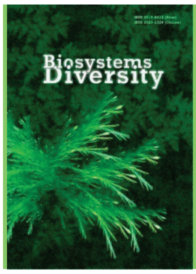

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Diversity of early flowering plants of the Ulytau mountains (Central Kazakhstan)

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Early flowering plants (ephemers and ephemeroids) are an important component of the biosystem of steppes and deserts. These species form perennial pasture communities, for early grazing. The present work was conducted to evaluate the floristic checklist and ecological uniqueness of early flowering plants of Central Kazakhstan, in the forest-steppe regions of Em-Bulak region and Edige mountains, during 2021 and 2022. A total of 26 species of ephemers and ephemeroids were recorded, which belong to 16 families: Liliaceae – 3 species, Asteraceae – 3 species, Ranunculaceae – 3 species, Rosaceae – 3 species, Brassicaceae – 2 species, Boraginaceae – 2 species, the other families are represented by one species. According to ecomorphological characteristics: 8 species (31%) belong to the xerophyte group, 6 (23%) to the xeromesophyte group, 7 (27%) to the mesoxerophyte group and 5 (19%) to the mesophyte group. Also, as a result of our research we found two species of plants which are included in the Red Book of the Republic of Kazakhstan – *Pulsatilla patens* (L.) Mill. and *Tulipa patens* Agardh. ex Schult. f. The data obtained can be used for environmental monitoring and issues of rational nature management of wild plants of Central Kazakhstan.

Keywords: biodiversity; ephemeroid; early flowering; xerophytes; mesophyte; xeromesophyte; mesoxerophyte.

Introduction

The problem of biodiversity conservation became acute in the 20th century. In the 21st century, not only has this problem not been solved, but new circumstances have arisen. Extreme climate change, manifested in heatwaves, excessive drought and heavy rainfall, reduces the resilience of native species to biotic stress (Diez et al., 2012). The life cycle of plants, and hence the stability of many ecosystems, is largely controlled by climate variability (Seddon et al., 2016). Arid regions have an extremely fragile ecological environment and are very sensitive to global climate change. Climate change in arid regions has become one of the pressing problems of our time (Dai et al., 2016). The Central Asian arid region not only has its own unique geography, but also has a unique ecological environment (Yan et al., 2019). Studies have shown that in recent years this region has been suffering from an acute environmental crisis, such as the melting of a glacier in the Tien Shan mountains (Li et al., 2022), the significant shrinkage of the Aral Sea (Huang et al., 2022) and the intensification of land desertification (Yushanjiang et al., 2021).

Central Kazakhstan is located inland in an arid and semi-arid zone with features such as shortage of surface water, scarce rainfall and uneven seasonal distribution. These features lead to sparse vegetation and intensified desertification trends (Schierhorn et al., 2020). Also, factors such as anthropogenic change in vegetation cover, urbanization and the construction of transport corridors contribute to the fact that the areas occupied by useful plants, previously widespread in the wild, are decreasing every day. This concerns not only species of medicinal, fodder, melliferous, ornamental plants but also the plant communities themselves (Rew et al., 2018). Therefore, at present, one of the main tasks set for scientists conducting research in botany is a comprehensive study of the plant communities of both known and previously little-studied areas, identifying natural thickets of useful plants and determining ways of their rational use.

Poorly studied ecological groups of plants include ephemers and ephemeroids. Ephemers are annual herbaceous plants whose development cycle is completed in a brief time (from 2–6 weeks to 2 months) before the onset of a drier period. They usually grow in deserts and steppes. Ephemers mainly develop in the autumn-winter-spring period, most often in spring or autumn. Ephemeroids are perennial plants in which only the above-ground part dies off with the onset of adverse conditions (Bykov, 1988). The study of ephemers and ephemeroids is especially important for Central Kazakhstan. This is due to the fact that Kazakhs have ceased to be nomadic people and have not lost the need to breed cattle (Kerven et al., 2020). The early cattle drive coincides with the beginning of vegetation of ephemers and ephemeroids because these species form perennial halophytic shrub-ephemeral pasture communities. Any fluctuations in the species composition of early flowering plants are reflected in the economic component of the economy of Central Kazakhstan. When analyzing the literature, it was found that there are few studies on the biodiversity of useful plants of Central Kazakhstan (Lednev, 2021; Pozdnyakova et al., 2022a, 2022b). The purpose of our study is to establish the species composition of early flowering plant species in the territory of Central Kazakhstan (Ulytau mountains), to rank plants by ecological groups and the degree of prevalence.

Materials and methods

Study area. Our study was conducted for the territory of Central Asia, namely Central Kazakhstan. Central Kazakhstan occupies an area of steppe and semi-desert zones within the Turgai plateau in the west and the Kazakh highlands in the center and east. The Ulytau Mountains are located in the Ulytau District of Karaganda Region, the center of Kazakhstan. The center consists of the low hill massif of Southwestern Kazakhstan. It borders with Tobolsk-Ishim, Kokshetau and Irtysh districts in the north, with Betpakdala in the south, with the low western hills in the east and with the Turgai flor district in the west. The Ulytau Mountains are home to the Ulytau State National Nature Park, which covers 58,912 ha, including 7,644 ha of forest (Maksutova et al., 2005). The coordinates of the route in the Em-Bulak region covered a radius of 48°36′52″ N 67°00′10″ E and 48°40′21″ N 67°00′14″ E. The coordinates of the route in the Edige region covered a radius of 48°34′36″ N 66°48′58″ E and 48°37′25″ N 66°48′42.49″ E (Fig. 1).

The geographical location of the region is responsible for its arid climate, being located in the center of the Eurasian continent and remote from the oceans. The territory of the Ulytau mountain and hill range, located within the semi-desert zone, is little suitable for agricultural development due to the arid climate. Most of the territory is sparsely populated. This is due to arid climate, very sparse hydrographic network and heterogeneous natural conditions. The Ulytau Mountains are solid, weakly wind-damaged large rocks and granite slabs, covered mainly with stone lichen. The higher plant communities occupy small areas here (Maksutova et al., 2005) (Fig. 2).

