Dandroflora species distribution by floristic areas and altitude belts

Z I Iriskhanova¹, A A Ataeva², Z N Amalova¹, H R Hanaeva³ and M K Dakieva⁴

¹ Department of Botany, Zoology and Bioecology, Chechen State University
² Department of General and Inorganic Chemistry, Grozny State Oil Technical University named after Academician M.D. Millionshtchikov
³ Department of Biology and Teaching Methods, Chechen State Pedagogical University
⁴ Department of Biology, Ingush State University

E-mail: pk@chesu.ru

Abstract. Any floristic study, which gives an idea of the total number of species, is based on the distribution of flora by genera, families, orders, classes, etc. More than 2000 plant species grow in the Chechen Republic, which belong to 88 families and 460 genera. The republic is characterized by the alternation of different plant species from north to south. This paper analyzes the distribution of dendroflora species in the floristic regions of the Chechen Republic. The composition of wild representatives of dendroflora is peculiar and original and remains little studied. The analysis is based on the processing of herbarium materials and field observations.

1. Introduction

The flora of the Chechen Republic is characterized by its diversity of environmental species. The following types of habitats are found in the studied territory: rocks and slides, slopes of high mountains, semi-arid slopes of middle altitude, coniferous and deciduous forests, slopes of plains and foothills, sands, water bodies and swamps, pebble gravel, weed plants.

Zonality is an important feature of the mountain landscape. The steppe belt has the largest number of species – about 800 species, the forest belt has 700 species, and the subalpine belt – about 400 species. The oreoxerophyte belt and alpine belt account for the least number of species.

The variety of a relief, climate and soil determined a wide variety of vegetation cover in the republic. Its distribution is subject to the laws of horizontal and vertical zonality.

Almost the entire territory of Tersko-Kumskaya lowlands represents the semi-arid zone. It is characterized by highly sparse vegetation cover with a harsh prevalence of xerocolous and drought-resistant vegetation [1].

The flora of Tersky sand massif is interesting and diverse. Stabilized sands with typical fodder plants serve as beautiful pastures are: Siberian spruce, sheep fescue, blue lucern, etc. [7].

The forest steppe occupies the Chechen plain, which is adjacent to the Black Mountains. The forest that used to grow in this territory is cut down. Now there is a forest steppe, open spaces are covered with Christ-thorn, buckthorn, oak, cotoneaster. On the Tersk Ridge there are ravine forests with oak, field maple, elm.

The lower parts of the Black Mountains are covered with low forest having various wild fruit trees: apples, pears, cornel, plum. On wet areas there are elms, poplars, alders. The height is dominated by beech and mixed beech-hornbeam forests with some elm, linden, ash trees. The population here is
harvesting ramson, the reserves of which are depleted. Oak forests occupy a large territory in the
middle mountains, among other wood breeds the most typical are field maple, ash, hornbeam, 
Caucasian linden, hazelnut, rhododendron, etc.

Above the forest belt there is the subalpine belt between the heights of 1800 and 3800 m. High-
mountain climate contributes to long and splendid blossom. The flowering of subalpine meadows
begins in July.

The alpine belt occupies the highest mountain strip in the vegetation cover of Chechnya. It lies
above 2300–2500 m above sea level. There are mostly short grass meadows compared to the subalpine
belt [7].

2. Object and methodology
The object under study is flora of trees and shrubs of the Chechen Republic.

The analysis of materials of field expeditions of 2009–2017, literary data of previous studies was
carried out (Iriskhanov, Ivanov, 2009). All herbal material was defined by I.S. Kosenko,
A.I. Galushko. The herbal fund of Stavropol State University (SPI, A.I. Galushko, A.L. Ivanov, etc.),
Chechen State University, Stavropol Botanical Garden (SBG) was processed.

3. Floristic zoning
In terms of its phytogeographical aspect the analyzed area is characterized by four floristic provinces
(Figure 1). In this work we used the system of floristic zoning for the North Caucasus adopted by
A.I. Galushko (1978). For Fore-Caucasus this system is accepted by A.L. Ivanov (1998) and for the
territory of the Russian Federation – by R.V. Kamelin (2004). The scheme of florogenetic areas of
North Caucasus corresponds to the boundaries of the areas.

