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Species diversity of the family *Poaceae Barnhart* in the flora of the Betpakdala Desert (Ulytau region)

P.V. Vesselova[1], D.I. Maralov*[1], G.M. Kudabayeva[1], G.T. Sitpayeva[1], Z.A. Inelova[2], A.Z. Childibaeva[2], K.S. Izbastina[3,4]

[1]*Institute of Botany and Phytointroduction, Almaty, Kazakhstan*
[2]*Al-Farabi Kazakh National University, Almaty, Kazakhstan*
[3]*Astana Botanical Garden, Astana, Kazakhstan*
[4]*S. Seifullin Kazakh AgroTechnical Research University, Astana, Kazakhstan*

**Corresponding author: izbastina.k@gmail.com*

Abstract. This article presents the results of a comprehensive study of the species composition of the *Poaceae Barnhart* family in the flora of the Betpakdala Desert. The research is based on a critical review of published literature, examination of herbarium specimens from collections housed at AA and MW, and extensive fieldwork conducted by the authors. As a result, an updated checklist of *Poaceae* taxa for the region has been compiled. It includes 106 species distributed across 44 genera, 17 subtribes, 14 tribes, 7 supertribes, and 6 subfamilies. The taxonomic arrangement follows the contemporary classification system adopted by the Angiosperm Phylogeny Group IV (APG IV), and species names are aligned with the nomenclature recognized in the Plants of the World Online (POWO) database. For each species, the checklist provides detailed information on its taxonomic placement, latin binomial with author citation, life form, ecological grouping based on water availability and substrate type, habitat conditions, and flowering period. The genera with the highest species richness in the region are *Stipa* L. (11 species), *Puccinellia* Parl. (9), *Poa* L. (8), *Bromus* L. (8), and *Leymus* Hochst. (7). The article also includes a comparative analysis of the Poaceae species composition of Betpakdala with adjacent regions, including the Central Kazakh Upland, the Ulytau Mountains, and the Moyinkum Desert. Using the Sørensen similarity coefficient, it was determined that the highest floristic similarity exists between Betpakdala and Moyinkum, with a similarity index of 0.7. These findings contribute to a deeper understanding of grass diversity in Central Kazakhstan's arid ecosystems.

Keywords: Betpakdala, *Poaceae,* outline, species composition, modern classification, ecological features

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Introduction

The conducted research is a part of research works aimed at an inventory of modern species composition of Ulytau region, including a part of the territory of the Betpakdala desert. Difficult accessibility and low water availability of this desert an obstacles to regular study of its territory. The main idea about the flora of this desert can be made mainly from herbarium collections. Studies conducted in the middle of the last century by famous botanists demonstrated that the main ecological feature of the vegetation of Betpakdala is its resistance against extreme conditions of existence [1-4].

We conducted a preliminary analysis using available literature, materials from the herbarium of the Institute of Botany and Phytointroduction in Almaty (AA) and Lomonosov Moscow State University (MW) [5-14]. Available summaries show that Betpakdala and western Pribalkhash are characterized by a high level of endemism, which further emphasizes the floristic uniqueness of this area. Here, there are such endemic and subendemic species for Central Kazakhstan as *Lepidium jarmolenkoi* V.M.Vinogr.*, Megacarpaea iliensis* Golosk. et. Vassilcz. (Brassicaceae), *Artemisia hippolyti* A. Butkov *(Asteraceae), Spiraeanthus schrenkianus* (Fisch. & C.A. Mey.) Maxim. *(Rosaceae), Allium trachyscordum* Vved*. (Amaryllidaceae), Lappula duplicicarpa* Pavlov, L. glabrata Popov (Boraginaceae), Asparagus angulofractus Iljin (Asparagaceae), and some others. However, representatives of the Poaceae family, one of the leading taxa of the desert flora of Kazakhstan in terms of the number of species, are not found among them. This circumstance substantiates our scientific interest in studying the species composition of this family. It should be noted that the majority of herbarium collections of the listed species belong to the first half – middle of the XX century. Modern data on the distribution of most species and the number of their populations are not available.

To understand the role of the Poaceae family in shaping the floristic composition of adjacent regions, a comparison was conducted between the grass flora *(Poaceae)* of Betpakdala and that of neighboring regions (Moyinkum, the Kazakh Upland, and the Ulytau Mountains) using quantitative indicators and the Sørensen similarity coefficient. Floristic similarities and differences were identified, which are explained by both geographical proximity and the ecological conditions of the habitats.

Such information is extremely important for the inventory of floristic diversity of Betpakdala, in particular, the current species composition of the *Poaceae* family. New information about it will serve as a basis for the formation of the State Plant Cadastre of the newly created Ulytau region, which will serve as a basis for the formation of an inventory of the floristic diversity of Betpakdala.

Materials and research methods

When performing research work, such botanical methods were used as: route-reconnaissance; ecological-systematic; ecological-geographical; phytocenotic [15]. Collection of herbarium material was carried out according to the classical method of A.K. Skvortsov [16].

Determination of species affiliation of plants was carried out on the basis of floristic summaries: [17-20]. The nomenclature of taxa was verified according to Cherepanov S.K. and checked against the POWO database [21-22].

When compiling the list of species of the family *Poaceae* of the Betpakdala flora, available materials were used [14,23]. The structure of the species synopsis is given taking into account the modern classification adopted in the APG IV system [24,25].

To understand the ecological preferences of *Poaceae* species in relation to habitat conditions, the species synopsis distinguishes ecological groups of plants based on soil moisture and soil texture.

When comparing the species composition of the *Poaceae* family of the Betpakdala flora with the representation of this family in the floras of adjacent regions, the Serensen coefficient was applied [26]:

$$K = 2\ S_{ab}/S_a + S_b,$$

where,
a and b are the number of species in the compared areas,
ab is the number of total species.

Results

As a result of the research, a species outline of the family *Poaceae* Barnhart of the flora of the Betpakdala Desert was compiled, including 106 species distributed among 44 genera, 17 subtribes, 14 tribes, 7 supertribe and 6 subfamilies.

Glyceria notata Chevall. Perennial. Grows on swampy banks of streams, ditches, lakes, and rivers in the plains. Mesophyte. Pelitophyte. Blooms V-VIII.

