

Національна академія наук України
Державний природознавчий музей

НАУКОВІ ЗАПИСКИ ДЕРЖАВНОГО ПРИРОДОЗНАВЧОГО МУЗЕЮ

Випуск 30

*Надруковано за фінансової підтримки проекту "Динамічний
Музей" Фонду Ріната Ахметова "Розвиток України"*



Фонд Ріната Ахметова
Розвиток України

 **ДИНАМІЧНИЙ МУЗЕЙ**
проект підтримки музеїв

Львів 2014

УДК 57+58+591.5+502.7:069

Наукові записки Державного природознавчого музею. – Львів, 2014. – Вип. 30. – 232 с.

До 30-го випуску увійшли статті з музеології, екології, зоології, палеонтології, а також інформація про перші результати реалізації проекту "Природничий музей: від теорії еволюції життя до практики живого музею", з яким музей переміг у конкурсі у рамках програми "Динамічний Музей" Фонду Ріната Ахметова "Розвиток України".

Для екологів, ботаніків, зоологів, палеонтологів, працівників природничих музеїв, заповідників, національних парків та інших природоохоронних установ.

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*Рекомендовано до друку вченою радою
Державного природознавчого музею*

ISSN 2224-025X

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УДК 581.526:581.524

Tsaryk Y. ¹, Malynovsky A. ², Kyyak V. ³, Bilonoha V. ³, Nesteruk Y. ³

**THE STRUCTURE OF POPULATIONS AND THE FACTORS OF THREATS
TO RARE PLANT SPECIES OF INTERNATIONAL RED LISTS
IN THE UKRAINIAN CARPATHIANS**

Protection and renewal of species variety is an important problem nowadays. Genetic information accumulated in the course of evolution is unique and vanishing of any species or population leads to their irreversible losses. It is especially urgent for the rare, relict and endemic species of plants which mainly have a small number of populations and limited natural habitats. Disappearance of any population results in the irretrievable loss of a part of species' features. The investigation of population is considered to be the base to fill the content of the Red Lists, besides the investigations help to determine the level of threat of a species and develop measures as to the protection and renewal of population.

*The Ukrainian Carpathians numbers 20 species registered in the basic international Red Lists. The article contains information concerning 6 rare herbaceous species in the Ukrainian Carpathians, namely: *Achillea schurii*, *Heracleum carpaticum*, *Larix polonica*, *Pulmonaria filarszkyana*, *Silene dubia*, *Silene zawadskii* which has been accumulated and supplemented.*

Key words: *population, adaptation, rare plant, Red List, Carpathians, Ukraine.*

"European Red List of endangered animals and plants on the global scale" composed in 1991 involves thirteen plant species which grow in the Ukrainian Carpathians, including *Heracleum carpaticum* (Porc.) Porc. (category V – vulnerable), *Pulmonaria filarszkyana* Jáv. (category V – vulnerable), *Silene nutans* L. subsp. *dubia* (Herbich) Zapal. (*S. dubia* Herbich) (category I – indeterminate), and *Silene zawadskii* Herbich (category R – rare). The World List of endangered plant species [25] among other includes *Achillea oxyloba* (DC.) Schultz Bip. subsp. *schurii* (Schultz Bip.) Heimerl (*A. schurii* Sch. Bip.) (category R – rare), *Larix decidua* Miller subsp. *polonica* (Racib.) Domin (*L. polonica* Racib.) (category R), and *Armeria pocutica* Pawł. (category Ex/E).

Until now, data of these species research could not be considered sufficient. In particular, the information concerning their distribution, size of natural habitats, quantity, and intra-population structure is not available. The factors of threaten were not determined for these species and there was no information on the direction of dynamic processes in the populations. The goal of the investigation was to determine their state and trends of changes.

The data on spreading the threatened species of the European and World Red Lists in the Ukrainian Carpathians are indispensable condition for the development and application of nature-conservative measures. Information on spreading, ecology and coenotic traits of threatened species gives the possibility to forecast and forestall the possible arising and progressing of negative tendencies in vegetation cover. This investigation will enable us to

avoid certain mistakes while working on integrating programs of the Carpathian region development.

Conservation of species diversity is an extremely actual problem in general, and it is the main task of applied nature conservation, in particular. This problem is especially critical for small populations of rare, relict and endemic plant species. As each species consists of separate populations, which are the bearers of the specific original information, the process of studying populations is a compulsory precondition of species conservation in general. Vanishing of any population causes an irreversible loss of a part of species characteristics.

Technical approach

Route and stationary research methods were applied to succeed. The route methods were used to conduct a non-permanent registration. Thus, the distribution of some plants population was found out in the Ukrainian Carpathians. We determined their exact geographical location and sizes, and made geobotanical descriptions of coenosis. The mapping of the populations was conducted with the aid of GPS and geographical maps of the territories of different types and different scale. Data from different foreign sources were used too [16-18, 20-22]. Stationary researches carried out with the aid of model plots and transects were applied for continuous monitoring. We conducted registrations of parameters on population and individual levels of the mentioned above species.

The spatial pattern, age composition of population, vitality, seed productivity and individual development were studied. The ontogenesis was studied in accordance with the methods worked out at the Department of Population Ecology of the Institute of Ecology of the Carpathians [5]. Life span for some age status was studied by means of direct observation of the fixed plants; others – by registration of the amount of individuals which got next age stage.

