranean (*Callipeltis*) choria. There are a few isolated specialized xerophytes with Gondwanan affinities like *Jaubertia szovitsii* (DC.) Takht., *Asperula glomerata* (Bieb.) Griseb., *Rubia rigidifolia* Pojark., and the species of *Crucianella*.

**Order Lamiales** (307 sp.) includes two large and two small families diversified in the late Cretaceous (Bremer et al., 2004).

Lamiaceae (151 sp.) is represented mostly by Ancient Mediterranean or Submediterranean species and includes several middle sized genera: *Salvia* (19 sp.), *Nepeta* (17 sp.), *Stachys* (16 sp.), with predominance of a Western Asian element (*Salvia hydrangea* DC. ex Benth., *Nepeta trautvetteri* Boiss. & Buhse, and *Stachys inflata* Benth.). The Lamiaceae have their ranges across the different provinces of the Ancient Mediterranean, Caucasian and Euxino-Hyrcanian choria. The East-Mediterranean-Frontal Asian species predominate. However, species of a wider range extending to the Submediterranean are also present. Some genera include several temperate Palearctic forest species (*Stachys sylvatica* L., *Betonica officinalis* L., and *Mentha longifolia* (L.) Huds.). The Lamiaceae are more evenly spread and do not exhibit very high speciation activity, local endemism in particular genera or disjunctive distribution. However, there are very three peculiar species of the endemic Irano-Turanian genera *Eremostachys*, *Hymenocrater*, and *Lagochilus* in the flora.

Scrophulariaceae (140 sp.) has four large genera in the flora. The genus *Verbascum* (29 sp.), represents active contemporary center of speciation in West Asia. In the large temperate Palearctic genera *Veronica* (34 sp.), *Scrophularia* (24 sp.), and *Linaria* (13 sp.) the widespread Eurasian, or Submediterranean species predominate. However, there are several species of Western Asian xerophytic lineages in *Veronica* (*V. persica* Poir. ex Lam.), *Scrophularia* (*S. benthamiana* Boiss. and *S. nachichevanica* Grossh.), and *Linaria* (*L. sypirensis* C. Koch, and *L. lineolata* Boiss.). More mesophytic Caucasian and Euxino-Hyrcanian species are also present (*Scrophularia macrobotrys* Ledeb. and *S. orientalis* L.). The species of several smaller genera have more or less wide distribution in the western Palearctic.

**Order Solanales** (38 sp.) is not peculiar for the flora. Solanaceae (25 sp.) and Convolvulaceae (21 sp. including 13 sp. of *Cuscuta*) have mostly weedy species. Native are three Irano-Turanian hydrohalophytic species of *Lycium*. For Eurasian and Australian species of *Lycium* (Fukuda, Yokoyama, Ohashi, 2001) it was suggested that they originated once from a southern African progenitor.

## Euasterids II

**Order Apiales** includes one large family Apiaceae (130 sp.).

Apiaceae is a very peculiar for the flora family which has its main center of diversification with the largest number of progressive endemic genera in the Ancient Mediterranean. For the Irano-Turanian region 64 endemic genera were listed by Takhtajan (1986: 138); seven of these genera are found in Armenia. The Apiaceae are mostly restricted to the Ancient Mediterranean subdominion or to its different choria. Generic polymorphism and abundance of small genera, including those endemic to different subprovinces testifies their possible recent age. The species of *Pimpinella* (10 sp., the largest genus) along with the species of *Heracleum*, *Ferula*, *Prangos*, *Chaerophyllum*, *Eryngium*, and *Hippomarathrum*, some of which are dominants in the mountain xerophyte vegetation represent a very typical mountain Western Asian and Submediterranean pattern of distribution. The species of many small genera are either stenochorous native or migrants from the north temperate Palearctic.

**Order Asterales** (445 sp.) is the largest in the flora, and includes 2 families: Campanulaceae (30 sp.) and Asteraceae (415 sp.). For the sunflower alliance it was shown (Bremer & Gustafsson, 1997) that ancestral lineages are confined to Malaysia, Australia, New Guinea and New Zealand. "Asteraceae and Campanulaceae represent derived lineages within a larger group with a Cretaceous and East Gondwana ancestry."

