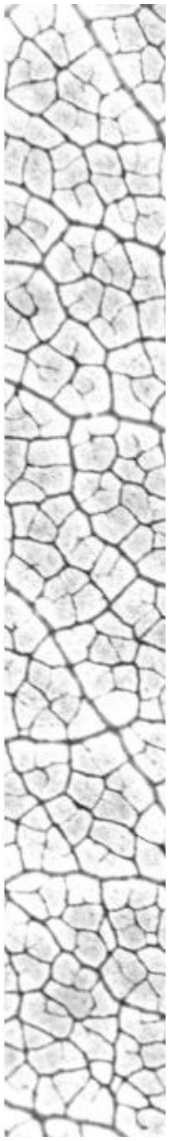

EurAsian Journal of BioSciences
Eurasia J Biosci 14, 249-254 (2020)

The analysis of the Dongyztau chink flora (Aktobe region)

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Abstract
This article provides analysis of the Dongyztau flora. The result of floristic analysis found out that 314 species of vascular plants belonging to 170 genera and 40 families grow on the territory of Dongyztau chink. The analysis of the family-species spectrum reveals that the 5 leading families make up 78.3 % of the total species composition, or 246 species. The leading families in this area are *Amaranthaceae, Asteraceae, Brassicaceae, Poaceae, Fabaceae*. The leading position is occupied by the *Amaranthaceae* family represented by 67 species that makes up 21.3 % of the species composition of the flora. The second position is occupied by the *Asteraceae* family including 40 species (12.7 %). The predominance of these families in the flora of the area characterizes it as a continental territory with arid habitat conditions. The presence of 5 endemic and 18 relict species was noted. Life forms are represented by 7 groups, among which the perennial herbaceous plants are dominant. The analysis of rare and endangered species of Dongyztau chink plants showed the growing of 21 species, of which 5 ones are listed in the Red book of Kazakhstan; 16 species are recommended for protection in the region.

Keywords: flora, Dongyztau chink, vascular plants, taxonomic analysis, endemic and relict species, life-form, rare and endangered species of plants

Kuanbay ZI, Abiyev SA, Ishmuratova MY, Admanova GB, Kukenov ZZ, Maksutbekova GT (2020) The analysis of the Dongyztau chink flora (Aktobe region). Eurasia J Biosci 14: 249-254.

INTRODUCTION

Creating conditions for more effective use of natural resources in the interest of man is one of the most important missions at the present stage of economic development. Flora and plant resources refer to unique and renewable sources of raw materials for the needs of various fiekds of industry. World practice shows that up to 4.5 % of the gross national product can be obtained through the exploitation of wild plant species (Ryumina 1991, Saimon 2005).

The inventory of plants growing on the territory of a region or a country makes up the primary basis required as precondition to assess the bio-diversity and hold profound research in botany and plant ecology like to model patterns of plant diversity or to comprehend species distribution and assigns high priority to basic conservation issues (Bazrafshan 2019, Jayakumar et al. 2011).

One of the unique and little-explored regions in Western Kazakhstan is Dongyztau chink located in a remote part of the Aktobe region at the junction of the Atyrau and Mangystau regions. This area has not been previously surveyed from a floristic point of view which determines the relevance of this study.

The purpose of this work is to study and analyze the flora of vascular plants of Dongyztau chink (Aktobe region).

Subject and Procedure of Research

The study subject was the flora and vegetation of Dongyztau chink.

The following was used as the material for the study - own field collections of 2016-2019 years, herbarium materials of Mangyshlak experimental Botanical garden (city of Aktau), Institute of Botany and Phytointroduction (city of Almaty), Botanical Institute after V.L. Komarov (St. Petersburg), and the literary data (Aipeisova 2012, Aralbay et al. 2006). The study was conducted by route-reconnaissance method; the areas were visited 2-3 times during the growing season. All flowering and vegetating plants were taken into account and floristic lists of the surveyed areas were compiled on the basis

Received: April 2019
Accepted: October 2019
Printed: March 2020

of which a General list of vascular plant species was compiled.

The definition of plants and clarification of their systematic position in taxonomically complex groups was carried out according to classical determinants and the following literature sources (Aralbay et al. 2006, Flora of Kazakhstan 1956-1966, Gamayunova 1948, The Determinant of plants of Central Asia 1968-1993, The Illustrated Determinant of plants of Kazakhstan 1969, 1972, Tsvelev 1976). The Plant List (2013) Version 1.1 database was used to unify the material. The volume of the family of flowering plants was taken according to the APG IV system (Angiosperm Phylogeny Group) (2016).