Structure of populations and factors of threat

The investigation of the structure and dynamics of population parameters of the investigated species has been made in the localities known from published sources and discovered by us in the course of research work. The population parameters of *Silene dubia* has been studied in the main massifs of the Ukrainian Carpathians: the Beskydy (Mt. Pikuy), the Gorgany (valley of the river Teresva, nearby the village Lopukhiv); the Svydovets (Mt. Kotel, Mt. Dragobrat, Mt. Herashaska); the Chornohora (Mt. Pozhzhzhevska, Mt. Dancer, Mt. Shpytsi); the Marmarosh (Mt. Pip Ivan, Mt. Nienieska); the Chyvchyny (Mt. Preluchny, Mt. Gnietesa); the Bukovyna Carpathians (near Ukraine-Rumania border, mountain pass Dzhogul close to the village Selyatyn). The main population parameters of *Silene zawadskii* have been studied in all the known localities in the Chyvchyny (Mt. Velyky Kamin', Mt. Mokryniv Kamin', Mt. Preluchny); of *Achillea schurii* (in most localities) – in the Chyvchyny (Mt. Mokryniv Kamin'), the Svydovets (Mt. Dragobrat, Mt. Blyznytsia); the Chornohora (Mt. Petros); the Marmarosh mountains (Mt. Nienieska, Mt. Pip Ivan); *Heracleum carpaticum* – in the Chyvchyny (Mt. Chyvchyn, Mt. Pryluky, Mt. Palianytsia, Mt. Gnietesa), the Chornohora (Mt. Dancer, Mt. Shpytsi, Mt. Menchul, Mt. Pip Ivan); the Marmarosh mountains (Mt. Pip Ivan). Distribution and

demographic structure of *Pulmonaria filarszkyana* was studied in the mountain massifs of the Chornohora, the Svydivets, the Marmarosh and the Chyvchyny.

Larix polonica is a rare endemic species distributed in the West Carpathians (Peniny, Poland), in the East Carpathians (the Gorgany, Ukraine) and Romania (the Tsegled). Four localities of this species were known at the beginning of the XX century [14]. At present only 2 localities have been preserved. One of them is placed in the eastern ("Kedryn") and the second in the southern ("Manyavsky Skyt") mega-slope of the Gorgany. "Kedryn" is the only forest massif in Ukraine where endemic *Larix polonica* has been preserved in nature conditions. The discussion as to the artificial or natural origin of the larch in the locality "Manyavsky Skyt" has not been completed till now. A. Środoń [24], G. Koziy [6], S. Stoyko [9], I. Fedets [11] advanced the idea of natural origin of the larch. F. Herbich [15] was the first who expressed the opinion as to its artificial origin. E. Kondratyuk [7], P. Trybun [10] shared his opinion. Later, Yu. Bobersky [4] and L. Milkina [8] made experimental investigations and comparative analysis of the ecologic conditions of the habitats and confirmed the artificial origin of the locality "Manyavsky Skyt".

For the first time *Armeria pocutica* Pawł. was found and described nearby Topil'che settlement on the river-bank of the Chorny Cheremosh by Polish botanists B. Pawłowski and Y. Mondalski in the summer of 1935 [23]. Furthermore, B. Pawłowski noticed an abundance of *A. pocutica* on the meadows along the river. *A. pocutica* is a perennial plant with dense rosette of leaves; average height of flower-stalk – 42 cm (37-48 cm). It is taken for granted, that the species belongs to mesohygrophyte and mesoeutrophic plant groups.

Unfortunately up to now, all the attempts to find it again have been unsuccessful. Romanian and Ukrainian botanists disagreed with the information as to its new habitats in Romania

[12, 13, 19]. Thus, B. Pawłowski and Y. Mondalski herbarium collections kept in W. Shafer Botany Institute of the Polish Academy of Sciences in Krakow are the only evidences of *Armeria pocutica* being. Nowadays, *Armeria pocutica* is registered in several international and regional Red Lists under different status: European Red List – E*, Red book of Ukraine – 0, IUCN – Ex/E, Romanian Red List – R. The searching work carried out on the territory indicated by B. Pawłowski and Y. Mondalski (hayfields, altitude 725 – 750 m) in the summer of 2007 was of no effect.

Topographic maps analysis makes it clear that over last 70 years Topil'che settlement got wider along the riverbank and its housing density was increased. These changes as well as meadows melioration may result in habitat reducing or even species vanishing at all.

The majority of the abovementioned species (except *Larix polonica*) belongs to herbaceous perennial plants with long rhizomes or short rhizomes with different ratio of vegetative and seed propagation. For species with long rhizomes, clonal self-renewal is a primary mode. Seed propagation is considerable only in the plots unfavourable for profuse vegetative growth. Left-side age spectrum of population is typical for them. The main role in maintenance of population viability of species with short rhizomes belongs to seed propagation. Therefore, the most considerable characteristics of these populations are the quantity of reproductive individuals, seed yield and vitality of seeds, number of young growth and duration of reproductive stage of ontogenesis.

The fact that some species (e.g. *Achillea schurii*) even within one population have individuals (clones) belonging to morphs with long and short rhizomes should be taken for consideration. Therefore the analysis of ontogenesis should be carried out with the allowance for correlation of morphs in populations.

The specific feature of the individuals of the studied species is their sequential complete ontogenesis in favourable conditions. Long-term delays or sharp accelerations of ontogenesis are the most typical for the species with low clonal activity. Durable deceleration of the individuals development on one stage of ontogenesis or slowing down the ontogenesis arises from the deterioration of growth conditions.

