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Comparative Floristic Analysis for Biodiversity Conservation and Sustainable Land Management in Central Asia's Arid Zones

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ABSTRACT

This study aimed to conduct a comparative analysis of the flora of Donyztau, Zheltau, and the mountainous regions of Mangyshlak and Mugodzhar, situated within the arid zone of Asia. The main objective was to understand the similarities and differences in the floristic composition of these regions and their importance for biodiversity conservation. Standard botanical and floristic methods were employed, including field surveys and the analysis of herbarium specimens. Comparative floristic analysis was performed using the Jaccard similarity coefficient to quantify floristic relationships among the regions. A total of 312 species, representing a significant proportion of the group, are flowering plants. The flora of Donyztau showed the greatest similarity with the mountain flora of Mangyshlak, sharing 123 species, with a Jaccard coefficient of 0.21. The flora of Mugodzhar and Zheltau showed the least similarity, sharing only 34 and 63 species with Donyztau, respectively. These differences were attributed to variations in regional habitat conditions and floristic composition. The study enabled the authors to outline a general characterization of the previously unexplored flora of the Donyztau escarpment. Based on the identified spectrum of biodiversity, further studies could be undertaken to explore strategies for reducing aridity and enriching the regional flora.

1. INTRODUCTION

Drought in Central Asia (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan) is a major and growing challenge to biodiversity preservation, exacerbated by climate change and unsustainable water management [1, 2]. The Central Asia region heavily depends on water from the Amu Darya and Syr Darya rivers, both of which have been significantly depleted due to inefficient irrigation and reduced glacial melt [3]. In 2021, Central Asia suffered from an extreme agricultural drought caused by record-breaking heat, increased evapotranspiration, and a lack of precipitation. The harsh drought of 2021 was not an independent event; it was a result of a 50-year-old trend [4, 5]. Droughts are a common occurrence in Kazakhstan due to climate change; reanalysis data also showed that the strongest increase in dryness in the southwest and northwest regions of Kazakhstan was mainly due to reduced precipitation in the summer [6, 7]. In recent years, prolonged droughts have led to declining agricultural yields, desertification, and water shortages, affecting both rural communities and major urban centres. It is common to limit the cause of drought to climate change, but mismanagement of water resources, urbanization, and inefficient water use play considerable roles in encouraging aridity [8].

Drylands account for almost 30% of the global land surface and are characterized by a close relationship between water availability and vegetation dynamics [9-12]. Due to extremely variable climatic conditions, the risk of biosphere degradation is high. Under unfavorable conditions often accompanied by high grazing pressure, areas of bare soil may appear and the balance between woody and herbaceous vegetation may change to a state dominated by shrubs [13-15]. Once a degraded state is reached, restoration becomes difficult, and biodiversity and livestock productivity decline [16-18]. To prevent this, it is essential to conduct timely studies of such areas with measures to enrich their flora.

The Asian arid zone is the largest desert terrain system in the Northern Hemisphere, characterized by high biodiversity despite its arid nature. At present, this problem remains under-researched [19-21], which impedes efforts to preserve and restore this ecosystem.

A deeper understanding of biota can be achieved through comparative analysis of neighboring floras. As noted by Kamelin [22], any two neighboring floras, even taken without precise boundaries, differ. The extent of this difference is called the contrast of floras.

The contrast between floras, even adjacent, is significant, and this difference is especially noticeable in mountainous countries. Environmental factors, such as the height of the mountain formation, the ruggedness and exposure of slopes, steepness, the nature of the underlying parent material, soil composition, and moisture availability, play a significant part. Thus, comparing several neighboring floras provides a more accurate description of hard-to-reach areas, indicating the differences in the ecosystem from more developed areas, which helps form a complete picture of its overall development.