Neotrinia splendens (Trin.) M. Nobis, P.D. Gudkova A. Nowak Perennial [28]. It grows in deserts, dry steppes, from plains to highlands, along the banks of rivers and lakes, often forming extensive thickets. Mesophyte. Hemipelitophyte. Blooms V-VII.

Stipa caucasica Schmalh. Perennial. Grows on dry slopes and screes, rubbly and sandy plains. Xerophyte. Hemipetrophytes. Blooms IV-VI.

S. orientalis Trin. Perennial. Grows on dry rubbly steppes and stony mountain slopes. Xerophyte. Petrophytes. Blooms IV-VI.

S. hohenackeriana Trin. et Rupr. Perennial. Grows in steppes, on sandy and desert foothills, and slopes of the lower belt of mountains. Xerophyte. Hemipsammophyte. Blooms IV-VI.

S. arabica Trin. et Rupr. Perennial. Grows in dry steppes, on mountain slopes, and desert foothills. Mesophyte. Pelitophyte. Blooms V-VI.

S. kirghisorum P.A. Smirn. Perennial. Grows in steppes and foothills on rubbly and stony soil, reaching the subalpine belt of mountains. Xerophyte. Hemipelitophyte. Blooms VI-VII.

S. macroglossa P.A. Smirn. Perennial. On crushed stone, stony, loess, and sandy-pebble slopes from the foothills to the middle belt of mountains. Xerophyte. Hemipelitophyte. Blooms V-VIII.

S. richteriana Kar. et Kir. Perennial. It grows on steppes and slopes of low mountains. Xerophyte. Pelitophyte. Blooms V-VI.

S. capillata L. Perennial. Grows in steppes, deserts and on stony slopes. Xerophyte. Pelitophyte. Blooms VI-VII.

S. lessingiana Trin. et Rupr. Perennial. Grows in steppes on stony and fine-grained slopes of foothills. Xerophyte. Hemipetrophytes. Blooms IV-V.

S. sareptana A.K. Becker. Perennial. Grows in steppes, on sands and in deserts. Xerophyte. Hemipsammophyte. Blooms V-VI.

S. pulcherrima K. Koch Perennial. Grows in steppes and on dry slopes of mountains and hills. Xerophyte. Pelitophyte. Blooms V-VI.

Timouria conferta (Poir.) Sennikov Perennial. Grows in the lower belt of mountains, on plumes and dry valleys, on rubbly and clayey places in dry steppes and deserts. Mesophyte. Hemipelitophyte. Blooms V-VII.

Piptatherum songaricum (Trin. et Rupr.) Roshev. Perennial. Grows on stony, stony-rubble, stony-silty slopes, rocky outcrops and screes from the foothills to the subalpine belt of mountains. Xerophyte. Petrophytes. Blooms V-VII.

*Achnatherum sibiricu*m (L.) Keng ex Tzvelev Perennial. It grows on sands and sandy steppes. Mesophyte. Psammophyte. Blooms VI-VII.

Phalaris arundinacea L. Perennial. Grows along the banks of rivers, lakes and streams, in damp meadows. Mesophyte. Hemipelitophyte. Blooms VI-VIII.

Avena sativa L. Perennial. Occurs as a weed in wheat crops and on fallow lands. Mesoxerophyte. Hemipelitophyte. Blooms VI-VIII.

A. fatua L. Annual. Occurs as a weed in crops of predominantly cereal crops. Mesoxerophyte. Hemipelitophyte. Blooms VI-VII.

Koeleria pyramidata (Lam.) P. Beauv. Perennial. It grows in steppes, on steppe mountain slopes and steppe meadows; in mountains it rises up to the alpine belt. Xerophyte. Pelitophyte. Blooms V-VIII.

Helictotrichon desertorum (Less.) Pilg. Perennial. Grows in dry steppes and on dry mountain slopes. Xerophyte. Pelitophyte. Blooms V-VI.

Anthoxanthum nitens (Weber) Y. Schouten et Veldkamp Perennial. Grows in flooded, steppe meadows, often as a weed on fallow lands. Mesophyte. Pelitophyte. Blooms V-VI.

Agrostis gigantea Roth Perennial. Grows in damp places, along streams, on sazes, meadows, along river beds from the foothills to the upper belt of mountains. Mesophyte. Pelitophyte. Blooms VI-VIII.

Calamagrostis macrolepis Litv. Perennial. Grows along banks of aryks, on deposits, sometimes on saline places on the plain, on grassy fine-grained slopes, along riverbeds in the mountains up to the upper belt. Halomesophyte. Hemipelitophyte. Blooms VI-VIII.

C. epigejos (L.) Roth Perennial. Grows on sandy and swampy soils of the plains and foothills. Xerophyte. Hemipsammophyte. Blooms VI-VII.

C. pseudophragmites (Haller f.) Koeler Perennial. Grows on sandy soil, on the banks of rivers, lakes and ditches, on damp meadows. Mesophyte. Hemipsammophyte. Blooms VI-VII.

Polypogon maritimus Willd. Perennial. Grows on saline meadows, sands, and dry river beds. Haloxeromesophyte. Hemipsammophyte. Blooms V-VII.

P. monspeliensis (L.) Desf. Annual. Grows on damp, solonetzified places. Halomesophyte. Pelitophyte. Blooms V-VIII.

Helictochloa hookeri (Scribn.) Romero Zarco Perennial. Occurs in the middle and upper belts of mountains, on rubbly, rubbly-stony, rubbly-small-gravel slopes. Xerophyte. Hemipetrophytes. Blooms V-VIII.

Lolium arundinaceum (Schreb.) Darbysh. Perennial. It grows on moist solonetz meadows, on the banks of lakes and rivers, along aryks, in gardens, on clay cliffs, among crops, and on deposits from plains to the middle belt of mountains. Halomesophyte. Pelitophyte. Blooms V-VII.

Festuca valesiaca Schleich. ex Gaudin Perennial. Occurs in steppes, on dry and solonetz meadows, stony slopes of hills, foothill slopes, on stony, rubbly and sandy habitats, among rocks, on screes, on pebbles, moraine hills from plains to the upper belt of mountains. Mesoxerophyte. Hemipetrophytes. Blooms IV-VIII.

