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OVERVIEW OF THE FORESTS FLORA OF THE CENTRAL CISCAUCASIA

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This paper considers taxonomic, eco-coenotic, and geographic diversity of the forest flora of the Central Ciscaucasia comprising 735 species of vascular plants belonging to 101 family and 353 genera. The taxonomic structure of the first ten families of forest flora is similar to Ciscaucasian flora. The forests have a European–sub-Mediterranean–Eurasian range of geographic elements with boreal and Caucasian addition. Overall, the development of forest flora of this region and of the East European Plain showed the tendency toward the incubation of the European complex into sub-Mediterranean and boreal types with their gradual displacement.

Key words: *Central Ciscaucasia, forests, flora, taxonomic structure, eco-coenotic group, biomorph, geoelement*

Today, more than 70% of the forest area of the Central Ciscaucasia is concentrated on the Stavropol Upland and at the foothills of the Caucasian Mineral Waters. Its borderline position between the floristic complexes of the Russian Plain and the Northern Caucasia contributed to the enrichment of the Central Ciscaucasian forest flora with sub-Mediterranean, Caucasian and Mediterranean species. These forests are home to 58 threatened and endangered plant species listed in the Endangered Species List of the Stavropol Krai (2002) and the RF (2008) including such species as *Anemone caucasica*, *Asarum caucasicum*, *Erythronium caucasicum*, *Galanthus alpinus*, *Hedera helix*, *Ornithogalum arcuatum* etc. Central Ciscaucasian forests are defined by oak–hornbeam–ash and beech–oak–hornbeam communities. Beech communities only exist on the water divides of the Stavropol Heights, slopes of the Caucasian Mineral Waters and Terek-Sunzha crest. In the ravines of the steppe rivers of the Kalaus Heights there are ravine forests with predominant oak–hornbeam–ash and oak–ash communities. Widespread in the floodplains are oak–poplar and oak–elm–ash communities (Shevchenko, 2013; Shevchenko, Viktorov, 2014). The forests of the Central Ciscaucasia remain as small fragments of a single green belt that in the early Neoholocene spread along the line in the vicinity of the Mt. Elbrus – Stavropol Upland – Yergeni Hills (Grichuk, 1952; Fedorova, 1955; Matishov, Kalmykov, 2013).

The study objective was to carry out taxonomic, eco-coenotic and geographical analysis of the

forest flora of the Central Ciscaucasia.

MATERIALS AND METHODS

The material was collected by the author during field researches on the territory of the Central Ciscaucasia in 2005–2012. The forests were studied using route reconnaissance together with close investigation of flora and vegetation of certain areas. A total of about 3000 herbarium samples were collected. The collected material is currently stored as part of the Moscow Pedagogical State University (MOSP) herbarium.

Herbarium material stored in the funds of the Botanical Institute of the Russian Academy of Sciences (LE), Main Botanic Garden of RAS (MHA), Lomonosov Moscow State University (MW), MGPU (MOSP), Stavropol State University (SPI), Prozritelev and Prave Stavropol State Conservation Area (SMRS), Stavropol Botanic Garden (SBG), North Ossetian State University (SOGU), and Ecological and Botanic Station of the Botanical Institute of RAS (Pyatigorsk) has also been studied.

Species nomenclature is given according to the reports of S.K. Cherepanov (1995), A.S. Zernov, and V.G. Onipchenko (2011).

RESULTS AND DISCUSSION

We understand ***taxonomic structure*** as the ratio between variously ranked taxa. As the materials of our study show, the forest flora of the Central Ciscaucasia consists of 773 species of vascular plants, 735 of those being confirmed by the materials collected by the author personally and the herbarium material collected by other researchers (Shevchenko, Belous, 2013). All the species belong to 101 family and 353 genera, 9 of them are represented by not naturalized adventitious plants.