Around the world, various drought management practices have been implemented to detect and mitigate drought crises. In the Middle East and North Africa (MENA), the potential for assimilation of leaf area index (LAI) and soil moisture observations was studied to improve the representation of the hydrological and carbon cycles and drought by an advanced land surface model. This model's objective was the early detection of drought crises [23]. Sustainable water management was also implemented amongst farmers in Pakistan by the International Water Management Institute as a response to drought risk. In Australia, according to Hoque et al. [24], geospatial techniques were implemented to create a comprehensive agricultural drought risk assessment model involving all the risk components (hazard, vulnerability, exposure, and mitigation capacity). Other management practices involved helping farmers plan and manage drought risk. A Chinese study displayed a drought risk assessment model based on precipitation anomaly (Pa) and soil moisture content anomaly index [25]. Drought monitoring/early detection, vulnerability assessments, and rapid drought responses were also implemented [26].

This study aimed to conduct a comparative analysis of the floras of the Donyztau escarpment, Zheltau, and the mountainous regions of Mangyshlak and Mugodzhar in the arid zone of Central Asia. By analyzing the similarities and differences in floristic composition, the study sought to identify key factors influencing biodiversity conservation in these regions and to provide insights for sustainable land management and ecosystem restoration.

2. METHODS

2.1 Location of the study

The research focused on the flora of the Donyztau escarpment. The floras of Zheltau and mountainous Mangyshlak and Mugodzhar were also investigated for comparative analysis.

These regions were selected due to their ecological representativeness of Central Asia's arid zones and their contrasting topographical and edaphic conditions, which make them suitable for comparative floristic analysis (Table 1).

Table 1. Description of the region

Study Area	Location	Description of Relief/Soil	Average Temperature/Precipitation
Donyztau escarpment	The Aktobe region is at the junction with the Atyrau and Mangystau regions in the south-western part of the Aktobe region between 46°08' N – 46°68' N and 56°13' E – 57°60' W. The escarpment has maximum plateau elevations of 180-190 m, up to 215 m above sea level.	The area is dominated by complexes of steppe low-humus gray and chestnut soils, solonetzified everywhere, occasionally highly saline. The escarpment is a sharp ledge of the stratified plain of Ustyurt, where the plateau breaks off in its transition into the vast depression separating Ustyurt from the Shagyrai plateau. The depression is occupied by solonchaks of the lower reaches of the Shagan River. Stretching directly along the escarpment is the large Donyztau sor. A completely waterless area surrounded by pronounced arid conditions.	The general features of the region's climate are sharp temperature contrasts, cold harsh winters and hot summers, a rapid transition from winter to summer and a short spring period, unstable and scarce precipitation, high air dryness, intense evaporation processes, instability of climatic indicators over time (from year to year), and a considerable amount of solar heat. The region is marked by an abundance of heat and the prevalence of clear, dry weather. The annual sunshine duration reaches 2,300-2,500 hours.
Mugodzhar mountains	Located between 48°17' N – 49°61' N and 58°28' E – 59°01' E	The soil cover of the northern part of Mugodzhar is represented by chernozem; the central part is composed of igneous rocks, particularly rubbly soil-forming eluvium.	The climate is sharply continental, with cold, snowy winters (average temperature in January is –14°C) and hot, dry summers (average temperature in July is +24°C). Annual precipitation is 200-250 mm.
Mountainous Mangyshlak	Southwest of the Ural fold system between 42º88' N – 44°11' N and 52°15' E – 53°91' E	By the nature of relief, the region belongs to the type of erosion-tectonic and arid-denudation low-hill terrain. The territory has a highly fragmented and complex relief with elevations stretching in a sub-latitudinal direction. Its length does not exceed 47 km, with the height above sea level averaging 300-400 m and the highest points at 532 and 556 m (the Otpan and Besshoky mountains). It is characterized by the presence of a well-defined planation surface. These surfaces are composed of resistant Permo-Triassic metamorphic rocks, upper Cretaceous	Most of the precipitation falls in the form of rain. The amount of water does not exceed 200 mm and usually falls in spring in the form of thunderstorms. The winters are very short, relatively warm, with little snow.

