Advances in Biology & Earth Sciences
Vol.10, No.1, 2025, pp.177-184
https://doi.org/10.62476/abes.101177

ONTOGENESIS AND CENOPOPULATION STATUS OF SPECIES *Viola odorata* L., DISTRIBUTED IN THE NORTH-EASTERN PART OF THE LESSER CAUCASUS

Aynur Bayramova*, Zarifa Tagiyeva, Ramida Guliyeva, Sabina Akhundova, Elnara Huseynova, Farida Pashayeva

Ganja State University, Ganja, Azerbaijan

Abstract. The article studies the ontogenesis and cenopopulation status of the fragrant violet species *Viola odorata*, belonging to the genus *Viola* of the family *Violaceae* Juss., which is an element of the early spring flora in the North-Eastern part of the Lesser Caucasus and studies the individual development stages of the plant and the dynamics of its population. During the study, several developmental periods of the species *Viola odorata* L., starting from the germination stage of ontogenesis to the generative stage, were covered. To assess the status of *Viola odorata* L. populations, their demographic structure, age composition, density of distribution individuals and the influence of ecological factors were studied. Depending on ecological factors, migration and natural renewal are rapid in some areas, which is associated with the predominance of young and mature individuals. In some sample plots, population declines weaken vegetative reproduction and reduce seed germination capacity. This occurs during the expansion of pasture areas, collection of the species for medicinal purposes and unsystematic grazing. Studying the ontogeny and population dynamics of the *Viola odorata* species is of great importance for the conservation of the species and the sustainable maintenance of biodiversity.

Keywords: *Ontogenesis, cenopopulation, seed, species, generative.*

****Corresponding Author:*** *Aynur Bayramova, Ganja State University, Ganja, Azerbaijan, Tel: +9959064488, e-mail: aynur.bayramova@gdu.edu.az*

Received: *19 February 2025;* ***Accepted:*** *3 March 2025;* ***Published:*** *15 April 2025.*

1. Introduction

Under changing conditions of the biosphere, the natural ranges of some plant species, including some representatives of the families *Orchidaceae Juss., Violaceae Juss., Primulaceae Vent.,* are observed to decrease. As a rule, they are represented by small populations limited to certain ecological niches and characterized by weak competitiveness (Bayramova & Rzayeva, 2021; Sofronov *et al*., 2015).

It is impossible to ensure the protection of biological diversity without studying cenopopulations. Understanding the biology and structure of a species is the basis for predicting cenopopulations. When studying the state of cenopopulations of species, their age, morphological and population dynamic heterogeneity should be taken into account (Baghirova, 2017; Ismayilova & Quliyeva, 2014; Novruzov & Quliyeva, 2013; Primack, 1985; Salamin *et al*., 2010; Arockianathan & Balasundaram, 2018).

How to cite (APA):
Bayramova, A.A., Tagiyeva, Z.I., Guliyeva, R.Z., Akhundova, S.T., Huseynova, E.A. & Pashayeva, F.V. (2025). Ontogenesis and cenopopulation status of species *Viola odorata* L., distributed in the North-Eastern part of the Lesser Caucasus. *Advances in Biology & Earth Sciences, 10*(1), 177-184 https://doi.org/10.62476/abes.101177

It has been observed that most species of the early spring flora of the Lesser Caucasus are distributed in high mountain vegetation (Abduraimov, 2017; Bayramova & Rzayeva, 2021). The study of rare vegetation of the early spring flora at the population level has been little studied. The specific climatic conditions of the high mountains, the short vegetation period, sharp daily temperature changes, frost and snow, increased ultraviolet rays, strong winds create a number of specific features in plants to increase their tolerance to adverse conditions. One of the most important issues of the species' cenopopulation is to clarify the limiting factor, determine the population adaptations to the existing ecological and cenotic conditions, as well as demographic parameters (density, age and quantity spectrum), self-regeneration and strategy of the species (Smirnova *et al*., 2023; Guliyeva, 2021).

The North-Eastern part of the Lesser Caucasus, which is seriously exposed to anthropogenic anomalies, is of greater importance in solving the problem of studying early spring vegetation.

For this purpose, we studied the ontogenetic characteristics of the *Viola odorata* species, which is widespread in the North-Eastern part of the Lesser Caucasus, investigated the state of its cenopopulations and determined their ontogenetic and demographic structure.