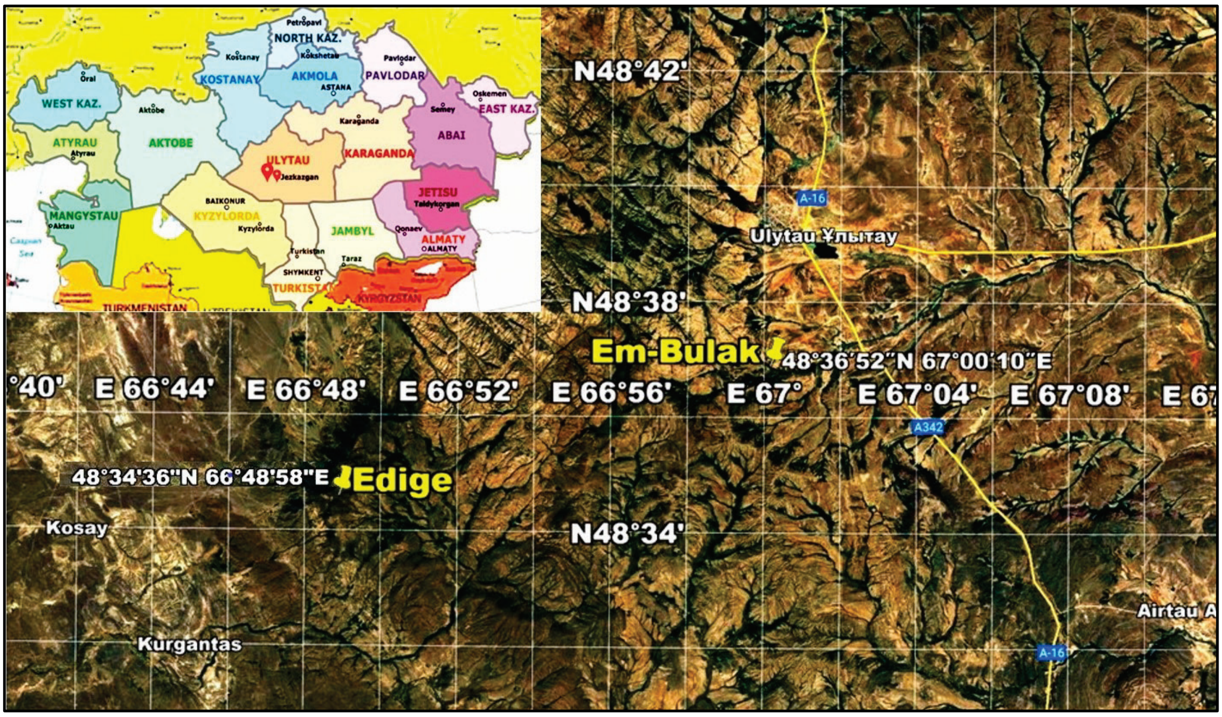

Fig. 1. The study area the Ulytau Mountains

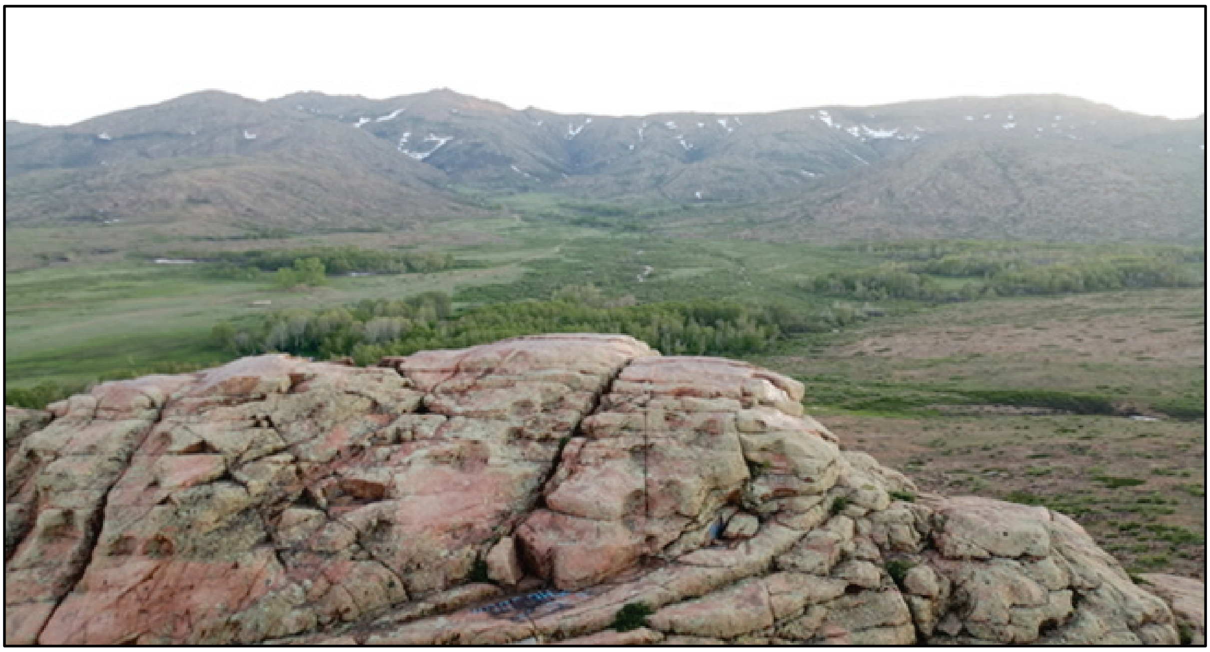

Fig. 2. Relief of the Ulytau mountains

In terms of plant geography, this area is dominated by birch-aspen massifs. The edges of the birch-aspen massifs consist of motley grass-wormwood-shrub associations. Most of the shrubs consist of *Lonicera tatarica* L., *Spiraea hypericifolia* L., and the dominant plant of the lower tier is *Artemisia gracilescens* Krasch. et Iljin. Steppe zones are occupied by herb-grass communities (*Ziziphora clinopodioides* Lam., *Achillea millefolium* L., *Artemisia austriaca* L., *Calamagrostis epigeios* (L.) Roth, etc.). Melkosopochnik consists of wormwood–feather grass communities in the gravel zone. The dominant species here are *Artemisia terrae-albae* Krasch. and *Festuca valesiaca* Schleich. ex Gaudin., etc. Streams flow from different places on Mount Edige. Meadows formed along streams and temporary watercourses are characterized by the predominance of grains and various grasses, a small share of shrub elements: *Achillea millefolium* L., *Phlomoides tuberosa* Moench, *Lathyrus pratensis* L., *Galium verum* L., *Medicago falcata* L., etc. Lithophytic shrubs form on stony and gravelly embankments, including *Juniperus sabina* L., *Ziziphora clinopodioides* Lam., *Hypericum scabrum* L., *Thymus crebrifolius* Klokov. On forest edges, hilly lowlands form steppe meadows, among which: *Veronica spicata* L., *Sanguisorba officinalis* L., *Artemisia absinthium* L. (Myrzaly et al., 2016).

Experimental fieldwork was conducted from mid-April to mid-May 2021 and 2022, the main growing season of ephemers and ephemeroids. The main method used in the fieldwork was route reconnaissance. The main goal of the reconnaissance was the general acquaintance with the territory and the components forming the landscape features of the study area. The first excursion was devoted to acquaintance with the geological structure and the features of the relief of the territory. For this purpose, special routes were chosen that best demonstrated these components. The second excursion, devoted to the review of the biogenic components, included a general acquaintance with the soil and vegetation cover of the territory (Ryabinina, 2004).

