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ALTITUDE-BELT DISTRIBUTION OF ALLIUM SPECIES IN TERSKY CAUCASUS AND DAGESTAN: PROTECTION ISSUES

Aishat Umaeva (a)*, Zlata Shakhgirieva (b), Yakha Sirieva (c)
*Corresponding author

(a) Kadyrov Chechen State University, Grozny, Russia, 0892179@mail.ru
(b) Kadyrov Chechen State University, Grozny, Russia, 1971zlata@mail.ru
(c) Kadyrov Chechen State University, Grozny, Russia, ysirieva@mail.ru

Abstract

The aim of the study was to assess the altitude-belt distribution of Allium species in the Tersky Caucasus and Dagestan and address associated protection issues. The research employed a combination of field surveys, botanical sampling, and laboratory analyses to gather comprehensive data on the distribution patterns and ecological preferences of Allium species across different altitudinal zones. The methodology involved systematic field expeditions to various altitudinal belts, collecting plant specimens, and recording relevant ecological parameters. Botanical identification and classification were conducted using established taxonomic methods, while laboratory analyses provided additional insights into the ecological requirements and adaptations of the studied Allium species. One notable result of the study was the documentation of specific altitude-related preferences and distribution patterns among Allium species, highlighting their ecological significance in different elevation zones. This information contributes to a better understanding of the local flora and aids in formulating targeted conservation strategies. In conclusion, the research underscores the importance of considering altitude-related factors in the conservation and protection of Allium species in the Tersky Caucasus and Dagestan. The findings provide a foundation for informed biodiversity management and contribute valuable data for the development of conservation policies in the region.

Keywords: Analysis, collection, environment, plants, territory

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1. Introduction

The flora of the North Caucasus is multifaceted, comprising 3,900 species of vascular plants. The process of identifying the taxonomic composition of the flora remains incompletely understood. The importance of studying ecologo-biological features of the Onion family is also due to the fact that they are used as medicinal and ornamental plants. Species of the Onion family (Alliaceae Juss) are the main plantings for urban landscaping. The cumulative gene pool of Allium species of the studied region has been formed in the process of long-term evolution and is now subjected to anthropogenic pressures, expressed in disturbance of species habitats and the disappearance of local populations. Its conservation in its entirety is extremely important because of the insufficient study of the useful properties of most species on the one hand, and the possibility of using the gene pool to create economically valuable plant species and varieties on the other. Species, in most cases, are bearers of information about the history of an area in the past geological epoch, and the preservation of their diversity is of great theoretical importance. The preservation of plant genetic resources can be a condition to ensure the ecological and economic security of the regions. The study of wild relatives of cultivated plants will make it possible to assess the state of plant genetic resources in the region. This is particularly relevant for the Terek Caucasus and Dagestan due to its unique geographical, climatic and ecological conditions.

There are three well-defined belt types in the Terek Caucasus and Dagestan area: central Caucasian, Dagestanian and eastern Caucasian. A generalised vertical zonal column for the whole area includes the following belts: semi-desert, steppe, forest-steppe, semi-arid, forest, subalpine, alpine and nival. The uppermost belt in this column (nival belt) is characterized by the spread of eternal snows and glaciers, which excludes the possibility of plant growth. Therefore, we do not consider it in further consideration of altitude-belt structure of Allium (Cheremushkina, 1993). The forest belt within the boundaries of the study area is divided into a number of independent strips, represented by different variants of forests: broad-leaved, small-leaved, coniferous and their various combinations. Below we consider this belt as a single forest belt, without detailing into different variants according to the nature of forest forming species. When analyzing the character of geographical distribution of species of the genus Allium in the territory of the Terek Caucasus and Dagestan, the scheme of zoning developed for the Caucasus by Yu.L. Menitsky was taken as a basis (Menitsky, 1991).

