STUDIES ON THE POPULATION BIOLOGY OF ORNITHOGALUM UMBELLATUM L. (LILIACEAE) FOR ELABORATION STRATEGY OF THE SPECIES SURVIVE IN TRANSCARPATHIA

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Abstract

On the basis of the complex study of demography of *Ornithogalum umbellatum* L. (Liliaceae) in Transcarpathia (determination of age and space structure, density, phytomass, viability and vitality of the populations) degree of stability of the species against the anthropogenic press and prospects of its survival have been revealed. The studied has been carried out by 28 morphometric features, the results have been processed by the method of the principal components (program from package BMDP). By means of correlation and factor analyses peculiarities of reaction of individuals and populations of *O. umbellatum* to the stress influences have been established. Measures for preserving of the genofond of the species in the investigated area are suggested.

Introduction

The most important condition for organizing the effective protection of rare and disappearing plants is estimation of the degree of threat to their existence, of the reasons of reducing their number, revealing the real state and stability of the local population. The most sensitive indication of the reaction of the population to the outer disturbances, including anthropogenic factors is its structure. It reflects the organization of populations in space and time, conditions their ability to resist different stress factors and determines the prospect of their further development.

In this connection keeping within the bounds of the complex program fo studying ephemeroids, the most threatened group of species of natural flora of Transcarpathia (KRICHFALUSHIY et *al.* 1987), we have studied the demography of the population of *Ornithogalum umbellatum* L. (Liliaceae) in various ecological phytocenotic conditions and recreation load regime. Once widely spread in the lowland near the river Tisa and in foothills of the Carpathians. *O. umbellatum* grows today in only 9 isolated localities as a result of the mighty anthropogenic influence. Progressive destruction of the biotopes occupied by the species, insularization and decrease of their areas cause the necessity of complex ecological and biological research for elaborating scientific grounds of genofond protection (MEZEV-KRICHFALUSHIY 1988). Results of quantitative population analysis of *O. umbellatum* are presented in this paper.

Materials and Methods

The objects of the research were 3 isolated populations of *O. umbellatum*: L. The lowland near the river Tisa — I) the outskirts of the village of Storozhnitsa Uzhgorod district, 116 m above the sea-level (*Festucetum pratensis* association of Molinio-Arrhenatheretea Tx. 1937 class). II. Foothils of the Carpathians — 2) the outskirts of the village of Kholmets of the same district, 250 m above the sea-level (*Querco-Carpinetum* association of Querco-Fagetea Br.-Bl. et Vlieger 1937 class); 3) the outskirts of the village of Onokovtsy of the same district, 180 m above the sealevel (*Luzulo-Quercetum petraeae* association of Quercetea robori petraeae Br.-Bl. et Tx. 1934 class). We have accepted the population volume of the corresponding cenopopulation as a work unit. The studied populations are located along increasing gradient of xerophytization of the habitat, and intensification of recreation loads.

In every population transects were lazed for determination of age and space structure, for density and phytomass control, and representative excerpts of generative plants (25 samples from each group) were also made for morphometric analysis. Age group selection and population classification have been carried out by T. A. Rabotnov (1950) and supplemented by other authors (Smirnova et *al.* 1976). For morphometric analysis 28 statistical, metric and allometric parametres have been studied in every individual (Zlobin, 1984). Obtained figures have been processed using correlation and factor methods (Lakin 1980, Iberla 1980, and others). The factor analysis has been carried out by means of the principal components according to BMDP-4M program (California University, USA). Calculations have been made by means ES—1020 computer in the computer centre of the Uzhgorod University.

Results and discassion

Age structure is one of the most important indications fo the population, which means the distribution of individuals according to the age state. The age spectrum is known to reflect the living state of an individual in the cenosis and the degree of its stability as to the influence of unfavourable factors of the environment and anthropogenic press. Besides it characterizes the definite stage in the development of the population, i.e. its age peculiarities as well as ontogenetic rate in separate individuals.

In earlier studies investigated ontogenesis process and determined age states of individuals of *O. umbellatum,* united into seven age groups (se- seeds, p- plantlets, j- juvenile, im- immature, v- virgin, g- generative plants). Senile individuals were not found out, as generative plants fall out of cenosis structure without developing into the following age condition. It has been found out, that in the process of the development of the individuals of Onokovtsy population, carrying out its self-maintenance by seeds pass the full cycle of ontogenesis (se-g_3 — atrophy) lasting 6—8 years. Plants of Storozhnitsa and Kholmets populations with vegetative means of renewal have incomplete ontoegnesis cycle (j-g_3-atrophy) during 4—5 years.