The presence in the Central Ciscaucasia forest flora of 29 species of vascular plants stated in the literature was not confirmed by field or desktop studies. These species are: *Adiantum capillus-veneris* L., *Equisetum sylvaticum* L., *Dactylis lobata* (Drej.) Lindb. f., *D. polygama* Horvat., *Poa iberica* Fisch. et Mey., *Carex depauperata* Curt. ex With., *Carex leporina* L., *Arum nordmannii* Schott, *Gagea chanae* Grossh., *Puschkinia scilloides* Adams, *Tulipa biebersteiniana* Schult. et Schult. fil., *Polygonum bellardii* All., *Paeonia caucasica* (Schipcz.) Schipsz., *Ranunculus. georgicus* Kem.-Nath., *Corydalis angustifolia* (Bieb.) DC., *Hesperis pycnotricha* Borb. et Degen, *H. sibirica* L., *Cotoneaster racemiflorus* (Desf.) Booth ex Bosse, *Crataegus meyeri* A. Pojark., *Viola selkirkii* Pursh ex Goldie, *Chaerophyllum prescottii* DC., *Melampyrum caucasicum* Bunge, *Orobanche hederae* Duby, *Campanula alliariifolia* Willd., *Anthemis tinctoria* L., *Hieracium acuminatifolium* (Litv. et Zahn) Juxip, *H. stauropolitanum* Juxip, *H. beschtavicum* (Litv. et Zahn) Juxip, *H. medianiforme* (Litv. et Zahn) Juxip. The distribution area of 412 species in the forest flora of the region of interest was made more specific based on field study materials and herbariums of other authors (Shevchenko, 2011; Shevchenko, 2013; Shevchenko, Belous, 2014).

The level of taxonomic diversity of the forest flora of the Central Ciscaucasia can only be assessed by comparing the existing data with the data on species diversity of the adjacent region flora (Fig. 1). Since there are no data on flora species diversity of these forests to compare with, in our work we have to use only the data on species diversity of the entire flora in these regions.

The species wealth and level of flora similarity of the Central Ciscaucasia forests resemble that of flora of East European Russia. Piedmont forests of the Central Ciscaucasia have more Caucasian species in their forest community flora, so we can consider the flora of the Central Ciscaucasia forests as a transitional type between eastern European Russia and Caucasus forest floras.

The basis of forest flora of this region consists of representatives of the phylum *Magnoliophyta* with 703 species of vascular plants (95.6% of the total number of species) (Table 1). 531 species belong to the class of *Magnoliopsida* and 172 species – to the class of *Liliopsida* (72.2% and 23.4%, respectively). The ratio of *Magnoliopsida* species number to that of *Liliopsida* is 3:1.

The study of taxonomic structure also includes the estimation of numerical ratios between flora species and genus composition (the average number of species per genus), between the size of genera and families or directly species and families being part of this flora, because these parameters are relatively stable. For the forest flora of the Central Ciscaucasia the average number of species per family is 7.27:1 and the average number of genera per family is 3.49:1.

An essential feature of every flora is the ratio between the leading families, i. e. the ratio between the numbers of species in different families (Morozova, 2008). Flora comparative analysis most often involves not the whole list but only the first 10–15 main families. Here are the first eleven families (Table 1) in terms of the number of species belonging to the flora studied: *Poaceae*, *Asteraceae*, *Rosaceae*, *Apiaceae*, *Fabaceae*, *Brassicaceae*, *Scrophulariaceae*, *Cyperaceae*, *Lamiaceae*, *Caryophyllaceae*, and *Ranunculaceae*. The species of these families make 53% of the total number of species (390 species).

The studied flora consists of 359 higher plant genera, of which 264 genera belong to the class *Magnoliopsida* and 77 genera – to *Liliopsida* (73.5% and 21.4% of the total number of genera, respectively). A genus has on average 2.05 species of higher vascular plants. For the Ciscaucasian flora on the whole this figure is 3.16 (Ivanov, 1998).

Genus richness of the Magnoliophyta family in the forest flora of interest makes 3.9:1. The largest families by number of genera (Table 2) are *Asteraceae*, *Poaceae*, *Apiaceae*, *Brassicaceae*, *Rosaceae*, and *Lamiaceae*.