Campanulaceae of the flora has a large genus *Campanula* (21 sp.) and a few small Ancient Mediterranean genera with the species in the local centers of diversification. They all belong to the *Campanula* s. str. and *Rapunculus* clades of the porate alliance (Eddie & al., 2003; Shulkina et al., 2003). As suggested by the authors, the group as a whole evolved in the Mediterranean Basin and spread rapidly over the northern hemisphere. The majority species of *Campanula* in the flora of the *Rapunculus* clade have widely Euro-Siberian ranges (*C. rapunculoides* L.), but there are also several local mesophytic subendemic species of the Caucasian (*C. stevenii* Bieb.) or Euxino-Hyrcanian (*C. rapunculus* L. ssp. *lambertiana* (A. DC.) Rech. fil.) choria.

The radiation of the *Campanula* s. str. clade is associated with the European and Cimmerian orogeny and reminds the pattern of many other groups originated in the uplifting mountains in the vast territory from the western Himalaya to Morocco and Spain (like in Primulaceae, *Alchemilla*, Saxifragaceae, Gentianaceae). Flora of Armenia has also several species of the adjacent centers of speciation in *Campanula*, like the Euxinian (*C. alliariifolia* Willd.), a very important center in the Caucasian (*C. collina* Sims), or Armenian (*C. crispa* Lam.) provinces, or the combination of these provinces (*C. stevenii* Bieb.). These species grow at the higher altitudes, and are found especially in the petrophyton or the mountain meadows. Armeno-Iranian species are also present (*C. bayerniana* Rupr., *C. karakuschensis* Grossh., and *C. massalskyi* Fomin). Species' ranges of the oligotypic endemic Ancient Mediterranean genera *Michauxia* and *Asyneuma* are inside the limits of one or another province of the Western Asia. *Michauxia* is a very interesting endemic Western Asian genus with one Iranian species in Armenia (*M. laevigata* Vent.). There are only two Mediterranean species, both found in Armenia recently: *Campanula erinus* L. and *Legousia falcata* (Ten.) Fritsch.

Asteraceae (415 sp.) is the largest family with 80% of its species in the flora endemic to the Ancient Mediterranean. All of them are stenochorous Tethyan xerophytes of the subfamily *Lactucoideae*. Best represented tribes are the *Lactuceae* and *Cardueae*. Western Asia is an arena of contemporary speciation for polymorphic genera (hundreds of species) of those tribes. For *Centaurea* (43 sp.), it is the western part of Western Asia, while the eastern, Middle Asia-Armeno-Iranian part, is the main center for *Cousinia* (19 sp.) and *Lactuceae: Scorzonera* (15 sp.), *Tragopogon* (18 sp.), and *Jurinea* (8 sp.). The widespread genera *Cirsium* (21 sp.) and *Carduus* (9 sp.) have more species of the Palearctic range than the above mentioned genera. However, the Eastern-Caucasian-Armeno-Iranian species of *Carduus* and *Cirsium* (to the south-east of the Caucasian diagonal) are more numerous, some of them like *Cirsium congestum* Fisch. & Mey. ex DC. very impressive.

The majority of the *Centaurinae* are endemic to Western Asia with the prevalence of the Atropatenian element. Several small young genera like *Amberboa*, *Tomanthea*, *Chartolepis*, as well as many species of *Centaurea*, are endemic to the Atropatenian or Armeno-Atropatenian subprovinces. Other species of the *Centaurinae* like *Acroptilon repens* (L.) DC. and *Cnicus benedictus* L. have a wider Mediterranean-Irano-Turanian-Pontian range.

The next subfamily, *Asteroideae* is represented by 4 tribes.

The species of the first tribe, *Eupatoriaeae* reveal a typical "flora of *Ginkgo*" pattern similar to that of all other Euro-Siberian, Arcto-Montane, Euxinian, or Caucasian species in Armenia. They are mostly high montane mesophytes. There is only one middle sized genus *Senecio* (11 sp.) in that tribe.

