

Vitality structure of cenopopulations of *Alyssum turkestanicum* var. *desertorum* (Brassicaceae) in the ecotone system of the coastal zone of the Chogray reservoir

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Abstract. The article presents the results of a study of the vitality structure of plant cenopopulations using the example of *Alyssum turkestanicum* var. *desertorum* (Brassicaceae) in the ecotone system of the coastal zone of the Chogray Reservoir located in the Kuma-Manych Depression, in the valley of the East Manych River in the vegetation periods of 2021-2022. In accordance with the concept of A.S. Zaletaev, successive blocks of the "water-land" ecotone system are distinguished on the coast of the reservoir. In the cenopopulations of *A. turkestanicum* var. *desertorum* from 5 communities located at different distances from the reservoir, an analysis of the frequency of occurrence of plants of three vitality classes was carried out and their vitality spectra were constructed. An assessment of the vitality of cenopopulations using the IVC vitality index allowed us to conclude that the populations of *A. turkestanicum* var. *desertorum*, growing in various plant communities of the ecotone system, mainly belonged to the vitality type "flourishing". During the study, it was found that the viability of populations of the species *A. turkestanicum* var. *desertorum* in various belts of the ecotone system of the coastal zone of the Chogray reservoir depends not only on the ecological and phytocenotic conditions of their growth, which change with distance from the reservoir, but also on the climatic conditions of a particular year.

1 Introduction

Ecotones and ecotone systems have geographical features that determine their specificity depending on the natural zone in which they are located. In regions with arid climates, water bodies play an important role in the landscape structure, being the basis of the ecological framework and biological diversity of the region. In this regard, data on the structural and functional organization of biogeocenoses and their constituent species populations in the coastal zones of water bodies are of particular relevance [1].

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Ecotone systems are characterized by the presence of a weak, not yet fully formed adaptive mechanism of self-regulation [2]. Currently, biology is actively accumulating knowledge about ecotones at the level of phytocenoses and biogeocenoses included in their composition [3-4]. There are also attempts to study adaptive mechanisms in ecotones at the population level [5-6].

The study of processes occurring in ecotone systems using the population approach can become the basis for creating a system of biological control of their condition.

Databases obtained as a result of such studies can become indispensable for monitoring the condition of coastal ecosystems of water bodies, and will allow forecasting and reducing the risk of their disruption. In addition, they can be used to forecast events that may occur during successional changes, to assess the situation in coastal ecosystems, and to forecast and reduce the risk of their disruption.

The study examined species populations of Turkestan desert alyssum – *Alyssum turkestanicum* Regel & Schmalh. var. *desertorum* (Stapf) Botsch. (Brassicaceae) growing in the coastal strip of the Chograi reservoir. These populations are characterized by a high degree of adaptive plasticity. The aim of the study was to characterize the vitality structure of species populations of *Alyssum turkestanicum* var. *desertorum* to identify the level of their adaptation to the conditions of phytocenoses of the ecotone system of the Chograi reservoir coast.

2 Materials and methods

The Chogray reservoir, the coast of which is covered by the studied ecotone system, is located in one of the three large morphostructures in the territory of Kalmykia – in the Kuma-Manych depression. The Kuma-Manych depression is composed of highly saline sediments of marine origin. The reservoir in the latitudinal direction from east to west has a length of 48.8 km, in diameter the greatest value is 8.8 km, its configuration is triangular. Chogray is a reservoir of the filling type, since it is replenished by the river water of the Kuma and Terek, as well as the Tersko-Manych canal.

In the work in the vegetation seasons of 2021 and 2022, five species populations of *A. turkestanicum* var. *desertorum* were involved in the study. They came from phytocenoses belonging to different components of the ecotone system "water-land" of the Chograi reservoir [2].