Sample identification. Phytocenological, bioecological characterization of useful plants was carried out according to the methods of B. A. Bykov. Xerophytes are plants that have adapted to exist in conditions without water, in areas prone to drought, or in physiologically dry areas such as salt marshes or sour marshes where salinity and acidity make water extraction difficult. They possess thick, fleshy leaves and stems in which they store water or have adaptive mechanisms related to reduction of moisture evaporation: reduced leaf surface, large number of small stomas, hairs, waxy coating.

Mesophytes are terrestrial plants that are adapted to live in an environment with more or less sufficient, but not excessive soil moisture. Mesophytes usually have a well-developed root system with branching roots, and broad, flat, green leaves with a wide variety of shapes. The leaves are thinner than those of xerophytes, sometimes with more stomata on the lower sides of the leaves, with a thin cuticle, and leaf hairs are rare or absent. Xeromesophytes are plants intermediate between mesophytes and mesoxerophytes. Mesoxerophytes are plants found in conditions of insufficient moisture. They are intermediate plants between xerophytes and xeromesophytes (Bykov, 1957).

The abundance of plant species in each plant association was determined according to Drude's scale: Cop1 – many, Cop2 – slightly more, Cop3 – very many, Sp – often-frequently found, Sol – few, Un – very few (Drude, 1890).

Laboratory processing of the source material was carried out in strict accordance with all requirements, and herbarium samples were stored in the herbarium collection of Karaganda Medical University (Bridson & Forman, 1995; Shcherbakov & Mayorov, 2006). To identify the collected materials, the main floristic annotations covering the territory of Kazakhstan were used "Flora of Kazakhstan" (Baitenov, 1999). Plant names are listed according to www.plantsoftheworldonline.org.

Results

Bioecological features of ephemers and ephemeroids recorded in the forest-steppe region of Em-Bulak. The region in which our field research work was conducted belongs to the Em-Bulak forest-steppe, mountainous zone. On the steppe lands dominate mainly cereals and perennial herbaceous associations, and on the mountain slopes in the rocky foothills, perennial herb-shrubs and grain and herbaceous communities have been identified (Table 1).

Table 1
Bioecological characteristics of ephemers and ephemeroids registered in the forest-steppe region of Em-Bulak