F. rupicola Heuff. Perennial. It grows in steppes, on steppe, dry and solonetz meadows, on steppe slopes in the lower belt of mountains. Xerophyte. Pelitophyte. Blooms V-VI.

Puccinellia distans (Jacq.) Parl. Perennial. Grows on moist, slightly saline or waterlogged meadows, sandy-clay shoals, cartilaginous-pebble habitats along the banks of rivers, lakes, streams and ditches from plains to the upper belt of mountains; weeds. Mesophyte. Hemipelitophyte. Blooms IV-IX.

P. diffusa (V.I.Krecz.) V.I. Krecz. ex Drobov Perennial. Grows on saline sands, solonchaks along the banks of rivers, lakes, streams, springs and along mountain loops. Haloxeromesophyte. Psammophyte. Blooms IV-VI.

P. dolicholepis (V.I. Krecz.) Pavlov Perennial. Grows on solonts, solonchaks, saline sands, in the lower part of rubbly slopes of hills, along the margins of takyrs, along the banks of rivers and saline lakes, near springs. Hyperhalomesophyte. Hemipsammophyte. Blooms V-VI.

P. poecilantha (K. Koch) Grossh. Perennial. Grows on damp solonetz meadows, wet solonchaks, sandy and loamy-sandy habitats, waterlogged depressions along the banks of seas, rivers, salt lakes, streams, and ditches from plain to foothills; weeds. Hyperhalomesophyte. Hemipelitophyte. Blooms V-VIII.

P. gigantea (Grossh.) Grossh. Perennial. Grows on solonetz meadows, banks of water bodies, and ditches, occasionally in foothills. Mesophyte, галофит. Halomesophyte. Hemipelitophyte. Blooms VI-VII.

P. hauptiana (V.I. Krecz.) Kitag. Perennial. Grows on damp and slightly saline meadows and marshes, on weedy places. Mesophyte. Pelitophyte. Blooms VI-VII.

P. roshetvitsiana (Schischk.) V.I. Krecz. ex Tzvelev Perennial. Grows on solonetz and solonetz meadows, in chia thickets. Halomesophyte. Pelitophyte.Blooms VI-VII.

P. macropus V.I. Krecz. Perennial. Grows on saline desert sands. Haloxerophyte. Psammophyte. Blooms V-VI.

P. tenuissima (Litv. ex V.I. Krecz.) Pavlov Perennial. Grows on dry and coastal solonetz steppes, in steppe hollows and depressions. Halomesophyte. Pelitophyte. Blooms V-VI.

Catabrosella humilis (M. Bieb.) Tzvelev Perennial. Grows in clay steppes and deserts, on sandy sediments, and less often on stony slopes of foothills and shallow hills. Mesoxerophyte. Hemipelitophyte. Blooms IV-V.

Poa annua L. Perennial. It grows in weedy places, meadows, near roads and ditches, and rises to the mountains. Mesophyte. Pelitophyte. Blooms IV-VIII.

P. bulbosa L. Perennial. It grows on steppes, in large-grass and wormwood-ephemeral deserts, on sands and dry slopes of foothills. Xerophyte. Hemipsammophyte. Blooms IV-VI.

P. pratensis L. Perennial. It grows in meadows and shrubs, near streams, from the plain to the subalpine belt of mountains. Mesophyte. Pelitophyte. Blooms V-VII.

P. angustifolia L. Perennial. Grows on dry meadows, steppes, and mountain slopes, up to the subalpine belt. Xerophyte. Pelitophyte. Blooms V-VII.

P. palustris L. Perennial. Grows in shrub and tree thickets, in meadows, along river and stream banks, and on mountain slopes in the lower belt. Mesophyte. Pelitophyte. Blooms V-VI.

P. versicolor Besser Perennial. Grows on mountain steppes and dry steppe slopes. Mesoxerophyte. Pelitophyte. Blooms VI-VII.

P. nemoralis L. Perennial. Grows on wet meadows, in river valleys, along the banks of water bodies and forest edges. Mesophyte. Pelitophyte. Blooms VI-VIII.

P. diaphora Trin. Annual. Grows on dry riverbeds, banks of rivers, lakes and streams on saline soil. Haloxerophyte. Hemipelitophyte. Blooms V-VI.

Beckmannia eruciformis (L.) Host Perennial. Grows along the banks of rivers and ditches, on moist solonetz meadows. Halomesophyte. Pelitophyte. Blooms VI-VIII.

Alopecurus arundinaceus Poir. Perennial. Grows on flood and solonetz meadows, on the banks of rivers and streams and in swamps. Галогигрофит. Hemipelitophyte. Blooms V-VII.

Apera interrupta (L.) P. Beauv. Annual. Grows on sands and as a weed in cultivated fields. Xeromesophytes. Psammophyte. Blooms IV-V.

Bromus scoparius L. Annual. It grows in swamps and fallow lands, in gardens, near roads, along river valleys, on dry clay slopes from plains to the lower belt of mountains, and weeds in rainfed crops. Xeromesophytes. Pelitophyte. Blooms IV-VI.

B. lanceolatus Roth Annual. It grows on meadows, lanes, storages, semifixed and fixed sands, on gravelly and sandy riverbeds from foothill deserts to the middle belt of mountains, less often on meadows in river valleys and along the shores of lakes, and in weeds in crops. Mesoxerophyte. Hemipsammophyte. Blooms V-VII.

B. inermis Leyss. Perennial. It grows on steppe meadows, meadow slopes, in shrubs, and rises to the mountains up to the alpine belt. Xeromesophytes. Pelitophyte. Blooms VI-VII.

B. tectorum L. Annual. It grows in southern ephemeral deserts, on sands, often as a weed on deposits, near roads and dwellings. Xeromesophytes. Psammophyte. Blooms IV-VI.

B. japonicus subsp. japonicus Annual. It grows in meadow steppes, on fallow lands, often as a weed near roads, in crops and near dwellings; it enters the middle belts of mountains. Mesophyte. Pelitophyte. Blooms V-VII.

B. danthoniae Trin. Annual. It grows in meadows, in swamps, along gravelly riverbeds, from foothill deserts to the middle belt of mountains; weeds in crops and gardens. Mesoxerophyte. Pelitophyte. Blooms V-VII.