I. Pontian Province
M – Mosdok district
II. Turan Province
KN – Kara-Nogai district
Kizl – Kizlyar district
III. Caucasus Province
TS – Tersko-Sunzhenskiy district
ChO – Chechen-Ossetian district
Ch – Chechen district
US – Upper Sunzhenskiy district
IV. Dagestan Province
BN – Braguno-Novolak district

This territory is divided into 9 districts. Each area is characterized by its own species composition.
The floristic district Mosdok (M) has 46 species, the specific species include Salix acutifolia. These
are species such as: Ephedra distachia, Salix triandra, Salix alba, Populus alba, Populus hybrida,
Alnus glutinosa, Ulmus suberosa, Halimione verrucifera, Campchorosma monspeliaca, 
Campchorosma lessingii, Kochia prostate, Suaeda microfylla, Salsola laricina, Salsola dendroides,
Herniaria besserii, Clematis orientalis, Purus calicifolia, Mespilus germanica, Crataegus ambigua,
Rosa pimpinellifolia.

The floristic district Kara-Nogai (KN) has 69 species, the specific species include: Populus
sosnovskyi, Astragalus lehmannianus, Astragalus Brachylobus, Astragalus Varius, Astragalus
Karakanus, Solanum persicum, Asperula graveolens.

The floristic district Kizlyar (Kizl) has 68 species; the specific species include: Alchagi
pseudoalchagi, Nitraria schoberi, Tamarix meyeri, Tamarix Laxa, Tamarix Hohenackeri. These are
such species as: Ephedra distachia, Salix caspica, Salix triandra, Salix alba, Salix fragilis, Populus
alba, Populus hybrida, Populus nigra, Ulmus suberosa, Halimione verrucifera, Campchorosma
monspeliaca, Campchorosma lessingii, Kalidium foliatum, Kalidium capsicum, Halostachis
belangeriana (Соляноколосник каспийский), Halocnemum strobilaceum.
The floristic district **Braguno-Novolak** (BN) includes trees and shrubs composed of 76 species, the specific species include: *Capparis herbacea*, *Rosa elasmocantha*, *Caragana mollis*, *Astranthia caucasica*, *Rhus coriaria*, *Hedera pastuchovi*, *Fraxinus parviflora*. These are such species as: *Ephedra distachia*, *Ephedra procera*, *Salix caprea*, *Salix cinerea*, *Salix purpurea*, *Salix wilhelmsiana*, *Salix alba*, *Populus nigra*, *Carpinus caucasica*, *Corylus avellana*, *Betula pendula*, *Alnus incana*, *Quercus robur*, *Quercus petrea*, *Ulmus glabra*, *Ulmus sukaczovii*, *Celtis caucasica*, *Calligonum aphyllum*, *Camphorosma lessingii*, *Kochia prostrate*, *Crataegus lathyrifolia*, *Crataegus orientalis*.

The floristic district **Paleo-Dagestan** (PD); the specific species include: *Cotoneaster suavis*, *Artemisia fruticulosa*. There are 21 species: *Berberis vulgaris*, *Spiraea hypericifolia*, *Prunus caucasica*, *Rubus caesius*, *Rubus pimpinellifolius*, *Rosa canina*, *Rosa corymbifera*, *Rosa balsamina*, *Rubus spinosus*, *Prunus divaricata*, *Cerasus incana*, *Colutea orientalis*, *Astranchia aurea*, *Crataegus monogyna*, *Euonymus europaea*.

The floristic district **Tersko-Sunzhenskiy** (TS) has 45 species: *Ephedra distachia*, *Salix caprea*, *Halimione verrucifera*, *Camphorosma monspeliaca*, *Kochia prostrate*, *Herniaria besseri*, *Clematis lathyrifolia*, *Pyrus caucasica*, *Malus orientalis*, *Mespilus germanica*, *Crataegus pentagyna*, *Crataegus curvisepala*, *Crataegus monogyna*, *Rubus caesius*, *Rosa pimpinellifolius*, *Rosa canina*, *Rosa corymbifera*.