A general picture of altitude-belt confinement of Allium species is presented in table 1. The widest range of altitudinal distribution is characterized by 3 species: A. globosum, A. inaequale and A. paniculatum. This group of species occurs in 4 altitudinal belts. There are 8 species whose altitudinal range of distribution covers 3 belts. These are species such as A. albidum, A. erubescens, A. fuscoviolaceum, A. moschatum, A. oleraceum, A. paczoskianum, A. rupestre, A. saxatile. These two groups of species are distinguished not only by their occurrence in a wide altitudinal range, but also by their fairly wide geographical range extending beyond the Greater Caucasus. In addition, all of them are capable of adopting a variety of habitats with different physico-chemical parameters of the environment. Apparently, the wide ecological valence of these species in relation to various environmental factors (see table 2, can explain the size of their geographic range and the altitude range of their growth. Against the background of climate change and increasing anthropogenic impact on mountain ecosystems, Aminov et

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al. (2020) and Chadaeva et al. (2018) studied the distribution and development of invasive species in mountains, including the mountains of the Central Caucasus.

2. Problem Statement

The taxonomic composition of the flora of the North Caucasus poses a significant challenge due to incomplete understanding, especially concerning the ecologo-biological features of the Onion family (Alliaceae). This knowledge gap hinders comprehensive conservation efforts for the cumulative gene pool of Allium species. Given the increasing anthropogenic pressures on their habitats and the potential economic value of the gene pool in developing new plant species and varieties, the conservation of Allium genetic resources becomes crucial.

Preserving the genetic diversity within the Allium species is essential not only for ecological sustainability but also for economic security in the region. The unique traits and adaptations of these plants may hold valuable resources for future agricultural and horticultural developments. Therefore, understanding the taxonomic nuances and ecological intricacies of the Onion family is pivotal for formulating effective conservation strategies and ensuring the long-term ecological and economic security of the North Caucasus region.

The taxonomic composition of the flora of the North Caucasus remains incompletely understood, particularly with regard to the ecologo-biological features of the Onion family. The conservation of the cumulative gene pool of Allium species is crucial due to the anthropogenic pressures on their habitats and the possible economic value of the gene pool in creating new plant species and varieties. The preservation of plant genetic resources is vital for ensuring the ecological and economic security of the region.

3. Research Questions

Several research questions are posed by the problem discussed in this paper: What is the taxonomic composition of the flora of the North Caucasus, specifically with regard to the ecologo-biological features of the Onion family? What are the potential economic benefits of conserving the gene pool of Allium species in the region? What measures can be taken to preserve plant genetic resources in the North Caucasus region?

4. Purpose of the Study

The purpose of this study is to contribute to the understanding of the taxonomic composition of the flora of the North Caucasus, particularly with regard to the ecologo-biological features of the Onion family. Additionally, this study aims to highlight the importance of conserving the gene pool of Allium species for their potential economic value and the ecological and economic security of the region. The findings of this study may inform measures for preserving plant genetic resources in the North Caucasus and other regions facing similar challenges.

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5. Research Methods

We used literature data on the flora of the region under study and our own field studies, carried out in various districts of the Chechen Republic using the conventional route method. When compiling a list of wild relatives of cultivated plants of the onion genus, numerous sources from 1978 to the present were analyzed. When selecting priority species for conservation, we used the points of the methodology for the conservation of plant genetic resources, adapted to the region. A species location map was constructed using the MARINFO program.

6. Findings

The research findings revealed a diverse distribution pattern of Allium species across different altitude belts in the Tersky Caucasus and Dagestan regions. Through extensive field surveys and botanical analysis, it was observed that certain Allium species exhibit distinct preferences for specific altitude ranges, indicating niche specialization within the ecosystem. Additionally, the study identified several previously undocumented populations of Allium species, highlighting the importance of continued botanical exploration and conservation efforts in the region.

Furthermore, the research uncovered significant threats to the conservation of Allium genetic resources, including habitat degradation, anthropogenic activities, and climate change-induced environmental shifts. These findings underscore the urgent need for targeted conservation measures to safeguard the genetic diversity and ecological integrity of Allium species in the study area.