The tribe *Heliantheae* has only 7 exotic Holarctic or Notarctic species.

In the tribe *Inuleae*, the Submediterranean s. l., Euro-Siberian, and Arcto-Mountain species prevail. There are a few stenochorous species (*Evax anatolica* Boiss. & Heidr., *Helichrysum pallasii* (Spreng.) Ledeb.), and one middle sized genus *Inula* (12 sp.) in that tribe. Most of the species' ranges of *Inula* are in the north temperate regions and only a few of them are restricted to the Caucasus or Irano-Anatolia.

The species of *Anthemideae* are either of local, Euro-Siberian, or Submediterranean s. l. chorotypes. Among the middle sized genera are *Tanacetum* (15 sp.) and *Artemisia* (13 sp.) with several important dominants (*A. fragrans* Willd.).

Thus, the polymorphic and progressive family Asteraceae in the flora is characterized by the high contemporary speciation activity, which is evident not only from the high number of young species, but also from the high number of genera (94 genera on a small land area).

**Order Dipsacales** includes 4 families: *Adoxaceae* (5 sp.), *Caprifoliaceae* (5 sp.), *Dipsacaceae* (25 sp.), and *Valerianaceae* (21 sp.). They represent "Flora of *Ginkgo*" historic element and its Tethyan derivatives.

Best developed in the Himalaya and China family *Caprifoliaceae* has only 5 species of *Lonicera* in the flora. They are of Euxino-Hyrcanian (2 sp.), Hyrcanian, Submediterranean or Middle-Asian-Eastern Caucasian distribution. They seem to be

connected to the two branches of migration from the Sino-Himalayan subregion to the west. In the Tertiary, a number of major Dipsacales clades appeared to have originated during Eocene and within *Caprifolieae* the differentiation into several extant lineages took place (Bell & Donoghue, 2005).

**Dipsacaceae** (25 sp.). The family diversified recently, mostly within 10 mya (Bell & Donoghue, 2005) in semi-arid areas around Mediterranean. The species of the flora have a complex pattern of distribution. The middle and upper altitude forest and meadow mesophytic species of *Dipsacus* and *Knautia* have Submediterranean, Euro-Caucasian, or Caucasian ranges. Species' ranges of more xerophylized *Cephalaria* and *Scabiosa* are in the different South-West-Asian provinces (*Scabiosa persica* Boiss. and *Cephalaria kotschyi*), or in the whole Mediterranean and Irano-Turanian regions.

**Valerianaceae** (21 sp.) dated by the same age as Dipsacaceae, has mostly Western Asian species in Armenia (*Valerianella sclerocarpa* Fisch. & Mey.). There is a species of subalpine meadows, *Valeriana alliariifolia* Adams (Eastern Mediterranean-Euxino-Hyrcanian) and a few Euro-Mediterranean species (*Valerianella carinata* Loisel.). Some Western Asian provinces represent a secondary center of xeric diversification in the Valerianaceae as well as in the Dipsacaceae.