		sediments, and marls. The flat depressions are divided by cuestas and mountain chains, formed in friable Jurassic and Lower Cretaceous sediments. The region has low-humus gray and chestnut soils, generally solonetzified, occasionally strongly salinized.	
Zheltau mountains	46°50' N; 55°50' E	The relief of mountains is characterized by the elements of mountain landscape with high escarpments, rock outcrops, buttes, deep and long ravines, and arroyos. In terms of soil composition, the region is dominated by sands and underdeveloped sandy desert soils and solonetz, and solonchak soils.	The average temperatures are −9°C in January and +26°C in July. The average annual precipitation is 140-150 mm.

2.2 Methods

The primary methods of plant research were the conventional classical methods of botanical, floristic, and geobotanical studies [27-29]. Field studies were conducted using the traditional route method, supplemented with systematic sampling to ensure representativeness. In each study region, we established 3 to 5 transects of 2-3 km in length, selected based on habitat heterogeneity and accessibility. Along each transect, sample plots (quadrats) measuring 10 × 10 meters were laid out at regular intervals of 200–300 meters. The number of quadrats per region ranged from 10 to 15, depending on terrain variability and vegetation density.

2.3 Material collection

The analysis involved a set of plant species growing exclusively within the boundaries of the regions. The materials for the work were specimens collected in the field by the authors [30, 31].

Comparative analysis relied on the results of studies on the flora of the Aktobe floristic district, Mangystau, and Zheltau [32-34].

The plots were visited 2-3 times throughout the season. All flowering and vegetative plants were considered in the floristic lists of the surveyed plots, based on which a general list of vascular plant species was drawn up. In the course of the study, we analyzed herbarium specimens stored in the herbarium collection of the Institute of Botany and Phytointroduction of the Ministry of Education and Science of the Republic of Kazakhstan, the Mangyshlak Experimental Botanical Garden, V.L. Komarov Botanical Institute of the Russian Academy of Sciences and research data from the "Results of a comprehensive expedition to the southeastern part of Zhylyoi District, Atyrau Region, Republic of Kazakhstan" [34].

During the herbarium identification process, the following floristic references were used: The Flora of Kazakhstan [35], Determinant of Plants in Central Asia: Critical Synopsis of Flora [36], Conspectus of the Flora of the Aktobe Floristic District [37], and State Cadastre of Plants of Mangystau Region [38].

2.4 Data analysis

The Plant List Version 1.1 database was used to unify the material [39]. The volume of the flowering plant family was considered according to the APG IV (Angiosperm Phylogeny Group) system [40].

The similarity of the Donyztau escarpment flora with other regions (Zheltau, Mugodzhar, and mountainous Mangyshlak) was analyzed based on the coefficient of floristic similarity proposed by P. Jaccard:

$$J = \frac{C}{A+B-C}$$

where, *A* – the number of species in the 1st examined territory; *B* – the number of species in the 2nd examined territory; *C* – the number of species common to the 1st and 2nd territories.

The Jaccard similarity coefficient was chosen for its effectiveness in comparing presence–absence data of species across regions. Unlike other indices, it emphasizes shared species while minimizing the influence of absent species, making it especially useful in regions with varying levels of biodiversity and sampling intensity.

3. RESULTS AND DISCUSSION

The vegetation cover of Donyztau is poor and heterogeneous. The predominant plant species are desert formations [41]. While sandy pastures are populated by trees, shrubs, prostrate shrubs, perennial grasses, and perennial and annual ephemeral plants, the basis of Donyztau vegetation is composed of shrubs and ephemerals. Perennial grasses are found in the region in much smaller quantities.