Overall, the findings contribute valuable insights into the distribution, ecology, and conservation status of Allium species in the Tersky Caucasus and Dagestan regions, providing a foundation for future research and conservation initiatives aimed at preserving the biodiversity and ecosystem services associated with these plants.

This study has not only theoretical but also practical importance. Many Allium species are stenochore and stenotopus plants (Kadyrbaeva et al., 2020; Khapilina et al., 2021). Among them there are many endemics for Tersky Caucasus and Dagestan. The obtained data on the refined species composition are important for compilation of a general summary of the flora of the Caucasus and regional floristic lists. The data on geographic distribution and geographic-genetic relationships of onions are important for determining the genesis of the genus Allium and the general history of the flora of the late Tertiary and Quaternary periods (Daeva, 1971). The results of the study may be important for solving questions of florogenesis of other high-mountainous localities. Flora is a source of species diversity; its components form the most diverse plant communities. The objectives of our study do not include a detailed description of the vegetation cover, but information about it is a kind of background, showing the diversity and characteristics of the studied Allium species (Kontsevaya, 2019; Mityukov et al., 2021; Olonova & Levchenko, 2021). A wide range of fluctuations of physical and geographical environment parameters and high species diversity is the primary cause of heterogeneity of phytocenoses within the Tersky Caucasus and Dagestan. As a natural consequence of heterogeneity of landscapes and habitats within the study area form a variety of organizational and structural features of plant communities belonging to different types of vegetation characteristic of the Greater Caucasus. Allium species habitats

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and landscape components in the study area include rocks, talus, moraine deposits and other forms of stony relief; semi-arid bottoms and lower horizons of basin sides; coniferous, deciduous and mixed forests, humid slopes and plateaus of upper mountain belts and others, and generalized variants of florocenotypes characteristic of Allium species (figure 1).

Table 1. Distribution of Allium species by altitude zone

Species name	Semi-desert	Steppe	Forest-steppe	Semi-arid	Forest	Subalpine	Alpine	Number of belts
A. victorialis	—	—	—	—	+	+	—	2
A. albidum	—	—	—	+	+	+	—	3
A. choenoprasum	—	—	—	—	—	+	+	2
A. saxatile	—	—	+	+	—	+	—	3
A. globosum	—	+	+	+	—	+	—	4
A. gunibicum	—	—	—	+	—	—	—	1
A. mirzajevii	—	—	—	+	—	—	—	1
A. charadzeae	—	—	—	—	—	+	—	1
A. salthynicum	—	—	—	+	—	—	—	1
A. daghestanicum	—	—	—	+	—	—	—	1
A. samurense	—	—	—	—	—	+	—	1
A. pseudostrictum	—	—	—	—	—	+	—	1
A. szovitsii	—	—	—	—	—	+	—	1
A. rotundum	—	+	+	—	—	—	—	2
A. erubescens	—	+	+	+	—	—	—	3
A. leucanthum	+	+	—	—	—	—	—	2
A. atroviolaceum	—	+	+	—	—	—	—	2
A. uscoviolaceum	—	+	+	+	—	—	—	3
A. phaerocephalon	—	+	+	—	—	—	—	2
A. affine	—	+	+	—	—	—	—	2
A. aucheri	—	—	—	—	—	+	—	1
A. moschatum	—	+	+	+	—	—	—	3
A. inaequale	+	+	+	+	—	—	—	4
A. rubellum	—	+	+	—	—	—	—	2
A. paczoskianum	—	+	+	+	—	—	—	3
A. kunthianum	—	—	—	+	—	+	—	2
A. rupestre	—	—	—	+	+	+	—	3
A. paniculatum	—	+	+	+	+	—	—	4
A. oleraceum	—	+	+	—	+	—	—	3
A. candolleanum	—	—	—	—	—	+	+	2
A. paradoxum	—	—	—	—	+	—	—	1
A. ursinum	—	—	—	—	+	—	—	1
A. oreophilum	—	—	—	—	—	—	+	1
A. caspium	+	—	—	—	—	—	—	1
A. decipiense	—	+	+	—	—	—	—	2
A. grande	—	—	—	—	+	—	—	1

