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SYSTEMATIC STUDY OF ARID TERRITORIES

Assessment of the State of the *Allium praemixtum* Vved. Cenopopulation (Amaryllidaceae) on the Ridges of Uzbekistan

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Abstract—This article presents the results of a study of the state of the cenopopulation of a rare species, *Allium praemixtum* Vved. in the Nurata and Turkestan ranges. The ontogenetic structure of the cenopopulation was studied by the generally accepted methods (Uranov, 1975; *Tsenopopulyatsiya rastenii*..., 1976). Cenopopulations were characterized according to the classifications of A.A. Uranov and O.V. Smirnova (1969) and "delta–omega" (Zhivotovsky, 2001). The ecological density was determined by the method of W. Odum (1986). Geobotanical descriptions were made according to the standard methodology on sites of 100 m^2 (Field geobotany, 1964). The characteristic ontogenetic spectrum is left-sided, with an absolute maximum in one of the pregenerative groups (Cheremushkina, 2004). Cenopopulations (CP) 1, 5, 6 correspond to the characteristic left-sided ontogenetic spectrum with a maximum peak in the virginal state of the species. The centered ontogenetic spectrum does not coincide with the characteristics, culminating in middle age. The bimodal ontogenetic spectrum is then considered as a temporary left-sided variant with an equal peak in the medium generative and virginal states. The density of individuals in the studied cenopopulations varied from 1.1 to 9.7 ind./m^2, and the ecological density is from 2.3 to 17.63 ind./m^2. According to the "delta-omega" classification Allium praemixtum cenopopulation CP 1 is maturing, CP 5 and 6 are young, CP 2 and 4 are transitional, and CP 3 is mature. Existing cenopopulations are mainly located on unprotected territory, with the exception of CP 3 (near Mazhrumsay) and 4 (near Gurdarasay). The only solution to this problem can be the strict protection of cenopopulations.

Keywords: biodiversity, *Allium praemixtum* Vved., phytocenosis, ontogenetic structure, cenopopulation, plant protection

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In recent years, many plants have been threatened by anthropogenic pressure and climate change. A particularly high risk of extinction threatens species with a limited range and small populations. The first edition of the *Red Book of the Republic of Uzbekistan* (1984) includes 163 taxa. The latest edition includes 314 taxa (*Krasnaya kniga* ..., 2019). For 90% of taxa, the state of their cenopopulations has not been assessed. In recent decades, employees of the Institute of Botany of the Republic of Uzbekistan have studied some rare and endangered plant species. We studied the species of their *Red Book of the Republic of Uzbekistan* (2019), the state of cenopopulations and developed measures for their protection (Shomurodov et al., 2015; Saribaeva, Shomurodov, 2017; Rakhimova et al., 2020; Saribaeva et al., 2022). The species we are studying is *Allium praemixtum* Vved., a very rare endemic of the Nurata Mountains and the Western Tien Shan. Included in the *Red Book of the Republic of Uzbekistan* (2019) with status 1, on the verge of extinction. According to N. Beshko (2000a), the number of these plants in nature is about 1000 individuals. *A. praemixtum* is of interest as a valuable medicinal and food plant. The species is considered a wild relative of common onion cultivated plants (Keusgen et al., 2006). The local population collects its leaves and bulbs and uses them fresh as a seasoning (Khojimatov et al., 2015).

MATERIALS AND METHODS

In order to study the Allium praemixtum cenopopulation we conducted route research on the Nurata and Turkestan ranges. Six cenopopulations (CPs) were found in different plant communities in the middle mountain belt (Fig. 1).