The selection of plant life forms was carried out in accordance with the method developed by I.G. Serebryakov (Serebryakov 1964).

The identification and justification of rare endangered species is based on the work of M. S. Baitenov (Baitenov 1986, 1999, 2001), the Red book of Kazakhstan (2014) (Red book of Kazakhstan), the list of rare and endangered plants of the Aktobe region (Aipeisova 2011) and the Red book of the Mangystau region (Aralbay et al. 2006).

The ratio of autochthonous and allochthonous tendencies in the process of florogenesis was estimated as per L.I. Malyshev's indicator of the flora separateness (Malyshev 1969). It represents the relative difference between the actual (S) and estimated (S^1) number of species:

$$A = \frac{(S - S^1)}{S}$$

The estimated number of species is determined by the empirical quadratic equation:

$$S^1 = 314.4 + 0.0045383 \times G^2$$

where G is the number of genera in a given flora.

RESULTS

Dongyztau chink lies in the south-western part of the Aktobe region between 46º08'n.l. - 46º68' n.l. and 56º13' e.l. - 57º60' e.l. It is the Northern part of the Ustyurt plateau covering an area about 900 km^2. The territory is located on the rocky and hollow-wavy surface of the accumulative-denudation plain within the Ustyurt plateau (Safronova 1996).

In the East the chink is limited with high ledges of Chagray Cape, in the South – with higher spurs of the Ustyurt plateau and in the East – with a very low ridge of Karamay spurs of Ustyurt, in the West – with the Zheltau Mountains and in the North-West – with Zmystan island hill.

The climate of the region is sharply continental and arid (Safronova 1996, Dzhanaliyeva 1998). The General features of the climate of the district are sharp temperature contrasts, cold harsh winter and hot summer, rapid transition from winter to summer, short spring period, lack of stability and shortage of precipitation, great dryness in the air, the intensity of evaporation processes, instability of climate indicators over time and a large amount of solar heat. The duration of sunshine is 2300-2700 hours per year. According to long-term observations of Ayakum weather station the coldest month of the region is January with average air temperature -10,1 °C, absolute minimum temperature -36 °C; the hottest month is July with average air temperature of +26.6 °C, absolute maximum is +40,7 ºC.

Table 1. The Key taxonomic indicators of the Dongyztau flora

Taxonomic indicators	Dongyztau flora
General number of species	314
General number of genera	170
General number of families	40
Average number of species in a genus	1.8
Average number of species in a family	7.6
Average number of genera in a family	4.1
Number of single-species genera	11
Number of single-species families	11
Maximum number of species in a genus	13
Maximum number of species in a family	67
Maximum number of genera in a family	25
Proportion of species in 10 leading families %	78.3
The proportion of monocotyledons among flowering plants, %	12.1
Proportion of dicotyledons among flowering plants, %	87.2

The insignificant rainfall amount and high air temperatures cause large shortage of humidity. The total amount of evaporation per year from the water surface reaches 1200-1500 mm, exceeding 5-6 times the amount of annual precipitation. Summer precipitation is almost completely spent on evaporation (Dzhanaliyeva 1998). For the territory under study steppe low-humus serozem complexes and chestnut soils are common, everywhere is alkali, in some places is highly saline (Safronova 1996).

The conducted researches enable to establish that 314 species of vascular plants belonging to 170 genera and 40 families grow on the studied territory. *Gnetopsida* class is represented by two species (0.63 % of the total number of flora species). The vast majority of species refer to angiosperms; *Magnoliophyta* group numbers 312 species (99.3 %). 38 species out of them (12.1 percent) refer to the *(Monocots) Liliopsida* class, and 274 species (87.2 %) refer to *Eudicots (Magnoliopsida)* class. The ratio of monocotyledonous and dicotyledonous species is 1:7.2. The proportion of gymnosperms is insignificant (**Table 1**).

The proportion of the top ten according to the number of types of families is made up by 246 types, accounting for 78.3% of the total diversity of the Dongyztau flora (**Table 2**).