In the fluctuation block of the ecotone system under consideration, a santonina-wormwood (*Tamarix ramosissima* - *Artemisia santonica*) phytocenosis grows, within which species population No. 1 *A. turkestanicum* var. *desertorum* is localized. During periods when the reservoir temporarily overflows its banks, characteristic festoons are formed on its banks. Soils of the wet meadow type, highly saline and with features of solonchak, within the fluctuation block are distinguished by the sulfate-chloride type of salinization.

The dynamic block in the ecotone is occupied by the wormwood-tamarisk (*Tamarix ramosissima* - *Artemisia santonica*, *A. austriaca*) plant community. In this part of the ecotone system, the soil cover is made up of meadow soils that were practically not saline. The community of this part of the ecotone system includes coenopopulation No. 2 *A. turkestanicum* var. *desertorum*.

The distant block of the ecotone is associated with the grass-wormwood (*Artemisia santonica*, *A. austriaca* - *Poa*) community, which grows on meadow chestnut soils. Within the framework of this plant community, species population No. 3 *A. turkestanicum* var. *desertorum* grew.

The marginal block corresponded to the belt where the bulbous bluegrass-wormwood with anabasis (*Artemisia taurica*, *A. austriaca* - *Poa bulbosa*) community was localized.

The soils in this place, as in the place of growth of the previous community, are meadow-chestnut, non-saline. This community included population No. 4 *A. turkestanicum* var. *desertorum*.

The zonal wormwood community, confined to meadow-chestnut soils, borders the ecotone system under consideration. The wormwood communities are dominated by wormwood species such as *Artemisia taurica*, *A. austriaca* and *A. lerchiana*.

In five studied populations of the species *A. turkestanicum* var. *desertorum*, 30 plants in the mid-generative age were randomly selected [7]. For each organism, 14 characteristics were taken into account.

The vitality of individuals of the species *A. turkestanicum* var. *desertorum* was assessed using the individual vitality index (IVI) [8]. Its calculation was preceded by a correlation analysis of all 14 characteristics, which made it possible to determine the key characteristics [9]. They coincided in two years of the study and included plant height, length of the above-ground part of the plant, leaf length, number of fruits on one plant, and number of seeds per plant.

In order to construct the vitality spectra, a method developed by Yu. A. Zlobin [8] was used.

According to this method, all plants that made up the sample were first arranged in a row in order of decreasing vitality index IVI value. Then, within this ranked row, individuals were distributed into three categories: "a" - plants with a high level of vitality, "b" - average, and "c" - with a low one. The number of individuals belonging to the category with the average vitality class was previously found within the confidence interval of the arithmetic mean value ($\bar{x} \pm \delta$).

The species population vitality type was identified using the approach of Yu. A. Zlobin [8]. The "flourishing" type included those populations in which half of the sum of the frequencies of individuals with high and medium vitality levels was greater than the frequency of individuals with low vitality levels; accordingly, in the "equilibrium" type these values had equal significance, while in the "depressed" type there were fewer individuals with low vitality levels.

The analysis of the species population vitality was carried out using the vitality index (IVC) [9].

Information on the weather during the vegetation period of *A. turkestanicum* var. *desertorum* was obtained based on the analysis of weather data in the archive of the Iki-Burul weather station, which was the closest to the Chograi reservoir, from the website www.rp5.ru.

3 Results

In all five considered species populations of *A. turkestanicum* var. *desertorum*, growing in successive "belts" of the ecotone "water-land" system, respectively, in different phytocenoses, organisms belonging to three vitality classes were noted: "a" - high, "b" - intermediate and "c" - low. In 2021, the frequency of individuals belonging to the high vitality class varied from 11.8% in cenopopulation No. 3 to 17.6% in cenopopulations No. 2 and No. 5; the frequency of individuals from the intermediate vitality class - from 50.0% in cenopopulation No. 1 to 76.5% in cenopopulation No. 3; the frequency of individuals from the lower vitality class ranges from 11.8% in cenopopulation No. 3 to 33.3% in cenopopulation 1 (Figure 1).