Geobotanical descriptions were made in all communities where the population structure of species was studied, according to the generally accepted methodology, on sites of 100 m^2 (*Polevaya geobotanika*, 1964). Latin names of plant species are given according to the work of S.K. Cherepanov (1995), as well as in accordance with the international taxonomic database Plants of the World Online (2023). When studying the

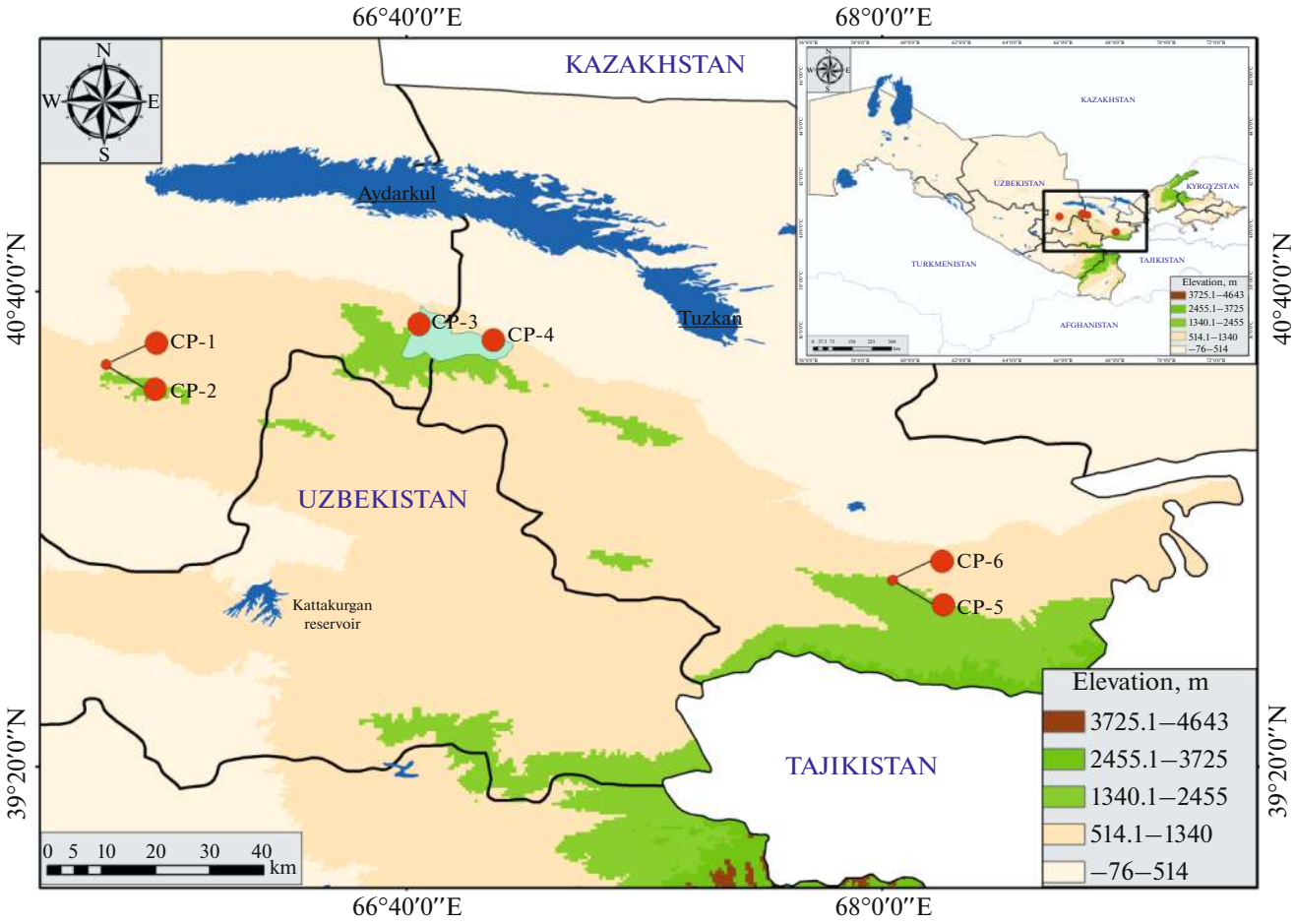


Fig. 1. A location map of Allium praemixtum cenopopulations.

ontogenetic structure of the CP, conventional methods were used (Uranov, 1975; *Tsenopopulyatsiya rastenii*..., 1976; Zhivotovsky, 2001). Transects 1-m wide and 5–10-m long were divided into trial plots of 1 m^2 each; we carried out a continuous count of individuals of each ontogenetic state.