Age structure analysis of population of Storozhnitsa adn Kholmets shows clearly marked leftsidedness of their spectra, the successive raws of age groups from juvenile to generative ones demonstrating sharp decrease in number (Fig. 1, Table 1). These populations are characterized by full predominance of juvenile and immature individuals (88,81—90,14%) over adult ones (9,86—11,19%). There are few generative individuals, middle-aged ard young ones dominating among them. Senile individuals are absent. Though these populations grow in different associations: forest (Kholmets) and meadow (Storozhnica), yet they are characterized by the same (vegetative) way of maintenance its number. The irregular, in the form of more or less distinctly marked groups, location of plants over the cenosis, surface testifies to the fact too. It is quite possible, that such distintly marked leftsidedness of age spectra is explained not only by ontogenesis pecularities of the given species,

Table 1. *Age structure and density of the populations*

Population	Type of phytocenose	Density of individuals sp/m²	Age group					
			j	im	v	g	j+im	v+g
STOROZHNITSA	*Festucetum pratensis*	268	187	51	18	12	238	30
			69,78	19,03	6,72	4,47	88,81	11,19
KHOLMETS	*Querco-Carpinetum*	264	190	48	16	10	234	30
			71,96	18,18	6,06	3,80	90.14	9,86
ONOKOVTSY	*Luzulo-Quercetum petraeae*	353	241	23	36	53	264	89
			68,27	6,52	10,19	15,02	74,79	25,21

Foot-note: individuals quantity for 1 m² in numerator; percentage of individuals quantity for 1 m² from number of plants of all age group in denominator.

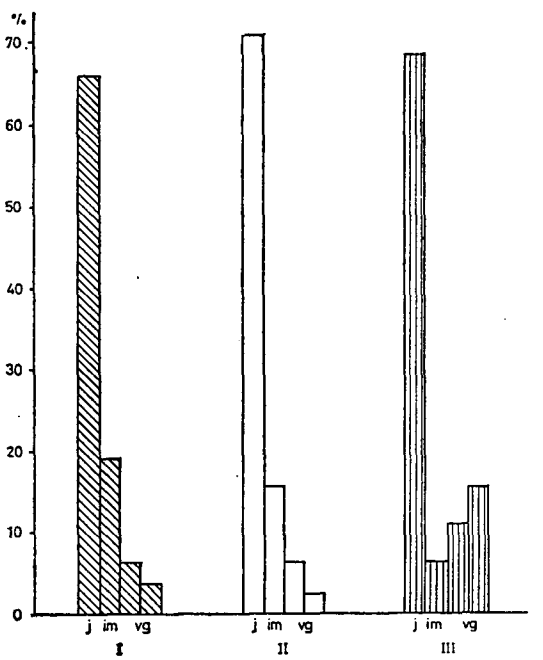

Fig. 1. Ages spectrums of populations I — STOROZHNITSA, II — KHOLMETS, III — ONOKOVTSY j — g — indexes of age states

but largerly by quite sufficient and constantly existing store of diaspores in the soil which gives the advantage in the immediate occupation of reappearing free patches in the cenosis.

Age spectrum of the population of ONOKOVTSY as compared with the previous ones is characterized by two peaks on juvenile and generative individuals; the share of the latter increases by 25,21%. Age composition is marked by sharp decrease of the relative abundance from juvenile to immature individuals and then by increase in number for groups of adult vegetative and generative individuals. This age po-

pulation structure is biologically explicable in that the juvenile group supplemented only by means of seeds, and appearing plantlets often die in winter. Reproduction by seeds of the given population has the periodical character, which causes unstableness and dynamics of its age structure. Distribution of individuals on the cenosis surface is relatively even diffuse.

If we take into account the fact that the juvenile group isn't model for the age structure, we shall see that the population of O. umbellatum greately differ (left- and right-sided). Their structure is correlated with the means of reproduction and maintenance of population number. In totality of characteristic features the populations of STOROZHNITSA and KHOLMETS belong to normal type incomplete young populations and those of ONOKOVTSY — belong to normal type incomplete mature, populations.