Family	Name	Types of plant associations		
		ecomorphs/ morphology	abundance	coordinates
				48°36'51" N 67°00'22" E
				48°36'49" N 67°00'13" E
				48°36'54" N 67°00'02" E
				48°36'33" N 67°00'24" E
				48°36'20" N 66°58'30" E
	**Tulipa patens* Agardh. ex Schult.f.	MesXer/per	Cop$_2$	48°36'46" N 67°01'48" E
				48°37'11" N 66°59'36" E
				48°36'33" N 66°58'06" E
				48°38'00" N 67°00'06" E
Liliaceae				48°39'29" N 67°00'03" E
				48°38'20" N 66°59'31" E
				48°38'46" N 67°02'50" E
				48°36'47" N 67°00'39" E
	Tulipa sylvestris L.	XerMes/per	Cop$_1$	48°36'46" N 67°00'52" E
				48°36'36" N 66°59'44" E
				48°36'22" N 66°58'39" E
				48°36'47" N 67°01'04" E
	Fritillaria meleagroides Patrin ex Schult. & Schult.f.	XerMes/per	Sp	48°36'45" N 67°00'29" E
				48°38'46" N 66°59'32" E
				48°39'14" N 66°59'19" E
				48°39'16" N 66°58'51" E
				48°39'46" N 66°59'15" E
				48°37'11" N 66°59'36" E
				48°36'33" N 66°58'06" E
				48°38'00" N 67°00'06" E
				48°39'29" N 67°00'03" E
				48°37'11" N 67°01'34" E
				48°37'42" N 67°01'16" E
	Chorispora tenella (Pall.) DC.	Xer/an	Cop$_2$	48°38'10" N 67°01'15" E
				48°38'41" N 67°01'38" E
				48°39'06" N 67°01'37" E
				48°39'40" N 67°01'32" E
				48°38'20" N 66°59'31" E
				48°38'46" N 67°02'50" E
Brassicaceae				48°36'23" N 67°00'28" E
				48°36'42" N 67°10'45" E
				48°37'42" N 67°03'00" E
				48°38'45" N 67°02'29" E
				48°39'35" N 67°01'52" E
				48°40'13" N 67°00'51" E
	Alyssum turkestanicum Regel & Schmalh.	Xer/an	Cop$_1$	48°38'25" N 66°58'57" E
				48°37'11" N 67°01'34" E
				48°37'42" N 67°01'16" E
				48°38'10" N 67°01'15" E
				48°38'41" N 67°01'38" E
				48°39'06" N 67°01'37" E
				48°39'40" N 67°01'32" E
				48°39'49" N 66°59'24" E
				48°39'12" N 66°58'42" E
	Scorzonera tuberosa Pall.	MesXer/per	Cop$_1$	48°38'01" N 66°59'40" E
				48°36'33" N 66°59'20" E
				48°36'36" N 67°02'27" E
				48°37'43" N 67°03'58" E
				48°39'42" N 67°00'47" E
				48°38'54" N 67°02'26" E
Asteraceae				48°37'49" N 67°02'18" E
				48°35'35" N 67°00'31" E
				48°36'39" N 66°58'37" E
	Taraxacum officinale (L.) Weber ex F.H.Wigg.	Mes/per	Cop$_2$	48°36'51" N 67°00'22" E
				48°36'49" N 67°00'14" E
				48°36'54" N 67°02'80" E
				48°36'33" N 67°00'24" E
				48°36'20" N 66°58'31" E
				48°36'46" N 67°01'48" E
				48°38'67" N 67°06'32" E
				48°39'29" N 67°03'21" E
	Ranunculus polyanthemos L.	MesXer/per	Sol	48°38'46" N 66°59'32" E
				48°39'14" N 66°59'19" E
				48°39'16" N 66°58'51" E
				48°39'46" N 66°59'15" E
				48°37'11" N 66°59'36" E
Ranunculaceae				48°36'33" N 66°58'60" E
				48°38'46" N 66°59'32" E
				48°39'14" N 66°59'19" E
	Ranunculus propinquus C.A.Mey.	Mes/per	Sol	48°39'16" N 66°58'51" E
				48°39'46" N 66°59'15" E
				48°38'46" N 66°59'32" E
				48°39'14" N 66°59'19" E
				48°39'16" N 66°58'51" E
				48°39'46" N 66°59'15" E
				48°37'32" N 67°00'28" E
				48°38'10" N 67°10'28" E
				48°38'41" N 67°00'15" E
				48°37'11" N 67°10'34" E
				48°37'42" N 67°10'16" E
	Onosma simplicissimum L.	XerMes/per	Cop$_2$	48°38'10" N 67°10'10" E
				48°38'41" N 67°10'38" E
Boraginaceae				48°39'60" N 67°10'37" E
				48°39'40" N 67°10'32" E
				48°39'10" N 67°10'45" E
				48°39'39" N 67°20'80" E
				48°41'20" N 67°10'22" E
				48°39'49" N 66°59'24" E
				48°39'12" N 66°58'42" E
	Myosotis caespitosa Schultz (Syn.: *M. laxa* subsp. *caespitosa* (Schultz) Hyl. ex Nordh.)	Xer/per	Cop$_2$	48°38'00" N 66°59'40" E
				48°36'33" N 66°59'20" E
				48°36'36" N 67°20'27" E
				48°37'43" N 67°30'58" E
				48°36'23" N 67°00'28" E
				48°36'42" N 67°10'45" E
				48°38'45" N 67°20'29" E
Alliaceae	*Allium strictum* Schrad.	MesXer/per	Cop$_1$	48°39'35" N 67°10'52" E
				48°40'13" N 67°00'51" E
				48°38'25" N 66°58'57" E
				48°38'46" N 66°59'32" E

Family	Name	Types of plant associations		
		ecomorphs/ morphology	abundance	coordinates
				48°39'14" N 66°59'19" E 48°39'16" N 66°58'51" E 48°39'46" N 66°59'15" E
Apiaceae	*Ferula songarica* Pall. ex Schult.	Xer/per	Cop_1	48°39'49" N 66°59'24" E 48°39'12" N 66°58'42" E 48°38'00" N 66°59'40" E 48°36'33" N 66°59'20" E 48°36'36" N 67°20'27" E 48°37'43" N 67°30'58" E 48°37'11" N 66°59'36" E 48°36'33" N 66°58'60" E 48°38'20" N 66°59'31" E 48°38'46" N 67°20'50" E
Iridaceae	*Iris scariosa* Willd. ex Link	Xer/per	Cop_3	48°36'28" N 67°00'40" E 48°37'42" N 67°00'48" E 48°38'16" N 67°02'28" E 48°39'30" N 67°02'27" E 48°39'23" N 67°01'26" E 48°39'52" N 67°01'17" E 48°37'11" N 67°01'34" E 48°37'42" N 67°01'16" E 48°38'10" N 67°01'15" E 48°38'41" N 67°01'38" E 48°39'60" N 67°01'37" E 48°39'40" N 67°01'32" E
Rosaceae	*Potentilla anserina* L. (Syn.: *Argentina anserina* (L.) Rydb.)	Mes/per	Cop_1	48°39'49" N 66°59'24" E 48°39'12" N 66°58'42" E 48°38'00" N 66°59'40" E 48°36'33" N 66°59'20" E 48°36'36" N 67°20'27" E 48°37'43" N 67°30'58" E 48°38'46" N 66°59'32" E 48°39'14" N 66°59'19" E 48°39'16" N 66°58'51" E 48°39'46" N 66°59'15" E
Capri-foliaceae	*Valeriana tuberosa* L.	XerMes/per	Cop_1	48°36'36" N 66°57'18" E 48°36'17" N 66°58'28" E 48°36'37" N 66°59'48" E 48°36'46" N 67°00'43" E 48°39'13" N 66°59'18" E 48°37'11" N 67°10'34" E 48°37'42" N 67°10'16" E 48°38'10" N 67°10'15" E 48°38'41" N 67°10'38" E 48°39'40" N 67°10'32" E
Polygo-naceae	*Rumex acetosa* L.	Mes/per	Cop_3	48°39'49" N 66°59'24" E 48°39'12" N 66°58'42" E 48°38'00" N 66°59'40" E 48°36'33" N 66°59'20" E 48°36'36" N 67°20'27" E 48°37'43" N 67°30'58" E 48°37'11" N 66°59'36" E 48°36'33" N 66°58'60" E 48°38'00" N 67°00'60" E 48°39'29" N 67°00'30" E 48°38'20" N 66°59'31" E 48°38'46" N 67°20'50" E
Fumariaceae	*Corydalis schanginii* (Pall.) B.Fedtsch.	XerMes/per	Sol	48°38'00" N 66°59'40" E 48°36'36" N 67°20'27" E 48°37'43" N 67°30'58" E 48°38'46" N 66°59'32" E 48°39'14" N 66°59'19" E 48°39'16" N 66°58'51" E 48°39'46" N 66°59'15" E
Caryo-phyllaceae	*Gypsophila rupestris* Kupr.	Xer/per	Cop_1	48°36'23" N 67°00'28" E 48°36'42" N 67°01'45" E 48°37'42" N 67°03'00" E 48°38'45" N 67°02'29" E 48°39'35" N 67°01'52" E 48°40'13" N 67°00'51" E 48°37'11" N 67°01'34" E 48°37'42" N 67°01'16" E 48°38'10" N 67°01'15" E 48°38'41" N 67°01'38" E 48°39'60" N 67°01'37" E 48°39'40" N 67°01'32" E