To identify the ontogenetic state of the species, we used herbarium samples collected during field studies and the results of previous studies of the species (Cheremushkina, 2004).

The ontogenetic spectrum of a CP is defined as the ratio of plants of different ontogenetic states, expressed as a percentage of the total number of individuals (*Tsenopopulyatsiya rastenii*..., 1976). The characteristic type of the CP spectrum was established according to the ideas of L.B. Zaugolnova (1994). To characterize the CP, demographic indicators of the index of age and efficiency were used (Uranov, 1975; Zhivotovsky, 2001); we used the classification of A.A. Uranov and O.V. Smirnova (1969). The cenopopulation type was established according to the "delta–omega" classification by L.A. Zhivotovsky (2001). The density of the populations was determined by the number of individuals per unit area (*Tsenopopulyatsiya rastenii*..., 1977). At the same time, special attention is paid to indicators of the average density, i.e., the number of individuals per unit of the entire space (total area), and the ecological density, i.e., the number per unit of habitable space that can actually be occupied by a population (Odum, 1986). When determining the aging index and recovery index, the method of N.V. Glotova (1998) was used. Statistical processing of the material was carried out using Microsoft Excel.

RESULTS AND DISCUSSION

The Phytocenotic characteristics of the studied species. The ontogenesis of *A. praemixtum* was previously studied by V.A. Cheryomushkina (2004). According to its morphogenesis *A. praemixtum* is a loose soddy particulating monocentric rhizome-bulbous species. The characteristic ontogenetic spectrum is left-sided, with an absolute maximum in one of the pregenerative groups. This spectrum in onions is formed during seed and vegetative self-maintenance.

Table 1. The characteristics of plant communities of the studied species

CP No.	Geographic locations of CP	Geographical coordinates, absolute height, m a.s.l. BS	Dominant species	Number of species in the community	Total projective cover, %	Projective cover of the studied species, %
1	Nurata mountains in Bakhiltau	40.461638° N, 65.823808° E, 759	*Prunus bucharica* (Korsh.) Hand.-Mazz.	27	40	≥1
2	Nurata mountains in Aktau	40.462703° N, 65.824401° E, 820	*Prunus bucharica* (Korsh.) Hand.-Mazz.		30	≤1
3	Nurata mountains near Mazhrumsay	40.573412° N, 66.708218° E, 980	*Crataegus songarica* K. Koch	19	14	≥1
4	Nurata mountains in the vicinity of Gurdarasai	40.52430° N, 66.914 348° E, 708	*Prunus bucharica* (Korsh.) Hand.-Mazz.	14	18	≥1
5	Turkestan ranges in the vicinity of Navalisay	39.857399° N, 68.031787° E, 1801	*Ferula kokanica* Regel & Schmalh	16	16	≤1
6	Turkestan range in the vicinity of Boshpishagarsay	39.857399° N, 68.031787° E, 1845	*Crataegus turkestanica* Pojark	18	20	≤1

During the study, four cenopopulations were found in the Nurata ridges, and two cenopopulations were found in the Turkestan ridges (Fig. 1).

The first cenopopulation (CP 1) is located in the Nurata Ranges in Bakhiltau on a rocky, gravelly slope (geographical coordinates: 40.461638° N, 65.823808° E; absolute height 759 m a.s.l. BS). The total projective cover is 40%. The number of species in the community is 27, dominated by *Prunus bucharica* (Korsh.) Hand.-Mazz, *Carex pachystylis* j.Gay, *Artemisia ferganensis* Krasch. ex Poljakov, co-dominate, *Pistacia vera* L., *Tulipa korolkowii* Regel, *Poa bulbosa* L. (Table 1).

