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Taxonomic diversity of partial flora found on chalk hills in North-Western Kazakhstan

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Taxonomic diversity of partial flora found on chalk hills in North-Western Kazakhstan

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Abstract. The chalk hills in North-Western Kazakhstan (NWK) are one of the unique in botanical and geographical terms objects located at the junction of Europe and Asia. Here, the calciphyte complex has been preserved, which is of scientific interest for the study of landscape and biological diversity, the main stages of the genesis of the flora of the region and as a refugium center for relict, endemic, red-book species.
The purpose of the work is to carry out an inventory and compare the features of the taxonomic, biomorphological, ecological-phytocenotic and geographical composition of the partial flora of the chalk hills in NWK. Field work was carried out by route method in combination with stationary key areas using generally accepted methods. The object of the study was the flora of the chalk hills of the Obshii Syrt (OS), Sub Ural plateau (SUP) and Emba plateau (EP). As a result of the conducted research, it was revealed that 938 species of vascular plants belonging to 389 genera and 84 families grow on the chalk landscapes of the NWK. On three chalk hills 11 partial floras have been identified. The most original of them are the partial flora of the SUP, here the dominant position belongs to families *Asteraceae*, *Poaceae*, *Brassicaceae*. The richest genera are *Astragalus*, *Artemisia*, *Allium* and etc. Here an endemic calciphytic complex stands out. Steppe species prevail in all partial flora. The research results were used in the program of environmental protection measures in the West Kazakhstan region.

1. Introduction

North-Western Kazakhstan (NWK) represents a natural physiographic region stretching from west to east of the Volga river to the Mugodzhar mountains, and from north to south from the Obshii Syrt to the coast of Caspian Sea, i. e. from latitude 48° to 52° N and from longitude 46° to 58° E.

This region is characterized by a continental climate. In general, the region is characterized by unstable and scarce precipitation, low snow and strong blowing of snow from the fields, high dry air and soil, intense evaporation and an abundance of direct sunlight throughout the growing season.

The uniqueness of edaphic factors and climatic conditions contribute to the formation of unique chalk landscapes here [1]. Chalk hills are one of the representative and unique landscapes located at the junction of Europe and Asia (figure 1, 2).

Figure 1. Separate chalk remains of the Ilek-Utvinsky watershed.

Figure 2. Surroundings of the chalk massifs of Ishkargan mountain.

Here are the borders of the turf-grass steppes and the north Caspian deserts [2, 3]. The formation of the North and Ancient Mediterranean flora of the chalk hills was influenced not only by the autochthonous Turanian species but also by the expansion of European and Eurasian species.

Within NWK the chalk hills of the Obshii Syrt (OS), Sub Ural plateau (SUP) and Emba plateau (EP) stand out. On the OS botanical and geographical areas are highlighted: Srednii Syrt, Derkul Syrt, Nizkii Syrt, Vysokii Syrt. The SUP consists of Chelkar, Pre-Syrt, Utva, Karagandy, Kiil regions. On the EP stand out Belyi Uzen, Iman-Kara [4].

The flora of chalk hills is a complicated complex of species formed as a result of the overlapping of plant groups of different origin in different phases of history. This overlapping took place through a long struggle against adverse climatic conditions and mutual adaptation between types of indigenous groups. As a result, environmentally specific plant groups arose, confined to certain narrow-local environmental conditions or ecotopes. According to the definition of Yurtsev and Kamelin, partial flora (PF) or flora of ecotopes is the natural flora of any ecologically distinctive subdivision of the landscape [5].

In recent years, the rapid development of the oil and gas industry has led to the widespread construction of oil and gas pipelines, industrial facilities, roads and railways. Long-term economic activity negatively affects the vegetation cover of chalk landscapes, as there is not only a reduction, but also the complete destruction of peculiar cretaceous communities. On steep slopes, intensive grazing will lead to increased erosion processes and destruction of the soil layer.