Viola odorata (fragrant violet) is a perennial herbaceous plant 3-22 cm tall. It is a creeping plant that takes root in the axils of thin, above-ground shoots and has no stem. The rhizome of the plant is thick and whitish. The leaf stalks are long. The leaves of the species are broad, ovate, with a heart-shaped base and serrate-rounded teeth on the edge. The tip of the leaf is slightly pointed or rounded. It is very short-haired or naked. Its flowers are located on a long stalk, are fragrant and are also blue-violet in color. The peduncles are located in the middle of the flower stalk or above the middle, giving the flower a special beauty. The fruit is a box-shaped, spherical or hemispherical, densely short-haired. Flowering occurs in III-IV and fruiting in V-VI months.

It is found in forests, thickets and sometimes on grassy slopes up to the middle mountain belt in the Greater Caucasus Guba, Northern Lesser Caucasus, Central Lesser Caucasus, Lankaran Highlands and Nakhchivan Plain botanical-geographic regions (Figure 1).

The seeds are obovate, smooth and small, measuring 1.5-1.80 mm. Width and thickness of the seeds reach 1 mm. The seeds are mainly spread by ants.

2. Material and methods

The materials for the study were collected from various areas of the North-Eastern part of the Lesser Caucasus in February-June. The modern APG IV taxonomic classification system of flowering plants (Angiosperm Phylogeny Group *et al*., 2016) and others were used (Sosnovsky & Karyagin, 1952). The geobotanical description of the coenoses in which the species participate was carried out according to a number of generally accepted methods used here (Korchagin *et al*., 1960). Observation of developmental signs in plants at the ontogenetic level was first carried out in stationary conditions by the method of Rabotnov (1950), Serebryakov (1975). Based on the system of Rabotnov (1950), age states of species were determined and the works of other researchers were also consulted.

The demographic parameters of the cenopopulation were studied on the basis of their composition: ontogenetic (age) spectrum, vitality and self-preservation methods.

The demographic structure was clarified as the ratio of different ontogenetic (age) groups. The type of cenopopulation was determined on the basis of the Δ-ω (delta-omega) classification of the normal population by Uranov (1975) and Zhivotovsky (2001).

$$\Delta = \frac{\sum k_i \cdot n_i}{N}$$

k_i – *coefficient of ontogenetic state I;*
n_i – *the number of individuals of ontogenetic structure I in the population;*
N – indicates the total number of individuals in the population.

$$\omega = \frac{\sum n_i \cdot e_i}{n_i}$$

n_i – *number of individuals in age group i;*
e_i – *efficiency of plants in ontogenetic status i.*

The main indicators of the viability of the species cenopopulation were assessed according to the classification of Isbridin et al. (2005), Zlobin and Terekhin (1993). The viability of the cenopopulation was classified according to Zlobin and Terekhin (1993) as follows:

1. Cenopopulation in developing- $(Q = 1/2(a + b) > c$
2. Cenopopulation in equilibrium - $(Q = 1/2(a + b) = c$
3. Cenopopulation in a crisis situation - $(Q = 1/2(a + b) < c$.

Discussion of the work: Sprout - up to 1 cm. It has 1 root protrusion and 2 oval-shaped lobed leaves.Leaves have light green stalk. Length is 2-3 mm, width is 1 mm. The main root is clearly visible, thin and light in color. It grows up to 2 cm and 1-2 additional roots emerge.

Figure 1. *Viola odorata* L.

Juveniles have rosette-shaped roots. The plant is up to 5-6 cm tall. It has 2-4 kidney-shaped leaves. The length of the leaf is 1 cm and the width is 1-1.5 cm. The tips of the leaf surface are toothed. The average length of the leaf stalk is up to 2 cm. The leaf and stalk have short hairs. The main root is larger.

Immature individuals grow up to 6 cm in height. It has 3-5 heart-shaped leaves. The average length of the leaf of an immature individual is 1.5 cm and its width is 2 cm. The length of the stalk of the leaf is up to 4 cm. The teeth at the tips of the leaves are already rounded. The leaves and stems are covered with short hairs. At this stage, a short epigeogenous root begins to form. The main root of the species goes to a depth of up to 6 cm, from which 2-3 additional roots develop.

Virgin individuals - have a height of 6-10 cm. The number of leaves is up to 6-8. The leaf stalks of these individuals are long, their average length is 5 cm. The elongation of the epigeogenic rhizome continues, the additional roots develop well, reaching a length of 7 cm. The main root dies.