Notes: * – Red Book of the Republic of Kazakhstan; Cop1 – many, Cop2 – slightly more, Cop3 – very many, Sp – often-frequently found, Sol – few; Xer – Xerophyte, Mes – Mesophyte, XerMes – Xeromesophyte, MesXer – Mesoxerophyte; per – perennial, an – annual.

As a result of our research, 19 species of different ephemers and ephemeroids belonging to 13 families were registered in the forest-steppe region of Em-Bulak. Among them the most numerous were the families Liliaceae – 3 species, Brassicaceae – 2 species, Asteraceae – 2 species, Ranunculaceae – 2 species and Boraginaceae – 2 species. The other families are represented by only one species.

According to ecomorph, 6 species belong to the xerophyte group, 5 species belong to the xeromesophyte group, 4 species belong to the mesomesophyte group, and 4 species belong to the mesophyte group. Two species, *I. scariosa* (xerophyte) and *R. acetosa* (mesophyte), are the most common (Cop3). Abundantly growing species (Cop2) include *C. tenella* (xerophyte), *T. officinalis* (mesophyte), *O. simplicissimum* (xerophyte), *M. caespitosa* (xerophyte). *T. patens* (mesoxerophyte), which is included in the Red Book of the Republic of Kazakhstan and is under state protection, also belongs to Cop2 group.

Bioecological characteristics of ephemers and ephemeroids recorded in the Edige Mountains. On the slopes of the Edige Mountains, the region in which the following study was conducted, 14 species of ephemers and ephemeroids were recorded (Table 2).

Table 2
Bioecological characteristics of ephemers and ephemeroids registered in the Edige Mountains

Family	Name	Types of plant associations		
		ecomorphs/ morphology	abundance	coordinates
Aste-raceae	*Taraxacum officinale* (L.) Weber ex F.H.Wigg.	Mes/per	Cop_2	48°34'90" N 66°50'29" E 48°34'60" N 66°49'58" E 48°34'28" N 66°50'32" E 48°35'16" N 66°50'20" E 48°35'32" N 66°51'11" E 48°34'30" N 66°50'41" E 48°34'54" N 66°50'33" E 48°35'80" N 66°51'45" E 48°35'22" N 66°48'37" E 48°36'80" N 66°48'90" E
	Scorzonera tuberosa Pall.	MesXer/per	Cop_1	48°33'50" N 66°47'55" E 48°35'58" N 66°48'90" E 48°36'50" N 66°48'20" E 48°35'47" N 66°47'58" E 48°35'30" N 66°49'70" E 48°34'54" N 66°49'40" E
	Scorzonera undulata Vahl	MesXer/per	Cop_1	48°33'50" N 66°47'55" E 48°35'58" N 66°48'90" E 48°36'50" N 66°48'20" E 48°35'47" N 66°47'58" E 48°34'90" N 66°50'29" E 48°34'60" N 66°49'58" E 48°34'28" N 66°50'32" E 48°35'16" N 66°50'20" E 48°35'32" N 66°51'11" E 48°35'30" N 66°49'70" E 48°34'54" N 66°49'40" E
Ranun-culaceae	**Pulsatilla patens* (L.) Mill.	MesXer/per	Cop_1	48°34'90" N 66°50'29" E 48°34'60" N 66°49'58" E 48°34'28" N 66°50'32" E 48°35'16" N 66°50'20" E 48°35'32" N 66°51'11" E 48°35'29" N 66°47'56" E 48°35'14" N 66°49'20" E 48°35'22" N 66°50'15" E 48°35'30" N 66°50'35" E 48°34'70" N 66°50'23" E 48°34'28" N 66°49'57" E
	Ranunculus polyanthemos L.	MesXer/per	Cop_1	48°35'38" N 66°48'43" E 48°35'34" N 66°48'29" E 48°35'20" N 66°47'53" E 48°35'59" N 66°48'31" E 48°35'59" N 66°48'53" E
Rosaceae	*Potentilla argentea* L.	MesXer/per	Cop_1	48°34'90" N 66°50'29" E 48°34'60" N 66°49'58" E 48°34'28" N 66°50'32" E 48°35'16" N 66°50'20" E 48°35'32" N 66°51'11" E 48°35'29" N 66°47'56" E 48°35'14" N 66°49'20" E 48°35'22" N 66°50'15" E 48°35'30" N 66°50'35" E 48°34'54" N 66°50'33" E 48°35'80" N 66°51'45" E 48°35'22" N 66°48'37" E 48°36'80" N 66°48'90" E
	Spiraea crenata L.	Xer/per	Cop_1	48°35'38" N 66°48'43" E 48°35'34" N 66°48'29" E 48°36'50" N 66°48'20" E 48°35'47" N 66°47'58" E