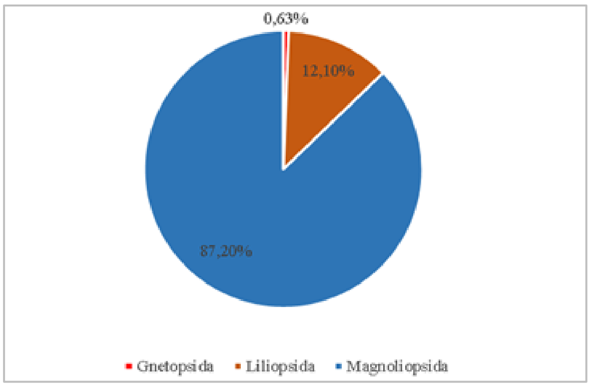

Figure 1. General composition of Donyztau flora

The studied area is home to 314 species of higher plants belonging to 170 genera and 40 families. Gymnosperm species are the least abundant in the Donyztau escarpment. The class Gnetopsida is represented by two species (0.63% of the total number of species in the flora). The overwhelming majority of species are flowering plants. The Magnoliophyta division includes 312 species (99.3%). Of these, 38 species (12.1%) belong to the class Liliopsida, and 274 species (87.2%) belong to the class Magnoliopsida. The ratio of monocotyledons to dicotyledons is 1:7.2 (Figure 1).

This ratio of the number of species of mono- and dicotyledonous plants is characteristic of Ancient Middle-earth [42].

The average species richness of families in the Donyztau escarpment is 7.6 species, and genus richness is 4.1.

A higher average species richness is demonstrated by ten families. The remaining 30 families account for 60% of all species.

The average level of species richness of a genus is ten. On average, each genus includes seven species.

The ten leading families by the number of species comprise 239 species, which constitute 78.3% of the total diversity of the Donyztau flora. The dominant families with more than 20 species are the Amaranthaceae – 67 species, Asteraceae – 40 species, and Brassicaceae – 31 species. Slightly inferior to the Brassicaceae are the Poaceae with 27 species and the Fabaceae with 26 species (Figure 2).

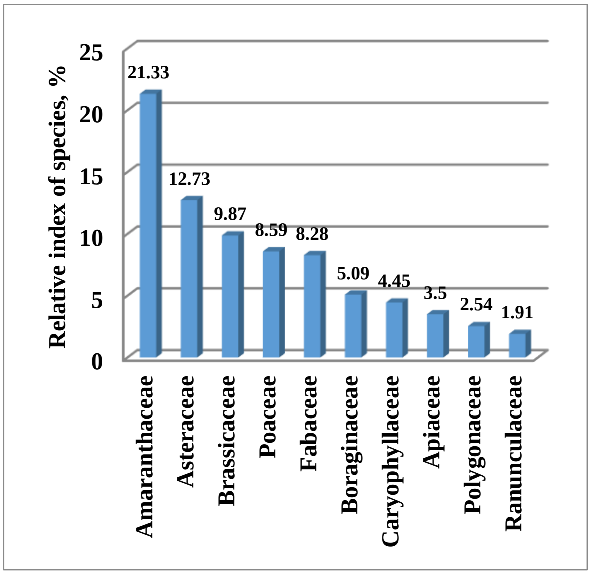

Figure 2. Representation of the leading families in Donyztau

Together, the first five families comprise 88 genera (51.7% of the total) and 190 species (61% of the total).

The family Amaranthaceae in the researched area comprises the genera Amaranthus, Anabasis, Agriophyllum, Atriplex, Arthrophytum, Bassia, Bienertia, Camphorosma, Caroxylon, Ceratocarpus, Chenopodium, Climacoptera, Corispermum, Dysphania, Girgensohnia, Halimocnemis, Halocnemum, Haloxylon, Kalidium, Nanophyton, Petrosimonia, Salsola, and Suaeda. Taxonomic analysis shows that the bulk of the family is represented by the genera Suaeda, Salsola, Atriplex, Anabasis, and Climacoptera. They include 35 species, which make up 52% of the total number of species within the family. In Donyztau, the series of monotypic genera is supplemented by 12 genera, two species each: Amaranthus, Agriophyllum, Arthrophytum, Bienertia, Camphorosma, Ceratocarpus, Corispermum, Dysphania, Girgensohnia, Halocnemum, Krascheninnikovia, Nanophyton. Genera Caroxylon, Chenopodium, Haloxylon, Kalidium, Kochia, Bassia, and Petrosimonia are represented by three species each. The only genus with four species is Halimocnemis.