The study of the flora of chalk landscapes and their distribution over the territory of NWK is necessary to preserve the unique calciphytic flora and vegetation and identify the reasons for its change, as well as to solve theoretical problems of the history of formation and their dynamics.

The purpose of the work is to carry out an inventory and compare the features of the taxonomic, biomorphological, ecological-phytocenotic and geographical composition of the partial flora of the chalk hills in NWK.

2. Materials and Methods

The work on the study of the chalk landscapes of NWK was carried out by the route method in combination with stationary key areas, where the structure and dynamics of the vegetation cover were observed.

Stationary key areas have been established on the chalk hills in NWK. For each landscape area, identified according to A.A. Chibilev [6], partial flora and types of ecotopes were identified, differing in their location in the relief, the nature of the chalk rock, soil cover and vegetation. Partial flora, or ecotope flora, are distinguished at the topological level as flora of any environmentally peculiar subdivisions of the landscape. They are distinguished by greater repeatability of composition, greater ecological condition of differences of adjacent partial flora, greater dependence on climatic fluctuation [7]. The names of the partial flora were given in accordance with the type of vegetation. The selected

identical types of ecotopes were combined into classes of ecotopes (CE). So, on OS 6 ecotope classes (CE) were identified, on the SUP – 7 CE, on the EP – 4 CE. Each landscape is characterized by its own set of ecotopes.

So, for the Obshii Syrt it is allocated:

– CE of plateaus and slopes of chalk hills with calciphyte-steppe communities;

– CE of north and west slopes along chalk ravines and gullies;

– CE of the sout and east slopes along chalk ravines and gullies;

– CE of plain steppe communities;

– CE of short-term pioneer communities in chalk ravines and gullies;

– CE of springs, streams and ponds arising among the chalk hills, with hygro- and mesophytic species composition.

On the Sub Ural plateau 7 classes of ecotopes are allocated:

– CE on foreheads, hacks and plateaus of chalk hills with mountainous-desert-calciphytic and calcephytic-steppe groups;

– CE of north and west slopes with a mesophytic-calcephytic complex;

– CE of south and east slopes with a xerophytic-calcephytic complex;

– CE of plain steppe communities;

– CE of short-term pioneer communities of chalk and marl slopes, ravines and gullies;

– CE of the foot of the chalk slopes with a complex of halophytic-desert and petrophytic-steppe communities;

– CE of springs, streams and ponds arising among the chalk hills with a complex of hygrophytic and mesophytic species.

On the Emba plateau, we have allocated 4 classes of ecotopes:

– CE on the foreheads, hacks and mesas of the plateaus of chalk outliers with mountainous-desert-calcephytic and calciphyte-steppe groups;

– CE of plain desert communities;

– CE of the foot of the chalk slopes with a complex of halophytic-desert communities.

For each class of ecotopes a floristic composition was identified indicating the leading families, genera and species. The flora list was compiled in accordance with the system of A.L. Takhtajan [8, 9]. Biomorphological analysis was carried out according to Serebryakov [10, 11]. The flora of chalk hills is quite heterogeneous in ecological and cenotic composition and consists of florocenotic complexes that are confined to certain habitats. The establishment of ecological-cenotic groups was carried out on the basis of our own observations with the involvement of literary sources [12, 13]. When analyzing the geographical structure (in the latitudinal direction), we adhered to the point of view of R.V. Kamelin (1973), A.L. Takhtajan (1970), A.I. Tolmachev (1974) and other authors [12, 14, 15]. The names of vascular plants are given taking into account the summary of S.K. Cherepanov [16]. In this work, the materials of the authors' long-term studies for 1985-2020 are analyzed and summarized. In total, about 3,000 sheets of herbarium were collected, which are stored mainly in the Herbarium of the M. Utemisov WKU (PPIN), duplicates of the most important collections were transferred to the herbarium of the BIN RAS (LE).

3. Results and Discussion

As a result of the conducted research, it was revealed that 938 species of vascular plants belonging to 389 genera and 84 families grow on the chalk landscapes of the NWK. Among them, the basis of the flora, as elsewhere in the temperate regions of the Holarctic, is made up of flowering plants (938 species; 99%), of which dicotyledonous 760 species or 82% predominate, monocotyledonous 18% (168). Archegonial plants account for one percent.