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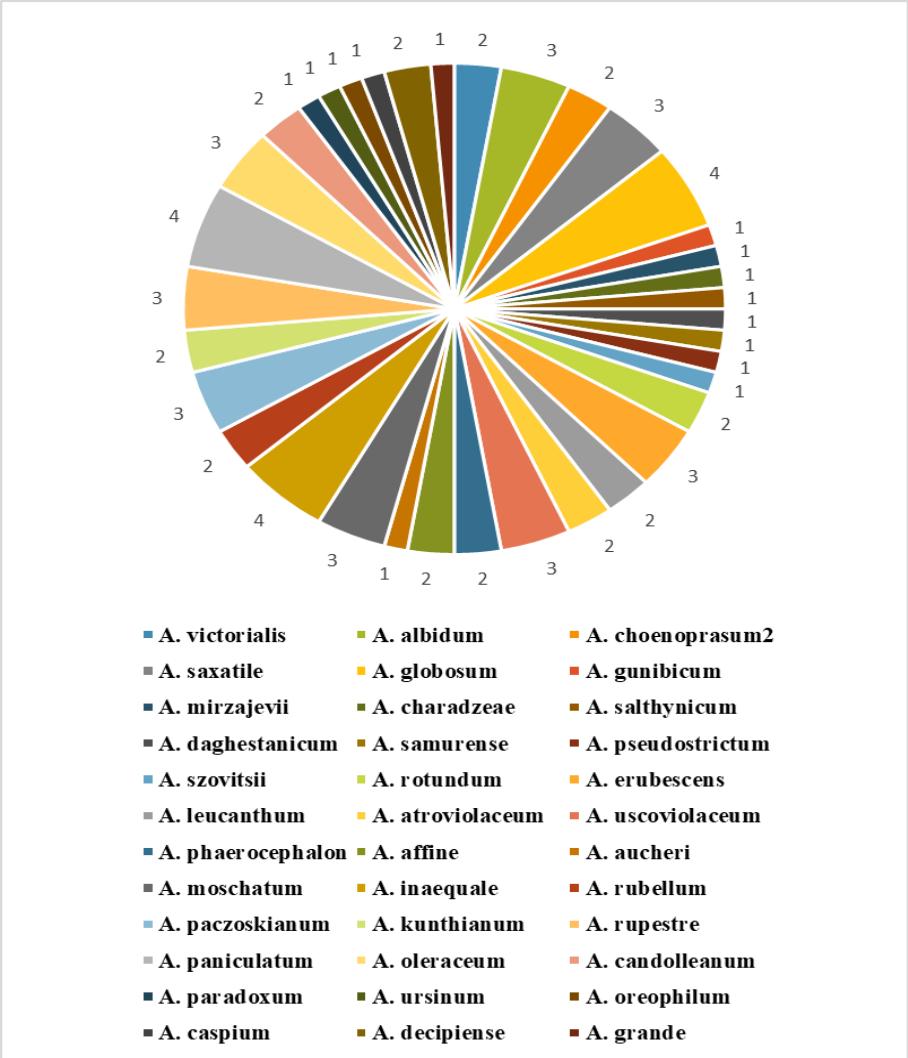

Figure 1. Distribution of species across altitudinal belts

Table 2. Characteristic habitats of widespread species

Name of species	Habitat
A.globosum	On stony slopes, on chalks, limestone, salts
A.inaequale	On steppe slopes, limestone, chalks, sands
A.paniculatum	On steppes, on sandy places, on slopes.
A.albidum	On stony slopes, rocky places.
A. saxatile	On rocks, stony slopes, sands, prairies.
A.erubescens	In meadows, among the bushes
A.fuscoviolaceum	On dry slopes, among bushes.
A.moschatum	On cliffs and dry slopes.
A.paczoskianum	On dry stony and rocky slopes.
A.rupestre	On rocky and sandy slopes and cliffs.
A.oleraceum	On meadows, steppes, slopes, in shrubs, sometimes as a weed