The second cenopopulation (CP 2) was determined in the Nurata ranges in Aktau. It is distributed on the maternal rocky slope (geographical coordinates: 40.462703° N, 65.824401° E; absolute height 820 m a.s.l. BS). The total projective cover is 30%. The number of species in the community is 27. The dominant is *Amugdalus bucharica* Korsh., the co-dominants are *Eremurus soogdianus* (Regel) Benth. & Hook.f., *Rheum maximowiczii* Losinsk, *Ferula diversivitata* Regel & Schmalh, *P. bulbosa* L. In community abundance *A. praemixtum* is about 1%. It has a load in the form of trampling (overgrazing).

The next cenopopulation (CP 3) was studied in the Nurata Mountains in the vicinity of Mazhrumsay (geographical coordinates: 40.573412° N, 66.708218° E, altitude 980 m a.s.l. BS). The cenopopulations are located on a rocky slope. The total projective cover is 14%. The number of species in the community is 19. The cenopopulation is dominated by *Crataegus songarica* K. Koch, whose projective cover is about 10%. The codominants are *Ephedra ciliata* Fisch. & Camey., *Ferula dshizakensis* Korovin, *Eremurus olgae* Regel (Table 1). Cenopopulations experience grazing here.

The fourth cenopopulation (CP 4) was examined in the Nurata mountains, in the vicinity of Gurdarasai (geographical coordinates: 40.52430° N, 66.914348° E; altitude 708 m a.s.l. BS). The cenopopulation is distributed on a rocky-rubbly slope. The number of species in the community is 18, the total projective cover of vegetation is 14%, of which 8% is the dominant *Prunus bucharica* (Korsh.) Hand.-Mazz. and the co-dominants are *Artemisia oliveriana* J. Gay ex Besser *Phlomis thapsoides* Bunge, *P. bulbosa* L. (Table 1). CPU 4 experiences intermittent trampling as it is frequented by small cattle.

The fifth cenopopulation (CP 5) was studied in the Turkestan ranges in the vicinity of Navalisay (geographical coordinates: 39.857399° N, 68.031787° E; absolute height 1801 m a.s.l. BS). The cenopopulation is distributed on a stony–gravelly slope. The number of species in the community is 16. Projective cover, 16%. The dominant is *Ferula kokanica* Regel & Schmalh., the co-dominants are *Spiraea hypericifolia* L., *P. bucharica* (Korsh.) Hand.-Mazz. The abundance