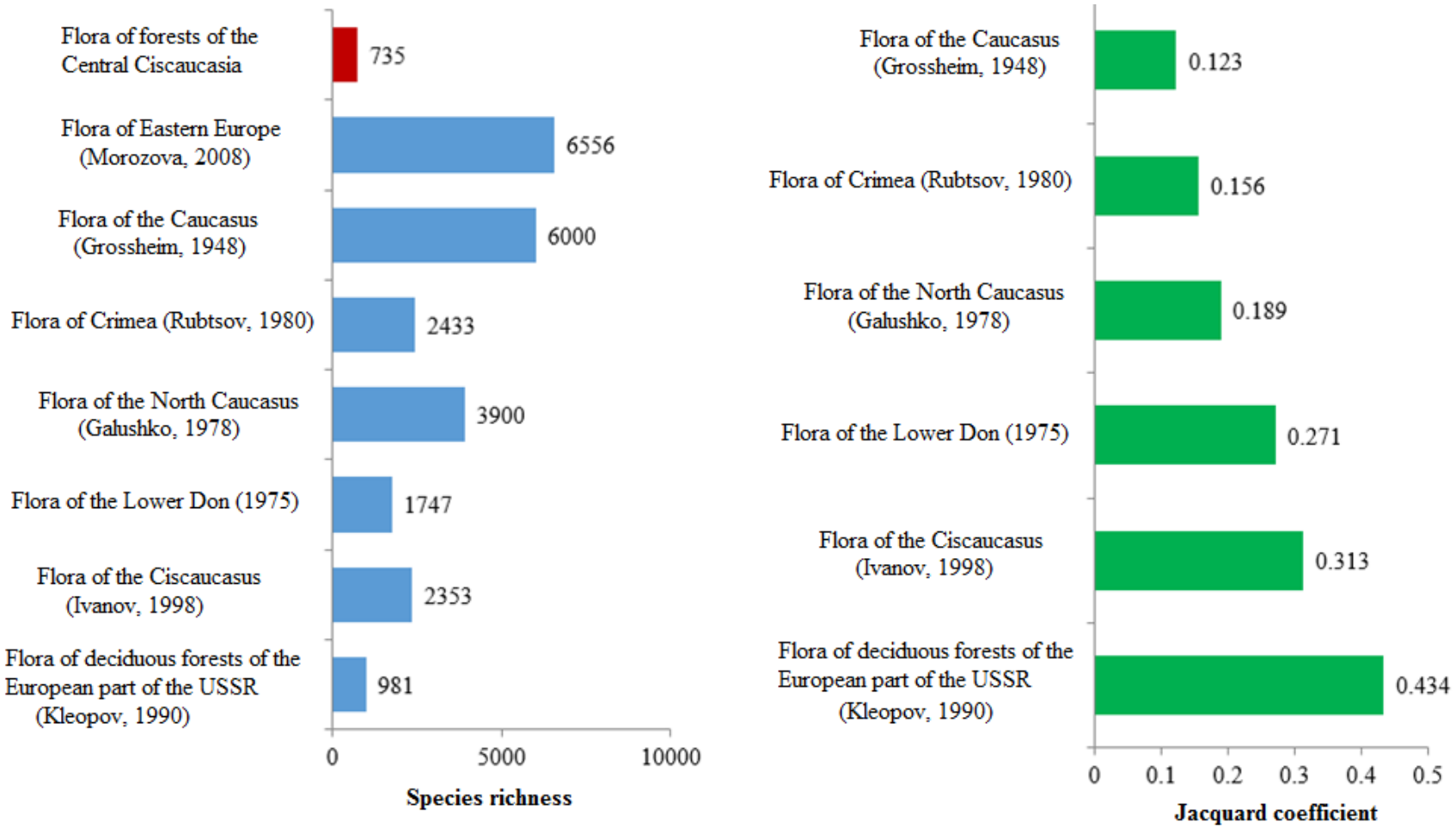

Figure 1. Ratio between the forest flora of Central Ciscaucasia and floras of adjacent regions

Table 1. General ratios of forest flora of the Central Ciscaucasia

Phylum	No. of species	%	No. of genera	%	No. of families	%	ratios	genus coeff.
Lycopodiophyta	1	0.13	1	0.28	1	0.99	1:1:1	1
Equisetophyta	5	0.68	1	0.28	1	0.99	5:1:1	5
Polypodiophyta	22	2.99	14	3.97	8	7.92	3:2:1	1.6
Pinophyta	4	0.55	2	0.57	2	1.98	2:1:1	2
Magnoliophyta	703	95.65	335	94.90	89	88.12	8:4:1	2.1
Total:	**735**	**100.0**	**353**	**100.0**	**101**	**100.0**	**7:3.6:1**	**2.1**

Table 2. Ratio between the ten major forest flora families of the Central Ciscaucasia by species number and genus number*

Seq. No.	family	No. of species	% of the total No. of species	No. of genera	% of the total No. of genera
1.	Poaceae	72	18.5	39	11.0
2.	Asteraceae	67	17.2	40	11.3
3.	Rosaceae	45	11.5	18	5.1
4.	Apiaceae	42	10.8	29	8.2
5.	Fabaceae	37	9.5	15	4.2
6.	Brassicaceae	31	7.9	20	5.7
7.	Scrophulariaceae	27	6.9	8	2.3
8.	Cyperaceae	25	6.4	5	1.4
9.	Lamiaceae	23	5.9	15	4.2
10.	Caryophyllaceae	21	5.4	9	2.5
	Total:	**390**	**53.0**	**198**	**56.1**

Note: * the families are listed in decreasing order according to the number of species.