Researchers believe that the increase in species diversity in the studied flora is connected with the increase in the ecotopic diversity of vegetation habitats in mountainous terrain [43].

As a result of this research, we found that 827 species of vascular plants belonging to 63 families and 290 genera were documented in the areas (Table 2).

Table 2. Information on the floristic richness of the compared floras

Flora	Total Number		
	Species	Genera	Families
Donyztau	314	170	40
Mugodzhar	273	156	43
Mountainous Mangyshlak	382	204	53
Zheltau	113	78	24
	827	**290**	**63**

The number of plant species in the floras varies considerably: the smallest list is that of Mount Zheltau (113 species). The dominant family with more than 20 species is the Amaranthaceae, which has 35 species; the second most abundant family is the Poaceae with 23 species; and the third is the Asteraceae with 15 species.

The dominant family in Mugodzhar is the Caryophyllaceae with 35 species. Ranking second by the number of species is the Asteraceae with 40 species; slightly inferior is the Fabaceae with 33 species present in the region.

The greatest variety of vegetation is found in the mountainous Mangyshlak – 382 species in total. The greatest variety of species includes the following families: Asteraceae – 55 species, Brassicaceae – 38 species, Poaceae – 33 species, and Amaranthaceae – 32 species. The difference in the number of species is mainly related to the size of the territories, as the richest floras are represented by combined floristic lists for rather large territories, exceeding the size of the rest of the territories. However, each flora is heterogeneous and specific and reflects the microconditions of its existence [44].

A way to identify distinctive features of a territory is to compare its family spectrum with that of neighboring territories. The construction of spectra of leading families and genera fulfills an auxiliary function in understanding the botanical and geographical features of the flora and serves as a reliable and objective indicator for comparing different floras and identifying differences and relationships between them [45].

Recent studies explored the impact of climate variability and land use changes on floristic composition in arid zones. For instance, the study by Du et al. [46] reported significant shifts in species dominance in Central Asian arid regions, with drought-tolerant species from the Asteraceae family showing an increase in prevalence, a finding that aligns with our observations in Donyztau. Similarly, Tu et al. [47] examined the adaptive strategies of the Amaranthaceae family in response to increasing aridity, further corroborating our results, which highlight the prominence of Amaranthaceae in both Donyztau and neighboring regions.

Table 3 presents information about the leading families by the number of species in the floras.

Table 3 demonstrates the difference in flora spectra by region. The top ten families in the four compared regions include five families: Amaranthaceae, Asteraceae, Brassicaceae, Poaceae, and Caryophyllaceae. The floristic spectra of Donyztau and the mountainous Mangyshlak are closest, with the first four families matching.

Table 3. The number of species in the top ten families of the floras compared

Overall Flora	Flora			
	Donyztau	**Mountainous Mangyshlak**	**Mugodzhar**	**Zheltau**
Ast^{115}	Amaranth^{67}	Ast^{55}	Ast^{40}	Poa^{23}
Amaranth^{93}	Ast^{40}	Brassic^{38}	Caryoph^{34}	Amaranth^{35}
Poa^{65}	Brassic^{31}	Poa^{33}	Faba^{33}	Ast^{15}
Brassic^{68}	Poa^{27}	Amaranth^{32}	Brassic^{23}	Caryoph^{7}
Faba^{68}	Faba^{26}	Caryoph –Faba^{25}	Cyperac^{14}	Brassic^{5}
Borag^{33}	Borag^{16}		Amaranth^{13}	
Caryoph^{58}	Caryoph^{14}	Borag^{20}	Scrophul^{12}	
Apia^{15}	Apia^{11}	Scrophul^{15}	Rosa^{11}	Lam – Apia – Rosa – Ranun – Polyg^{4}
Polyg^{19}	Polyg^{8}	Euphor^{10}	Poa – Ranun – Borag^{7}	
Ranun^{15}	Ranun^{6}	Lam^{8}		