B. gracillimus Bunge Annual. Grows in open places on sandy and clay soils in deserts and foothills, in mountains, on dry slopes, screes, and gravelly riverbeds up to the upper belt of mountains.Xerophyte. Hemipelitophyte. Blooms IV-VIII.

B. squarrosus L. Perennial. Grows in dry steppes of plains and foothills, clay deserts, as a weed in crops and near roads. Xerophyte. Pelitophyte. Blooms V-VII.

Henrardia persica (Boiss.) C.E. Hubb. Annual. Grows on dry, rubbly, and clayey, sometimes sandy slopes of foothills, occasionally as a weed in rainfed crops. Xerophyte. Hemipelitophyte. Blooms V-VI.

Agropyron fragile (Roth) P. Candargy Perennial. Grows on flat sandy steppes and sands. Xerophyte. Psammophyte. Blooms VI-VII.

A. cristatum (L.) Gaertn. Perennial. Grows on dry steppes, mountain and hill slopes up to the middle belt. Xerophyte. Pelitophyte. Blooms VI-VII.

A. desertorum (Fisch. ex Link) Schult. Perennial. Grows on clay and stony plain steppes. Xerophyte. Hemipelitophyte. Blooms VI-VII.

Hordeum bogdanii Wilensky Perennial. Grows on saline meadows and steppe estuaries. Halomesophyte. Pelitophyte. Blooms VI-VII.

H. brevisubulatum (Trin.) Link Perennial. Grows on saline meadows, banks of rivers and lakes. Halomesophyte. Pelitophyte. Blooms VI-VII.

H. murinum subsp. leporinum (Link) Arcang. Annual. Occurs in river valleys, foothill deserts, foothills and the lower belt of mountains, weeds in crops, gardens, on boundaries and foothills, and near dwellings. Mesoxerophyte. Pelitophyte. Blooms IV-VII.

Leymus paboanus (Claus) Pilg. Perennial. Grows on solonets, solonchaks and solonetz meadows. Halomesophyte. Pelitophyte. Blooms VI-VII.

L. racemosus (Lam.) Tzvel. Perennial. Grows on sands and sandy steppes. Xerophyte. Psammophyte. Blooms VI -VII.

L. ramosus (K.Richt.) Tzvelev Perennial. Grows on solonetz steppes, on solonetz and solonetz meadows, fallow lands, sometimes as a weed. Haloxeromesophyte. Pelitophyte. Blooms VI-VII.

L. karelinii (Turcz.) Tzvelev Perennial. Grows in clay desert. Xerophyte. Pelitophyte. Blooms V-VI.

L. akmolinensis (Drobow) Tzvelev Perennial. Grows on solonchaks and solonchak meadows, banks of lakes, rivers and streams. Haloxeromesophyte. Pelitophyte. Blooms VI-VII.

L. multicaulis (Kar. Kir.) Tzvelev Perennial. Grows on solonchaks and saline meadows. Halomesophyte. Pelitophyte. Blooms V-VI.

L. angustus (Trin.) Pilg Perennial. Grows on dry steppes, on hills and slopes of the lower belt of mountains, riverbanks. Mesoxerophyte. Pelitophyte. Blooms VI-VII.

Psathyrostachys juncea (Fisch.) Nevski Perennial. Grows in dry steppes, on solonchaks and steppe slopes, and on plumes of mountains up to the middle belt. Haloxerophyte. Pelitophyte. Blooms VI-VII.

Taeniatherum caput–medusae (L.) Nevski Annual. Grows along rocky slopes and plumes of the southern foothills. Xerophyte. Petrophytes.Blooms IV-V.

Thinopyrum intermedium subsp. Intermedium Perennial. Grows on dry slopes from the foothills to the middle belt of mountains, forming peculiar wheatgrass steppes. Xerophyte. Pelitophyte. Blooms V-VII.

Elymus repens (L.) Gould Perennial. It grows in steppes and meadows, on fallow lands and estuaries, often as a weed and crops. Xeromesophytes. Pelitophyte. Blooms VI-VII.

Eremopyrum triticeum (Gaertn.) Nevski Annual. It grows in steppes and deserts on rubbly, sandy and solonetz soils. Haloxerophyte. Hemipelitophyte. Blooms IV-V.

E. bonaepartis (Spreng.) Nevski Annual. Grows on plains, sands and clay soils of deserts. Xerophyte. Hemipelitophyte. Blooms IV-V.

E. orientale (L.) Jaub. et Spach Perennial. Grows in southern steppes and deserts, on dry slopes of the lower belt of mountains. Xerophyte. Pelitophyte. Blooms IV-V.

E. distans (K.Koch) Nevski Perennial. Grows in southern steppes and deserts, slightly occurs on dry mountain slopes of the lower belt. Xerophyte. Pelitophyte. Blooms IV-V.

Secale sylvestre Host Annual. Grows on sands and steppe sandy loam. Xerophyte. Hemipsammophyte. Blooms V-VI.

Digitaria sanguinalis (L.) Scop. Annual. It grows as a weed on sandy soils, in crops, near ditches, on lawns. Mesophyte. Hemipsammophyte. Blooms VII-X.

Echinochloa crus-galli (L.) P. Beauv. Annual. Grows as a weed in crops and vegetable gardens. Mesophyte. Pelitophyte. Blooms VI-VIII.

Cenchrus americanus (L.) Morrone Annual. Grows as a weed in crops, gardens and orchards, less often along riverbanks and on mountain loops. Mesophyte. Pelitophyte. Blooms VII-IX.

Setaria viridis (L.) P. Beauv. Annual. Grows as a weed in crops, gardens and orchards, less often along riverbanks. Mesophyte. Pelitophyte. Цв: VII-IX.

Bothriochloa ischaemum (L.) Keng Perennial. Grows on dry slopes of mountains and hills, less often in flat steppes. Xerophyte. Pelitophyte. Blooms VI-VII.

Stipagrostis karelinii (Trin. et Rupr.) H. Scholz Perennial. It grows on mobile barchan and bumpy sands. Xerophyte. Psammophyte. Blooms V-VI.

S. pennata (Trin.) De Winter Perennial. Grows on barchan and bumpy sands. Xerophyte. Psammophyte. Blooms V-VI.

Aristida adscensionis L. Annual. Grows on dry sandy and stony places, not rising high up into the mountains. Xerophyte. Hemipetrophytes. Blooms V-IX.