Many-genera families, presented in the Dongyztau flora with more than ten genera are the following: *Amaranthaceae* - 25 genera*, Asteraceae* – 20 genera*, Brassicaceae – 20 genera, Poaceae* – 16 genera*.* In total they include 81 genera (47.6% of the total number

Table 2. Taxonomic composition of the leading families of the Dongyztau vascular plants flora

#	Family	Number of genera, un.	Percent of the general number of genera, %	Number of species, un.	Percent of general number of species, %
1	*Amaranthaceae*	25	14,70	67	21,33
2	*Asteraceae*	20	11,76	40	12,73
3	*Brassicaceae*	20	11,76	31	9,87
4	*Poaceae*	16	9,41	27	8,59
5	*Fabaceae*	8	4,70	26	8,28
6	*Boraginaceae*	10	5,88	16	5,09
7	*Caryophyllaceae*	7	4,11	14	4,45
8	*Apiaceae*	8	4,70	11	3,50
9	*Polygonaceae*	5	2,94	8	2,54
10	*Ranunculaceae*	5	2,94	6	1,91

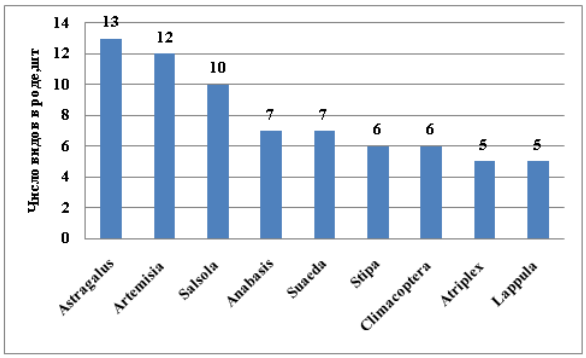

Fig. 1. The spectrum of the leading genera of vascular plants' flora of Dongyztau chink

of genera) and 165 species (52.5% of the total number). All the named genera are multiple-species ones.

The following families have the greatest species diversity (more than 6 species)*: Amaranthaceae* – 67 (21%), *Asteraceae* – 40 (12.7%), *Brassicaceae* - 31 (9.8%), *Poaceae* - 27 (8.5%), *Fabaceae* - 26 (8.2%), *Caryophyllaceae* - 14 (4.4%), *Boraginaceae* - 16 (5%), *Apiaceae* - 11 (3.5%), *Polygonaceae* - 8 (2.5%), *Ranunculaceae* - 6 (1.9%).

The other 68 species (21.6%) refer to 30 families which contain from one to five species. So *Polygonaceae* family contains 5 species. Families with 3-4 species number 10 (11.1% of the total number). So, families *Papaveraceae, Nitrariaceae, Lymoniaceae and Tamaricaceae* are marked with 4 species each. Families *Liliaceae, Amaryllidaceae (Alliaceae), Asparagaceae, Rubiaceae, Convolvulaceae, Lamiaceae* contain 3 species each. 18 families contain only 1-2 species each: *Zygophyllaceae, Rosaceae, Geraniaceae, Rutaceae, Capparaceae, Apocynaceae, Caprifoliaceae (Dipsacaceae), Ixioliriaceae, Cyperaceae, Berberidaceae, Crassulaceae, Elaeagnaceae, Euphorbiaceae, Malvaceae, Frankeniaceae, Solanaceae, Phrymaceae, Linderniaceae.*

The number of multi-species genera is little. For example the following genera include more than 10 species: *Astragalus* – 13 species, *Artemisia* – 12 species, *Salsola* – 10 species (**Fig. 1**).

Table 3. Life forms of vascular plants of the Dongyztau chink flora (as per I.G. Serebryakov)

#	Types of life forms	Absolute number of species, un.	% of the total number of species
1	**Tree species**	**21**	
	Trees	1	0.3
	Upright shrub	14	4.4
	Lianoid shrubs	1	0.3
	Sub-shrubs	5	1.5
	Semiarborescent specie		
	Semi-shrubs	26	8.2
	Dwarf sub-shrubs	17	5.4
4	**Polycarpic grasses**		
	Taproot	39	12.4
	Long rootstock	40	12.7
	Short rootstock	3	0.9
	Cespitose	17	5.4
	Root sucker	2	0.6
	Tuber formation	7	2.2
	Bulbous	6	1.9
	Monocarpic grasses	**123**	
	Perennial, biennial	4	1.2
	Annual grasses with long vegetation	89	28.3
	Ephemerals	28	8.9

Two genera (*Anabasis*, *Suaeda*) contain 7 species each, two genera (*Stipa*, *Climacoptera*) – 6 species, 2 genera (*Atriplex*, *Lappula*) – 5 species each. The major proportion of flora is made up by 1-2 species genera which number 26 (65% of the total number). They include 53 species which makes up 16.8% of the total number of species. So the flora under study is marked with the enrichment of genera which testifies to the predominance of allochthonous tendencies (Tolmachev, 1960) in the flora formation.