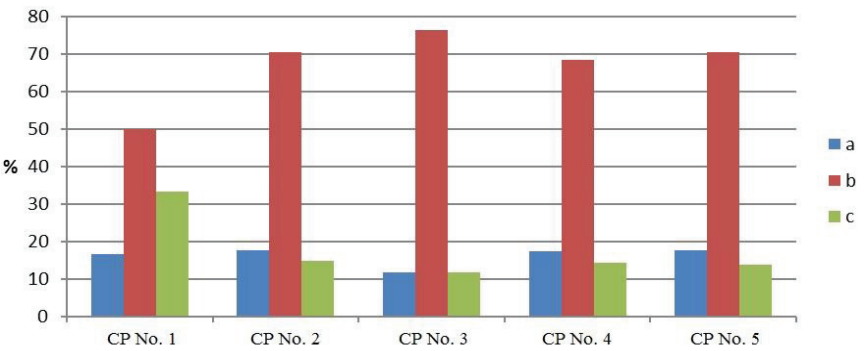


Fig. 1. Share (%) of plants of different vitality classes in cenopopulations of *Alyssum turkestanicum* var. *desertorum* in 2021: CP - cenopopulation.

In 2022, when moving from the water's edge along different belts of the ecotone system towards the zonal community, in the first three species populations there was an increase in the frequency of plants of the highest vitality class from 9.7% in cenopopulation No. 1 to 21.2% in cenopopulation No. 3. In cenopopulation No. 4 of the marginal block, the frequency of individuals of this vitality class decreased to 13.4% and remained approximately at this level in the zonal community in cenopopulation No. 5; the proportion of plants of the middle vitality class increased from 56.1% in cenopopulation No. 1 to 76.85 in cenopopulation No. 4, but in cenopopulation No. 5 from the zonal community it was 7.8% lower; the proportion of plants of the lower vitality class decreased from 34.2% in cenopopulation No. 1 to 3.03 in cenopopulation No. 3, but then it increased to 9.8% in cenopopulation No. 4, and in cenopopulation No. 5 of the zonal community it reached 17.2% (Figure 2).

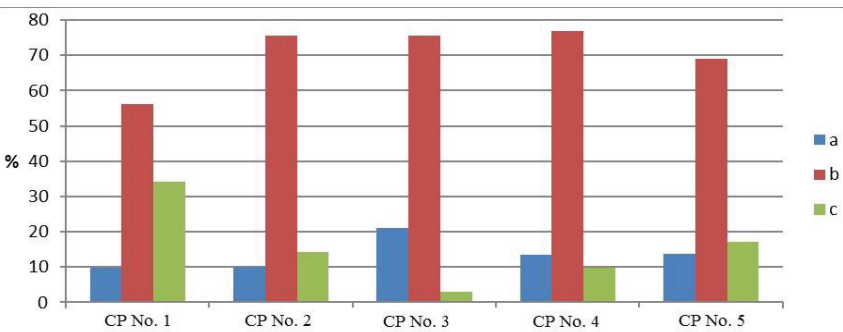


Fig. 2. Share (%) of plants of different vitality classes in cenopopulations of *Alyssum turkestanicum* var. *desertorum* in 2022: CP - cenopopulation.

In each of the belts of the ecotone system located in the coastal zone of the Chograi reservoir, with the exception of cenopopulation No. 1 in the fluctuation block, the proportion of plants of the highest and middle vitality classes exceeded 85%. This suggests that conditions have been created here that promote the full growth and development of individuals of this species.

The value of the Q index used to determine the type of population in relation to vitality revealed that its value exceeds the frequency of individuals of the lowest vitality class, and this made it possible to classify them as the "flourishing" vitality type. The exception was cenopopulation No. 1, which in 2021 was classified as "equilibrium" according to this indicator, and in 2022 - as "depressed" (Table 1).

Table 1. Vitality indices and vitality type of cenopopulations of *Alyssum turkestanicum* var. *desertorum*.