Phragmites australis (Cav.) Trin. Steud. Perennial. Grows in the mouths of rivers, forming huge thickets, along the banks of lakes, streams and ditches, on flood meadows, in depressions between bumpy sands and as a weed on irrigated lands. Hygrophyte. Hemipelitophyte. Blooms VII-X.

Schismus arabicus NeesAnnual. It grows on dry sandy or stony places. Xerophyte. Hemipsammophyte. Blooms IV-VI.

Eragrostis minor Host Annual. It grows on clay and sandy slopes, along the banks of rivers and ditches, as a weed in crops and vegetable gardens. Mesoxerophyte. Hemipelitophyte. Blooms VII-VIII.

E. cilianensis (All.) Vignolo ex Janch. Annual. It grows in weedy places, among crops and in storage on the plain, and enters the foothills and mountains. Mesoxerophyte. Pelitophyte. Blooms V-IX.

E. collina Trin. Perennial. Grows on saline places and saline sandy steppes. Haloxerophyte. Hemipsammophyte. Blooms VI-VII.

E. pilosa (L.) Beauv. Annual. Grows on sandy banks of rivers and reservoirs and in weedy places. Mesoxerophyte. Hemipsammophyte. Blooms VII-VIII.

*Sporobolus a*lopecuroides (Piller Mitterp.) P.M. Peterson [27] Annual. Grows on damp, sandy, and saline places. Haloxeromesophyte. Psammophyte. Blooms VI-VIII.

S. borszczowii (Regel) P.M. Peterson Annual. Grows in the valleys of desert rivers, on damp saline places. Mesophyte. Hemipelitophyte.Blooms VI-VII.

S. aculeatus (L.) P.M. Peterson [29] Annual. Grows on damp, saline soils. Halomesophyte. Pelitophyte. Blooms VI-VIII.

S. schoenoides (L.) P.M. Peterson Annual. Grows on damp, sandy, and saline soils. Haloxeromesophyte. Hemipsammophyte. Blooms VI-VIII.

S. turkestanicus (Eig) P.M. Peterson Annual [30]. Grows on saline sands and clays. Haloxerophyte. Hemipelitophyte. Blooms IV-VI.

Aeluropus littoralis (Gouan) Parl. Perennial. Grows on saline soils and saline sands. Halomesoxerophyte. Hemipsammophyte. Blooms IV-VII.

A. lagopoides (L.) Thwaites Perennial. On sandy sites, on saline soils, moist saline areas on the plain and in the foothills. Haloxerophyte. Hemipsammophyte. Blooms V-VIII.

Cynodon dactylon (L.) Pers. Perennial. Grows on sandy places and as a weed near dwellings, in crops, near ditches. Mesoxerophyte. Hemipsammophyte. Blooms V-VIII.

The leading genera in terms of number of species include the following genera: *Stipa* L. – 11 species, *Puccinellia* Parl. –9, *Poa* L. – 8, *Bromus* L. – 8, *Leymus* Hochst. – 7.

During the analysis of the species composition of the Betpakdala region, it was found that, according to current data, species such as *Puccinellia macropus* V.I. Krecz. and *Leymus karelinii* (Turcz.) Tzvelev, which were previously considered endemics of Kazakhstan, are no longer classified as such. Species of the *Poaceae* family, included in the Red Data Book of Kazakhstan (2014), were not recorded in the flora of Betpakdala.

In the flora of Betpakdala, the family *Poaceae* is represented by 106 species, among which 30 species are annual plants and 76 are perennials. The analysis of ecological features showed the following distribution of species: in relation to water regime: 22 mesophytes, 5 xeromesophytes, 2 hyperhalomesophytes, 12 halomesophytes, 6 haloxeromesophytes, 37 xerophytes, 13 mesoxerophytes, 7 haloxerophytes, 1 halomesoxerophyte and 1 hygrophyte (Figure 1). In relation to substrate: 10 psammophytes, 17 Hemipsammophytes, 48 pelitophytes, 23 hemipelitophytes, 3 petrophytes and 5 hemipetrophytes (Figure 2).

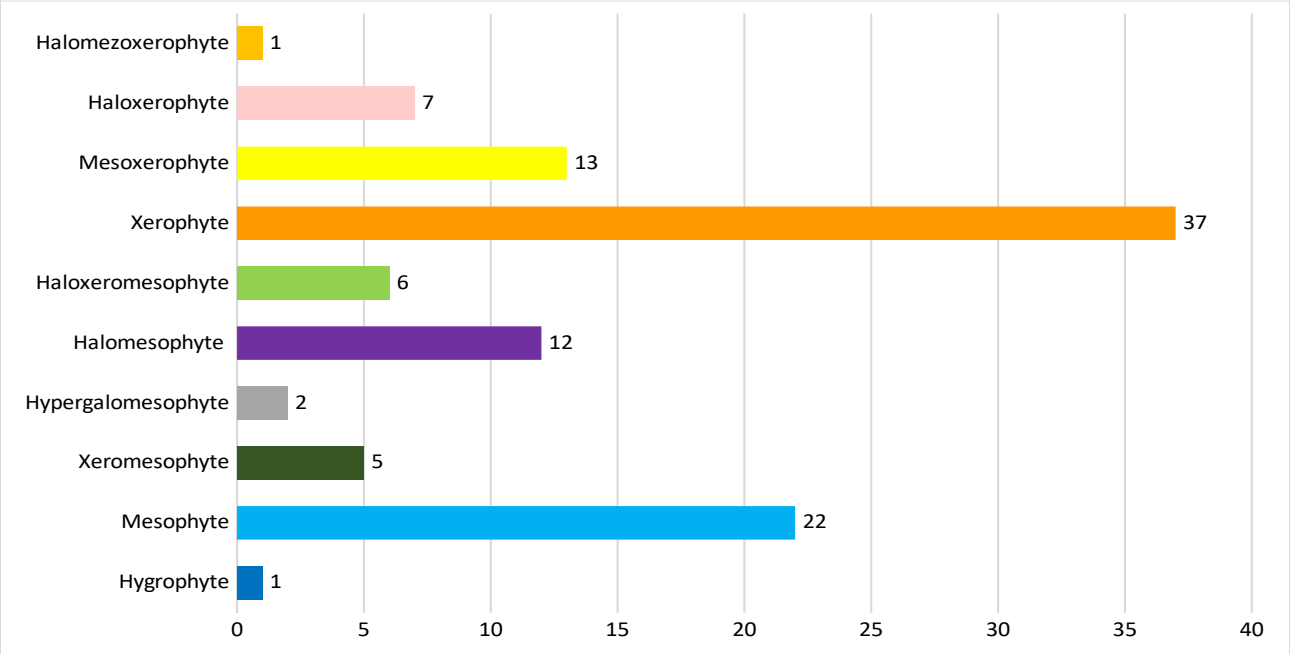

Figure 1. Distribution of the species composition of the *Poaceae* family in the flora of Betpakdala in relation to soil moisture