The ten genera with the greatest number of species in the forest flora are: *Carex* (17 species which makes 2.31% of the total number of species), *Viola* (13/1.77), *Veronica* (11/1.5), *Vicia* (9/1.22), *Geranium* (8/1.1), *Trifolium* (8/1.1), *Potentilla* (7/0.9), *Allium* (6/0.8), *Festuca* (6/0.8), and *Juncus* (6/0.8). The largest 20 genera account for about 20% of the total number of species.

There are no major genera containing 20 or more species each (Ivanov, 1998) in the forest flora of the Central Ciscaucasia. The smallest group is the group of large genera containing 10 to 19 species each.

They account for 41 species (5.5% of the total number of species) divided into 3 genera (0.9% of the total number of flora genera): *Carex* (17 species), *Viola* (13), and *Veronica* (11).

There are 28 (7.9%) medium-sized genera (9 to 5 species) in the forest flora of the region. They are divided by species number as following: 9 species – 1 genus, 8 – 2 genera, 7 – 1 genus, 6 – 11 genera, 5 – 13 genera. In total these genera account for 163 species (22.1%).

In terms of the number of species the forest flora of the region is dominated by species-poor genera (4 to 2 species): 129 genera (36.5%) represented by 338 species (45.9%).

Genera consisting of one species are the most numerous – there are 193 of them (54.6%) but in terms of the total number of species they lag behind – 193 (26.8%). The majority of genera are oligotypic or monotypic except some genera that are relatively rich in the number of species, i. e. *Lilium*, *Melandrium*, *Helleborus*, *Spirea* etc.

The taxonomic composition of the forest flora of the Central Ciscaucasia is diverse. For example, there is a large percentage of big families and genera consisting of one species. The forest flora composition of the largest ten families in the Central Ciscaucasia is similar to that of the Ciscaucasian flora on the whole. The proportions of these families differ, however: the family with the largest number of species is *Poaceae*. More common are such species as *Rosaceae*, *Apiaceae*, *Boraginaceae* and *Orchidaceae*, therefore the forest flora of the region of interest is similar to the forest flora of the East European Plain. The analysis of the species diversity (78.9%) and flora similarity correlation shows that the forest flora of the Central Ciscaucasia is similar to the forest flora of the East European Russia (Jaccard index 0.434). In view of the above, the forest flora of the Central Ciscaucasia can be considered a transitional form between the floras the East European Plain and the Northern Caucasus.

By the ***eco-coenotic structure*** we mean the ratios of flora species numbers in specific communities.

The coenotic composition analysis makes it possible to trace the relationship between flora development, the development of various vegetation types and the set of environmental conditions responsible for the development as well as to understand the unique ways of development of the plant cover of the territory (Tolmachev, 1974; Burda, 1991).

Having analyzed the eco-coenotic structure of the Central Ciscaucasia forest flora, we distinguished five groups of species (Fig. 2): forest, meadow, wetland, steppe and weed (ruderal) plants.

Forest species are by far predominant (332 species, or 45.7%) in the eco-coenotic structure of the flora. They can be found in 74 families, including 12 families (167 species) consisting of more than 10 forest species; 8 families (52) with 5 to 9 forest species; 33 families (92) with 2 to 4, and 21 family (21) with one forest species in each.