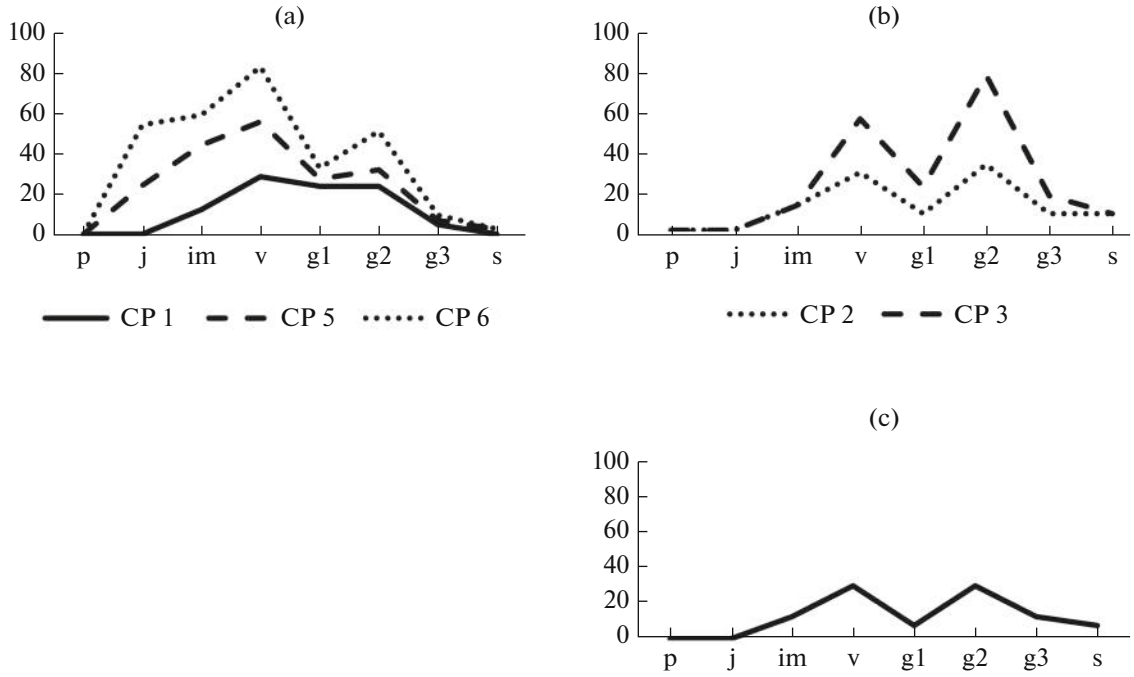


Fig. 2. The ontogenetic spectra of the *Allium praemixtum* cenopopulation. (a) Left-sided CP type 1, 5 and 6; (b) centered CP type 2 and 3; (c) bimodal CP type 4; along the axis *Y*, percentage, %; along the *X* axis, ontogenetic states.

Allium praemixtum in the plant community is 1% (Table 1).

The last cenopopulation (CP 6) was studied in the Turkestan ranges in the vicinity of Boshpishagars (geographical coordinates: 39.857399° N, 68.031787° E; absolute height 1845 m a.s.l. BS). The cenopopulation was found on a rocky, gravelly slope. The number of species is 18, the projective cover is 20%. The dominant is *Crataegus turkestanica* Pojark., its abundance in the community is 12%. Codominants are *P. bucharica* (Korsh.) Hand.-Mazz. and *Eremurus regelii* Vved. The abundance of the studied species is 1% (Table 1).

The Ontogenetic structure of the studied species. The studied Allium praemixtum cenopopulations according to A.A. Uranov and O.V. Smirnova (1969) are normal, but incomplete. In CPs 1, 3, and 6, individuals lack the juvenile and senile states, while individuals of the immature state are absent in CP 3 (Fig. 2).

The ontogenic structure of local cenopopulations has three types of spectra: left-sided, centered, and bimodal. According to morphogenesis, the following were distinguished: primary shoots, primary branched shoots, dense turf, bushy particula, and nonbushing particula (Cheremushkina, 2004).

The left-sided type of the ontogenetic spectrum, coinciding with the characteristic type, was found in CPs 1, 5, and 6 (Fig. 2a). Left-sided spectra are one- (CP 1, 5) and two-vertex (CP 6). In unimodal spectra, the absolute maximum falls on virginal individuals (28.6 and 31.9%). In CP 6, the ontogenetic spectrum has two peaks; the peak falls on juvenile (30.1%) and virginal (27.4%) individuals. A high proportion of virginal and juvenile individuals is associated with good seed reproduction and a long duration of the ontogenic pregenerative state.

The centered ontogenetic spectrum in CPs 2 and 3 differs from the typical one. The absolute maximum was noted for individuals of the medium generative state (33.3–45.4%; Fig. 2c). The studied cenopopulations live on the maternal rocky slope. When analyzing the ontogeny of onion species, it was noted that the duration of the generative phase in the ontogeny of species growing on rocks and rocky slopes is 13–15 years (Cheremushkina, 2004). This ensures the stability of the species under extreme conditions and the centered structure of cenopopulations. In these cenopopulations, a small number of young individuals are observed (im, v). This is due to the fact that in mountainous conditions, the arrival of floods adversely affects the washing away of young individuals with a dense arrangement of perennial shrubs in the plant community.

In CP 4, a bimodal spectrum was established with an equal predominance of individuals in the virginal (30.0%) and medium generative (30.0%) states (Fig. 2c). This is probably a reaction to heavy grazing, which contributes to a decrease in plant vitality, with a gradual increase in the lifespan of individuals in the generative period and their accumulation in the cenopopulation. The presence of a large proportion of young plants in the cenopopulation allows us to consider this spectrum as a temporary variant of the left-sided one.