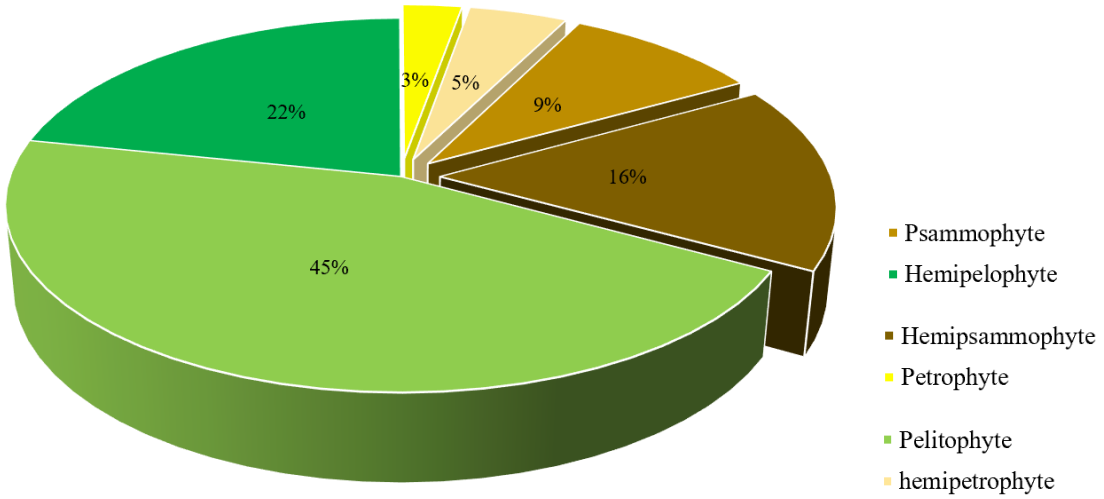

Figure 2. Distribution of the species composition of the *Poaceae* family in the flora of Betpakdala in relation to soil texture

The conducted comparative analysis showed the similarity of species composition of *Poaceae* family of Betpakdala flora and its representation in the floras of adjacent regions (Kazakh Upland, Ulytau mountains and sandy desert Moyinkum) (Table 1).

Table 1

Distribution of leading genera of the family *Poaceae* in the floras of Betpakdala, Moyinkum, Kazakh Upland and Ulytau

Betpakdala		
Leading genera	Number of species	% of total number of species
Stipa	11	10.3
Puccinellia	9	8.5
Poa	8	7.5
Bromus	8	7.5
Leymus	7	6.6
Total	106	40.5
Kazakh Upland		
Leading genera	Number of species	% of total number of species
Stipa	15	10.7
Poa	13	9.2
Puccinellia	9	6.4
Elymus	8	5.7
Leymus	7	5
Total	140	37.1

Moyinkum		
Leading genera	Number of species	% of total number of species
Stipa	9	11.2
Poa	7	8.7
Bromus	7	8.7
Puccinellia	4	5
Leymus	4	5
Total	80	38.8
Ulytau		
Leading genera	Number of species	% of total number of species
Stipa	9	13.6
Poa	8	12.1
Leymus	5	7.5
Puccinellia	3	4.5
Bromus	3	4.5
Total	66	42.4

A comparative analysis of the similarity of the species composition of representatives of the *Poaceae* family in the floras of adjacent territories yielded the following results, presented in Table 2.

Table 2

Comparative analysis of the similarity of the species composition of representatives of the *Poaceae* family

Comparison between the floras	Calculation method	Similarity coefficient
Betpakdala and Kazakh Upland	К = 2 x 82 / 246	0.6
Betpakdala and Ulytau	К = 2 x 49 / 172	0.5
Betpakdala and Moyinkum	К = 2 x 67/186	0.7

Thus, the highest floristic similarity was found between the species composition of the flora of Betpakdala and the Moyinkum Desert (К = 0.7), which is also supported by the proportional similarity of dominant genera: Stipa (10.3% in Betpakdala and 11.2% in Moyinkum), as well as comparable values for the genera Poa and Bromus. This is explained by similar arid ecological conditions, sandy substrates, and vegetation types dominated by grasses and xerophytic herbs.

The relatively small difference in the coefficient (К = 0.6) in the comparison between Betpakdala and the Kazakh Upland reflects not only the geographical proximity of these regions but also the mutual penetration and participation of species in the formation of their vegetation cover. Despite a greater total number of species, dominant genera such as Stipa and Poa demonstrate comparable proportions.

The lowest similarity was observed in the comparison between the species diversity of Betpakdala and Ulytau (K = 0.5), which may be due to the differences in terrain and landscape structure in the Ulytau region. Here, the representation of the genera Puccinellia and Bromus is noticeably lower. These results emphasize that not only geographical proximity but also ecological similarity plays a key role in shaping floristic composition.

Discussion

The Poaceae flora of the Betpakdala Desert demonstrates a high degree of ecological specialization and taxonomic richness. This work contributes new insights into the structure and dynamics of grass diversity in arid ecosystems of Central Asia. The identified patterns and hypotheses provide a foundation for future research focused on floristic change, ecological resilience, and conservation under the dual pressures of climate change and human impact.