Certain differences of life form and algorithms of morphogenesis may be influenced by various factors. The most substantial are the factors favourable or unfavourable for vegetative growth, clonal and seed propagation. Sharp accelerations of the morphogenesis frequently arise as the reactions on the optimisation of clonal propagation conditions – appearance of the plots free from plants or as a response on stressful factors.

The density of populations depends on the habitat conditions and the biologic peculiarities of species as well. The clear correlation can be observed between density and the modes of reproduction in the interrelation with the environment parameters. It has been established that in case of deterioration of the conditions, the processes of sexual reproduction are oppressed first of all. Decreasing of rate of the reproductive individuals in the age spectrum, caused by the simplifications of ontogenesis, is typical for *Heracleum carpaticum* especially in pessimal conditions resulted by overgrazing or interspecific competition. As the reaction on the increase of interspecific competition in community during cyclical succession or demutation,

H. carpaticum may exhibit pseudo-rejuvenation. The most influential negative factors are shading and high density of vegetation cover. It should be noted that in the case the considered factors cease their acting, the population rapidly renovates its age structure (within one or two years).

Characteristic feature of the populations with high buffering is their comparatively high density. Sparse density is typical for the populations of poor viability and low buffering (*H. carpaticum* – Mt. Chyvchyn). Thus, the size of area occupied by population not always serves as a significative characteristic of population state. Larger populations with low density comparing with smaller populations with high density are less capable to compensate losses caused by unfavourable factors.

Wide spacing between individuals to tens of meters may result in the rapid progressing of population vulnerability, and its buffering decreases. Buffering of population is higher in the habitats the contours of which are continuous or they are composed of closely situated localities (distance – tens of meters) and are not divided into outlying fragments with an irregular exchange of diaspores.

It has been determined that the species with high vegetative activity are characterized by the mutual cancellation effect of clonal and seeds reproduction. The effect consists in the activation of one of the reproduction mode in case of suppression of another one. If the conditions for vegetative profuse growth and clonal propagation are unfavourable, flowering and fruitage become more active. And on the contrary, in case of unfavourable conditions for seed reproduction, clonal growth intensifies.

All the investigated species may lack certain stages of ontogenesis, and get reversion and/or may have breaks in flowering of mature individuals. The phenomenon of the secondary rest, which is distinctive feature of widely distributed plants, has been revealed for few rare species. The considerable rate of flowering individuals in small populations is one of the significant preconditions of their stability and high viability. For species of different life forms the rate of reproductive individuals in small populations can make from several percents for the species with intensive vegetative propagation to 2/3 for low mobile species (e.g. *Silene zawadskii*).

An important indicator of population state is stable quantity of flowering individuals in long-term dynamics (e.g. populations of *Heracleum carpaticum* – Mt. Shpytsi). Sharp multiple fluctuations of the quantity of flowering individuals, breaks in flowering of all or the majority of individuals may indicate threatened state of population or pessimal conditions in coenosis. During the deterioration of conditions we can observe considerable reduction of the quantity of adult individuals in populations or increase of the role of vegetative propagation in self-support.

Table 1

Number and density of some model plant

Locality	Usage mode	Density, (on m ²)	Numbers, (individuals)
<i>Silene zawadskii</i>			
Velyky Kamin', 1400 m., s.-e.	reserve	17.8±2,5	7000
Preluchny, 1200 m., s.	reserve	4,5±0,4	1800
Mokrynyn Kamin', 1400 m., e.	reserve	0,03±0,001	150
<i>Heracleum carpaticum</i>			
Dancer, 1700 m., e.	reserve	0,02±0,001	280
Prelyky, 1570 m., n.-e.	pasture	0,2±0,02	100
Chyvchyn, 1600-1700 m., s.- e.	pasture	0,01±0,001	250
Palianytsia, 1700 m., n.- e.	pasture	1,7±0,1	240
<i>Silene dubia</i>			
Kotel, 1700 m., e.	pasture	0,4±0,05	600
Preluchny, 1200 m.,s.	reserve	0,2±0,01	800
Lopukhiv, 650 m., s.-w.	hayng	0,5±0,1	40
Selyatyn, 800-900 m., e.	hayng	0,1	10000
<i>Achillea schurii</i>			
Drahobrat, 1650 m., e.	reserve	3,0±0,5	20000
Nienieska, 1700-1800 m., e.	reserve	4,5±0,5	50000
Mokrynyn Kamin', 1400 m., n.-w.	reserve	0,9±0,1	850

Silene zawadskii and *Achillea schurii* are presented in the Ukrainian Carpathians only in rocky coenosis. Their phytocoenotic optimum is connected with shallow soil with thin low herbage. These species have similar ontogenesis mode at different levels of viability depending on the phytocoenotic situation. According to our investigations, fast passage of pregenerative stages is one of the criteria of optimal conditions of habitats. The species with comparatively high clonal mobility, in particular *Achillea schurii*, have higher range of morphogenesis variability and viability. Under natural conditions (in cracks of rocks, on

fine, sandy ground, among old turfs of grass and sedge), individuals can stay on a low level of vitality in pre- and postgenerative stages for some years almost without changing their morphological parameters. Such development delay has been rather often observed in immature stage. The changes of soil condition (erosion, silting, slide) resulted in the appearance of free space, thus the ontogenesis accelerates with especially fast transition to the reproductive state.

Changes of vitality within the amplitudes from high up to low and vice-versa has been revealed both for separate (partial) shoots and for morphologically integrated individuals. The density of the investigated populations fluctuates in wide rangers (table 1).