The average species richness per family is 11.1. The level of species wealth above the average is 15 families, the remaining 69 contain 1/3 of all species, of which 26 contain one species. The richest species of the family are *Asteracea* (129 species), *Poacea* (89), *Fabaceae* (85), *Chenopodiaceae* (72), *Brassicaceae* (59).

The largest genera are *Astragalus* (37 species; 9.4%), *Artemisia* 18 (4.5%), *Carex* 17 (4.4%), *Allium* 17 (4.3%), *Potentilla* 14 (3.5%), *Atriplex* 13 (3.3%), *Veronica* 11 (2.7%), *Silene* 11 (2.7%).

This distribution of taxa corresponds to the temperate-arid regions of the Ancient Mediterranean [8].

The flora of the chalk landscapes of OS includes 562 species belonging to 67 families and 279 genera. 736 species, consisting of 308 genera and 67 families, grow on the chalk hills of the SUP. 224 species, 97 families and 136 genera were recorded on the chalk hills of the EP. An analysis of the flora of three large chalk hills, occupying 59,624,2 square km, allows a deeper understanding of the structure of the vegetation cover using the study of PF. On three chalk hills we identified 11 partial floras (PF) (table 1).

Table 1. Taxonomic diversity of the PF of the chalk hills of the NWK.

№	Partial flora	Area, square km	Numberof			Average number of		
			species	genera	families	species in family	genera in family	species in genera
1	Region as a whole	59621.2	938	289	84	11.1	4.6	2.4
2	Obshii Syrt		562	279	67	8.3	4.1	2.0
3	Srednii Syrt	1137.7	318	185	50	6.3	3.7	1.7
4	Derkul Syrt	1630.3	369	211	52	7.0	4.0	1.7
5	Nizkii Syrt	1389.3	334	204	48	6.9	4.2	1.6
6	Vysokii Syrt	734.2	473	299	59	8.0	5.2	1.5
7	Sub Ural plateau		736	308	67	10.9	4.5	2.3
8	Chelkar	7002.6	365	191	36	10.1	5.3	1.9
9	Pre-Syrt	9552.1	205	144	32	6.4	4.5	1.4
10	Utva	9595.3	396	224	59	6.7	3.7	1.7
11	Karagandy	9500.0	194	123	30	6.4	4.1	1.6
12	Kiil	9300.0	184	105	30	6.1	3.5	1.
13	Emba plateau		224	136	37	6.0	2.0	1.6
14	Belyi Uzen	5342.0	120	76	25	4.8	3.0	1.5
15	Iman - Kara	3500.0	128	93	25	5.1	3.7	1.4

The most original are the partial flora of the SUP, here the dominant position is occupied by the families *Asteraceae, Poaceae, Brassicaceaea*, which we will consider in more detail. This is followed by *Fabaceae*, *Chenopodiaceae*, *Caryophyllaceae*, after followed by the *Liliaceae*, *Lamiaceae*, *Apiaceae*, *Rosaceae*.

The first three places in the number of species are occupied by *Astragalus, Artemesia, Allium*. Fourth place belongs to the genus *Potentilla*, 5 and 6 places – *Dianthus* and *Veronica*,7 and 8 places – *Lappula, Limonium, Salsola, Silene,* 9-10 – *Anabasis*, *Lepidium*.

The distribution of species by biomorphs shows that all PF are characterized by steppe features. The share of taproot plants is well expressed in the Pre-Syrt (36%) and Karagandy flora (35%).The share of monocarpics accounts for a large percentage in the Chelkar (34%) and Utva (24%) PF. The share of semishrubs and dwarf semishrubs increases from the north (Chelkar – 9%) and to the south (Kiil – 18%). The decrease in the proportion of shrubs and dwarf shrubs from north to south from 7% to 4% is due to both edaphic and ecological factors.