Additional insights into the floristic context of the Betpakdala Desert can be drawn from earlier works such as A.N. Kupriyanov and the foundational studies of Z.V. Kubanskaya [5,13]. These works highlighted that the northern boundary of the Betpakdala desert flora extends approximately along the 47°N parallel, where steppe communities begin to transition into desert vegetation. They also described a complex mosaic of phytocoenoses, including *Artemisia*-grass steppes and halophytic shrublands, which corresponds well with our observations of habitat heterogeneity and substrate-driven plant distribution. Particularly relevant is the record of rare grasses such as *Aristida heymannii, Piptatherum songaricum,* and *Stipa richteriana* on southern granite outcrops like Mount Pystan-species that reflect floristic continuity with our present records.

Our findings, especially regarding the presence of pelitophytic and xerophytic *Poaceae* species, align with Kubanskaya's estimation that northern deserts occupy around 90% of Betpakdala's territory, where dominant vegetation includes drought-adapted shrubs like *Anabasis salsa, Salsola laricina,* and halophytic taxa [5]. The floristic similarity further strengthens the ecological cohesion of the region's plant assemblages. Furthermore, the detection of ephemeral and ephemeroid species, such as *Catabrosella humilis* and *Eremopyrum orientale,* reported both in historical surveys and our current study, suggests that seasonal hydrological conditions continue to play a significant role in shaping the short-term composition of Poaceae communities. The expansion or contraction of these species may serve as a sensitive indicator of climate variability in arid environments.

We hypothesize that observed shifts in the species composition and ecological group balance, such as the dominance of perennial xerophytes and pelitophytes, may also reflect a gradual aridization trend, possibly amplified by reduced grazing pressure in some areas or localized microclimatic stabilization (e.g., due to changing land use or hydrology). Conversely, areas experiencing intensified anthropogenic influence, such as pasture degradation or soil compaction, might be favoring more resilient yet ecologically narrower taxa, which could result in a functional simplification of the grass layer over time.

The integration of historical floristic records and contemporary ecological analysis underscores the scientific novelty of this study: it not only updates species richness estimates

but also links them to ongoing ecological processes. This dual temporal-spatial perspective is essential for building a predictive understanding of floristic dynamics in fragile desert ecosystems like Betpakdala. Thus, as a result of study, critical analysis and generalization of available data on the species composition of the family *Poaceae* Barnhart in the flora of the Betpakdala Desert, 106 species distributed in 44 genera have been identified to date. *Perennials* dominate among them, accounting for 71.6% of the species. The genera Stipa L., Puccinellia Parl., Poa L. are predominant in number of species and together include 28 species or 26% of the total number of species. In relation to water, 10 groups of species were identified, with xerophytes – 35% and mesophytes – 20% predominating, and in relation to the substrate, 6 groups were identified with pelitophytes dominating 67%. Comparative analysis of *Poaceae* species composition of Betpakdala flora with representation of this family in the floras of neighboring regions naturally showed the greatest similarity (Serensen's coefficient is equal to 0.7) between Betpakdala and Moinkum deserts.

Author Contributions

V.P. and **K.G. –** supervisor of the study, critically revising its content; **M.D. –** conceptualization, investigation & data curation; **S.G.** – review & editing; **I.Z.** – supervisor; **I.K.** and **Ch.A.** – formal analysis. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest.

Compliance with ethical standards

This article does not contain a description of studies performed by the authors involving people or using animals as objects.

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Бетпақдала шөлінің флорасындағы Poaceae Barnhart тұқымдасының түрлік алуандығы (Ұлытау облысы)

П.В. Веселова[1], Д.И. Маралов[1], Г.М. Құдабаева[1], Г.Т. Ситпаева[1], З.А. Инелова[2], А.Ж. Чилдибаева[2], К.С. Избастина[3,4]

[1]Ботаника және фитоинтродукция институты, Алматы, Қазақстан
[2]Әл-Фараби атындағы Қазақ ұлттық университеті, Алматы, Қазақстан
[3]Астана ботаникалық бағы, Астана, Қазақстан
[4]С. Сейфуллин атындағы Қазақ агротехникалық зерттеу университеті, Астана, Қазақстан

Аңдатпа. Мақалада Бетпақдала шөлі флорасының Poaceae Barnhart тұқымдасының түрлік құрамын зерттеу нәтижелері келтірілген. Атап айтқанда, APG IV жүйесінде қабылданған заманауи классификацияны ескере отырып, түрлердің қысқаша мазмұны берілген. Түрлер үшін конспектте таксономиялық тиістілігі (субфамилияға, суприбеге, тайпаға, субтрибеге және тұқымға), автормен латын атауы, тіршілік формасы, су мен субстратқа қатысты топ, өсудің экологиялық жағдайлары, гүлдену мерзімдері, фотосинтез түрі және Қазақстан шегінде таралуы көрсетіледі. Конспект 44 туыс, 17 триба асты, 14 триба, 7 триба үсті және 6 тұқымдас асты арасында бөлінген 106 түрді қамтиды. Түрлердің саны бойынша жетекші туыстардың қатарына жатады: Stipa L. – 11 түрі, Puccinellia Parl. – 9, Poa L.-8, Bromus L.-8, Leymus Hochst. – 7. Бұдан басқа, Poaceae Бетпақдала флорасының түрлік құрамын осы отбасының іргелес өңірлердің (Орталық Қазақ ұсақ шоқысы, Ұлытау таулары мен Мойынқұм құмды шөлі) флораларында ұсынылуымен салыстырмалы талдау нәтижелері келтіріледі. Серенсен коэффициентінің формуласын қолдану негізінде Poaceae тұқымдасының құрамының ең үлкен ұқсастығы Бетпақдала және Мойынқұм флоралары болып табылады. Олардың ұқсастық коэффициенті 0,7.