Density and store of phytomass are among the most important characteristics of population field of plants. Density of individuals is determined by their number per surface unit.

As it is shown (Table 1), the population density of ONOKOVTSY (353 sperimen/m²) is much higher than that of STOROZHNITSA (268 sp./m²) and KHOLMETS (264 sp./m²), though its total phytomass (417,54 g/m²) is somewhat lower as compared with them (434—444,5 g/m²) (Table 2).

The highest total phytomass of the population of STOROZHNITSA — 444,5 g/m²) (Table 2). It is constituted in almost equal numbers by individuals of pregenerative part of the spectrum (50,64%) and adult plants (49,36%). Reserve of population phytomass of KHOLMETS is a little lower — 434 g/m². It consist of approximately equal shares of phytomass of juvenile and immature (50,97%) individuals on the one hand of virgin and generative ones (49,03%) on the other hand. Total population phytomass of ONOKOVTSY as compared with the population of STOROZHNITSA is lower by 1,06 times, and with the populations KHOLMETS — by 1,04 times. Though the population number of ONOKOVTSY is markedly higher than those two, its phytomass is lower due to the sharp decrease of average phytomass of virgin and generative individuals (Table 2). The average phytomass of juvenile and immature individuals in all populations is almost equal.

Thus as a result of xerophytization of habitats and increase of recreation loads sharp decrease of population of *O. umbellatum* takes place first of all due to lessened adult individuals (both vegetatvie and generative).

Table 2. *Phytomass of individuals and populations*

Population	Age group						Total phytomass of population gm/m²
	j	im	v	g	j+im	v+g	
STOROZHNITSA	0,50	2,58	6,31	8,82	3,08	15,13	444,50
	93,50	131,58	113,58	105,84	225,08	219,42	
KHOLMETS	0,51	2,59	7,63	9,07	3,10	16,70	434,00
	96,90	124,32	122,08	90,70	221,22	212,78	
ONOKOVTSY	0,41	2,48	2,72	3,09	2,89	5,81	417,54
	38,81	57,04	97,92	163,77	155,85	261,69	

Foot-note: weight of individuals in numerator, gm; weight of age group of individuals, gm/m² in denominator.

Viability and Vitality — are peculiarities of populations, displaying in the level of their stability and productivity. The most important indexes are: 1) age srectrum, 2) development rate of individuals, 3) density and 4) living state of adult individuals. The first three characterisrics of *O. umbellatum* population have been already elucidated above. Now we shall consider differentiation of individuals according to their living state which is manifested most fully in the generative period.

As Ju. A. Zlobin (1984) notes, living state of individuals is revealed only when analysing the complex of morphological parameters characteristic for them. To pick out the key morphoparameters from this complex research was carried out with finding out correlation matrixes and factor solutions for all the three populations by the method of principal components. Correlation matrixes of all the populations are fully described by the three factors which totally involve 98,09—99,77 of initial integrity with the contribution of 43,08—57,74% of the first factor. It means that picked out factors give the integral evolution to morphological phenomena.

As to the population of Storozhnitsa and Kholmets the largest contirbution to the first factor is made by such morphological parameters as total phytomass (W) and leaf area (A); as to the population of Onokovtsy — by leaf area (A) and leaf area per phytomass unit (LAR). That is why the first factor may be interpreted as the factor of photosynthetic effort. Such morphological features as flower stalk height, total phytomass (W) and reproductive effort (RE) contribute noticeably to the second factor. On this ground it may be considered as growth factor. Key morphoparametres for population with different means of number maintenance are apparently individual, but all of them belong to the dynamic group (W, A, Lar and others). When ecology conditions plant habitats become worse, their factor matrix structure changes and specific weight of the first factor decreases falls down (Storozhnitsa — 57,74%, Kholmets — 50,55%, Onokovtsy — 43,08%), and the key parameters of morphogenesis also changes. This phenomenon may be explained as general lowering of safety of plants as individuals at their ecological depression (Fig. 2—4).