The population density of some rare species (e.g. *Heracleum carpaticum*) makes up several individuals per 100 m². For the rest of species, even in the plots with high concentration of individuals, the density of populations is basically no more than several individuals per 1 m². The populations of certain species (e.g. *Achillea schurii*) have large quantity and high density of the individuals of young age groups.

Many alpine species used to have populations with normal full age composition even in case of low quantity of individuals (table 2). Therefore the age structure as the index of viability can not always be used. In certain cases the prevalence of virginal or reproductive plants in population may be considered as the evidence of unfavourable impact of exogenous, mainly anthropogenic factors. It does not concern the population of invasive stage.

Table 2

Population age composition of *Heracleum carpaticum*

population	mode of use	age						
		(above the line – individual numbers/100 m ² , under the line – %)						
		im	v	g ₁	g ₂	g ₃	ss	s
Chyvchyn	grazing	<u>7,0</u>	<u>4,0</u>	<u>0,5</u>	<u>0,3</u>	<u>0,7</u>	<u>0,4</u>	<u>0</u>
		55	31	4	2	5	3	0
Dancer	reserved	<u>14,0</u>	<u>5,4</u>	<u>2,4</u>	<u>1,5</u>	<u>0,6</u>	<u>0</u>	<u>0</u>
		59	23	10	6	2	0	0
Palianytsia	grazing	<u>76,0</u>	<u>64,0</u>	<u>16,0</u>	<u>11,0</u>	<u>4,0</u>	<u>1,0</u>	<u>0</u>
		45	37	9	6	2	1	0
Preluky	grazing	<u>7,8</u>	<u>5,5</u>	<u>1,3</u>	<u>0,7</u>	<u>0,8</u>	<u>0,2</u>	<u>0</u>
		48	34	8	4	5	1	0

Sometimes, incompleteness of age composition of population is connected with the peculiarities of individual development that depends on ecological or coenotic conditions as well as pasturing and recreation impact. These factors often result into the vanishing of adult individuals, the intensification of clonal propagation and increasing the number of young ramets in comparison with seedling. For instance, vanishing of reproductive individuals in populations of *Heracleum carpaticum* and *Achillea schurii* is caused by intensive pasturing.

High threshold of tolerance has been revealed for some alpine plants (e.g. *Achillea schurii*), which are resistant for moderate trampling and pasturing. Little reduction of

density and transition of reproductive individuals to the post-reproductive state do not change age structure of the populations.

In most cases metapopulation structure is not favourable for the viability of small populations and it often confirms the fact that there is a threat to their existence. We can give only few examples of metapopulation structure of small populations of the investigated species. Among the investigated plants only *Silene dubia* shows high viability in small linear metapopulations located along the roads. Successful colonization of road sides, hay-making plots along roads and eroded areas promote rather wide distribution of this species.

The seed productivity in small populations of rare plants comparing with abundant species is lesser by tens and hundreds times. As it is shown in the Table 3, two populations of *Achillea schurii* have absolutely different potency for renovation. The quantity of reproductive individuals with low viability on the top of Mokryniv Kamin' in the Chyvchyny mountains numbers to 350. Their seed productivity is 15 times lower than Dragobrat population on the Svydovets, which numbers approximately to 2000 reproductive plants with high viability on the rocks inapproachable for pasturing and recreation. These factors have considerable influence on the population of *Heracleum carpaticum*, which is fodder for sheep.

Table 3

Seed productivity in populations on different altitude*

Species	Population localities, m above s.l.	Vitality seed /generative individuals	Density of generative plants, Ind./m ²	Seeds/m ²
<i>Silene zawadskii</i>	Preluchny, 1180	97	2,3	2231
	Mokrynyn Kamin', 1450	81	0,1	8
<i>Heracleum carpaticum</i>	Pip Ivan, 1960	270	0,01	3
	Shpytsi, 1800	340	1,4	48
	Munchel, 1740	130	0,2	26
<i>Achillea schurii</i>	Blyznytsia, 1800	184	15	2760
	Mokrynyn Kamin', 1440	72	0,7	50
<i>Silene dubia</i>	Hnietiesa, 1760	1100	0,1	110
	Preluky, 1550	3800	0,2	760
	Preluchny, 1180	5700	0,2	1140

Note: variation coefficient within 16%.

The main factors which have an impact upon the morphometrical parameters, ontogenesis and propagation of *Achillea schurii* are the slope exposure, insolation and soil characteristic. The particular population, differing from populations on Petros, Dragobrat and Nienieska mountains, has been formed on the northern and north-western slope of the mountain Mokryniv Kamin' (1450 meters above the sea level) in the Chyvchyny Mountains. It has been formed under the forest canopy on very limited soil resources in the moist cracks of rock. The plants on Mt. Mokryniv Kamin' have thinner and longer shoots, leaflets and leaflets. Reproductive individuals even in their prosperity state have few shoots

whereas in the other habitats they number to tens. The rootstock is short-lived and it particulates at the age of 2-4 years.

The majority of viable and stable small populations has normal complete age structure with maximum quantity of adult individuals in virginal and generative age groups. The indicators of low viability and instability of population are incompleteness of age spectrum, in particular, unavailability or crucially low rate of reproductive individuals and frequent breaks of their flowering. Considerable part of mature individuals in small populations indicates their high viability; the steady number of flowering individuals in long-term dynamics confirms population stability in general. It has been determined, that among the species with determining role of sexual reproduction, more viable populations are those in which the quantity of reproductive individuals numbers to tens, and the total quantity of adult individuals numbers to hundreds.