Young generative individuals are 6-9 cm tall and have 1-2 purple flowers. The number of leaves is up to 11. The leaf surface is heart-shaped. The leaf stalk is 5 cm. The length of the leaf is 2.5 cm and the width is up to 2.3 cm. The average length of the rhizome is 1-1.5 cm. At this stage, a polycentric system is formed. This occurs mainly on the basis of above-ground stolons.

Middle-aged generative individuals - up to 20 cm. The number of leaves increases, reaching 15-18. The leaves grow slightly. Their length is 3-3.5 cm and their width is 3-4 cm. Mass flowering occurs. The rhizome extends up to 1.5 cm.

Old generative individuals - up to 10-12 cm high. The size and shape of the leaves do not differ from middle-aged generative individuals. The leaves at the base of the rosette die off. The rhizome darkens, reaches a length of up to 2 cm. A polycentric system develops.

Subsenile individuals - have many dead leaves. Their height reaches 7-8 cm. The number of leaves is from 2 to 5. The rhizome of this individual is darker and the number of additional roots is small.

Senile individuals - up to 5 cm high. The number of leaves varies from 2-4. The rhizome shortens and the number of additional roots decreases.

The 1st cenopopulation (CP 1) of *Viola odorata* L. (fragrant violet) was studied in the forest around Mollalar village (N 40°03'32.6" E 46°48'48.2") of Tovuz region at an altitude of 931 m above sea level. The soil of the area is black and humid. The projected cover of herbaceous plants of the village is 70%. The number of individuals of this cenopopulation in different age states reached 186. *Quercus petraea*. Subsp. *Iberica.*, *Acer campestre*. (L.), *Quercus macranthera* Fisch.et.C.A.Mey., *Mespilus germanica* L. plants participated in the tree layer. *Corylus avellana* L. species predominated. Among the shrub-type plants, *Crataegus pentagyna* Willd. and *Rubus ideaus* L. Subsp.idaeus. taxa were found. In the herbaceous layer, along with this plant, there were also *Viola arvensis* Murr., *Scilla siberica* Haw., *Veronica officinalis* L., *Primula acaulis* L, *Dentharia quinquifolia* Bieb, *Arum elongatum* auct.non Stev. and *Ajuga genevensis* L.

CP 2 - The forest area around Toganali village (N 40°25'41.2"E 46°19'04.1") of Goygol region was studied. The area is located at an altitude of 1317m above sea level. The soil of the village is dark brown and moist. The projected cover of grass is 90%. The number of plant individuals per 1 m^2 of the area is 3. *Fagus orientalis* Lipsky., *Carpinus betulus* (L.), *Acer campestre* (L.), *Cornus mas* L.., shrubs *Crataegus kyrtostyla* Lindm., *Rubus caucasicus* Focke., grasses *Cordyalis caucasica, C.angustifolia* (M.Bieb.) DC., *Cardamine quinquefolia*., *Anemone caucasica, Primula acaulis* L. and *Orobanche alba* Willd. *Corydalis angustifolia* (M. Bieb.) DC., *Trifolium pratense*., *Primula woronowii* Losinsk., *Galium rubioides* L., Laser trilobum (L.) Borkh., *Alliaria petiolata* (Bieb.) Cavara et Grande, *Ranunculus.cicutarius* Schltdl., *Stachys byzantina*., *Bellis perennis* L.,

Fragaria.viridis Weston., *Plantago lanceolata* L., *Silene italica* (L.) Pers. types were involved.

CP 3 The Slavyanka village of Gadabay district, Lower Narzan (40°39'33.0"N 45°49'01.0"E) was studied. The projective cover of herbaceous plants is 80-85%. The number of plant individuals per 1 m^2 is equal to 4. The soil of the study area is black, fertile and moist. *Quercus macranthera* Fisch. et C.A.Mey., *Carpinus betulus* L., *Fagus orientalis* Lipsky. trees, *Rosa canina* L., Juniperus *pygmea* C. Koch., *Prunus spinosa* L. shrubs, *Poa bulbosa* L., *Medicafo coerelea* Less. ex Lebed, *Scilla siberica* Haw, *Veronica officinalis* L., *Anthemis candidissima* Willd. ex Spreng., *Valerianella uncinata* (M. Bieb.) Dufr., *Plantago lanceolata* L., *Silybum marianum* (L.) Gaertn. herbaceous plants are widespread in the cenose.