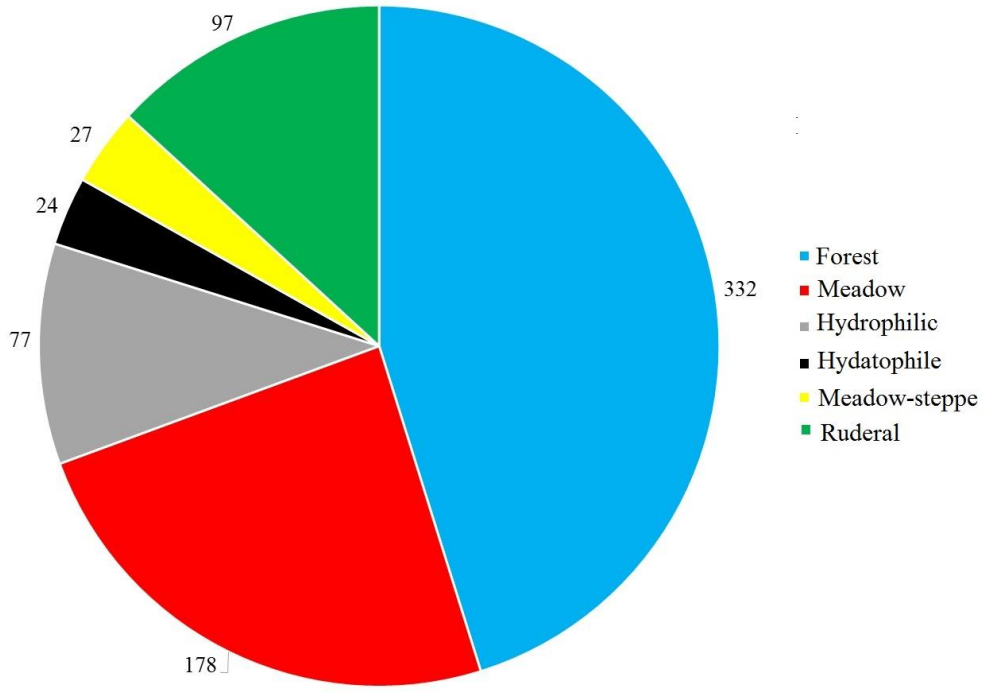

Figure 2. The ratio of eco-coenotic groups in the forest flora of Central Ciscaucasia

Meadow species (178 species, or 24.2%) are prevalent mostly on forest edges and in light forests. They can be found in 42 families and 117 genera. There are 7 (112) families having more than 10 meadow species; 2 (14) – having 5 to 9; 14 (33) – having 2 to 4 and 19 (19) families containing 1 species each. Meadow species include 26 subalpine ones (14.6%). For example, these are *Lilium monadelphum*, *Dactylorhiza flavescens*, *Trifolium caucasicum*, *Bupleurum falcatum*, *Heracleum wilhelmsii*, *Rhododendron luteum*, *Cicerbita macrophylla* etc.

Speaking about species living in or near the water, there are 101 species (13.8%), belonging to 30 families and 48 genera. There are 2 families with more than 10 species each (27 species in total); 5 families with 5 to 10 species each (29 species in total); 14 families (37 species) with 2 to 4 species and 9 families (9 species) with only 1 species in each. This group of species can be divided into three subgroups: hygrophile, hydrophilic and hydatophile.

Hygrophile species (77 species, or 76.3% of the total number of aquatic and semi-aquatic species) grow in habitats with increased soil moisture: *Mycelis muralis*, *Petasites albus*, *P. hybridus*, *Tussilago farfara*, *Salix alba* etc.

Species of the hydrophilic subgroup are represented by 8 species inhabiting banks of water bodies (7.8%): *Carex hordeistichos, Eleocharis acicularis*, *Polygonum amphybia*, *Ranunculus repens* etc.

Hydatophile species (16 species, or 15.7%) grow in water or float on its surface: *Lemna minor*, *Nuphaea alba*, *Potamogeton crispus* etc.

It is very rarely that we find singular specimens of meadow and steppe plants (27 species, or 3.6%) on forest edges, in light forests and transitional communities with highly heterogeneous growing conditions: *Agropyron pectinatum*, *Eragrostis minor*, *Crocus speciosus*, *Cotinus coggygria* etc.

Ruderal (weed) species, just like the steppe ones, are more often seen in communities with highly heterogeneous growing conditions, i. e. along forest roads, edges, ditches etc. These species are *Urtica dioica*, *Sclerochloa dura*, *Cannabis ruderalis*, *Chenopodium album*, *Ambrosia artemisifolia* etc.

The eco-coenotic structure of the Central Ciscaucasia forest flora is very diverse. Forest species here dominate not only in terms of the number of species, but also in terms of their role in the structure of forest communities. Other eco-coenotic groups mostly play second fiddle. By and large, the eco-coenotic structure of the regional flora is similar to the flora structure of broad-leaved forests of the Eastern Europe (Kleopov, 1990).

As far as is known, a ***plant life-form*** (***life form***) emerged historically and reflects the adaptation of plants of certain groups to environmental conditions. Life forms diversity in a plant community and the ensuing complexity of synusial composition of the latter ensure the full scale use of the living resources of the habitat by living beings, more or less sustainable maximum of plant products and the largest environmental impact, i. e. biogenic transformation of the environment. Biomorphological structure of each flora shows adaptation capabilities of the species making it (Shevchenko, Belous, 2008).

The bases of our studies are represented by two classification systems of life forms: the one by C. Raunkiær (1905) and the one by I.G. Serebryakov (1962).

The biomorphological system by C. Raunkiær (Fig. 3) considers a life form as a set of adaptive traits and a way of protecting plant vegetation buds during the adverse season in the first place. The range of life forms typical for the forest flora of the region of interest consists of five plant form groups with various ratios in terms of both the number of species and their significance in the structure of plant communities. The majority of flora species are herbaceous plants (638 species, or 86.8%). Trees, shrubs and dwarf semishrubs (phanerophytes + chamaephytes) are represented by 97 species (13.2%).