The structure of the vertical distribution is quite clearly illustrated in Table 3. In compiling this table, it was taken into account that species can be represented in one, two or more belts. The steppe,

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forest-steppe and semi-arid belts are the richest in number of species, with 15 species each, accounting for 41.67% of the total number of species in the region. The subalpine belt is next in species richness (13 species or 36.11%). Allium is even poorer in the forest belt (Romanov, 2022; Seredin et al., 2020; Tukhvatullina & Abramova, 2022). Finally, the semi-desert and alpine belts close this row with 3 species each (2.78%), (Figure 2). In (Phillips et al., 2006), an analysis of molecular variance was carried out and showed that 66% (A. acuminatum), 83% (A. passeyi) and 64% (A. brandegei) of the observed variation are found within populations. Genetic divergence among populations (F ST) was higher in widely distributed species, suggesting that gene flow between populations may have a negative correlation with range size. Genetic diversity within a population was not correlated with elevation for any of the three species. Based on ecological-geographical and morphological studies, Allium 'new type' (Pandey et al., 2021) has been identified as a neodomesticate' for the western Himalayan region, Uttarakhand, along with other potential lesser-known taxa, viz. A. stracheyi, A. wallichii and A. przewaliskianum. Analysis of the genetic diversity of natural populations of endangered and disappearing plant species (Khapilina et al., 2021) is a key aspect of the conservation strategy. The endangered species Allium altaicum is a relict plant of the glacial period and natural populations are located in the extreme climatic conditions of the Kazakh Altai.

Table 3. Structure of the altitude-belt distribution of species

Altitudinal belt	Number of species	% of total number of species	% single-belt species	Proportion of original species
Semi-desert	1/3	8,33	2,78	0,33
Steppe	0/15	41,67	0	0
Forest-steppe	0/15	41,67	0	0
Semiarid	4/15	41,67	11,11	0,27
Forest	3/8	22,22	8,33	0,38
Subalpine	5/13	36,11	13,89	0,38
Alpine	1/3	8,33	2,78	0,33

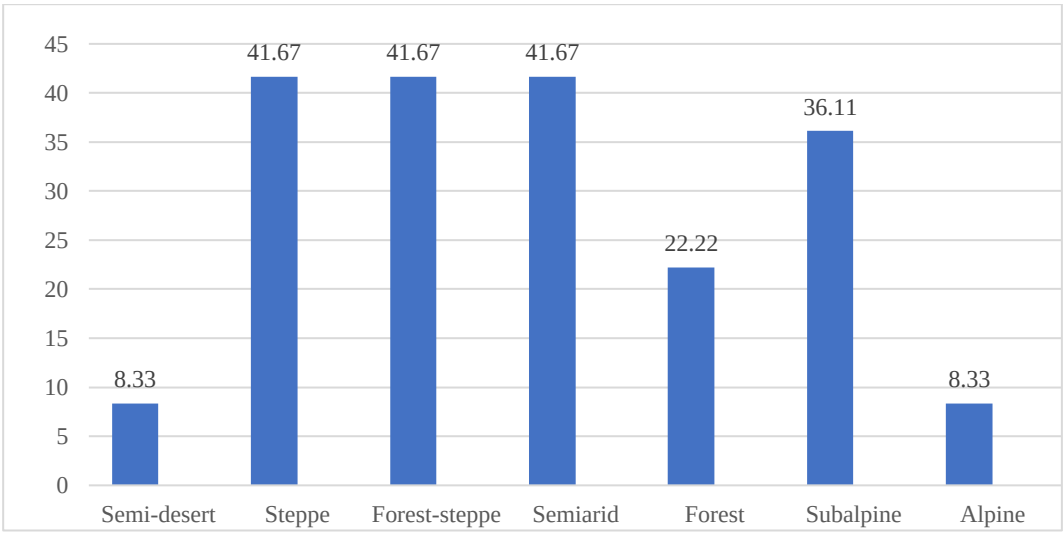

Figure 2. Distribution of species across altitudinal belts

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If we analyse the originality of the belts in terms of species composition, the subalpine belt takes the lead, with 5 species out of 13 not exceeding its borders. Correspondingly, the originality index is 13.89%. Second place in this row belongs to the semiarid belt (11.11%) and third place to the forest belt (8.33%).

