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Distribution and morphometric indicators of cenopulations of the rare species *Linaria cretacea* Fisch. EX Spreng. under the conditions of Aktobe Region, Kazakhstan

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ABSTRACT

The article presents the results of the study of natural cenopopulations of a rare species in the Republic of Kazakhstan, i.e., *Linaria cretacea* Fisch. ex Spreng., on the territory of Aktobe region. Description of biomorphological parameters in nature showed that many parameters of the species differ in their natural habitat, which is due to the inconsistency of ecological conditions of its growth.

Keywords: *Linaria cretacea* Fisch.ex Spreng., Endemic, Morphometric parameters, Calcephyte community.
Article type: Short Communication.

INTRODUCTION

The study and conservation of biodiversity in general, and floristic diversity in particular, are global problems of our time. The little-studied, intensively developed steppe areas, to which the Aktobe floristic district belongs, located in the centre of Eurasia, at the junction of Europe and Asia, deserve special attention for the preservation of the gene pool of the natural environment. The territory of the district preserves unique steppe communities, chalk massifs, relict forest and bog tracts, which need conservation measures. Aktobe floristic district is located within two geomorphological regions: Podural plateau and Mugodzhar. G.I. Dokhman (1954), I.N. Safronova (1971,1980), Ye.M. Lavrenenko, Z.V. Karamysheva, R.I. Nikulina (1991) note that the vegetation cover of the Podural Plateau and Mugodzhars is characterised by heterogeneity associated with the geological structure and soil cover (Aipeissova 2012). As noted by B.A.Skalov, during the Cretaceous epoch the Mugodzhary Mountains rose in the form of a long but narrow island separating the western part of the Cretaceous Sea from the eastern part, being separated from the northern part of the continuous mass of the Ural Mountains by a comparatively shallow strait of the Cretaceous Sea running along the south-eastern part of the Aktobe district. The Mugodzhars stretching along the border of Irgiz county of Turgai and Temir counties in Ural regions almost up to Ust-Urt are the southernmost spur of the Ural Range, brought to the surface by the same mining processes as the Ural Range itself (Skalov 1909). The uplift of the Obshchy Syrt and the Podural Plateau occurred at the end of the Miocene. The Cretaceous flora was formed on these uplands. The Cretaceous flora penetrated the Podural plateau from the west, which are interglacial relicts, including *Anthemis trotzkiana*, *Artemisia salsoloides*, *Crambe aspera*, *Lepidium meyeri*, *Linaria cretacea*, *Crambe tatarica*, species that are related to species of the Volga and Middle

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Russian uplands (Darbaeva 2006). The Cretaceous uplands are unique botanical and geographical objects located in the steppe and semi-desert zones of the Eurasian continent. On the territory of these uplands, in places of outcrops or close to the surface of carbonate rocks of the Upper Cretaceous age, specific communities of calciphytic species have spread (Darbaeva 2003). The chalk outcrops are distinguished by their original species composition. They are a concentration of many relics and species of mountain and arctic regions. There are endemic species: *Linaria cretacea* Fisch. ex. Spreng., *Lepidium meyeri* Claus, *Silene cretacea* Fisch. ex. Spreng. The peculiarity and originality of the flora and vegetation of chalk outcrops are primarily due to the peculiarities of the chalk substrate, which has its own microclimatic and water regime, special physical and chemical properties. Researches of many scientists have shown that chalk hills are characterised by high calcium content (from 32% to 99%), high pH, low thermal conductivity, high water capacity, abundance of reflected light and especially thermal regime of soils (sodden chalks have warmer soils, and outcrops have colder soils than soils of the adjacent zonal steppe). The most important feature of chalk as a substrate is its hardness, stoniness and mobility. There are two types of chalk outcrops - outcrops of dense and loose chalk. The surface of the dense (bedrock) chalk is fractured by cracks into rough quadrangles and individuals with an insignificant layer of rubble and crushed stone. Under the influence of flowing water, erosive hollows and furrows appear on the bedrock chalk, which gradually turn into larger erosive forms - "potholes". Potholes in the process of their development turn into gullies. Gullies, potholes and scour holes are composed of loose chalk, which is characterised by the presence of a thick layer of chalk rubble. The studies have shown that restoration of chalk vegetation with different substrate character is carried out differently. Thus, for instance, *Hyssopus cretaceous* Dud settles first in areas with constantly crumbling chalk rubble or chalky layer, preferring steep gully slopes, screes and areas with intensive stream erosion. At the same time *Scrophularia cretacea* Fisch appears. Together they form the first stage of overgrowth of young outcrops of the Cretaceous. Closed grass cover is not formed here. Overgrowing of old chalk outcrops "foreheads", where crushed chalky rock has been washed away and the bedrock of the chalk comes to the surface, takes a different path. The dense chalk is dominated by *Matthiola fragrans* Bunge and *Plantago maritima* saubsp. *salsa*, and in some places thickets of *Oligosporus salsoloide* are formed. *Linaria cretacea* Fisch. ex. Spreng., which prefers stony blocks, steep slopes of ravines and gullies, is often found on such outcrops (Ryabinina & Ryabtsova 2006). The study of rare plant species in nature is one of the prerequisites for organising the conservation of their gene pool (Darbaeva 2006).