Note: Amaranthaceae – Amaranth, Asteraceae – Ast, Brassicaceae – Brassic, Poaceae – Poa, Fabaceae – Faba, Boraginaceae – Borag, Caryophyllaceae – Caryoph, Apiaceae – Apia, Polygonaceae – Polyg, Ranunculaceae – Ranun, Scrophulariaceae – Scrophul, Euphorbiaceae – Euphor, Rosaceae – Rosa, Lamiaceae – Lam. The number of species in a family is indicated in the superscript.

The Amaranthaceae and Asteraceae families make up the spectra of Donyztau, mountainous Mangyshlak, and Mugodzhar, generally holding leading positions. In Zheltau, the number of species in the Poaceae family exceeds that of the Amaranthaceae and Asteraceae families, though insignificantly. In Mugodzhar, however, the Amaranthaceae family is inferior to the Caryophyllaceae family. A high position of the Caryophyllaceae family is characteristic of the flora of Mugodzhar, where it ranks second.

The family Amaranthaceae holds first place in Donyztau, second place in Zheltau, fourth place in the mountainous Mangyshlak, and sixth place in Mugodzhar.

It is reasonable to compare floristic areas directly based on plant species lists rather than by the spectra of families or genera (Table 4).

The highest number of common species is found in Donyztau and the mountainous Mangyshlak, while the lowest number of shared species is observed in Mugodzhar and Zheltau.

A separate analysis was conducted on the flora of the Donyztau escarpment. The floristic lists compiled for each territory were compared (Table 5).

Table 4. The number of common species in the compared floras

Flora	Donyztau	Mountainous Mangyshlak	Mugodzhar	Zheltau
Donyztau	-	123	34	63
Mountainous Mangyshlak	123	-	22	38
Mugodzhar	34	22	-	11
Zheltau	63	38	11	-

Table 5. The Jaccard similarity coefficient for the compared territories

Flora	Donyztau	Mountainous Mangyshlak	Mugodzhar	Zheltau
Donyztau	-	0.21	0.06	0.17
Mountainous Mangyshlak	0.21	-	0.03	0.08
Mugodzhar	0.06	0.03	-	0.03
Zheltau	0.17	0.08	0.03	-

Considering the degree of similarity, the values of the Jaccard index for the floras of the Donyztau escarpment and Mugodzhar are scattered, with 34 species in common (Jaccard index – 0.06). Most common species in the floras of Mugodzhar and Donyztau belong to the family Asteraceae. In total, the territories are home to 40 species of the family Asteraceae, 11 of which are shared. Of the 23 species in the family Brassicaceae, the number of common species is eight.

Zheltau is the most distinct among the regions, possessing the most species-poor flora. The similarity coefficient with the flora of Donyztau is 0.17 (63 common species). Common species of the Poaceae family found both in Donyztau and Zheltau include Agropyron desertorum (Fisch. ex Link) Schult., *Agropyron fragile* (Roth) P. Candargy., *Eragrostis collina* Trin., *Eragrostis minor* Host., *Eremopyrum orientale* (L.) Jaub. & Spach., *Eremopyrum triticeum* (Gaertn.) Nevski., *Hordeum spontaneum* K. Koch., *Phragmites australis* (Cav.) Trin. ex Steud., *Poa bulbosa* L., *Psathyrostachys juncea* (Fisch.) Nevski., *Puccinellia diffusa* (Krecz.) Krecz. ex Drobov., *Stipa caspia* C. Koch., and *Stipa sareptana* Beck. In second place by similarity are species of the family Amaranthaceae: *Anabasis aphylla* L., *Anabasis salsa* (C.A. Mey.) Benth. ex Volkens., *Atriplex aucheri* Moq., *Atriplex sphaeromorpha* Iljin., *Bassia hyssopifolia* (Pall) Kuntze., *Bassia prostrata* (L.) Akhani & E.H. Roalson., *Climacoptera lanata* (Pall.) Botsch. *Climacoptera crassa* (M. Bieb.) Botsch., *Climacoptera turcomanica* (Litv.) Botsch., Girgensohnia oppositiflora (Pall.) Fenzl., *Halimocnemis karelinii* Moq., *Halimocnemis sclerosperma* (Pall.) C.A. Mey., *Halocnemum strobilaceum* (Pall.) M. Bieb., *Haloxylon persicum* Bunge., *Kalidium caspicum* (L.) Ung.-Sternb., *Kalidium foliatum* (Pall.) Moq., *Krascheninnikovia ceratoides* (L.) Gueldenst., *Petrosimonia brachiata* (Pall.) Bunge., *Petrosimonia brachyphylla* (Bunge) Iljin., *Salsola arbusculiformis* Drobow., *Suaeda acuminate* (C.A.Mey) Moq., *Suaeda altissima* (L.) Pall., *Suaeda physophora* Pall.