The study of plants by life forms resulted in finding out that the basis of the Dongyztau flora is herbaceous plants (78.6%), the number of species that belong to the types of Polycarpic (39.4%) and monocarpic (39.1%) grasses. Trees and shrubs number are only 21 species or 6.6 % (**Table 3**).

DISCUSSION

Taxonomic analysis. The analysis of the flora reveals that the dominant family with more than 20 species is the *Amaranthaceae* family - 67 species, the second position is with *Asteraceae* - 40 species, in the third position is *Brassicaceae* - 31 species, *Poaceae* slightly steps back to the preceding family -27 species. In the fifth position is the *Fabaceae* family - 26 species. In total the first five families include 89 genera (52.3% of the total number of genera) and 191 species (60.8% of the total number of species).

The predominance of such families as *Amaranthaceae, Asteraceae, Brassicaceae* and *Poaceae* indicates the aridity of the territory of Dongyztau chink. So the *Amaranthaceae* family is the most characteristic family for the deserts of the globe (Sukhorukov et al. 2019). A large number of species of this family testify to the presence of significant areas of saline areas. The species of this family mainly belong to

the group of plants with summer-autumn vegetation (Lavrenko 1982, Rusakova et al. 2013).

The *Asteraceae* family serves as an edificatory in the flora of arid territories such as steppes and deserts (Ulanova et al. 2019).

The *Brassicaceae* family takes the third position in the list of flora; species of this family are also associated with dry and desert habitats, or are of ephemeral nature, that is, they contain many annuals that are on time to complete vegetation before the beginning of the summer period (Veselova 2016). In the spring period representatives of the family make up sporadic communities with the following edificatory plants: *Lepidium perfoliatum, Descuraunia sophia, Alyssum desertorum, Chorispira tenella, Syrenia siliculosa* and others.

The *Poaceae* family contains groups of species that play the role of edificatory and sub-edificatory of steppe (Zhu et al. 2019) and desert flora (*Agropyron desertorum, Eremopyrym*) and form small areas of vegetation along water sources (*Phargmites australis, Calamagrostis, Pucinella distans, Cynodon dactylon*).

This species' spectrum of the Dongyztau flora is a clear indicator of the heterogeneity degree of the flora territory, testifies to the diversity of its geographical conditions. This family structure is the result of the location of the area under study near the border of the Boreal and ancient Mediterranean sub-kingdoms of the Holarctic Kingdom (Kamelin 2012). The leading position of *Amaranthaceae, Boraginaceae, Polygonaceae* families are typical for Turanian flora, the high number of species of the *Asteraceae, Poaceae* and *Fabaceae* families testifies to the influence of Mediterranean flora proper, the *Caryophyllaceae, Ranunculaceae, Brassicaceae, Cyperaceae* families are indicative of the boreal features of flora (Alain et al. 2016). The described structures of genera are typical for the Turanian floristic province.

The autonomy index of flora made up -0.45. The negative value of the autonomy index shows the allochthonous nature of the flora. Since the ratio of species to genera also depends on the size of the distribution area, this can be partly explained by the relatively small size of the studied region (Malyshev 1969).

Thus the flora of the Dongyztau chink stands out for its poor composition of species. The distribution per family shows a significant influence of the arid climate. The predominance of single-genera families in the flora and a large number of single-species species indicates the youth and allochthonicity of the studied flora.

Analysis of life forms. I.G. Serebryakov's distribution of plant species per life forms showed that the largest number of plants refer to Polycarpic grasses-124 plants (39.4%). Almost the same proportion of plants refer to monocarpic plants-123 species (39.1%). It is worth noting a significant proportion of annuals of long vegetation which is a characteristic feature of the Dongyztau chink vegetation cover.

Polycarpic grasses are marked with the dominance of taproot herbaceous plants represented by 39 species or 12.4%. They include such species as *Medicago falcata* L. (*Medicago romanica* Prod.), *Medicago medicaginoides* (Retz.) E. Small. (*Trigonella arcuata* C. A. Mey.), *Melilotus albus* Medik., *Melilotus officinalis* (L.) Pall., *Astragalus stenoceras* C. A. Mey., *Astragalus testiculatus* Pall., *Astragalus turczaninowii* Kar. & Kir. Taproot plants are typical for dry semi-deserts and deserts; this life group successfully extracts water from deeper soil layers (Alain et al. 2016).