Investigated species differ on individual, intra- and interpopulation levels. According to these characteristics we determine the following groups of species:

- the species with low variability on individual and population levels (e. g. *Silene zawadzki* – stenotopic species with low plasticity);
- the species with high interpopulation and low intrapopulation variety (e. g. *Achillea schurii*);
- the species with high intra- and interpopulation variability (first of all it concerns *Heracleum carpaticum*).

Among the abovementioned groups, the species of the third group have the highest adaptive capability in spite of small quantity of the individuals in their population. The lowest adaptive capabilities and evolutionary prospects have the species of the first group, in particular, those which are represented by small populations. Low intrapopulation variability of the species belonging to the second group in comparison with their high interpopulation variety testifies to the old isolation of their populations and, evidently, to the impoverishment of their genetic diversity. Small populations of these species are especially vulnerable to the influence of anthropogenic factors.

Perennial herbaceous plant *Pulmonaria filarszkyana* belongs to obviously polycentric pattern of biomorphs with early disintegration of maternal individual and high clonal activities that results in fast growth and developmental autonomy of derived monocarpic shoots. Dicyclic type of shoot-forming of *P. filarszkyana* includes development of the axillary bud for vegetative sprout (first cycle) and then flower-bearing stem (second cycle) in 2 years. Basal plagiotropic part of stems can stay viable up to 2-3 years and be tied with new generation of shoots. Sporadically, axillary buds form on last year's stem but usually it remains in a dormant condition. Only destruction of derived shoots could stimulate its activity. Due to biomorphosis of *P. filarszkyana*, its population age composition is nonfactual as well as difficult to assess. In this case, for analysis of the population state the number of stems, ratio of vegetative stems and flower-bearings may be rather sufficient information. For example, predominance of vegetative stems in population over several years could be evidence of some obstacles to accomplish second cycle of shoot's development. Seed propagation of *P. filarszkyana* depends on different external factors and greatly varies by years and in different localities. In optimal conditions – in communities with *Alnus viridis* as a dominant, germs density during several years was 0 to 4 per m² in

spite of quite high seed yield and seed vitality. Seed propagation tends to decrease in direction to upper edge of the *Alnus viridis* elfin-wood and above. It concerns number of flowers, and seed production, as well as decreasing of the leaves' size (up to 15–40% of average measures) and stem weight. Model populations of *P. filarszkyana* prove influence of the intrapopulation diversity on pattern of the vegetative rejuvenation and reproduction. In different habitats *P. filarszkyana* has various structures of stems, leaf's size and shape, and inflorescence. In optimal condition *P. filarszkyana* (namely, under *Alnus viridis* canopy) the rejuvenation could be find even for sub-senile plants; in pessimal condition (open grassy habitats at high elevation) – such examples were not revealed. Revealed differences of the generative sphere of *P. filarszkyana* that concern phytomass accumulation, effectiveness of pollination, buds development and seeds ripen have to be considered as an adaptation to low temperature, short vegetation period, strong wind etc. At high elevation flowers number is half of normal quantity. Seeds do not exceed 30% (average value 21%) of the upper bound in *Alnus viridis* communities. Moreover, stem length and leaf size in separate clones get decrease. On average, plagiotropic stem length becomes shorter – from 10.3 cm to 7.4 cm; mass decreases from 1.9 g to 0.6 g. Leaf's length/width ratio as well as total leaf's length change depends on ecological condition. In some clones the length/width ratio differed up to 30-37%. For *P. filarszkyana* at different elevations width of leaves change reaches 35%. Reduction of total leaf's size can be at level of 15-40% of average value in whole population [1, 2].

Large number of buds on plagiotropic part of the stem promotes formation of the thick clone up to several m² with density of shoots to 300 per m² in *Alnus viridis* elfin-woods. In grassy coenosis numbers of stem in clones as well as clones quantity decreases up to a few items. In the same year ratio of generative/vegetative shoots at elevation 1750 m (*Deshampsia cespitosa* community) was 0.05 and on 1550 m (*Alnus viridis* communities) – 0.13. However, species remain stable component of coenosis and displays high viability.

Analysis of the separated local populations indicates the differences in their spatial pattern as well as in demographic dynamics. It is possible to assume that during dozens and hundreds years the natural habitat of *P. filarszkyana* in the Ukrainian Carpathians was appreciably transformed because of climate changes and man impact. Mainly it concerns lowest and upper periphery zones of elevation where ecological and coenosis changes caused decreasing of numbers and density and, in the result, the population gets fragmentation. In subalpine zone under intense grazing and/or because of natural rise of upper timberline of *Picea abies* forest, some isolated localities disappeared or consist of a few individuals. In spite of low viability and absence of seed reproduction such population's fragments could be the centers for population restoration in the event that conditions become optimal again. Thus, long-term variations of population's size (e.g. numbers and area) are common occurrence.

In forest belt *P. filarszkyana* is presented by isolated local subpopulations remote from the population's core. Accidental migration of seeds, fragments or whole plant along mountain streams promotes formation of temporal or quite stable compact groups of the individuals within distance of hundred or thousand meters from basic permanent localities. Survivals of such formations vary from one season to indefinitely extend. In case of satisfactory conditions it could be regarded as structured sustainable local population.

Despite some negative processes, a lot of localities, size and density of local populations, and features of reproduction of *Pulmonaria filarszkyana* make it possible to say that the species is out of menace.