If the system of correlation bonds of morphological features is considered as manifestation of a vegetable organism integrity stability of correlation bonds appears to be a reaction measure of individuals to different stress influences. To get this characteristics the index of morphological integration of individuals (I) in the form of relation of number of statistically essential bonds (B, P 0,05) in correlation matrix

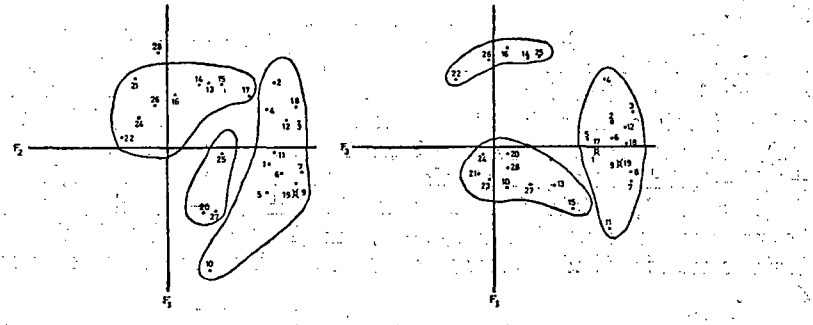

Fig. 2

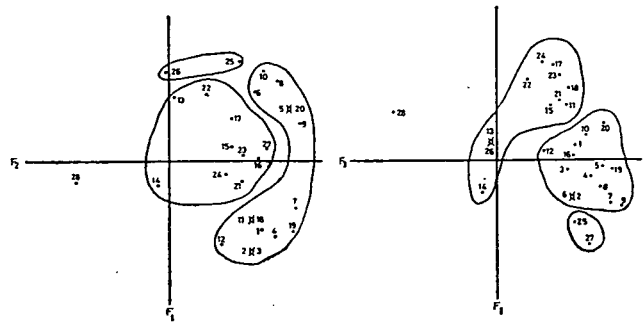

Fig. 3

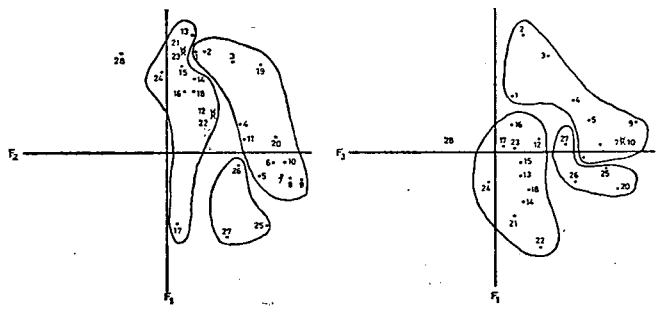

Fig. 4

to their total number (OLSON, MILLER 1958) may be used:

$$I = \frac{B}{(n^2 - n):2} \times 100\ \%,$$

where n is the total number of measured parameters. In finding the total number of bonds diagonal elements were excluded, and the calculation was carried out only in one half of the matrix because of its symmetry. As a result of calculation it was found that for the cenopopulation of STOROZHNICA I=42,00%, KHOLMETS — I= =38,33, ONOKOVTSY — I=35,00, which for certain testifies to the decrease of morphological integrity of individuals of *O. umbellatum* under worse conditions of their growth.

It may become possible of the basis of the parameters to rereveal tendencies of living conditions of ephemeroids by ecology and recreation gradients. When ecological conditions become worse and anthropogenic loads increase, the weight of individuals of O. umbellatum noticeably decrease (fom 9,07±0,38 to 3,09±0,13 gm), the leaf are (55,51±4,07–27,19±2,11 cm²) and the bulb diametre (2,27± ±0,08—1,17±0,04 cm), indication of reproductive effort (68,81±3,30—62,36± ±0,94 gm/gm), height flowers talks (21,03±0,74—16,88±0,55 cm), number of flowers per individual (7,64±0,46—5,36±0,29 specimen) and others decrease too. Living state of individuals along both gradients is seen to become worse without any doubt.

Result of factor analysis may be used for defining population vitality spectra having a number of advantages over revealing the age spectra. The procedure of the

given analysis presented in details in the book by JU. A. ZLOBIN (1984) makes it possible to formalize the determination of structural types of population and to exclude intuitive ways of their estimation. The carried out stuol established that flourishing type of vitality is characteristic of the populations with vegetative maintenance growing in the ecology optimum conditions. Equilibrum type is characteristic of the populations with generative reproduction occuring in phytocenotic optimum conditions. Hence the populations under consideration vary in vitality type and shifts in these vitality spectra reffect conformities to natural laws of inhabitance conditions in different habitats. Quality population trend by recreation gradient is slightly expressed.