Table 2. The demographic characteristics of *Allium praemixtum* cenopopulations

CP No.	Demographics							CP types
	I_r	I_a	Δ	ω	average density of pieces, m^2	P_{ecol} pieces, m^2	total number of individuals, pcs.	
1	1.22	0.05	0.33	0.64	1.05	2.3	21	Maturing
2	1.2	0.2	0.73	0.62	1.2	2.4	24	Transitional
3	0.4	0	0.38	0.78	1.1	2.75	21	Mature
4	0.85	0.08	0.37	0.61	2.0	3.1	40	Transitional
5	6.0	0.02	0.14	0.32	9.7	17.63	194	Young
6	2.65	0	0.17	0.42	3.65	6.63	73	Young

I_r is the recovery index, I_a is the aging index, Δ is the age index, ω is the efficiency index, P_{ecol} is the ecological density.

Onion species growing on stony parent soils are mainly characterized by high seed yield (Cheremushkina, 2004).

The density of individuals in the studied cenopopulations varied from 1.1 to 9.7 ind./m^2 and the ecological density is from 2.3 to 17.63 ind./m^2 (Table 2). The low density of individuals is due to the high level of vegetation in the cenopopulation (40%), the large number of species (27), and the lack of area for the growth of *Allium praemixtum*.

The indices of recovery and aging were compared, reflecting the dynamic state of cenopopulations of *A. praemixtum*.

A high recovery index (6.0) was determined in CP 5, near the Turkestan ranges in the vicinity of Boshpishagars (Table 2). This indicates a good seed renewal of the studied species. The number of pregenerative individuals is 83.48%. A low recovery index was determined in CP 3 in the Nurata mountains in the vicinity of Mazhrumsay, which is associated with the absence of juvenile and immature individuals in the cenopopulations.

The aging index in all cenopopulations is close to zero, most individuals die in the old generative state. A similar biological characteristic occurs for most bulbous plants (Shomurodov and Abduraimov, 2017).

According to the "delta–omega" classification the cenopopulations *A. praemixtum* according to A.A. Uranov and O.V. Smirnova (1969), as well as L.A. Zhivotovsky (2001), were as follows: CP 1 is maturing, CP 5 and 6 are young, CP 2 and 4 are transitional, CP 3 is mature. The indices fluctuate significantly: ω, from 0.32 to 0.78; Δ, from 0.14 to 0.73 (Table 2).

CONCLUSIONS

The studied Allium praemixtum cenopopulations are normal, incomplete. The absence of pregenerative individuals is explained by the high anthropogenic load (grazing). The absence of individuals in the senile state is associated with the biological characteristics of the species. The type of the ontogenetic spectrum of the cenopopulation in the zone with low pasture load is left-handed (CP 1, 5, 6), while in the area with intensive grazing it is centered and bimodal (CP 2, 3 and CP 4, respectively). Based on the biology of the species (high seed productivity, high seed germination and vegetative propagation), the characteristic spectrum of the cenopopulation of the studied species is left-sided, with a maximum peak of the virginal stage. The low density of individuals in the cenopopulation is due to the large number of species in the community and the height of the vegetation cover. The recovery index of all cenopopulations is above zero, which indicates a good seed regeneration *A. praemixtum*. The zero values of the aging index of this species are explained by the fact that most individuals die in the old generative period.

Existing cenopopulations are located in a protected area, in addition, near Mazhrumsay and Gurdarasai there is the territory of the Nurata Reserve. The local population collects specimens of species for food, and small cattle graze here in the valleys of the sais and in the lower and middle parts of the slopes all year round. According to N. Beshko (2000a, b), sheep also graze illegally in the Nurata Reserve throughout the year. An analysis of the anthropogenic disturbance of the ecosystems of the reserve shows that 5% of its area is occupied by areas with highly degraded vegetation and soils. All cenopopulations require protection due to uncontrolled harvesting of plants and grazing. In the future, the number *Allium praemixtum* may be greatly reduced and the species may disappear in the area. The only solution to this problem can be the strict protection of these cenopopulations until they are fully restored.

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COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interests. The authors declare that they have no conflicts of interest.

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