The analysis shows a relatively high percentage of therophytes (16.6%) that can be attributed to a large number of synanthropic elements in the flora of interest. The majority of these species, however, grow as singular plants only in places badly damaged by man-induced impact (along the roads and paths, near localities etc.).

The percentage of chamaephytes is rather small (8.2%). The leading position in plant communities is held by hemicryptophytes (32.5%). The ecological structure of this group implies the presence of not only forest and meadow but hygrophile and weed groups as well.

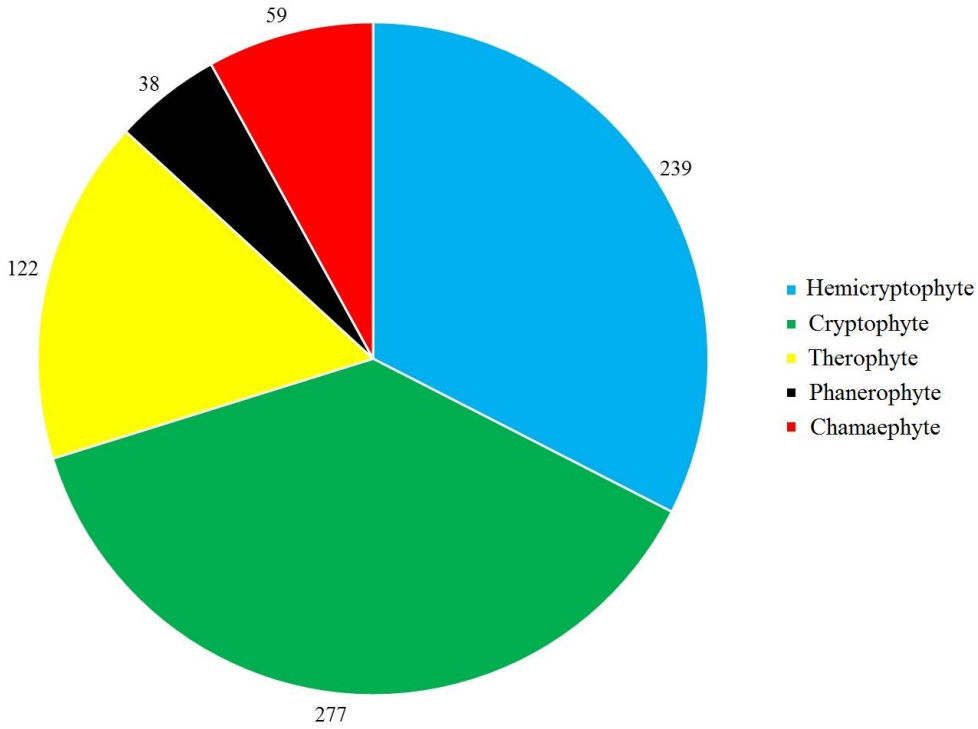

Figure 3. Distribution of life forms of the Central Ciscaucasia forest flora (according to C. Raunkiær, 1905)