Sufficiently informative, in our opinion, is the proportion of original species of the belt, calculated as the ratio of their number to the total number of species recorded in this belt. According to this indicator, at first glance, the forest and subalpine belts seem to be the most original, where the share of original species is 0.38 each. As follows from Table 1, the steppe and forest-steppe belts are not original at all according to this indicator. However, species such asA. atroviolaceum, A. decipiense, A. affine, A. rubellum, A. rotundum, A. sphaerocephalon are distributed only in these belts, which is connected with small ranges of variation of many environmental factors during transition from steppe belt to forest-steppe belt. Taking into account this observation, the share of original species of these belts should be taken as 0.4. Of some interest is the comparison of systematic lists of the belts according to the Sørensen-Chekanovsky coefficient (Ksc) to determine the level of relationship between them (Table 4).

Table 4. Sorensen-Chekanovský species similarity coefficients (Ksc) (by altitude zone)

	Semi-desert	**Steppe**	**Forest-steppe**	**Semi-arid**	**Forest**	**Subalpine**	**Alpine**
Semi-desert	**3**	2	1	1	0	0	0
Steppe	0,2222	**15**	14	7	2	1	0
Forest-steppe	0,1111	0,9333	**15**	8	2	2	0
Semi-arid	0,1111	0,4667	0,5333	**15**	3	5	0
Forest	0	0,1739	0,1739	0,2609	**8**	3	0
Subalpine	0	0,0714	0,1429	0,3537	0,2857	**13**	2
Alpine	0	0	0	0	0	0,2500	**3**

Analysis of this table shows that the alpine belt stands apart, which has insignificant similarity (Ksc=0.2500) with the subalpine belt, and has absolutely no connection with the rest of the underlying belts. The semi-desert belt, on the contrary, does not have in its composition species entering above semi-arid belt, and therefore its connection with forest, subalpine and alpine belts is zero. The greatest similarity in species composition is observed between steppe and forest-steppe belts (Ksc=0.9333). Also, it is possible to state more or less expressed similarity between forest-steppe and semi-arid belts (Ksc=0,5333). In other cases, the similarity of the systematic lists of the belts is low.

Disappearance of biological species, including Allium species, is a natural process occurring over a fairly long period of time (Dvoryashina, 2021; Isaenko, 2019). According to evaluations of different authors, the time of plant species existence is within 1 million to 250 thousand years. Signs of species extinction are global range disjuncture and difficulty of seed reproduction, transition to vegetative reproduction. The process of natural species extinction is greatly accelerated by anthropogenic impacts, and not only extinct species, most sensitive to increased anthropogenic pressure, but also species that are ecologically more plastic and at the evolutionary pinnacle of their development disappear. The main cause of species extinction is disturbance of their habitat - ploughing of steppes and meadows, cutting of forests, development of quarries, construction of roads etc. In the second place in degree of influence is

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excessive cattle grazing: in those places where the terrain is very sloping and unsuitable for agriculture, great damage to the population of rare plant species is inflicted by domestic animals, especially goats. Species also disappear when individual specimens are directly destroyed. Particularly affected are those species which have a subterranean part, such as onions (Pandey et al., 2021). The collection of rare species for bouquets causes considerable damage to the gene pool.

The basis of gene pool protection is based on the fact that for scientific and practical purposes the whole flora should be conserved, which is a determining condition for the rational use of plant resources and reconstruction of vegetation cover. To compile the regional list of plants to be protected, we followed two criteria - the category of protection and the status of the species. The category of protection refers to the degree of importance of preserving the gene pool of a given species.

According to this criterion, species to be protected are divided into five categories.