The leading position from 51% of Utva PF to 70% in the Karagandy PF is occupied by steppe species. The second place is occupied by meadows from 6% in the Karagandy flora to 17% in the Chelkar PF. The output of forest-steppe species in 3rd place is explained by the fact that in the north part of the SUP bayrack forests with rich grasses are developed. There is a small percentage of desert species from 3%, in the Pre-Syrt area to 11% in the Kiil flora. With the predominance of steppe

species in all partial flora, the flora naturally depletes to the south and east, which is associated with the loss of forest elements that are not compensated by the increase in Turan species.

When comparing the geographical elements, it turned out that the predominance is wide-area Eurasian (Kiil – 27%, Pre-Syrt PF – 34%); European (20% in Pre-Syrt and 25% in Karagandy). The share of Turanian species increases from 8% in Utva to 14% in Karagandy PF. The number of narrow-areal species varies from north to south (Utva PF – 109 species, 28%, Pre-Syrt – 71 species, 34%).

The most rich ecotopically Utva landscape area, where all 7 classes of ecotopes are represented. The relief is represented by a rolling undulating plain with absolute heights of 180-260 m, dissected by a system of rather wide river valleys (Utva, Ishkargan, Ilek). Sal-dome tectonics and erosion processes are well developed here [17]. This area includes chalk ridges that start from the village Mirgorodka (263 m). 396 species have been recorded here. Chalk hills, individual cretaceous remains are occupied by calcephytic and petrophytic groups, where 33 specific species are concentrated: *Anabasis cretacea* Pall., *Hedysarum gmelinii* Ledeb, *H. razoumowianum* Fisch. & Helm ex DC., *Jurinea kirghisorum* Janisch., *Limonium macrorhizon* (Ledeb.) O.Kuntze, *Linum flavum* L., *Rhammatophyllum frutex* Botsch. & Vved and etc.

In the west part of the SUP – Chelkar landscape region, only four classes of ecotopes are described. There are no ravines and gullies, springs and streams, the foot of the chalk hills is not clearly expressed. On the territory there is a large lake basin Chelkar, on the outskirts of which rises the chalk mountain Santas (73 m) and the salt-dome rise of mountain Sasai (94 m). The area is characterized by a motley combination of halophilic plant groups. There are 365 species on this territory, of which 30 are specific: *Anabasis aphylla* L., *A. salsa* (C.A.Mey.) Bentz. ex Volkens., *Artemisia pauciflora* Web., *Atriplex cana* C.A. Mey, *Kraschenninnikovia ceratoides* (L.) Gueldenst., *Limonium gmelinii* L., *L. suffruticosum* (L.) O.Kuntze, *Salvia aethiopsis* L.and etc.

Five classes of ecotopes have been identified for the Pre-Syrt part of the SUP. The relief is flat, dissected weakly. It is characterized by low chalk ridges (90-110 m): Djirentau, Akkuduksay and Stepnaya, on which 305 species grow, of which 27 are differential (*Alyssum lenense* Adams, *Centaurea ruthenica* Lam., *Crambe litvinovii* K.Gross., *Scabiosa isetensis* L. and etc.).

In the east part of the studied region, the Karagandy landscape region is distinguished, where 6 classes are well expressed. This territory is a wavy-ridged plain with heights of 260-288 m, dissected by ravines, gullies and small rivers. The surface is composed of chalk and alluvial sediments of sandy mechanical composition. Here, chalk hills stand out in the basin of the river Kiil, Karagandy and Khobda for 110 km from north to south and include mountain Itas (286 m), m. Karatau (272 m), m. Kosoba (247 m). 194 species grow on the chalk landscapes of the Karagandy region, among which 23 are specific: *Anabasis cretacea, A. eriopoda* (Schrenk) Bentz. ex Volkens., *A.truncata* (Schrenk) Bunge, *Artemisia lessingiana* Bess, A. *salsoloides* Willd., *Astragalus albicaulis* DC, *Oxytropis cretacea* Basil., *Salsola arbuscula* Pall. and etc.