Table 1. Ontogenetic characteristics of the species Viola odorata L.

CP	J	İm	V	G_1	G_2	G_3	Ss	S	∑
CP I	13	18	22	74	34	22	2	1	186
CP II	9	6	12	8	6	3	1	0	45
CP III	15	24	28	28	11	5	15	14	140
∑	37	48	62	110	51	30	18	15	371

The ontogenetic structure of the fragrant violet, which belongs to the early spring flora, is reflected in Table 1. As can be seen from the table, the ontogenetic structure of the species was studied on a total of 371 individuals. As a result of favorable climatic conditions in CP I, the normal development of vegetative and generative individuals of the species *Viola odorata* L. increases the percentage of development of the species in that area. The high number of virgin individuals is an indicator of the vegetative reproduction of the species. In CP II, a total of 45 individuals were found. This is due to the unsystematic use of the forest around the village of Toganali in the Goygol region. In CP III, individuals developed at the maximum level in all age states of the virgin age period (j=15, im=24, v=28).

The number of individuals in the pregenerative age state was g_1=28 and in the generative and postgenerative age states it was lower (g_2=11, g_3=5). This situation may result in a future reduction of the species' distribution area in that area.

A diagrammatic representation of the ontogenetic spectrum age groups is depicted (Figure 2).

In the 3 cenopopulations of the studied species, the percentage of pregenerative individuals was 28.49%-60%-47.85%, generative individuals were 69.89%-37.77%-31.43% and postgenerative individuals were 1.61%-2.22%-20.71%, respectively.

The demographic values of the cenopopulations of the *Viola odorata* L. plant are reflected in Table 2.

Table 2. Demographic indicators of Viola odorata L. cenopopulations

Indexes	n	Td	Ai	Ri	Ir	Δ	ω	Type
CP 1	186	12,4	0,41	0	0,41	0,33	0,67	Maturing
CP 2	45	3	1,59	0	1,59	0,261	0,492	Young
CP 3	140	9	0,89	0,66	0,56	0,36	0,45	Transition

Note: n - number of individuals; Td - total density of individuals; Ri - regeneration index; Ai - aging index.; Ir - replacement index.; Δ - age index; ω - efficiency index.

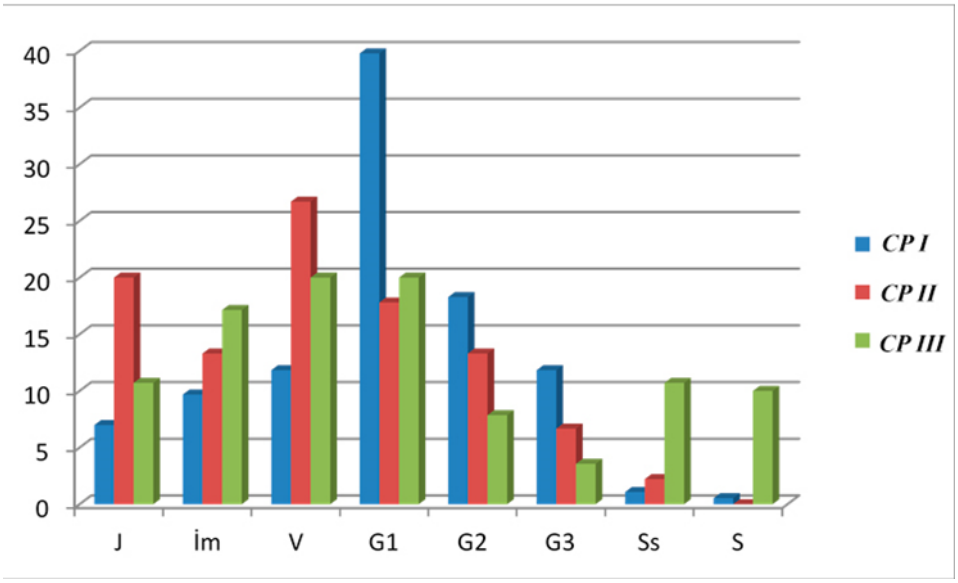

Figure 2. Ontogenetic spectrum of the cenopopulations of the *Viola odorata* L. plant

The number and average density of individuals were the highest in CP 1 and the lowest in CP 2. The replacement index has the highest value in CP 2.