Larix polonica locality "Kedryn" (166 ha; N 48°25'18,5"; E 24°00'46,6") situated 1080-1240 m above sea level in Tyachiv region (Zakarpattia). The state of the population is satisfactory (Table 4). Natural seed reproduction is exclusively observed in the sunlit rocky places where sole individuals aged 5-10 years are found.

Table 4

***Larix polonica* localities analysis**

Locality	Community	Status and threats
1. "Kedryn" (166 ha)	<i>Lariceto (polonicae)- Cembreto-Piceetum myrtillosum.</i>	The state of the population is satisfactory. Natural regeneration is exclusively observed in the sunlit rocky places where sole individuals of 5-10 years of age are found. Juvenile individuals eliminate under the crown cover of fir-trees. Germination capacity of larch seeds is low (15-20%). The vitality of the population is predetermined by low competitiveness of <i>Picea abies</i> . The population is of great scientific importance for the investigation of the history of forest development. Besides it has practical value as a seed plot. Threats: rock slides, the development of spontaneous successions and forest fires cause threat for the larch population. Lately foresters have been transplanting saplings of <i>Pinus cembra</i> . In our opinion, in prospect it will cause negative changes in the structure of phytocoenosis.
2. "Manyavsky Skyt" (356 ha)	The total area is occupied by pure stand of larch as well as by the larch trees with <i>Picea abies</i> , <i>Fagus sylvatica</i> and <i>Abies alba</i> (approximately 12 hectares).	To support the population constant anthropogenic interference is required. Natural regeneration occurs only after thinning of tree layer and selective felling of young grows of <i>Picea abies</i> , <i>Fagus sylvatica</i> and <i>Abies alba</i> . The forest plantation is of great importance as a monument of Forestry of Ukraine. Besides, it has practical value as a seed plot.

Juvenile individuals eliminate under the canopy of fir-trees. Germination capacity of larch seeds is low (15-20%). The viability of the population is predetermined by low competitiveness of *Picea abies*. The population is of great scientific importance for the investigation of the history of forest development. Besides it has practical value as a seed plot. Rock slides, the development of spontaneous successions and forest fires cause threat for the larch population. Lately foresters have been transplanting saplings of *Pinus cembra*. In our opinion, in prospect it will cause negative changes in the structure of phytocoenosis. Locality Manyavsky Skyt occupies 356 ha (N 48°39'33,44"; E 4°23'33,34"; 507-573 m a.s.l.) and is situated in Bohorodchany region (Ivano-Frankivsk). The total area is occupied

by pure stand of larch as well as by the larch trees with *Picea abies*, *Fagus sylvatica* and *Abies alba* (approximately 12 hectares). To support the population, constant anthropogenic interference is required. Natural seed reproduction occurs only after thinning of tree layer and selective felling of young grows of *Picea abies*, *Fagus sylvatica* and *Abies alba*. The forest plantation is of great importance as a monument of Forestry of Ukraine. Besides, it has practical value as a seed plot.

On purpose to discover *Armeria pocutica* there was committed field research around Topilche village (Verkhovyna region, Ivano-Frankivsk) where species was found and described by B. Pawłowski. The research on the territory along the Chorny Cheremosh river valley with similar ecological, hydrological and soil parameters was carried out too. Clearings, hay-lands and pastures on both slopes of the Chorny Cheremosh valley on the route from Valylo farm site to the Dzembronja river were studied. On the whole, the territory from river bank to elevation 760 m was examined. In some cases searches were conducted up to the altitude 780-800 m. Nevertheless the *Armeria pocutica* was not found. Thus, we can make the conclusion that if the population of *A. pocutica* really disappeared it happened due to:

- usage of chemical fertilizers on hay-lands, plowing or hay-land recultivation in 1960-1980;
- spontaneous reforestation of clearings (local people deny this fact)
- catastrophic flood which happened in June 1969 when banks were washed and meadows were buried in silt, rocks etc.;
- mass construction works (this version is the most plausible if you compare maps of 1930-s and contemporary maps you can see that nowadays built-up area is much wider and massive).

If the population of *A. pocutica* still exists, it could be missed due to:

- inaccuracy or mistakes in B. Pawłowski notices (looks unlikely);
- population is in stagnation, there is not any generative stem or there are only few of stems (it is hard to recognize species without them).

Conclusions

The conducted investigation determined the priority and indicating significance of the group and individual characteristics of viability of small populations. The most important characteristics are their genetic variability, effective and total number, the area of habitats, quantity dynamics (in particular, flowering individuals), effectiveness of seed and vegetative propagation etc.

Quantitative characteristics, vectors and amplitude of changes of these parameters serve as the top priority indicating characteristics of the state and prospects of small population development. Whereas the most important characteristics of vitality and viability of large populations are: density, age structure, seed efficiency, vegetative mobility, phytomass stock and vitality structure.

The majority of viable and stable small populations have the structure of normal full member populations. The maximum quantity of adult individuals is within virginal – generative age groups. Whereas the indicators of low viability and stability are incompleteness of age spectra,

in particular, unavailability or crucially low percentage rate of generative individuals, frequent breaks in generative individuals flowering and flashes of flowering. Considerable part of generative individuals in the structure of small populations is a significant index of their high viability, and the steady number of flowering individuals in long-term dynamics is the indicator of population stability in general.

Stochastic changes of natural environment and the influence of anthropogenic factors do cause reduction of the part of generative individuals in the structure of populations and increasing the role of vegetative way of self-support.