Cenopopulations	Year	IVC	Q	Vitality type
No. 1	2021	0.97	33.3	equilibrium
	2022	1.00	32.9	depressive
No. 2	2021	1.32	44.1	prosperous
	2022	1.26	42.8	prosperous
No. 3	2021	1.08	44.1	prosperous
	2022	0.74	48.5	prosperous
No. 4	2021	0.82	43.0	prosperous
	2022	0.64	45.1	prosperous
No. 5	2021	0.79	43.2	prosperous
	2022	0.59	41.4	prosperous

4 Discussion

An important biological characteristic of populations is their vitality, assessed by the IVC index. During the study period, the vitality index values were the highest (1.317 in 2021 and 1.262 in 2022) in cenopopulation No. 2 from the dynamic block. It can be assumed that for *A. turkestanicum* var. *desertorum* plants, the ecological and cenotic conditions of the wormwood-tamarix (*T. ramosissima* - *Artemisia santonica*, *A. austriaca*) community of the dynamic block of the ecotone system of the reservoir are the most optimal for ensuring such a level of vitality. In other studied communities of *Al. turkestanicum* var. *desertorum*, as the distance from the shore of the Chogray reservoir increased towards the zonal community, there was a gradual decrease in the IVC index value and, accordingly, in vitality: in coenopopulation No. 3 by 0.23 in 2021 and 0.52 in 2022, in coenopopulation No. 4 - by 0.50 and 0.62, in coenopopulation No. 5 - by 0.53 and 0.67, respectively (Table 1).

The study analyzed the vitality indicators of the *A. turkestanicum* var. *desertorum* species in the "water-land" ecotone system in the coastal zone of the Chograi reservoir, taking into account key climatic parameters such as average monthly temperature and total precipitation for March and April, which are predominantly the vegetation period of the species under study (Table 2).

Table 2. Average air temperature and precipitation amount (weather archive data from the Iki-Burul meteorological station).

Year	Temperature (°C)			Precipitation (mm)		
	March	April	Average	March	April	Average
2021	2.1	11.3	6.7	41.3	38.1	39.7
2022	1.0	12.8	6.9	15.0	23.5	19.2

In species populations No. 1 - No. 2 *A. turkestanicum* var. *desertorum*, growing in the fluctuation and dynamic blocks of the ecotone system, the differences in the IVC index value and, accordingly, the vitality of populations in different years of the study are not significant. It can be assumed that the comparative stability of the vitality of these two populations is due to their territorial proximity to the reservoir. In three other cenopopulations from different plant communities, following each other belts of this ecotone system, in 2021 the IVC index and, accordingly, the vitality of populations are 22.1-31.6% higher than in 2022.

In these cenopopulations, such vitality dynamics in two years of the study correlates with climatic data. In March-April, where most of the life cycle of the studied species takes place, the average temperature in March and April in both years of the study had similar values, while the amount of precipitation in 2021 was significantly greater than in 2022.

5 Conclusion

Cenopopulation No. 1 of *A. turkestanicum* var. *desertorum* in the fluctuation block of the considered ecotone system "water-land" of the Chograi reservoir, in the first year of the study had the vitality type "equilibrium", passing to the type "depressed" in the following year. Cenopopulations No. 2 - No. 4 in successive blocks of the ecotone system, including cenopopulation No. 5 in the zonal community, belonged to the type "flourishing".

The values of the IVC index in the cenopopulations of *A. turkestanicum* var. *desertorum* indicate that the conditions that develop in the dynamic block of the reservoir ecotone contribute to the greatest vitality of cenopopulation No. 2.

The dynamics of the IVC index values in the cenopopulations of *A. turkestanicum* var. *desertorum* in successive blocks of the ecotone system shows that the most favorable conditions for the growth and development of plants of the species are those that develop in the dynamic block where cenopopulation No. 2 is localized. It was also revealed that the vitality of the cenopopulations of *A. turkestanicum* var. *desertorum* from different belts of the ecotone system of the coastal zone of the Chogray Reservoir depends not only on the ecological and phytocenotic conditions of their growth, developing with distance from the reservoir, but also on the climatic conditions of the year.

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