Family	Name	Types of plant associations		
		ecomorphs/ morphology	abundance	coordinates
				48°35'30" N 66°49'70" E 48°34'54" N 66°49'40" E 48°36'20" N 66°48'00" E 48°35'52" N 66°48'18" E 48°35'15" N 66°48'40" E 48°35'46" N 66°46'50" E 48°35'10" N 66°48'20" E 48°36'40" N 66°49'18" E
Umbe-lliferae	*Eryngium planum* L.	Xer/per	Un	48°35'52" N 66°48'12" E 48°34'90" N 66°50'29" E 48°34'60" N 66°49'58" E 48°34'28" N 66°50'32" E 48°35'32" N 66°51'11" E
Liliaceae	*Fritillaria meleagroides* Patrin ex Schult. & Schult.f.	XerMes/per	Sp	48°33'47" N 66°51'32" E 48°34'90" N 66°50'54" E 48°34'90" N 66°50'29" E 48°34'60" N 66°49'58" E 48°34'28" N 66°50'32" E 48°35'16" N 66°50'20" E 48°35'32" N 66°51'11" E
Geraniaceae	*Geranium pratense* L.	Mes/per	Cop_1	48°33'47" N 66°51'32" E 48°34'90" N 66°50'54" E 48°35'00" N 66°50'52" E 48°35'32" N 66°50'29" E 48°35'18" N 66°50'24" E 48°34'90" N 66°50'29" E 48°34'60" N 66°49'58" E 48°34'28" N 66°50'32" E 48°35'16" N 66°50'20" E 48°35'32" N 66°51'11" E
Fabaceae	*Oxytropis argentata* (Pall.) Pers.	Xer/per	Cop_2	48°35'38" N 66°48'43" E 48°35'34" N 66°48'29" E 48°35'20" N 66°47'53" E 48°35'59" N 66°48'31" E 48°35'59" N 66°48'53" E 48°33'47" N 66°51'32" E 48°34'90" N 66°50'54" E 48°35'00" N 66°50'52" E 48°35'32" N 66°50'29" E 48°35'18" N 66°50'24" E
Boraginaceae	*Onosma simplicissimum* L.	XerMes/per	Cop_2	48°37'58" N 66°48'55" E 48°36'26" N 66°48'42" E 48°35'29" N 66°48'14" E 48°35'10" N 66°47'52" E 48°34'31" N 66°47'33" E 48°36'20" N 66°48'00" E 48°35'52" N 66°48'18" E 48°35'15" N 66°48'40" E 48°35'46" N 66°46'50" E 48°35'10" N 66°48'20" E 48°36'40" N 66°49'18" E
Caprifoliaceae	*Valeriana tuberosa* L.	XerMes/per	Cop_1	48°33'47" N 66°51'32" E 48°34'90" N 66°50'54" E 48°35'00" N 66°50'52" E 48°35'32" N 66°50'29" E 48°35'18" N 66°50'24" E 48°36'20" N 66°48'00" E 48°35'52" N 66°48'18" E 48°35'15" N 66°48'40" E 48°35'46" N 66°46'50" E 48°35'10" N 66°48'20" E 48°36'40" N 66°49'18" E
Iridaceae	*Iris scariosa* Willd. ex Link	XerMes/per	Cop_2	48°35'38" N 66°48'43" E 48°35'34" N 66°48'29" E 48°35'20" N 66°47'53" E 48°35'59" N 66°48'31" E 48°35'59" N 66°48'53" E 48°36'16" N 66°48'12" E 48°35'36" N 66°48'10" E 48°36'20" N 66°48'00" E 48°35'52" N 66°48'18" E 48°35'15" N 66°48'40" E 48°35'46" N 66°46'50" E 48°35'10" N 66°48'20" E 48°36'40" N 66°49'18" E

Notes: * – Red Book of the Republic of Kazakhstan; Cop1 – many, Cop2 – slightly more, Sp – often-frequently found, Un – very few; Xer – Xerophyte, Mes – Mesophyte, XerMes – Xeromesophyte, MesXer – Mesoxerophyte; per – perennial, an – annual.

A total of 14 species of different ephemers and ephemeroids, which belong to 10 families, were registered on the slopes of the Edige mountains. Among them the most numerous were the families Asteraceae – 3 species, Ranunculaceae – 2 species, Rosaceae – 2 species. Other families are represented by only one species. In terms of ecomorph, the xerophyte group includes 4 species, the xeromesophyte group includes 4 species, the mesoxerophyte group includes 5 species, and the mesophyte group includes 2 species. *I. scariosa* (xeromesophyte), *T. officinalis* (mesophyte), *O. simplicissimum* (xeromesophyte), *O. pillosa* (xerophyte) are abundant species (Cop2). The group of plants that occur in large numbers includes (Cop1) – *S. tuberosa* (mesoxerophyte), *S. undulata* (mesoxerophyte), *P. patens* (mesoxerophyte) – included in the Red Book of the Republic of Kazakhstan, *R. polyanthemus* (mesoxerophyte), *P. argentea* (mesoxerophyte), *S. crenata* (xerophyte), *G. pratense* (mesophyte), *V. tuberosa* (xeromesophyte).