Category I. Regional endemics whose distribution is often limited to local areas or are known from several locations. Species in this category should be protected as a matter of priority irrespective of the state of their populations or the clarity of their systematic isolation as bearers of a rare and unique gene pool.

Category II. Sub-endemics whose ranges extend beyond the region into adjacent areas. In this case, special attention should be paid to local populations, especially those with disjunctive ranges.

Category III. Relict species with point ranges in the region and rare outside the region. These may include geographic, climatic and systematic relicts.

Category IV. Species found in the region at the range boundary; medicinal and food plants; ornamental species collected for bouquets; species described from the region to be protected in locus classicus.

Category V. Species not falling into the first four categories that are rare due to natural causes.

Status of species characterizes state of populations in nature and corresponds to designations adopted in IUCN Red Data Book (IUCN Plant Red Data Book, 1978), List of rare, threatened and endangered plants in Europe (1977), Red Book of the RSFSR (1988).

Species 0 are presumably extinct species whose occurrence in the region has been confirmed in the last few decades. These are species whose occurrence is indicated in literature or collected in single specimens. There are no species with this status among Allium of Tersky Kavkaz and Dagestan.

i. Disappearing species, occurring in single specimens, known from one or two or a few locations, immediately threatened. These include such species asA. grande.

ii. Vulnerable species, whose populations decline due to natural causes or due to habitat modification (destruction) and other anthropogenic factors. These species are not directly threatened with extinction, but occur either in small numbers or in limited areas and in specific ecological niches, among them A. gunibicum, A. mirzajevii, A. charadzeae, A. salthynicum, A. daghestanicum, A. samurense.

iii. Declining species, restricted to small areas or scattered over large areas, not currently endangered, but nevertheless declining. These are species such asA. paradoxum.

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iv. Undetermined species, for which there is currently no information on their population status, having any of the above statuses A. caspium, A. affine, A. aucheri, A. oreophilum and A. Candolleanum.

7. Conclusion

In conclusion, the research on the altitude-belt distribution of Allium species in the Tersky Caucasus and Dagestan has provided valuable insights into the ecologo-biological features of this plant family in the region. The study has revealed the importance of understanding the taxonomic composition of the local flora, particularly for the conservation of the cumulative gene pool of Allium species.

The identified threats to the conservation of Allium genetic resources underscore the need for immediate and effective conservation strategies. Conservation efforts should address habitat degradation, anthropogenic pressures, and the potential impacts of climate change to ensure the long-term survival of Allium species in their natural habitats.

The documented distribution patterns and ecological preferences of Allium species at different altitudes contribute to our knowledge of the region's biodiversity. This information is crucial for formulating targeted conservation measures and land management practices that promote the sustainable coexistence of Allium species with other components of the ecosystem.

In light of the findings, it is recommended to implement conservation programs, raise awareness about the ecological importance of Allium species, and establish protected areas to safeguard these plants and their genetic diversity. The research outcomes provide a foundation for future studies on plant biodiversity, contributing to the broader efforts aimed at preserving the natural heritage of the Tersky Caucasus and Dagestan regions.

i. In the flora of the Terek Caucasus and Dagestan 36 Allium species belonging to 14 sections and 4 subgenera were found.

ii. Among altitudinal belts of Terek Caucasus and Dagestan the steppe, forest-steppe and semi-arid belts are the richest in number of species; 15 species are registered in them, which is 41.67 % of total number of species each. The subalpine belt comes next in terms of species richness (13 species or 36.11%). The rest of the belts are significantly poorer than the forest belt. Alpine and semi-desert belts show very little similarity with other belts in terms of common species composition.

iii. The phenotypic fidelity of onions of the Terek Caucasus and Dagestan is characteristic of 12 species, which is1/3 of their total number. The remaining 2/3 of Allium species are ecologically plastic, do not have a strict confinement to a certain cenosis or phytocoenological niche, and can occur in two, three or more different habitats.

iv. Regional protection is granted to 13 species, of which 8 are of different territorial status and the rest are rare species with decreasing range.

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