It has been determined that the level of intra- and interpopulation variability positively and proportionally correlates with the adaptability of species. The species with high intra- and interpopulation variability (*Heracleum carpaticum*) have the highest adaptive capabilities. The species with high interpopulation and simultaneously low intrapopulation variability are especially endangered (*Achillea schurii*). Small populations of these species are especially vulnerable to the external negative influence and endogenic stochasticities.

The availability and localization of positive individuals-neighbours in the coenosis should be taken into account while providing the measures as to the repatriation of the populations, support or renovation of their viability. The factor of interference between the species is of great importance to the viability of *Heracleum carpaticum* populations.

The existence of small populations is being mostly endangered by overgrazing, picking plants for making herbariums, stochastic endogenic genetic and demographic interpopulation changes and variable unexpected natural disturbance in coenoses.

The majority of the populations of rare species have a low adaptive capability to the negative anthropogenic impact. Under the moderate or short-term loading their adaptation mostly consists in the transition to the lower levels of vitality. Prolonged anthropogenic impact (more than 2-4 years) results in the elimination of some part of individuals and reducing the density of populations. The intermediate link of anthropogenic adaptations for the majority of small populations is their capacity to sharp activation of the processes of seed propagation which has vital practical importance. However, the mentioned adaptive reaction is not prolonged, and mostly lasts for one year; henceforth it is accompanied by decrease of the individuals' vitality. The slightest changes have been revealed for the species with high vegetative mobility.

Among the investigated species the populations of *Heracleum carpaticum*, *Silene zawadskii*, and *Achillea schurii* need urgent protection. Considerable part of the studied populations has crucial total or effective quantity. Endogenous factors of threat, in particular, demographic and genetic stochasticity are also mostly caused by this fact. The factors of direct anthropogenic impact – grazing, trampling, picking plants or indirect impact caused by the disturbance of the integrity of the ecosystems components and fixed interrelations between species increase the threat to the viability of the populations.

Overgrazing is the main anthropogenic threat to the populations of *Heracleum carpaticum*. As *H. carpaticum* belongs to the fodder herbs and is willingly eaten by cattle and sheep in the pastures (Mt. Chyvchyn, Mt. Pip Ivan Marmaros'ky), in most cases its density is very low and makes less than one individual per 100 m², while the total number of individuals is 200-300, among which only 20-40 individuals are actually reproductive.

The majority of generative individuals is damaged (primarily inflorescences) by farm animals. These circumstances cause the threat to the existence of populations in consequence of low seed productivity, and in the result, they predetermine little effectiveness of seed propagation, which is the main way of self-support of this species.

Stenotopic of *Silene zawadskii* and *Achillea schurii* predetermine their rareness. The populations experience the threat of stochastic ecological and coenotic changes during primary and secondary successions and unexpected endogenic (genetic and demographic) changes as a result of low quantity of individuals and small area of habitats. One more factor of threat is man's impact, in particular, gathering of medicinal plants, which causes the disturbance in rocky coenoses.

Small populations of *Silene zawadskii* and *Achillea schurii* on Mt. Mokryniv Kamin' are endangered because of the influence of negative endogenic (genetic and demographic) and exogenic (weathering of rocks, silvatisation etc.) stochastic changes. The tendency to the reducing the quantity of individuals and vitality of the populations on Mt. Mokryniv Kamin' and Mt. Velyky Kamin' has been determined. It is caused by the overgrowing of these local reserves with forest and bushes as a result of conservancy.

Silene dubia is an expletent, the eco-phytocoenotic optimum of which covers grassland and partly eroded plots within forest belt and open rocky communities at high altitude. Owing to the intensification of management activity in the Carpathians during the past century the number of populations of the species within its area has been increased at the expense of developing numerous newly formed inter-forest meadows and pastures, and also sides of mountain roads and tracks. In high altitude rocky coenoses, which experienced insignificant anthropogenic transformations, the processes of colonization of new habitats are unnoticeable. The species is out of threat in the larger part of the Ukrainian Carpathians territory. Only the populations in the north-western part (the Beskydy), where they occur separately, need protection.

It is necessary to organize an efficient protection of ecosystems in which the habitats of rare species, in particular, small populations of endangered species are concentrated. The majority of them can be protected only on condition that phytocoenosis and biotopes will be preserved as integral systems. Interrelationships between the species and, in particular, between the plant species in high altitude communities are fixed and close. In case of disturbance, the so-called effect of "hole in stocking" when the loss of even one component of the system imbalances the interrelationships and results in the elimination of the other components.

For the purpose to protect nature diversity of the Ukrainian Carpathians, it is necessary to create an integrated special-purpose programme of preservation and renovation of biodiversity which will stipulate:

- Inventory (mapping, description, database creation) of the rare species populations;
- Development of the principles of individual approach to the preservation and renovation of certain populations;
- Joining new plots which have rare populations and phytocoenoses to the protected areas;
- Following the regimes of protection in the preserved areas and effectual control;
- Regulation of visiting the preserved areas;

- Working out an acting mechanism as to the adhering to the recommendations stated in the conclusions of independent professional ecologic inspections while planning and implementation of recreation objects and conducting sport actions;
- Development and implementation of the programmes of ecological information, education and training;
- Granting *Heracleum carpathicum* the status of a protected object and/with entering/listing it into the Red Book of Ukraine.

It is necessary to enlarge extant nature protected areas and to create the new ones, in particular, at the high altitude of the Chornohora and the Svydovets massifs. The status of the protected objects should be granted to the massifs of Mt. Rebra, Mt. Berbeneska, Mt. Munchul, and Mt. Pip Ivan. The ground for the protection of these massifs is concentration of small populations of the rare species which are under the threat of vanishing [3].