The most similar flora was the flora of the mountainous Mangyshlak (Jaccard index – 0.21).

More significant differences between the regional floras were shown when considering the species composition of individual families (Table 6).

Table 6. Comparison of the spectrum of families in Donyztau with other floras based on the Jaccard index

Family	Flora											
	Number of Dongyztau species (D)	Number of mountainous Mangyshlak species (MM)	Number of species common to D and MM	Jaccard index	Number of Mugodzhar species (M)	Number of species common to D and M	Jaccard index	Number of Zheltau species (Zh)	Number of species common to D and Zh	Jaccard index
Asteraceae	**40**	55	17	**0.21**	40	11	**0.16**	15	2	**0.04**
Amaranthaceae	**67**	32	19	**0.24**	13	7	**0.10**	35	25	**0.32**
Brassicaceae	**31**	38	14	**0.25**	23	8	**0.17**	5	2	**0.06**
Poaceae	**27**	33	9	**0.18**	7	0	**0**	23	12	**0.32**

As indicated in Table 6, the family Amaranthaceae ranks first by the number of common species. Of the 32 species found in the mountainous Mangyshlak, 19 are also present in Donyztau. These include *Anabasis truncata* (Schrenk) Bunge, *Agriophyllum lateriflorum* (Lam.) Moq. ex DC., *Atriplex aucheri* Moq., *Atriplex tatarica* L., *Bassia hyssopifolia* (Pall) Kuntze., *Ceratocarpus arenarius* L., *Chenopodium glaucum* L., *Chenopodium strictum* Roth., *Climacoptera affinis* (C.A. Mey. ex Schrenk) Botsch., *Climacoptera brachiata* (Pall.) Botsch., *Climacoptera lanata* (Pall.) Botsch., *Girgensohnia oppositiflora* (Pall.) Fenzl., *Kochia iranica* Bornm., *Kochia odontoptera* Schrenk., *Salsola arbuscula* Pall., *Salsola arbusculiformis* Drobow., *Salsola orientalis* S.G. Gmel., *Salsola paulsenii* Litv., and *Suaeda physophora* Pall.

The family Asteraceae is represented in the regions by the shared species *Artemisia kelleri* Krasch., *Artemisia lerchiana* Weber., *Artemisia scoparia* Waldst. & Kitam., *Carthamus gypsicola* Iljin., *Centaurea squarrosa* Willd., *Cichorium intybus* L., *Cousinia astracanica* (Spreng.) Tamamsch., *Cousinia onopordioides* Ledeb., *Cousinia tenella* Fisch. et C.A. Mey., *Echinops ritro* L., *Koelpinia turanica* Vassilcz., *Lactuca tatarica* (L.) C.A. Mey., *Rhaponticum nitidum* Fisch., *Tanacetum santalina* C. Winkl., and *Tragopogon ruber* S.G. Gmel.