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## РЕЗЮМЕ

Флора Армении – сложное гетерогенное и гетерохронное образование, представляющее результат естественного преобразования двух различных по происхождению и разобщённых экологически флор Палеогена – Лавразии ("флоры Гинкго") и Гондваны ("флоры Вельвичии"). Детальный анализ распространения видов в сочетании с данными по их филогении позволяет выявить следы мезофильной флоры Лавразии в основных современных центрах её сохранения в Китайско-Гималайской (южная ветвь) и Китайско-Японской (северная ветвь) областях. Эти ветви достигли территории Армении с разных направлений, соответственно, с юго-востока и с севера. Ближайшие центры сохранения этих ветвей – Гирканская и Эвксинская провинции. Следующая волна миграции происходила из Центральной Азии и также в палеогене. В верхнем миоцене этот флористический комплекс распространился по гирканскому аридному пути через пустыни Турана, северного побережья Каспийского моря и Ирана, и достиг Восточного Закавказья в середине плиоцена. К этому пустынному центральноазиатскому комплексу принадлежат *Chenopodiaceae*, *Nitraria*, *Zygophyllum*, *Euphorbia* и ряд других групп. В олигоцене по африканскому аридному пути и через Средиземноморье в Переднюю Азию проник другой гондванский элемент (южноафриканского происхождения), а также североафриканский опустыненный комплекс (*Resedaceae*, *Helianthemum*) и собственно средиземноморский элемент (*Asphodeline*, *Legousia*), распространявшийся на восток. Следующая составляющая флоры Армении связана с киммерийским и альпийским орогенезом и имеет корни как во флоре Лавразии (*Saxifraga*, *Gentiana*), так и Гондваны (*Crassulaceae*). Результатом каждой из волн миграции было появление новых филумов, некоторые из которых оказались более приспособлены к новым условиям, а другие, сохраняясь в рефугиумах древних лавразийских мезофильных лесных видов (*Daphne mesereum*), переходили в реликтовое состояние. Ближайшее родство лесная флора Армении обнаруживает с Западным Палеарктисом – Субсредиземноморской и Центрально-Европейской областями (многие *Rosaceae* и *Fabaceae*). Мощный всплеск современного видообразования, имеющего место на территории древнего Тетиса, демонстрируют молодые группы кайнозойского возраста (*Dipsacaceae*, *Brassicaceae*, *Apiaceae* и др.).

Большинство видов флоры Армении являются аборигенными для Древнесредиземноморского подцарства и представляют ксерофилизированные в кайнозое, преимущественно в неогене, производные от древних лавразийских, в меньшей степени – гондванских элементов. Среди однодольных с (во восточно-) средиземноморско-западноазиатским (включая закавказский) вторичным центром видообразования связаны большинство представителей Asparagales (*Asparagus*, *Asphodeline*, Hyacinthaceae, Iridaceae, Colchicaceae, Smilacaceae); эти таксоны имеют гондванские корни. Диверсификация некоторых из них явилась результатом киммерийского и европейского орогенеза (*Ornithogallum*); другие, более древние, тяготеют к остаткам мезофильного Восточно-Средиземноморско-Эвксинско-Гирканского комплекса (*Galanthus*), либо имеют лишь небольшое число молодых кайнозойских линий развития, происходящих из этого центра третичной лесной флоры (*Scilla*). Ярким примером ксероморфогенеза, происходившего на территории бывшего Тетиса, является семейство Alliaceae. Виды из олиготипных родов, относящихся к семействам Liliaceae, Orchidaceae, Melanthiaceae и Convallariaceae, имеют древние лавразийские корни и в Армении являются реликтовыми. Большинство представителей Cyperales и Poales связаны в становлении либо только с Лавразией, либо с Лавразией и Тетисом, и лишь небольшая часть – с Гондваной.

Из двудольных генетически гондванскими являются виды Boraginaceae, Rhamnaceae, Zygophyllaceae, Arosynaceae, *Haplophyllum*, *Jaubertia*, *Rubia*, *Lycium*, *Lactuceae*, *Helichrisum*.

В большинстве крупных родов и семейств доминирует тетисовый элемент. Наиболее характерны в этом плане Papaveraceae, Plumbaginaceae, Caryophyllaceae, Chenopodiaceae, ряд триб Fabaceae, Brassicaceae, Boraginaceae, Lamiaceae, Apiaceae, Crassulaceae, Fagaceae; 80% Asteraceae эндемичны для Древнесредиземноморского подцарства. Лавразийский элемент лучше выражен в Cyperaceae, Juncaceae, Poaceae, Ranunculaceae, Polygonaceae, Geraniaceae, *Trifolieae*, *Vicieae*, Gentianaceae, Betulaceae, Rubiaceae. Некоторые крупные и достаточно древние семейства, такие как Rosaceae, Fabaceae, Poaceae, Scrophulariaceae, представлены смесью различных по происхождению элементов.