MATERIALS AND METHODS

Linaria cretacea is a herbaceous perennial plant. Tap root, numerous stems, sloping or erect, 10-35 cm long, usually ending in a simple short inflorescence. Leaves are bluish, somewhat succulent, ovate, up to 1.5 cm long. The lower ones are arranged in several three-leaved tufts, the upper ones are reduced, ordinary. Flower calyxes are small, five-lobed; sepals are yellow, sometimes with reddish-orange lines, bilobed, with shoots 3-4 mm long, ash tube 3 mm long, bilobed curved, 4-5 mm long. Herbaceous perennial herb with a rod-like rhizome. Grows on chalk slopes, in places with very sparse petrophytic communities. Reproduces by seeds. The Trans-Volga-Kazakhstan species, according to S. A. Aypeisova, encompasses species distributed within the Trans-Volga-Kazakhstan Steppe Province. These include: *Linaria cretacea*, *Astragalus buchtormensis*, *Astragalus macropus*, *Thymus stepposus*, *Eremogone koriniana*, *Filipendula stepposa*, *Peucedanum morisonii*, *Allium praescissum*, *Euphorbia gmelinii*, *Oxytropis mugodsharica*, *Galium mugodsharicum*, *Centaurea turgaica*, *Serratula gmelinii*, *Anthemis trotzkiana*, *Centaurea carbonate*, etc. *L. cretacea* is unevenly distributed, growing from eastern Ukraine to the Ural region of Kazakhstan (Podural Plateau), on the territory of Russia in Voronezh, Belgorod, Saratov, Ulyanovsk, and Orenburg Regions. In the Orenburg region it occurs very rarely in more western chalk outcrops; it is reliably known only in the territories of the landscape-geomorphological and botanical nature monument "Upper Chibendinskie chalk mountains", geological and botanical nature monument "Troitskie chalk mountains" in Sol-Iletskiy district, nature monument "Chesnokovskie white mountains" in Perevolokskiy district (Skalov 1909; Darbaeva 2003, 2006; Ryabinina & Ryabtsova 2006; Aipeissova 2012). In Voronezh region - on the northern border of the area: Liskinsky (vicinity of Vladimirovka village), Petropavlovsky (vicinity of Krasnoselovka village, Staromelovoye village), Rossoshansky (vicinity of Arkhipovka village), Kantemirovsky (vicinity of Volokonovka village), Repyevsky (vicinity of Serdyuki village), Kalacheevsky, Bobrovsky (vicinity of Lipovka, Shestakovo villages). Populations are small and tend to decrease. In Kalacheevskiy District (along the Tolucheevka River), Kantemirovskiy District (right bank of the Belaya River) and along the Don River in