Based on the indicators of Δ and ω indices, CP1 is a maturing type, CP2 is a young type and CP 3 is a transitional type.

One of the most important indicators for assessing the state of a cenopopulation is vitality. Vitality is a common indicator of the development of a cenopopulation. The vitality of individuals is associated with the strong development of vegetative and generative organs (resistance to unfavorable environmental conditions, regeneration ability) and depends on the resistance of individuals to unfavorable conditions. To determine the vitality of a population, indicator signs present in individual individuals can be used as diagnostic criteria (Puchnina, 2017; Murazakanova & Shkhagapsoev, 2005). The vitality of each individual in ontogenesis changes with a stepwise curvature. It can both increase and decrease. One age state in a cenopopulation can have different vitality. Such fragmentation in a cenopopulation can occur as a result of poor-quality seeds, their germination at different times, environmental conditions, the influence of humans and animals and competition.

CP 3 In the village of Slavyanka in the Gadabay region, the species Viola odorata L. occurs in a scattered form in Ashagi Narzan and quickly invades other areas. Initially, only one juvenile individual is formed and when it becomes immature, reproduction begins. It covers all age periods of the cenopopulation. In this case, development begins from the juvenile stage. The replacement of individuals during the development stage is cyclical. All cenopopulations are subject to fluctuation changes. In other cenopopulations, one population replaces another and biomorphological analysis of individuals shows that the morphogenesis of the species cannot fully use its potential. During the studies conducted by us, the vitality of the developing populations of the species Viola odorata L. was monitored (Table 3).

Table 3. Viability of Viola odorata L. cenopopulations

CP	CP	Number of individuals in CP in %			IQ	Q	The vitality of CP
		a	b	c			
I CP	I CP	69,7	28,8	1,5	32,8	49,2	In developing
	II CP	37,8	60	2,2	22,2	48,9	In developing
	III CP	31,4	47,8	20,8	1,9	39,6	In developing

3. Conclusion

In the article, the ontogenesis and modern state of the cenopopulation of the fragrant violet species *Viola odorata*, belonging to the genus *Viola* of the family *Violaceae* Juss., which is an element of the early spring flora in the North-Eastern part of the Lesser Caucasus, were studied in various plant groups, individual development stages of the plant and the dynamics of population development were investigated. As a result of favorable climatic conditions, the development of vegetative and generative individuals of the species *Viola odorata* L. in CP I is normal, increasing the percentage of development of the species in that area. The high number of virgin individuals is an indicator of the vegetative reproduction of the species. According to the Δ - ω criteria, the cenopopulation type CP1 is maturing, CP2 is young and CP 3 is transitional, reflecting the normal development of the species. The developing vitality of populations of the species Viola odorata L. was monitored.

References

Abduraimov, O.S. (2017). Biological features and state of cenopopulations of Tulipa L. species in Kyzylkum desert. Abstract of doctoral Dissertation, Tashkent.

Angiosperm Phylogeny Group, Chase, M.W., Christenhusz, M.J., Fay, M.F., Byng, J.W., Judd, W.S., ... & Stevens, P.F. (2016). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. *Botanical Journal of the Linnean Society*, *181*(1), 1-20. http://doi.org/10.1111/boj.12385

Arockianathan, S., Balasundaram, R. (2018). Population status, habitat selection and people's perception on Pavo cristatus (Aves: Phasianidae) in Sigur Plateau, the Nilgiris, Tamil Nadu, India. *Nature Conservation Research*, *3*(1), 80-87. http://dx.doi.org/10.24189/ncr.2018.010

Baghirova, A.Kh. (2017). Eco-biological characteristics of the main components of the Eldar plain vegetation cover Azerbaijan. *International Journal of Science and Research Methodology*, *8*(2), 106-114. https://ijsrm.humanjournals.com/wp-content/uploads/2018/01/9.A.-Kh.-Baghirova.pdf

Bayramova, A.A. Rzayeva, F.V. (2021). Spring flora of the northeast part of the Lesser Caucasus and its classifications. *Bulletin of Science and Practice,* *7*(5), 85-89. http://doi.org/10.33619/2414-2948/66/10

Guliyeva, R. (2021). Evaluation of developmental structures and cenopulation state Cerastium davuricum Fisch. ex Spreng. in the highlands of the Lesser Caucasus. *Bulleten of Science and Practice, 7*(6), 17-21. https://doi.org/10.33619/2414-2948/67/02 (In Russian).