The floristic district **Chechen-Ossetian** (ChO) has 68 species, the specific species include: *Betula pubescens*, *Viscum album*, *Rosa jundzillii*. These are: *Huperzia selago*, *Salix caprea*, *Salix cinerea*, *Salix caucasica*, *Salix purpurea*, *Salix alba*, *Salix fragilis*, *Populus hybrida*, *Corylus avellana*, *Betula pendula*, *Betula pubescens*, *Alnus glutinosa*, *Alnus incana*, *Quercus robur*, *Quercus petrea*, *Fagus orientalis*, *Ulmus glabra*, *Ulmus sukaczovii*, *Viscum album*, *Kochia prostrate*, *Cydonia oblonga*, *Pyrus caucasica*, *Malus orientalis*, *Mespilus germanica*, *Crataegus pentagyna*, *Crataegus curvisepala*, *Crataegus monogyna*, *Rubus caesius*, *Rosa pimpinellifolia*, *Rosa canina*, *Rosa balsamina*, *Rosa boissieri*, *Rosa jundzillii*, *Prunus spinosus*, *Prunus divaricata*, *Amygdalus nana*, *Armeniaca vulgaris*, *Euonymus europaea*, *Acer platanoides*, *Rosa pimpinellifolia*, *Paliurus spin-christi*.

The floristic district **Chechnya** (Ch) has 111 species, the specific species include: *Taxus baccata*, *Pinus sosnowskyi*, *Salix aegyptiaca*, *Ostrya carpinifolia*, *Quercus dalechampii*, *Ribes orientale*, *Grossularia reclinata*, *Sorbus torminalis*, *Rubus candidans*, *Euonymus latifolia*, *Acer laetum*, *Tilia platyphyllos*, *Vaccinium arctostaphylophora*, *Asperula alpina*.

The floristic district **Upper Sunzhenskiy** (US) is the richest – 132 species; the specific species include: *Salix arbuscula*, *Salix pontosericea*, *Salix hastate*, *Salix excels*, *Salix pentandroides*, *Salix kazbekensis*, *Quercus iberica*, *Celtis glabrata*, *Herniaria caucasica*, *Saxifraga subverticillata*, *Saxifraga meyeri*, *Saxifraga pseudoleavies*, *Saxifraga scleropoda*, *Sorbus migarica*, *Sorbus fedorovii*, *Pentaphylloides fruticosa*, *Rosa oxyodon*, *Rosa Buschiana*, *Rosa Dunalis*, *Cerasus incana*, *Padus avium*, *Astranchia aurea*, *Astranchia denudate*, *Cotinus coggyria*, *Rhamnus tortuosa*, *Helianthemum nummularium*, *Rhododendron caucasicum*, *Rhododendron vitis-ideas*, *Vaccinium myrtillus*, *Teucrium orientale*, *Scutellaria leptostegia*, *Scutellaria raddeana*, *Scutellaria oreophila*, *Hyssopus angustifolius*, *Thymus nummularius*, *Asperula dasyancha*, *Linnaea borealis*.

The floristic wealth is the number of species typical for a certain territory. The statistical comparison of identified floristic areas characterizes or refutes the validity of this fact.

In modern floristics, the issues of comparative study of quantitative characteristics – flora species wealth – are relevant and covered in literature [3–5, 8; 13–17, 19].

Several similarity coefficients are used in floristic-systematic studies [4].

The most commonly used index of floristic similarity is the Jaccard index [19]:

$$K_j = \frac{c}{a+b-c},$$

where $a$ – number of species of one area, $b$ – number of species of another area, $c$ – number of species common to the two floras.

The Sorensen-Čekanovsky formula discovered in 1913 is equally relevant and informative [19]:

$$K_{sc} = \frac{2c}{a+b},$$

where $a$ – number of species of one area, $b$ – number of species of another area, $c$ – number of species common to the two floras.
common to the two floras.

A comparative analysis of floristic composition of trees and shrubs of the studied districts of the Chechen Republic was carried out on the basis of the calculation of Jackar and Sørensen-Čekanovsky similarity coefficients (Tables 1 and 2). The dendrites (Figures 3 and 4) illustrate the maximum correlation path (algorithm) – Tables 1 and 2, on the basis of which the correlation pleiades of different levels.