Semi-shrubs or dwarf sub-shrubs are often included in communities as dominant or co-dominant species. They include 42 species (13.4%). It is explained by the fact that semi-shrubs and dwarf sub-shrubs are characteristic of arid habitats; they have quite a variety of adaptations to harsh living conditions including saliniced soils and sands. And the studied area is distinguished with pronounced heterogeneity of vegetation cover associated with different types of soils and edaphic variants of the desert and the proximity to the steppe zone (Sukhorukov et al. 2019).

Rare and endangered plants. The list of Dongyztau chink plants protected and subject to protection numbers 21 species. 5 plants of them are listed in the Red book of Kazakhstan: *Tulipa biflora* Pall., *Tulipa schrenkii* Regel., *Malacocarpus crithmifolius* Retz. C. A. Mey., *Crambe edentula* Fisch. & C. A. Mey. ex Korsh., *Rubia cretacea* Pojark.

Regionally rare 16 species are proposed by us to be added to the list for protection (**Table 4**).

The main measures for protection are the following: monitoring the condition of populations and protection of habitats with restriction of economic activity (livestock grazing). Thus the surveyed territory can be proposed for inclusion in the list of specially protected areas of local significance.

CONCLUSION

The comprehensive analysis held on the flora of the Dongyztau chink vascular plants detected the growing of 314 species from 170 genera and 40 families. 5 leading families have been identified (*Amaranthaceae, Asteraceae, Brassicaceae, Poaceae, Fabaceae*), which number 246 species, or 78.3%. The largest genera: *Astragalus* - 13 species, *Artemisia* - 12 species, *Salsola* - 10 species. A significant proportion is made up by single-genera families and single-species genera. The family-generic composition shows the allochthonous character of the flora typical for the sharp-continental and arid climate. This aspect identified the relatively poor species composition of the Donguztau chink. The presence of 5 endemic and 18 relict species is specified.

Table 4. List of the Dongyztau chink rare vascular plants and the plants in need of protection

#	Species	Status	Condition of the population	Protection measures	Comment
1	*Ephedra lomatolepis* Schrenk	3(R)	Rare specie	Monitoring the condition of the population. Prrotection of habitats	Relict species
2	*Ephedra distachya* L.	3(R)	Rare specie	Study of the species" area.Protection of the habitat	Relict species
3	*Stipa capillata* L.	2(V)	Vulnerable specie	Monitoring the condition of the population	Relict species
4	*Stipa sareptana* A. Beck.	3(R)	Rare specie	A nature reserve is to be established	
5	*Astragalus filicaulis* Fisch. et C.A. Mey.	3(R)	Rare specie	Conservation of species in wild habitats	
6	*Glycyrrhiza korshinskyi* Grig.	3(R)	Rare specie	Study of the area, protection measures are to be taken	Relict species
7	Nitraria schoberi L.	2(V)	Vulnerable specie	Monitoring the condition of the population. Prrotection of habitats	Relict species
8	*Matthiola robusta* Bunge.	2(V)	Vulnerable specie	Conservation of nature habitats	
9	*Capparis sicula* subsp herbacea (Willd.) Inocencio, D.Rivera, Obón & Alcaraz. (*Capparis herbacea* Willd.)	2(V)	Vulnerable specie	Conservation of nature habitats	Relict species
10	*Anabasis cretaceae* Pall. ex Bunge	3(R)	Rare specie	Monitoring the condition of the population. Prrotection of the area	Relict species
11	*Arthrophytum lehmannianum* Bunge	2(V)	Vulnerable specie	Study of the population	
12	*Haloxylon persicum* Bunge	3(R)	Rare specie	Monitoring the condition of the population.	
13	*Salsola arbusculiformis* Drobow.	2(V)	Vulnerable specie	Monitoring the condition of the population.	
14	*Onosma staminea* Ledeb.	2(V)	Vulnerable specie	Monitoring the condition of the population.	
15	*Convolvulus fruticosus* Pall.	3(R)	Rare specie	Protection of the habitat	
16	*Linaria leptoceras* Kuprium.	3(R)	Rare specie	Protection of the habitat, study of the status of species	

7 groups of plant life forms were identified, among which perennial herbaceous plants prevail. The small number of tree and shrub plants is explained by the lack of precipitation and continental climate.

The analysis of rare and endangered species of the Dongyztau chink plants showed the growing of 21 species, of which 5 ones are listed in the Red book of Kazakhstan; 16 species are recommended for protection in the region. Suggestions for security measures are presented.

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