Discussion

Plants need favourable environmental conditions to grow. But early flowering plants have adapted to unfavourable, sometimes even extreme environmental conditions, i.e., to grow in the springtime. Spring is often accompanied by sharp fluctuations in air and soil temperatures, and sometimes with frosts, which adversely affects the growth and development of plants. Also, a small amount of winter and spring rainfall affects the development of plants. It is during this period that early flowering plants grow and develop and are adapted to vegetation in extreme environmental conditions. During ontogenesis, plants experience various stress influences. Plants are most sensitive to them during active growth – vegetation before flowering, during this period the formation of the future plant takes place (Akhmetzhanova & Nurzhanova, 2018). The problem of studying early flowering plants is quite relevant, as the area of natural communities is subjected to intensive human impact. Many of the early flowering plants have become rare and are included in the Red Book of Kazakhstan (Baitulina, 2014). Early flowering plants are the most vulnerable part of the wild flora. The decrease in the species diversity of these plants is due to a number of reasons, both as a result of anthropogenic impact and natural causes. Mass extermination of rare flower species can affect the existence and functioning of different ecosystems. Since all living organisms in an ecosystem are interconnected, when one of the elements disappears, these connections are lost. The disappearance of rare species will have a direct negative impact on the environment (Anapiev, 1996).

Over the past century, global climate change has resulted in rising temperatures, melting glaciers in high altitude and polar regions, and even rising sea levels (Chen et al., 2011). Global warming has also changed the amount and nature of precipitation in the 21st century in many parts of the world, leading to prolonged droughts (Hao et al., 2018). Drought stress can alter plant species interactions, thereby potentially altering carbon and nutrient cycling in terrestrial ecosystems (Pugnaire et al., 2019). Extreme droughts and abnormal heat are important drivers of changes in understory biodiversity in forests (Koelemeijer et al., 2022). Studies on plant biodiversity in Saudi Arabia have shown that as rainfall decreased, the occurrence of valley plants also decreased, while species growing in rocky and mountainous habitats were less affected (Alsherif & Almaghrabi, 2022). Studies in a grassland biodiversity experiment have shown that during extreme weather conditions, communities with low diversity lose productivity over time, while communities with high diversity are more stable (Wagg et al., 2022). Therefore, knowledge about the species biodiversity of regions will allow us to predict more accurately the change of species composition in case of further negative climate change.

Central Asia, consisting of the five countries of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, is an important global hotspot of biodiversity, but a botanically understudied part of Asia (Li et al., 2020). The predominant ecosystem types of the region are deserts, semi-deserts and steppes. These ecosystems cover almost 75% of Central Asia and can be found on the lower slopes of mountains and in the foothills, as well as in some remote ridges and large basins. As one of the largest arid and semi-arid regions in the world, Central Asia is at risk of increasing precipitation due to global climate warming and glacial melt (Donat et al., 2017). A study of the bioclimate in Kazakhstan showed that over the past 50 years there has been – an increase in warmth in 36.2% of the area, an increase in continentality in 7.3% of the area, and an increase in annual aridity in 10.3% of the area. In the mountains there is a risk of disappearance of all three mountain bioclimates (Lopez Fernandez et al., 2020). Plants make up the majority of terrestrial biomass worldwide. Plants serve as habitats for various forms of life. Plants are a food source for other groups of organisms (Bar-On et al., 2018). Climate change will cause predicted changes in plant species diversity. A warmer and wetter climate usually favours the growth and development of taller plants because they compete better for light and nutrients (Baruah et al., 2017).

Ephemeral plants are an important component of the vegetation of a desert ecosystem. Ephemeral plants are particularly sensitive to changes in water quantity and temperature changes (Abudureheman, 2014). Therefore, the study of the biodiversity of ephemers and ephemeroids is highly relevant and is being studied in many areas.

Thus, in Krasnodar (Russia) 23 species of early flowering plants belonging to 19 species, 13 families were identified. The most represented families are Ranunculaceae, Brassicaceae, Violaceae and Liliaceae. The largest number of primroses is found in the forest and glade-and-fallow phytocenotypes (Teleschuk & Litvinskaya, 2014).

When studying the biodiversity of ephemers and ephemeroids of the Donguz steppe, in the Ural-Ilek watershed, 28 plant species, including 21 (75%) ephemeroids and 7 (25%) ephemeroids belonging to 16 families and 24 genera were noted. The leading families are Liliaceae, Ranunculaceae (5 species each), Poaceae (3 species), Brassicaceae, and Fabaceae (2 species each); all other families are monospecific (Mushinskaya & Dorohina, 2016).

The flora of early flowering plants in the vicinity of Khadyzhensk (a lowland part of the northern slope of the Western Caucasus) contains 18 species included in the Red Books of different ranks. The main threat to these species is posed by human activities such as logging, cattle grazing, and haying (Leonidova et al., 2016).

Only 65 species were registered in the vicinity of Makhachkala, including 30 (46.2%) ephemers and 35 (53.8%) ephemeroids belonging to 59 species and 21 families. Among them, most of them are melliferous and medicinal plants. The group of fodder plants is very important in economic respect. The Red Book of Dagestan includes 4 species of ephemera: *Galanthus caucasicus*, *Tulipa biebersteiniana*, *Scilla sibirica*, *Merendera trigyna* (Rashidova et al., 2019).

The study of the floristic features of the ephemeroids of Lower Priamurye revealed 90 species belonging to 47 species and 28 families. The first three families – Ranunculaceae, Violaceae, and Liliaceae (39 species, 43.4%) clearly stand out in the family spectrum. A characteristic feature common to all life forms is the presence of underground hoarding organs, which ensure the overwintering and early spring development of the plants. According to the rhythm of seasonal development of true ephemeroids or spring-green plants, in which after the early spring flowering in summer there is a dormant period, there were only 14 species (16%). As representatives of indigenous vegetation types, the studied ephemeroids are extremely vulnerable to anthropogenic disturbances. *Adonis amurensis* Regel et Radde, *Fritillaria ussuriensis* Maxim., *Gagea nakaiana* Kitag., *Plagiorhegma dubia* Maxim., *Eranthis stellata* Maxim., *Viola muehldorfii* Kiss, *Corydalis gorinensis* Van are protected in the Lower Amur region (Tsyirenova & Varfolomeeva, 2019).