Түйін сөздер: Бетпақдала, Poaceae, конспект, түрлік құрамы, қазіргі классификациясы, экологиялық ерекшеліктері

Видовое разнообразие семейства Poaceae Barnhart флоры пустыни Бетпакдала (Улытауская область)

П.В. Веселова[1], Д.И. Маралов[1], Г.М. Кудабаева[1], Г.Т. Ситпаева[1], З.А. Инелова[2], А.Ж. Чилдибаева[2], К.С. Избастина[3,4]

[1]Институт ботаники и фитоинтродукции, Алматы, Казахстан
[2]Казахский национальный университет имени аль-Фараби, Алматы, Казахстан
[3]Астанинский ботанический сад, Астана, Казахстан
[4]Казахский агротехнический исследовательский университет имени С. Сейфуллина, Астана, Казахстан

Аннотация. В статье приводятся результаты изучения видового состава семейства Poaceae Barnhart флоры пустыни Бетпакдала. В частности, дается конспект видов с учетом современной классификации, принятой в системе APG IV. Для видов в конспекте указывается таксономическая

принадлежность (к подсемейству, надтрибе, трибе, подтрибе и роду), латинское название с автором, жизненная форма, группа по отношению к воде и субстрату, экологические условия произрастания, сроки цветения, тип фотосинтеза и распространение в пределах Казахстана. Конспект включает 106 видов, распределенных между 44 родами, 17 подтрибами, 14 трибами, 7 надтрибами и 6 подсемействами. К числу ведущих по количеству видов относятся следующие роды: Stipa L. – 11 видов, Puccinellia Parl. – 9, Poa L. – 8, Bromus L. – 8, Leymus Hochst. – 7. Кроме того, приводятся результаты сравнительного анализа видового состава Poaceae флоры Бетпакдалы с представленностью этого семейства во флорах смежных регионов (Центрального Казахского мелкосопочника (ЦКМ), гор Улытау и песчаной пустыни Мойынкумы). На основании применения формулы коэффициента Серенсена показано, что наибольшее сходство состава семейства Poaceae видов имеют флоры Бетпакдалы и Мойынкумов. Коэффициент их сходства равен 0,7.
Ключевые слова: Бетпакдала, Poaceae, конспект, видовой состав, современная классификация, экологическая особенность

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Сведения об авторах:

Веселова Полина Васильевна – кандидат биологических наук, заведующая лабораторией флоры и высших растений, Институт ботаники и фитоинтродукции, ул. Тимирязева 36 д, 050000, Алматы, Казахстан.

Маралов Дамир Икрамович – лаборант лаборатории флоры и высших растений, Институт ботаники и фитоинтродукции, ул. Тимирязева 36 д, 050000, Алматы, Казахстан.

Кудабаева Гульмира Маулетовна – кандидат биологических наук, ведущий научный сотрудник лаборатории флоры и высших растений, Институт ботаники и фитоинтродукции, ул.Тимирязева 36 д, 050000, Алматы, Казахстан.

Ситпаева Гульнара Токбергеновна – доктор биологических наук, ведущий научный сотрудник, Институт ботаники и фитоинтродукции, ул. Тимирязева 36 д, 050000, Алматы, Казахстан.

Инелова Зарина Аркенжановна – кандидат биологических наук, профессор кафедры биоразнообразия и биоресурсов, пр. аль-Фараби 71, 050000, Алматы, Казахстан.

Чильдибаева Асел Жумагуловна – PhD, исполняющая обязанности доцента кафедры биоразнообразия и биоресурсов, пр. аль-Фараби 71, 050000, Алматы, Казахстан.

Избастина Клара Сержановна – PhD, ассоциированный профессор, старший преподаватель кафедры «Биология, защита растений и карантин», просп. Женис 62, 010000, Астана, Казахстан.

Авторлар туралы мәліметтер:

Веселова Полина Васильевна – биология ғылымдарының кандидаты, Ботаника және фитоинтродукция институты, флора және жоғары өсімдіктер зертханасының меңгерушісі, Тимирязев көшесі 36, 050000, Алматы, Қазақстан.

Маралов Дамир Икрамович – Ботаника және фитоинтродукция институты, флора және жоғары өсімдіктер зертханасының зертханашысы, Тимирязев көшесі 36, 050000, Алматы, Қазақстан.

Кудабаева Гульмира Маулетовна – биология ғылымдарының кандидаты, Ботаника және фитоинтродукция институты, флора және жоғары өсімдіктер зертханасының жетекші ғылыми қызметкері, Тимирязев көшесі 36, 050000, Алматы, Қазақстан.

Ситпаева Гульнара Токбергеновна – биология ғылымдарының докторы, Ботаника және фитоинтродукция институтының жетекші ғылыми қызметкері, Тимирязев көшесі 36, 050000, Алматы, Қазақстан.

Инелова З.А. **–** биология ғылымдарының кандидаты, биоалуантүрлілік және биоресурстар кафедрасының профессоры, Әл-Фараби даңғылы 71, 050000, Алматы, Қазақстан.

Чильдибаева Асел Жумагуловна – PhD, Биоалуантүрлілік және биоресурстар кафедрасының қауымдастырылған профессор міндетін атқарушы, Әл-Фараби даңғылы 71, 050000, Алматы, Қазақстан.

Избастина Клара Сержановна – PhD, қауымдастырылған профессор, биология, өсімдіктерді қорғау және карантин кафедрасының аға оқытушысы, Жеңіс даңғылы 62, 010000, Астана, Қазақстан.

Authors' information:

Vesselova Polina Vasilevna **–** Candidate of biological sciences, Head of the Laboratory of Flora and Higher Plants, Institute of Botany and Phytointroduction, Timiryazev street 36 d, 050000, Almaty, Kazakhstan.

Maralov Damir Ikramovich – laboratory assistant, Laboratory of Flora and Higher Plants, Institute of Botany and Phytointroduction, Timiryazev street 36 d, 050000, Almaty, Kazakhstan.

Kudabayeva Gulmira Mauletovna – Candidate of biological sciences, Leading Researcher, Laboratory of Flora and Higher Plants, Institute of Botany and Phytointroduction, Timiryazev street 36 d, 050000, Almaty, Kazakhstan.

Sitpayeva Gulnara Tokbergenovna – Doctor of biological science, Leading researcher, Institute of Botany and phytointroduction, Timiryazev street 36 d, 050000, Almaty, Kazakhstan.

Inelova Zarina Arkenzhanovna – Candidate of biological sciences, Professor, Department of Biodiversity and bioresources, Al-Farabi avenue 71, 050000, Almaty, Kazakhstan.

Childibayeva Asel Zhumagulovna **–** PhD, Acting associate professor, Biodiversity and Bioresources, Al-Farabi avenue 71, 050000, Almaty, Kazakhstan.

Izbastina Klara Serzhankyzy **–** PhD, Associate Professor, Senior Lecturer, Department of Biology, Plant Protection and Quarantine, Zhenis avenue 62, 010000, Astana, Kazakhstan.