Table 1. Group of common representatives (c) and numerical total component of floristic composition (d) of trees and shrubs of the Chechen Republic

|     | M   | KN  | Kizl | BN  | PD  | TS  | CHO | CH  | US  |
|-----|-----|-----|------|-----|-----|-----|-----|-----|-----|
| M   | M   | KN  | Kizl | BN  | PD  | TS  | CHO | CH  | US  |
| 51  | 118 | 117 | 125  | 70  | 94  | 117 | 160 | 181 |
| M   | M   | M   | M    | M   | M   | M   | M   | M   |
| KN  | M   | KN  | Kizl | BN  | PD  | TS  | CHO | CH  | US  |
| 41  | 74  | 140 | 148  | 93  | 117 | 140 | 183 | 204 |
| KN  | KN  | KN  | KN   | KN  | KN  | KN  | KN  | KN  | KN  |
| Kizl| M   | KN  | Kizl | BN  | PD  | TS  | CHO | CH  | US  |
| 40  | 55  | 71  | 147  | 92  | 116 | 139 | 182 | 203 |
| Kizl| Kizl| Kizl| Kizl | Kizl| Kizl| Kizl| Kizl| Kizl| Kizl|
| BN  | M   | KN  | Kizl | BN  | PD  | TS  | CHO | CH  | US  |
| 28  | 34  | 36  | 79   | 100 | 124 | 147 | 190 | 211 |
| BN  | BN  | BN  | BN   | BN  | BN  | BN  | BN  | BN  | BN  |
| PD  | M   | KN  | Kizl | BN  | PD  | TS  | CHO | CH  | US  |
| 18  | 19  | 18  | 19   | 24  | 69  | 92  | 135 | 156 |
| PD  | PD  | PD  | PD   | PD  | PD  | PD  | PD  | PD  | PD  |
| TS  | M   | KN  | Kizl | BN  | PD  | TS  | CHO | CH  | US  |
| 26  | 26  | 26  | 24   | 20  | 48  | 116 | 159 | 180 |
| TS  | TS  | TS  | TS   | TS  | TS  | TS  | TS  | TS  | TS  |
| CHO | M   | KN  | Kizl | BN  | PD  | TS  | CHO | CH  | US  |
| 24  | 25  | 30  | 26   | 20  | 43  | 71  | 182 | 203 |
| CHO | CHO | CHO | CHO  | CHO | CHO | CHO | CHO | CHO |
| CH  | M   | KN  | Kizl | BN  | PD  | TS  | CHO | CH  | US  |
| 20  | 22  | 25  | 25   | 20  | 41  | 56  | 114 | 246 |
| CH  | CH  | CH  | CH   | CH  | CH  | CH  | CH  | CH  | CH  |
| US  | M   | KN  | Kizl | BN  | PD  | TS  | CHO | CH  | US  |
| 19  | 22  | 23  | 27   | 22  | 38  | 54  | 92  | 135 |
| US  | US  | US  | US   | US  | US  | US  | US  | US  | US  |

The common correlation pleiad in dendrite (Figure 1) is formed by all areas on the basis of a minimum bond (0.297).

4. Conclusions

Isolation of lower correlation pleiades is accompanied by the separation of areas (Table 3).

For Bragun-Novolak district (BN) is characterized by the lowest level of correlation, so from the common pleiade it is split off first. Then there are two pleiades: Kara-Nogai (KN) – Kizlyar (Kizl) – Mosdok (M) and Paleo-Dagestan (PD) – Tersko-Sunzhenskiy (TS) – Chechen-Ossetian (CHO) – Chechen (H) – Upper Sunzhenskiy (US). Then goes the Mosdok district (M), and Kara-Nogai (KN) – Kizlyar (Kizl), this territory has composition of dendroflora similar to Turan province.

In the second pleiad there is Paleo-Dagestan district (PD), then the pleiad is split into two – Tersko-Sunzhenskiy (TS) – Chechen-Ossetian district (CHO) – territory of the Caucasus province of Fore-Caucasus, and Chechen (Ch) – Upper Sunzhenskiy (US). The splitting of pleiades shows how the province breaks down into pleiades. On the one hand Pontic and Turanic, on the other hand Caucasus Province. The areas with lower values are more similar in their floristic characteristics.