There are 38 species of the Brassicaceae family in the mountainous Mangyshlak area, of which 18 species are also present in Donyztau. These include *Alyssum desertorum* Staph., *Crambe edentula* Fisch. & C.A.Mey. ex Korsh., *Descurainia Sophia* (L.) Webb ex Prantl., *Diptychocarpus strictus* (Fisch. ex M. Bieb.) Trautv., *Isatis minima* Bunge., *Lachnoloma lehmannii* Bge., *Lepidium aucheri* Boiss., *Lepidium latifolium* L., *Lepidium perfoliatum* L., *Lepidium ruderale* L., *Matthiola robusta* Bunge., *Matthiola tatarica* (Pall.) DC.

The comparative analysis of family spectra of the floras shows that the floristic spectra of Donyztau and the mountainous Mangyshlak are closest, particularly with respect to the families Asteraceae (0.21), Amaranthaceae (0.24), and Brassicaceae (0.25). The greatest similarity in the family Poaceae is observed with the flora of Zheltau.

4. CONCLUSIONS

This study provides a comprehensive comparative analysis of the floristic composition of Donyztau, Zheltau, and the mountainous regions of Mangyshlak and Mugodzhar, contributing to the broader understanding of plant biodiversity in the arid zones of Central Asia. The flora of the northern escarpment of Ustyurt, or Donyztau, has not been properly studied before. Our results indicate that the flora of the escarpment comprises 314 species. Flowering plants account for 312 species (99.3%). Of these, 38 species (12.1%) belong to monocotyledons and 274 (87.2%) to dicotyledons. According to the literature studied to compare the vegetation, the flora of the mountainous Mangyshlak includes 382 plant species, Zheltau – 113 species, and Mugodzhar – 273 plant species.

Theoretically, the fundamental ecological principle that states that floristic composition is a product of climatic, geological, and edaphic factors is confirmed by the dominance of drought-resistant species, Amaranthaceae, and Asteraceae in multiple regions of arid nature. The study validates the relevance of floristic similarity indices, such as the Jaccard coefficient, in assessing biodiversity relationships and ecological connectivity between geographically distinct yet climatically similar regions. The results also reinforce the notion that biodiversity patterns in arid zones are not only driven by historical biogeographical events but also by contemporary environmental stressors, such as temperature fluctuations, precipitation variability, and anthropogenic influences.

The study highlights the need for targeted conservation strategies to mitigate biodiversity loss and land degradation in Central Asia’s arid regions. The identification of key plant species that contribute to ecosystem stability, such as drought-tolerant species within the Amaranthaceae and Asteraceae families, provides a foundation for the development of restoration programs.

The main conclusion is that when comparing the flora of Donyztau with the floras of neighboring territories, its greatest similarity is with the flora of the mountainous Mangyshlak. The number of common plant species in these territories is 123, the similarity coefficient being 0.21. The flora of Zheltau contains 63 species in common with Donyztau, with the Jaccard index amounting to 0.17. The lowest degree of similarity is observed when comparing the flora of Donyztau with that of Mugodzhar. The number of species in common between them is insignificant, totaling 34, the similarity coefficient being 0.06. This difference results from the history of flora formation, reflected by a significant diversity of plant species in the biosphere.

The findings of the present study have a direct bearing on the critical ecological concerns of Central Asia's arid regions, particularly in view of climate change and ineffective use of resources. The fragile environment of these regions is under threat with continued precipitation loss, increased temperatures, and increased anthropogenic factors such as overgrazing and inefficient use of water. There is a strong case for an integrated conservation of biodiversity through a mix of policy interventions and scientific studies, according to the study. To make these fragile environments more resilient, habitat restoration, ecological monitoring, and ecological approaches to grazing must receive high priority. Ultimately, this study provides a critical baseline for future research aimed at addressing the multifaceted environmental challenges of Central Asia's arid zones. By enhancing our understanding of floristic composition and ecological relationships, it lays the groundwork for more effective conservation strategies and sustainable land management policies.

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