Guliyeva, R.Z. (2023). Development dynamics of some carnations (Caryophyllaceae) met in the north-east part of the Small Caucasus. *Proceedings of IX International Scientific and Practical Conference*, 21-28. https://sci-conf.com.ua/ix-mizhnarodna-naukovo-praktichna-konferentsiya-european-scientific-congress-2-4-10-2023-madrid-ispaniya-arhiv/ (In Russian).

Ishbirdin, A.R., Ishmuratova, M.M. & Zhirnova, T.V. (2005). Life strategies of the cenopopulation Cephalanthera rubra (L.) Rich. on the territory of the Bashkir State Reserve. *Bulletin of the Nizhny Novgorod University named after N.I. Lobachevsky, Series: Biology*, *1*(9), 85-98. (In Russian).

Ismayilova, Z.M., Quliyeva, R.Z. (2014). Evaluation of populations of Agrostis planifolia C. Koch type on the high mountains of the Lesser Caucasus. *European Academic Research*, *1*(12), 5476-5483. https://www.euacademic.org/UploadArticle/382.pdf

Korchagin, A.A. et al. (1960). *Field Geobotany*, in 4 volumes. Moscow: Science, 499. (In Russian).

Murazakanova, L.Z., Shkhagapsoev, S.Kh. (2005). Age characteristics and structure of the cenopopulation of Saxifraga dinnika in the gorges of the Cheroksky district. Nature of the Cheroksky district of the Kabardino-Balkarian Republic and its protection. *Nalchik*, 120-123. (In Russian).

Novruzov, V., Quliyeva, R. (2013). Bioecological characteristics and dynamics of senopopulations of some rare cereals (Agrostis planifolia C. koch, Agrostis lazica Balans) in the highlands of Little Caucasus. *Turkish Journal of Scientific Reviews*, *6*(1), 98-100. (In Turkish).

Primack, R.B. (1985). Patterns of flowering phenology in communities, populations, individuals and single flowers. In *The Population Structure of Vegetation*, 571-593. Dordrecht: Springer Netherlands.

Puchnina, L.V. (2017). Status of Calypso bulbosa and Cypripedium calceolus (Orchidaceae) populations in the Pinega state nature reserve. *Nature Conservation Research*, 2, 125-150. http://dx.doi.org/10.24189/ncr.2017.023

Rabotnov, T.A. (1950). Life cycle of perennial herbaceous plants in meadow cenoses. *Proceedings of the Botanical Institute of the USSR Academy of Sciences, Geobotany*. Moscow, 204. (In Russian).

Salamin, N., Wüest, R.O., Lavergne, S., Thuiller, W. & Pearman, P.B. (2010). Assessing rapid evolution in a changing environment. *Trends in Ecology & Evolution*, *25*(12), 692-698.

Serebryakov, I.G. (1952). Morphology of vegetative organs of higher plants. Moscow: Modern Science, 376. (In Russian).

Smirnova, E.B., Zanina, M.A., Semenova, N.Y., Arushanyan, H.S. & Shelop, V.V. (2023). Resources and ontogenetic structure of cenopopulations of the Genus Viola (Violaceae, Magnoliópsida) on the Right Bank of the Volga River in Saratov Oblast. *Biology Bulletin*, *50*(10), 2567-2571. https://doi.org/10.1134/S1062359023100151

Sofronov, G.Y., Glotov, N.V. & Ivanov, S.M. (2015). Analysis of ontogenetic spectra of populations of plants and lichens via ordinal regression. In *Symposium on Biomathematics (SYMOMATH 2014)*, *1651*(1), 118-127. American Institute of Physics.

Sosnovsky, D.I., Karyagin, I.I. (1952). *Flora of Azerbaijan*, in 8 volumes. Baku, 317. (In Russian).

Uranov, A.A. (1975). Age spectrum of phytopopulations as a function of time of energy wave processes. *Biological Sciences*, 2, 7-34. (In Russian).

Zhivotovsky, A.A. (2001). Ontogenetic states, effective density and classification of plant populations. *Ecology*, 1, 37. (In Russian).

Zlobin, Yu.A., Terekhin, E.S. (1993). Population and cenotic regulation of reproduction in angiosperms. *Proceedings of the Botanical Institute*, 8, 8-15. (In Russian).