Areas close in the composition of flora form pleiades of low values, the first areas identified belong to the Dagestan province – Paleo-Dagestan (PD) and Braguno-Novolak (BN).
Table 2. Jackar (K\textsubscript{J}) and Sørensen–Čekanovsky (K\textsubscript{sc}) similarity coefficients, distribution of trees and shrubs across floristic regions of the Chechen Republic

|          | M    | KN   | Kizl | BN   | PD   | TS   | CHO  | CH   | US   |
|----------|------|------|------|------|------|------|------|------|------|
| K\textsubscript{Sc} |      |      |      |      |      |      |      |      |      |
| M        |      |      |      |      |      |      |      |      |      |
| KN       |      |      |      |      |      |      |      |      |      |
| Kizl     |      |      |      |      |      |      |      |      |      |
| BN       |      |      |      |      |      |      |      |      |      |
| PD       |      |      |      |      |      |      |      |      |      |
| TS       |      |      |      |      |      |      |      |      |      |
| CHO      |      |      |      |      |      |      |      |      |      |
| CH       |      |      |      |      |      |      |      |      |      |
| US       |      |      |      |      |      |      |      |      |      |

Typical patterns are observed in the splitting of dendrogram constructed using Sørensen–Čekanowski similarity coefficients (Figure 2, Table 4).

The method of similarity analysis of dendroflora floristic structure demonstrates the correctness of
the chosen zoning in general for the entire flora and for its separate components (trees, bushes, low shrubs and dwarf shrubs).

Figure 1. Correlation pleiades of different values and dendrogram by the method of maximum correlation path based on Jacquar similarity coefficient

Figure 2. Correlation pleiades of different levels and dendrogram of maximum correlation path based on Sørensen-Čekanovsky similarity coefficient

References
[1] Aliroev I Yu 2001 Flora and Fauna of Chechnya and Ingushetia (Moscow: Academia) pp 65–82
[2] Alikhajiev M H and Erzhapova R S 2019 Flora of Grozny City (Grozny: Publ. House of Chechen State Univer.) 292 p
[3] Bailey N 1962 Statistical Methods in Biology (Moscow) 260 p
[4] Vasilevich V.N 1969 Statistical Methods in Geobotany (Leningrad) 129 p
[5] Vykhhandu L K 1964 On the study of multi-crisis biological systems Applicat. of Mathem. Methods in Biol. 3 19–22
[6] Galushko A I 1976 Analysis of Flora of the Western Part of the Central Caucasus, Flora of the North Caucasus and Issues of its History Rev. 1 (Stavropol) pp 5–130
[7] Zabruskov B.G 1975 Protect and increase the wealth of nature (Grozny: Chechen-Ingush Publ. House)
[8] Zaki A M and Schmidt V M 1972 On systematic structure of flora of the southern Mediterranean countries. I. Methodology and Analysis of the Structure of Five Regional and 11 Local Flora LSU Bull. 9 57–69
[9] Ivanov A L 1998 Flora of Fore-Caucasus and its genesis (Stavropol: Stavropol State Univer. Publ. House) 204 p
[10] Ivanov A L 2002 Flora and florogenesis of Rhododendron caucasicum Pall. Thickets (Stavropol: Stavropol State Univer. Publ. House) 144 p
[11] Kamelin R V 2004 Plant world, Great Soviet Encyclopedia, vol. Russia (Moscow: BRE Publ. House) pp 84–8
[12] Red Book of the Chechen Republic. Rare and endangered plant and animal species 2007 (Grozny) 432 p
[13] Malyshev L I 1975 Quantitative analysis of flora: spatial diversity, level of species wealth and representativeness of survey sites Botanical J. 60(11) 1537–50
[14] Rebristaya O V and Schmidt V M 1972 Comparison of the systematic structure of flora via rank correlation Botanical J. 57(11) 1353–64
[15] Tamarin P V and Schmidt V M 1975 Comparative analysis of some similarity coefficients”, Successes of biometrics: Works of the Leningrad Society of Natural Sci. 72(5) 54–75
[16] Terentyev V P 1959 Method of correlation pleiade J. of LSU 9 137–41
[17] Tolmachev A I 1941 On quantitative characteristic of flora and floristic regions Works of the Northern Base of the USSR Academy of Sciences iss 8 (Moscow; Leningrad: Publ. House of the USSR Acad. of Sci.) 41 p
[18] Umarov M U and Taisumov M A 2011 Concept flora of the Chechen Republic (Grozny) 152 p
[19] Schmidt V M 1974 Quantitative indicators in comparative floristics Botanical J. 59(7) 929–40
[20] Schmidt V M 1980 Statistical methods in comparative floristics (Leningrad: Publ. House of Leningrad Univer.) 176 p