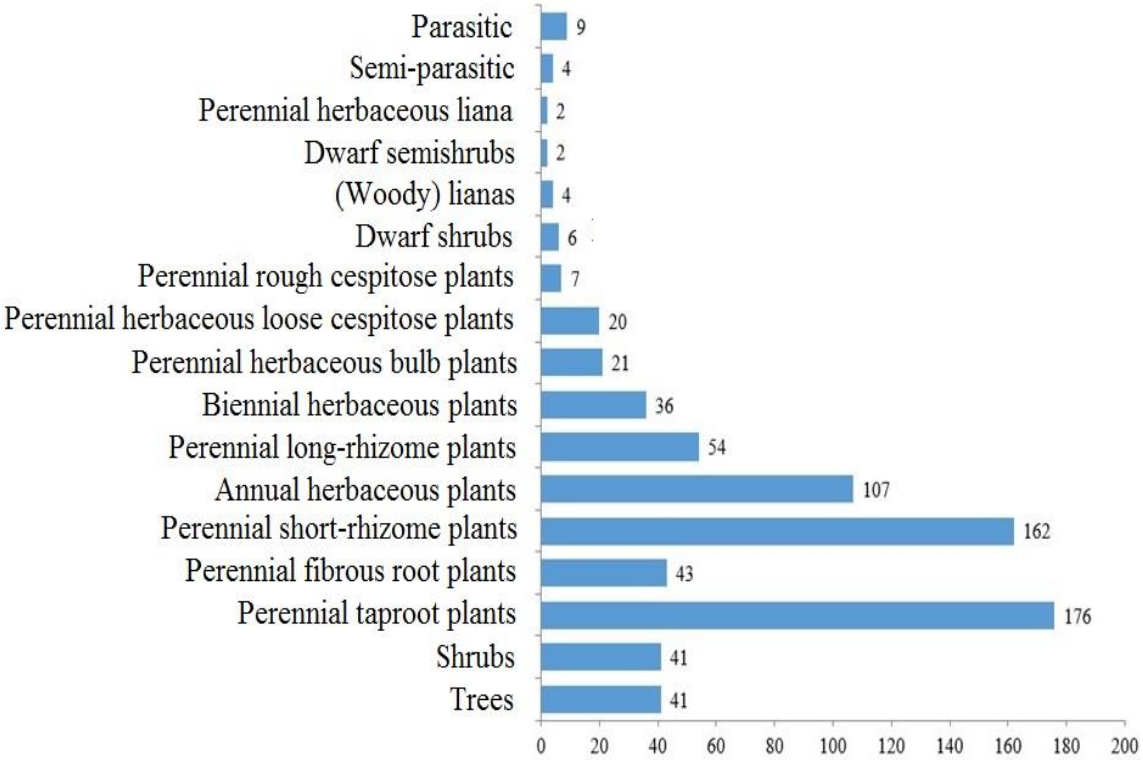

Figure 4. Distribution of biomorphs of the Central Ciscaucasia forest flora (according to I.G. Serebryakov, 1962)

The structure of life forms according to I.G. Serebryakov shows (Fig. 4) the predominance of herbaceous polycarpic plants (485 species, or 65.9%), among which the most numerous ones are taproot plants (23.4%), followed by short-rhizome (22%), long-rhizome (7.3%), fibrous root (5.8%) and bulb species (2.8%). Herbaceous monocarpic plants include 156 species (21.2%), predominantly biennial (4.8%) and annual plant species (14.5%).

Woody plants include 92 species (12.5%) with the equal number of trees and shrubs. Dwarf semishrubs are only represented by two species.

The ratio between woody and herbaceous plants in the forest flora of the Central Ciscaucasia fully conforms to its zonal location.

Geographical pattern is the distribution of the species of this flora by groups based on their area similarities. Flora geographical analysis makes it possible to trace a connection between the species included and is also important for florogenesis research (Novosad, 1992; Shevchenko Belous, 2009).

The issues of area studies and fundamental principles of defining geographical elements are set forth in the works of Ye. V. Vulf (1933), A. I. Tolmachev (1974; 1986), G. Walter (1975), B. A. Yurtsev (1987) etc. Depending on the study objectives, different classification systems are used. Their choice is specified by the type of flora material itself and study and research tasks.

A wide variety of geographical systems based on different concepts and views were developed for Caucasus (A. A. Grossgeim (1936; 1948), A. L. Kharadze (1966), R. I. Gagnidze (1976), A. I. Galushko (1976), A. A. Sagatelyan (1997), N. N. Porteniera (2000) etc.).

The basis of the geoelement system of the forest flora of the Central Ciscaucasia is the system proposed by Yu. D. Kleopov (1990) who suggested defining geoelements with the use of parameters describing the shape of the species area and its large fragments and leaving aside peripheral parts where the species becomes more rare or not typical. This geoelement system proved effective during Yu.D. Kleopov's studies of broad-leaved forests flora of the European part of the USSR. This system is rather flexible and easy to use.

We found a total of 27 subtypes forming 13 types of geoelements as part of the forest flora of the Central Ciscaucasia (Fig. 5).

The European type is clearly the predominant one being the basis of the entire forest flora. The main element here is the European one per se followed by the West European, then disjunctive European and only then – Central European. At the same time, Central European and West European elements are not a permanent part of forest communities.

The European type is followed by the sub-Mediterranean, Eurasian and boreal elements. Since the plants belonging to sub-Mediterranean and boreal species are mostly light-requiring and the main

body of the modern forest flora of the Central Ciscaucasia (European and Eurasian types) is represented by more or less shadow-requiring types, it can be believed that the entire flora evolution of these forests had a tendency toward the incubation of the European complex into the sub-Mediterranean and boreal types with their gradual displacement. Speaking about the steppe nomad type, its share in the absolute spectrum is a small one (1.5%). These species can be mostly found in transition communities, in the clearings in the woods as well as in light woods and openings.