In spite of nature protected status of the area, the unique communities having a lot of rare species located in the massif of the Svydovets in the north-western part of Mt. Dragobrat and Mt. Komyn (1650–1700 meters above the sea level), the area is being used for pasturing. The species listed in the Red Book of Ukraine and the Carpathians endemics such as: *Saussurea alpina*, *Achillea schurii*, *Minuartia zarenchnyi* (Zapał.) Klok. are grown on small area (0.5 hectare). The small area and permanent pasturing predetermines its high vulnerability. It is necessary to establish an effective protection regime in this massif.

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¹ Львівський національний університет ім. Івана Франка
e-mail: zoomus@franko.lviv.ua;

² Державний природознавчий музей НАН України, Львів
e-mail: akm@museum.lviv.net;

³ Інститут екології Карпат НАН України, Львів
e-mail: vlodkocyjak@rambler.ru

Царик Й., Малиновський А., Кияк В., Білонога В., Нестерук Ю.

Структура популяцій і чинники загрози рідкісних видів рослин міжнародних червоних списків в Українських Карпатах

У статті подано інформацію щодо поширення та сучасного стану загрозованих видів рослин європейського та світового червоного списків в Українських Карпатах: *Achillea oxyloba* (DC.) Schultz Bip. subsp. *schurii* (Schultz Bip.) Heimerl (A. *schurii* Sch. Bip.), *Armeria pocutica* Pawł., *Heraclium carpathicum* (Porc.) Porc., *Larix decidua* Miller subsp. *polonica* (Racib.) Domin (L. *polonica* Racib.), *Pulmonaria filarszkyana* Jáv., *Silene nutans* L. subsp. *dubia* (Herbich) Zapal. (S. *dubia* Herbich), *Silene zawadskii* Herbich.

Серед досліджених видів першочергової охорони потребують популяції *Heraclium carpaticum*, *Silene zawadskii*, *Achillea schurii*, *Larix polonica*. Значна частина вивчених популяцій мають критичну загальну або ефективну чисельність. Переважно цим зумовлені й ендегенні фактори загрози, зокрема демографічна та генетична стохастичності. Загроза для життєздатності популяцій посилюється чинниками антропогенного впливу – випасом, витоптуванням, а також безпосереднім зриванням або опосередкованим впливом через порушення цілісності компонентів екосистем і усталених взаємозв'язків між видами.

Необхідною є дієва охорона екосистем, в яких сконцентровані місцезростання рідкісних видів, зокрема малих популяцій загрозованих видів. Збереження багатьох з них можливе лише за умов охорони фітоценозів і біотопів як цілісних систем.

Ключові слова: популяція, адаптація, червоні списки, Карпати, Україна.

Царик И., Малиновский А., Кияк В., Билонога В., Нестерук Ю.

Структура популяций и факторы угроз для редких видов растений Украинских Карпат занесенных в международные красные списки

В статье представлена информация о распространении и современном состоянии видов растений европейского и мирового красного списков в Украинских Карпатах: *Achillea oxyloba* (DC.) Schultz Bip. subsp. *schurii* (Schultz Bip.) Heimerl (*A. schurii* Sch. Bip.), *Armeria pycnantha* Pawł., *Heraclium carpaticum* (Perc.) Perc., *Larix decidua* Miller subsp. *polonica* (Racib.) Domin (*L. polonica* Racib.), *Pulmonaria filarszkyana* Jáv., *Silene nutans* L. subsp. *dubia* (Herbich) Zapal. (*S. dubia* Herbich), *Silene zawadskii* Herbich.

Среди исследованных видов первоочередной охраны нуждаются популяции *Heraclium carpaticum*, *Silene zawadskii*, *Achillea schurii*, *Larix polonica*. Значительная часть изученных популяций имеют критическую общую или эффективную численность. Преимущественно этим обусловлены и эндогенные факторы угрозы, в частности демографическая и генетическая стохастичности. Угроза для жизнеспособности популяций усиливается факторами антропогенного воздействия – выпаса, вытаптывания, а также непосредственным срыванием или опосредованным влиянием из-за нарушения целостности компонентов экосистем и устоявшихся взаимосвязей между видами. Необходима действенная охрана экосистем, в которых сконцентрированы местообитания редких видов, в частности малых популяций пребывающих под угрозой видов. Сохранение многих из них возможно только при условии охраны фитоценозов и биотопов как целостных систем.

Ключевые слова: популяция, адаптация, красные списки, Карпаты, Украина.

Національна академія наук України
Державний природознавчий музей

Наукове видання

НАУКОВІ ЗАПИСКИ ДЕРЖАВНОГО ПРИРОДОЗНАВЧОГО МУЗЕЮ

Випуск 30

Научные записки Государственного природоведческого музея
Proceedings of the State Natural History Museum

Українською, російською та англійською мовами



Головний редактор Ю.М. Чернобай

Комп'ютерний дизайн і верстка О.С. Климишин, Т.М. Щербаченко

Технічний редактор О.С. Климишин

Адреса редакції:
79008 Львів, вул. Театральна, 18
Державний природознавчий музей НАН України
телефон / факс: (032) 235-69-17
e-mail: museologia@museum.lviv.net
<http://museum.lviv.net>

Формат 70x100/16. Обл.-вид. арк. 22,9. Наклад 150 прим.

Виготовлення оригінал-макета і друк здійснено в Лабораторії природничої музеології та видавництва Державного природознавчого музею НАН України