In the south part, the allocated Kiil landscape district covers the basin of the Kiil river from the village Zharsai in the north, to the village of Uil in the south (for 120 km). The absolute heights here are 230-237 m. Chalk rocks emerge on the surface, forming the Akchatau (237), Terektytau and Karatau (174 m) ridges where 184 species grow. The Kiil flora has a peculiar set (40 species) of cretaceous species: *Capparis herbacea* Willd., *Cousinia astracanica* (Spreng) Tamamsch, *Lagochilus acutilobus* (Ledeb.) Fisch. & C.A. Mey., *Litvinovia tenuissima* (Pall.) Woronov ex Pavl., *Nanophyton erinaceum* (Pall.) Bunge and etc.

The richness of partial floras was influenced by the geographic location of the studied area, which ensured their enrichment with species of both the European, Eurasian, and Turanian complexes.

Many of the species noted here are rare and endangered species which listed in the "List of Rare and Endangered Plant Species" (2006) [18] and the Green Book of the West Kazakhstan Region (2001) [19]: *Adonis vernalis* L., *Anthemis trotzkiana* Claus, *Hedysarum grandiflorum* Pall., *Linaria cretacea* Fisch. ex Spreng., *Silene cretaceae* Fisch.ex Spreng., *Tulipa schrenkii* Regel. and etc.

4. Conclusion

The analysis of partial floras showed that both by taxonomic indicators and by the composition of life forms and ecological and phytocenotic groups, they are typical for the steppe territory of Eurasia, and the composition of geographical elements characterizes the steppe zone located on the border of the Boreal and Ancient Mediterranean kingdoms.

Probably, the endemic calcephite complex was formed from the end of the Miocene – the beginning of the Pliocene on the basis of regional Turanian (*Nanophyton erinaceum*), Aral-Caspian (*Anabasis brachiata Fisch. & C.A. Mey*., *A. cretacea*, *A. eriopoda*, *A. truncata*), east Black sea-West Kazakhstan (*Capparis herbacea*, *Crambe aspera* M. Bieb., *C. tatarica* Sebeok), Lower Volga-Pre-Ural (*Anthemis trotzkiana*, *Artemisia salsoloides*) and West Kazakhstan (*Rubia cretacea* Pojark.) relics. The formation of the calciphyte complex was influenced not only by the local Aral-Caspian (*Asparagus inderiensis* F.K. Blum ex Pacz., *Lagochilus acutilobus* Ledeb., *Lepidium songaricum* Schrenk, *Matthiola fragrans* Bunge, *Zygophyllum turcomanicum* Fisch. ex Bunge) endemics, but also regional trans-Volga-Kazakhstan (*Astragalus helmii* Fisch., *A. physodes* L., *Eremogone koriniana* (Fisch. ex Fenzl) Ikonn., *Galatella divaricata* (Fisch. ex M. Bieb.) Novopokr., *G. trinervifolia* (Less.) Novopokr., *Hedysarum razoumowianum* Fisch., *Oxytropis cretacea* Basil.) and Pontic-trans-Volga-Kazakh endemics (*Astragalus albicaulis* DC., *A. macropus* Bunge, *Dianthus rigidus* M. Bieb.). The final formation of the flora of chalk hills took a long time from the Pliocene to the Holocene, so it can be assumed that the unique narrow-rock Mugodzhar (*Astragalus mugodsharicus* Bunge, *A. subarcuatus* Popov, *A. temirensis* Popov), West Kazakhstan (*Artemisia lessingiana*, *Jurinea kirghisorum*), Caspian (*Heterocaryum rigidum* A. DC.) species have a relatively young age (Pleistocene – Holocene).

Thus, the chalk landscapes in North-Western Kazakhstan are a refugium for the preservation of relict, endemic, Red Book and Green Book species. Research materials will be used to identify and design natural monuments and the "Zhaiyk Ormany" State Natural Reserve, and to prepare a list of protected plants in North-Western Kazakhstan.

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