On the basis of the analysis of particular fleatures of behaviour of. *O. umbellatum,* according to the ecology cenotic strategy type this species should be reffered to the false explerents (RL). Its overwhelming integral peculiarity is its reactivity characterized by rapid occupation of free areas due to the large store of vegetative diaspores in the soil and high realization of the environmental resources, most distinctly displayed in the populations with vegetative reproduction. Besides, reactivity in combination with great cenotic isolation of clones designates the possibility of long lasting existence of the populations in the loci of climax synusiae.

Thus, the reaction of *O. umbellatum* to worse ecological conditions of habitats and increase of anthropogenic influences is displayed in reduction of density of populations and decrease of their phytomass. Restructuring of morphostructure and general lessening of individuals take place, their viability and morphological integrity decrease. Under the influence of the above factors flourishing populations turn into equilibrium ones, their age and space structure changes.

Our studies showed that *O. umbellatum* is resistant enough to the anthropogenic press, in particular, its populations with vegetative self-maintenance, and reduction of its area is due to destruction of its habitats. By the complex of autophytosoological features the species belongs to class III of the threatened plants (reducing by the International Union of Nature Protection scale) and requires special protectiom measures. With this purpose, practical recomendations have been worked out to preserve the genofond of *O. umbellatum* in Transcarpathia, comprising:

a) creation of two nature memorials in the habitats, exerting intensive anthropogenic loads;

b) organization of constant control over the state of local populations;

c) creation of collection nursery for preservation of intraspecific variety and genetic bank (seeds, meristems) in the botanical garden of the Uzhorod State University;

d) propagation of ecological knowledge among the people.

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A kárpátaljai Ornithogalum umbellatum L. (Liliaceae) populációjának demográfiai vizsgálata a fajfennmaradás érdekében

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Kivonat

Az *Ornithogalum umbellatum L.* (Lililaceae) populációjának komplex vizsgálata (a környezetszennyeződés, az előfordulása, a fitomassza, az életképesség) szerint az antropológiai behatások a faj fennmaradását veszélyeztető határig érkeztek el.

A kutatások 28 morphometriai karakterisztika tanulmányozásán alapulnak.

Az eredmények a főkomponens módszerrel kerülnek feldolgozásra (programterv a BMDP csomagból).

A stressz hatások alatt végzett regressziós-, korrelációs- és tényezős módszerrel kerülnek megismerésre a tanulmányozott populáció jellemvonásai.

A kárpátaljai populáció megvédésére az eredmények eddig igen kedvező úton haladnak.

Популяционно-биологические исследования Ornithogalum Umbellatum L. (Liliaceae) с точки зрения разработки стратегии выживания этого вида в Закарпатии

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Резюме

На основании комплексного исследования динамики популяций *Ornithogalum umbellatum L.* (Liliaceae) в Закарпатии (определение возрастной и пространственной структуры, плотности, фитомассы, жизнеспособности популяций) были выяснены устойчивость видов в отношении антропогенного давления и перспективы их выживания. Было исследовано 28 морфометрических характеристик, результаты обработывали по методу основных компонентов с использованием программ BMDP. Методом корреляционного и факторного анализа были определены особенности стрессовых реакций особей и популяций O. umbellatum. Предложены меры для сохранения генофонда видов исследуемой области.

Izučenje demografije populacije Ornithogalum umbellatum L. (Liliaceae) da bi izradili strategiju preživljenja ovog roda u podgorju Karpata

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Abstrakt

Kompleksno izučenje populacije *Ornithogalum umbellatum* L. (Liliaceae) (struktura okoline, zbijanje, fitomasa, vitalitet) izneo je da antropološki utjecaji doveli do opasnosti za opstanak ove populacije.

Istraživanje osniva se na izučenje 28 morfometrijskih karakteristika. Rezultati su obradjeni na osnovi glavnih komponenata (program iz paketa BMDP). Sa regresivnom-, korelativnom- i faktorskom metodom upoznaju se osobenosti izučene populacije prilikom stres utjecaja.

Rezultati pokazuju najbolji put da bi zaštitili ovu populaciju u podgorju Karpata.