Bogucharskiy District, groupings where Cretaceous flaxseed dominates have been recorded, but the areas of groupings are very small. Quite isolated localities are known in the right bank of the Bityug River in Bobrovsky District (vicinity of the villages of Shestakovo and Lipovka [Red Book of the Russian Federation (Plants and Fungi) 2008], In the Volgograd region on the territory of the Donskoy Nature Park, it prefers dense chalk "foreheads" of chalk slopes of southern exposure (Ryabinina & Khrolodenko 2008). In Saratov region, Ozinsky district, vicinity of Melovoye village, 3-7 km from the state border with Kazakhstan (Shilova *et al.* 2009). Within the limits of North-Western Kazakhstan is spread rarely on Cretaceous outcrops, which occupy a large area in the NWK – 103953 km^2. Cretaceous sediments are widely distributed in NWK. According to Darbaeva T.E. it is rare in all landscape districts: Middle Syrt (Abyshsai, Krutaya), in Derkul Syrt the highest points of Mt. Ichka and Mt. Glazistaya are distinguished, Utva landscape district, this district includes chalk ridges, which start from Mirgorodok settlement of West Kazakhstan region through Mt. Melovaya of Orenburg region to Mt. Shangrow in Aktobe region. In the Karaganda landscape area the surface is composed of Cretaceous sediments of sandy mechanical composition. Here there are Cretaceous uplands in the basin of the Kiyil, Karaganda and Khobda rivers for 110 km from north to south and include Mount Itas, Mount Karatau, Mount Kosoba. The Cretaceous remains Iman-Kara and Koy-Kara stand out on the Emben plateau (Darbaeva 2006). In the Aktobe region, the Akshatau hills, including the Terektitau tract, stretching for 20 km from north to south along the right bank of the Uil River, are of great interest. Large chalk massif Ishkargantau in the south-western part of Akyrap village. The Ishkargantau chalk chain ridge is located to the south-west of the village of Akyrap, Kobda district, Aktobe region (about 15-17 km) and 70-80 km to the north-west of the village of Kursai. The chalk ridge consists of high cliffs and deep ravines rising separately from the surrounding plains. Two chalk massifs in Khobdinsky district of Aktobe region should be singled out as natural monuments. One of them, Mount Shangrow, is located 15 kilometres west of the village of Akrab, on the left bank of the Bolshoi Khobda. The other is Mount Itas, or Zhantyztau, located 13 kilometres southwest of the village of Novonaezhdinekiy in the upper reaches of the Kiyil River. The Aktolagai ridge is located in Baiganinsky district. The mountain range is 90 km long, 5-10 km wide, the highest point is Mount Kiyakty (217 m). The height difference on the plateau ledge reaches more than 130 metres. It is adjacent to the Caspian lowland along the bank of the Zhem River. The ridge is composed of Cretaceous rocks. Bestau is a chalk mountain occupying the east and north-east of the settlement, 40-45 km from the village of Kobda. It is about 4-5 km south of the nearest rural district of Bestau (former Pyatigorka). The study of natural cenopopulations of *L. cretacea* was carried out in 2023 in the natural population of the species in the Ishkargantau Cretaceous massif (Figs. 1, 2, 3 and 4; photos by the author), territory of Aktobe region. The names of natural cenopopulations were given according to the neighbouring settlements.

Fig. 1. Cretaceous massif of Ishkargantau.

Fig. 2. *L. cretacea* in the Ishkargantau chalk massif.

Morphometric parameters of rare species in nature were studied according to the method of V. N. Golubev in 25 generative plants of each cenopopulation (Golubev 1962, 1965). Observations and measurements were carried

out in the flowering phase, and the following morphometric parameters were included in the study: height of generative shoo, (cm; h); number of leaves on one generative shoot, (pcs.; Nl); leaf length (cm; Ll); leaf width, (cm - Sl; number of flowers per generative shoot.

Figs. 3 & 4. *L. cretacea* in the Ishkargantau chalk massif.

In the study of seed yield, the percentage of fruit flowering was determined (Vaynagiy 1974). Statistical processing was carried out in MS Excel 2010 programme and using Statistica 5.0 statistical software package (Borovikov 2003). In statistical analysis of quantitative indicators, arithmetic mean values, standard deviation, and coefficients of variation were calculated (Zaitsev 1984; Lakin 1990). Seeds were examined using an Olympus SZ2-ILST microscope.

RESULTS

When studying the state of rare species cenopopulations, it is important to analyse the variability of qualitative and quantitative traits. The results of morphometric parameters of *Linaria cretacea* plants in natural coenopopulations are presented in Table 1.

Table 1. Morphometric parameters of Linaria cretacea plants in natural coenopopulations.