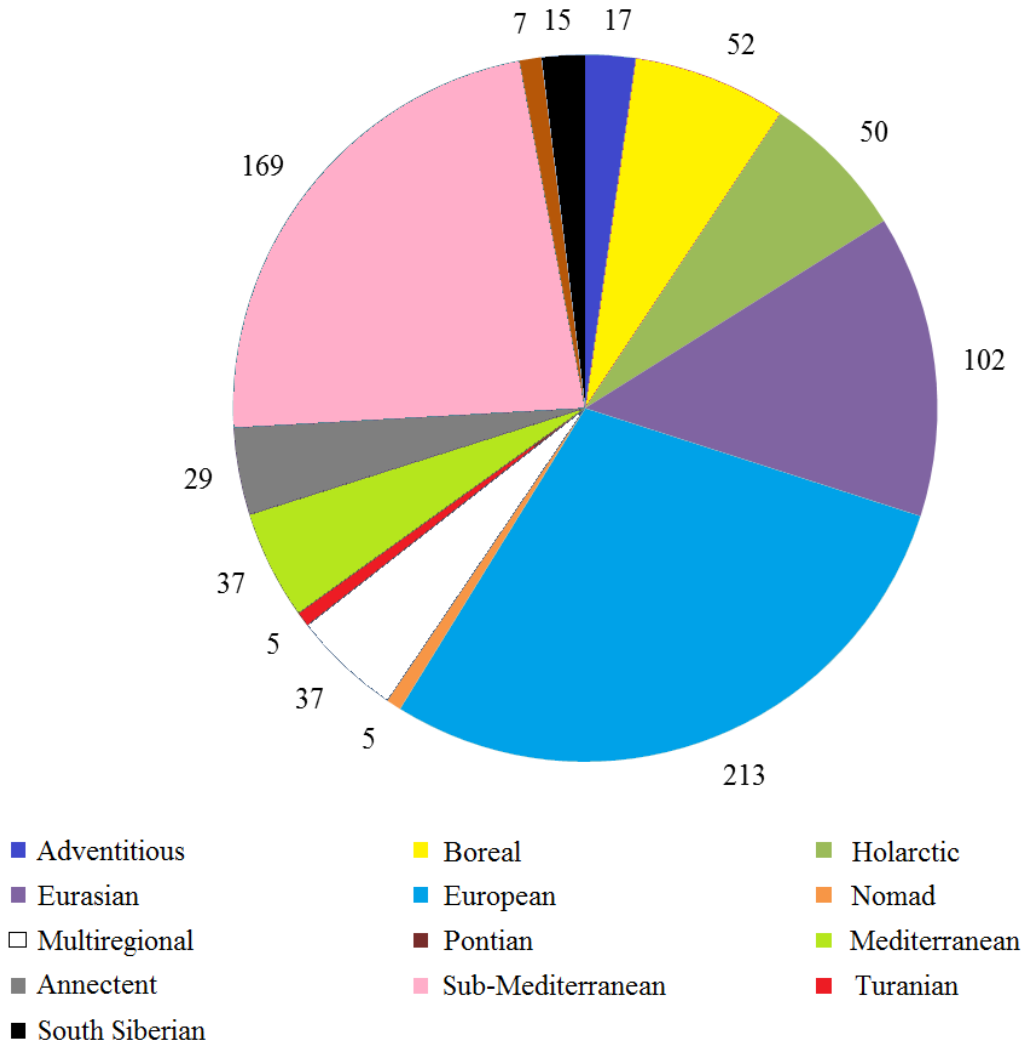

Figure 5. Distribution of geographical elements of the forest flora of the Central Ciscaucasia

A meaningful role in the geographical spectrum of the flora studied is played by eurychoric species, i. e. Eurasian (palearctic), Holarctic and multiregional. They include meadow, semi-aquatic and half-ruderal species. The most numerous of the above is the group of Eurasian species which are the basis of Eurasian middle latitudes flora.

On the whole, the forests of the Central Ciscaucasia are characterized by European–

sub-Mediterranean–Eurasian geographical elements with a boreal and Caucasian addition. We can agree with Yu. D. Kleopov that the main formative factor for the forest flora of the Central Ciscaucasia as well as for the forests of the East European Plain is the competition between shade-requiring and light-requiring floristic complexes, the latter being to a large extent represented by more thermophilic groups (sub-Mediterranean and Mediterranean) and by more cold-hardy plants (boreal и South Siberian species).

CONCLUSION

Despite the fact that the territory of the Central Ciscaucasia has an extremely low level of forest cover and woodland area its compound relief and the combination of natural and climatic factors contributed to development of rich flora. The study of these forests has special scientific value since they are the remains of a single woodland which covered a large part of this region and was linked to the forests of the East European Plain which is confirmed by noticeable flora similarity and close taxonomic structure of the forest flora of these regions.

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