During the study of the Novogrudskaya Upland, data were presented on the occurrence of 8 species of wild introduced ephemers and ephemeroids confined mainly to the housing stock or places of plant waste storage (Bakey, 2023). During seasonal surveys (early spring) of vegetation of the Dnieper forest-steppe on the outskirts of Kanev (Ukraine), 34 plant communities were identified. These are mainly secondary or semi-natural groups of plants of spring perennials, ephemers and ephemeroids with winter type of germination on light compacted substrates, drying up in summer (Shevchyk, 2018).

Ecological monitoring of ephemeral plants of Tugay ecosystems in the conditions of the southern regions of the Republic of Karakalpakstan showed that they are divided into three main categories: ephemers, perennials and species that successfully grow in all seasons. Ephemeral plants, to which most of the plants of Karakalpakstan belong, have no special adaptations for life in the desert, except for their drought-resistant seeds. But they have developed the ability to grow and flower in a very short time. Perennial plants die from drought, but retain roots and tubers underground, coming to life at the first rain (Saparova & Norboev, 2021).

The ecological-geobotanical state of the vegetation cover of the Apsheron Peninsula (Azerbaijan) is represented mainly by annual and ephemeral plants, with mesophytes, ephemers and ephemeroids among the leading species in the herbage composition. Most representatives of this group belong to the species Chenopodioideae and Asteraceae and are distributed in almost all major semi-desert groupings (Guliyeva, 2021).

The Ustyurt Plateau (Kazakhstan and Uzbekistan) is an elevated plateau occupying the northern part of the Aralo-Caspian watershed. The plateau is bounded on almost all sides by steep escarpments, which are precipitous shores of the ancient Triassic Sea. In the eastern escarpment of Ustyurt, ephemers and ephemeroids, such as *Poa bulbosa*, *Geranium transversale* (Kar. & Kir.) Vved., *Delphinium camptocarpum*, etc., form the basis of ephemeral vegetation (Begzhanova, 2019).

The study of biodiversity of ephemers and ephemeroids in the territory of Central Kazakhstan was carried out for the first time. We studied two biogeographic zones – the forest-steppe region of Em-Bulak and the slopes of the Edige mountains. Combining the obtained data, we eventually found 26 species of ephemeroids and ephemeroids, which belong to 16 families: Liliaceae – 3 species, Asteraceae – 3, Ranunculaceae – 3, Rosaceae – 3, Brassicaceae – 2, Boraginaceae – 2, Umbelliferae – 1, Geraniaceae – 1, Alliaceae – 1, Fabaceae – 1, Apiaceae – 1, Caprifoliaceae – 1, Iridaceae – 1, Polygonaceae – 1, Fumariaceae – 1, Caryophyllaceae – 1 species. As a result of our research, we found two plant species which are included in the Red Data Book of the Republic of Kazakhstan – *P. patens* and *T. patens* (Baitulina, 2014).

According to ecomorph, 8 species (31%) belong to the xerophyte group, 6 species (23%) belong to the xeromesophyte group, 7 species (27%) belong to the mesomesophyte group, and 5 species (19%) belong to the mesophyte group. The predominance of xerophytes and xeromesophytes in the study area corresponds to the climatic conditions of the study area.

Only some species of ephemers and ephemeroids that we found have medical or economic value. *P. patens* – preparations of the plant are used as a sedative and sleeping aid. In folk medicine it is used for many diseases. Water extract has a strong bactericidal and fungicidal effect and is used externally for rapid healing of wounds and fungal skin diseases. Vodka tincture of the herb is used as a rubbing for rheumatism (Lebedeva & Zhamsaranova, 2018). *S. crenata* – is used in ornamental gardening and forestry. It is widely used in landscaping and organization of hedgerows. A honey plant (Moiseeva & Shcherbakov, 2011). *E. planum* – infusion is used as an antispasmodic expectorant and sedative for cough, especially for whooping cough, tracheitis, bronchitis (Arykbaeva et al., 2018). *G. pratense* – is used in folk medicine in the form of infusion and decoction for insomnia, epilepsy, fever, rheumatism, against diarrhea, bleeding in female diseases, with eczema, toothache, scabies (Maznev, 2004). *T. patens* is an ornamental species, promising for alpinaries and landscape gardening (Qu et al., 2017). *F. songarica*, a sticky, aromatic gumdesmole called galbanum produced by some ferula species, is widely used in cooking and medicine (Zhestovskaya et al., 2018). *I. scariosa* – used as an early spring perennial for alpinaries and landscaping. It contains potential anti-inflammatory components (Yang et al., 2018). *P. anserine* used as an infusion and decoction medicine has anti-inflammatory, styptic, antiseptic, strong astringent and diuretic effects (Liu et al., 2015). *R. polyanthemus* is used in folk medicine. The plant is used internally in small doses for stomachaches, migraines, and as a tonic. The fresh above-ground part is used externally as an analgesic for neuralgia, migraine, rheumatism, gout, and as a wound-healing agent (Aralbay, 2014). *R. acetosa* is used in folk medicine as an antiscorbutic. Raw leaves or juice are used to improve digestion (Podgurskaya, 2021). *T. officinale* has choleretic, antipyretic, laxative, expectorant, sedative, antispasmodic properties and is used as a mild sleeping pill (Platonov et al., 2022).

Conclusion

Thus, as a result of our work, the species composition of early flowering plant species in Central Kazakhstan (the Ulytau Mountains) has been clarified, and the ranking of plants by life forms, ecological groups and degree of prevalence has been conducted. A critical evaluation of the literature on the medicinal properties of the plants we found, showed that they are not only part of the trophic chain and indispensable components of plant communities, but also have the potential for improving human health. Some of the herbs we found have analgesic, bactericidal, antispasmodic, antiseptic and hemostatic properties. The data obtained can be used for environmental monitoring and issues of rational nature management, conservation of the gene pool, preparation of special resolutions and decisions on the protection of wild plants of Central Kazakhstan.

The authors declare that they have no competing interests.

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