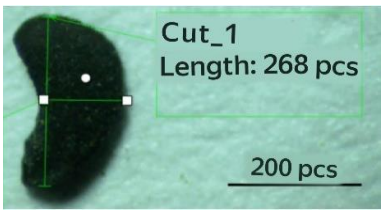
	Coenopopulation of the Ishkargantau massif
H height of generative shoot (cm)	
NL number of leaves in 1 generative shoot (pcs.)	
Ll Max leaf length (cm)	
SL Max leaf width (cm)	

From the natural cenopopulations studied in 2023, it can be seen that generative shoots in Kopala cenopopulation have the highest value in terms of parameters such as height (20.62 cm), number of leaves in generative shoot (33.16 pieces), length (0.904 cm) and leaf width (0.452 cm). The leaf width on the stem is close to the value in all populations (0.42-0.488 cm). The height of generative shoot (14.82 cm) and the number of leaves per generative shoot (26 pieces) of *L. cretacea* in the Utek cenopopulation are significantly lower than in the Kopaly and Akkudyksai cenopopopulations. Due to the fact that in the Otek coenopopulation, *L. cretacea* grows near the village, probably exposed to grazing and due to lack of moisture, most biomorphological indicators in these plants are lower than the values in other cenopopopulations. The only indicator is a significantly larger width of leaves on the stem (0.488 cm), which may be an indicator of adaptation to drought.

Table 2. Linaria cretacea seed yield indicators.

	Coenopopulation of the Ishkargantau massif		
		Akkudyksai	**Otek**
(			
	69.1	43.6	58.7
(			

Table 2 shows the indicators of seed productivity of the species in natural conditions. In the cenopopulation Akkudyksai, the number of flowers in the generative growth of *L. cretacea* is 10.32 ± 0.17 pcs., however, at this stage, the number of seeds was recorded in a small number, i.e., 7.4 ± 0.12, and the average number of seeds: 10.32 ± 0.17 pcs. and 12.01 ± 3.57 pcs. Percentage of flowering, i.e. percentage of fruiting flowers in nature ranged from 43.6 ± 11.2 to 69.1 ± 0.33% in populations with low anthropogenic load in Ishkargantau. The lowest biomorphological indices are observed in populations near Otek village, and the flowering percentage in this cenopopulation is 58.7 ± 2.8 among the studied cenopopopulations, which is close to the same indicator of the Akkudyksai population. In the Ishkargantau massif, the average flowering index in the Kopala population is 15.5% higher than that of the lowest cenopopopulation Akkudyksai. The highest average seed length index in the Ishkargantau massif was observed in the Kopaly cenopopulation (2.6 ± 12.55 mm), and the shortest in the Otek cenopopulation (2.01 ± 0.19 mm; Figs. 4, 5 and 6)



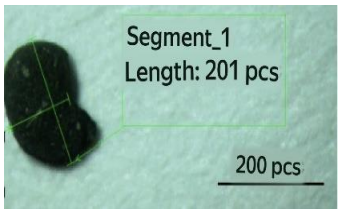


Fig. 5 Fig. 6 Fig. 7

Figs. 5, 6 and 7: Average seed length index in the Ishkargantau massif.

The number of flowers in the Kopala and Akkudyksai cenopopopulations is approximately the same. The highest reproduction rate is observed in the Akkudyksai cenopopulation, which has a preserved ecosystem and is located furthest from Aktobe City. The Kopala cenopopulation had significantly more seeds per plant than other populations (12.01 ± 3.57 seeds per plant), the low values in other cenopopulations may be related to the lack of moisture in the cenopopulation area.

CONCLUSION

Thus, the Kopaly cenopopopulation is the leader in most morphometric parameters, where, apparently, the most favourable conditions for plant growth are formed. The observed minimum values for parameters such as seed production and characteristic of generative shoots may be due to the degree of impact of anthropogenic load, such as grazing on natural cenopopopulations, which were higher in intact cenopopulations located far from settlements, compared to cenopopulations with anthropogenic load. Cretaceous outcrops are one of the valuable natural landscapes, on their territory. There is a complex of rare and endemic plant species, including *Linaria cretacea*. To preserve the population of rare *L. cretacea* species on the Ishkargantau chalk massif, it is necessary to take conservation measures.

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