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## AGE STRUCTURE OF *POLYGONATUM MULTIFLORUM* (L.) ALL. CENOPULATIONS IN THE PRECARPATIAN REGION

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**Abstract.** For population studies, the determination of age status is more important than the determination of calendar age. The research conducted in the biotopes of Precarpathian region indicates that according to the age structure the populations of *Polygonatum multiflorum* (L.) All. belong to the normal type. Self-maintenance of coenopopulations occurs in a combined way as a result of generative and vegetative reproduction, the intensity of which depends on local edaphic and coenotic conditions. The spectra of their age states and reproductive potential are determined by a set of biotope conditions and have species specificity. The nature of the spectrum of age conditions and the value of the recovery index are the most informative indicative markers. Left-sided spectra in combination with high recovery indices indicate the presence of favorable conditions and a high reproduction potential of cenopopulations. The biotopes of felling areas are the most favorable for the realization of the reproduction potential of most cenopopulations of the studied species; the least favorable are the mainline biotopes.

**Keywords:** age structure, recovery index, *Polygonatum multiflorum* (L.) All., Precarpathian region.

### 1. INTRODUCTION

An important and adaptively valuable property of populations is heterogeneity, which increases their stability in changing environmental conditions. Population-ontogenetic approach is the main one in the study of populations. At the same time, the peculiarities of large and small ontogenetic cycles of plants and their conditioning by ecological and coenotic conditions are investigated, as well as the study of differences in the vital state of plants and the assessment of the population vitality structure (Baglei, 2008; Berko, 1976; Chekanov & Didenko, 2013; Didukh, 1998; Kyyak, 2015; Kyrylchuk, 2007; Ziman et al., 2004).

These approaches are the basis of our study of the population and ecological features of species of *Polygonatum* Mill. genus in the biotopes of Precarpathian region.

In the conditions of Precarpathia, representatives of the aboriginal boreal-immortal flora are of significant scientific interest, among which species of the genus *Polygonatum* Mill. occupy a prominent place.

For population studies, the determination of age status is more important than the determination of calendar age. This is due to the fact that different individuals of the same species reach a certain age state at different calendar times, but since they are at the same stage of

individual development, their role in the population and coenosis is the same. Individuals of plants of different species and different life forms go through the same age states during different times, so a comparative assessment of their role in the plant group can be carried out only on the basis of determining the biological age. In addition, determining the absolute age of most plants is practically impossible due to the constant renewal of perennial parts, but their classification by age is quite real (Berko, 1976; Chekanov & Didenko, 2013; Kyrylchuk, 2007; Riznychuk et al., 2019; Smirnova & Toropova, 1974; Dyduch-Falniowska & Zajac, 1996).

## 2. MATERIALS AND METHODS

According to the landscape-geographic zoning, the territory of our research is limited to Precarpathia. This is part of Western Ukraine, within the Lviv, Ivano-Frankivsk and Chernivtsi regions (Didukh, 1998; Marynych & Shyshchenko, 1993; Melnyk, 1999). It stretches along a relatively narrow strip between the Dniester valley and the northeastern foothills of the Ukrainian Carpathians (Rudenko, 2007). The biotopic (settlement) principle is the basis for the allocation of research plots (Didukh et al., 2012; Didukh et al., 2011; Kagalo & Kolodij, 2013). When defining the biotopes, we were guided by the European classification according to the EUNIS scheme (Dyduch-Falniowska & Zajac, 1996; Davies & Moss, 1999; Davies et al., 2004; Davies & Moss, 2002; Devillers et al., 1991; EEA, 2004; "Interpretation Manual of European Union Habitats," 2003).

Cenopopulations of *Polygonatum multiflorum* (L.) All. were studied within seven territorial divisions of Precarpathia. 59 plots were assigned to 14 types of biotopes:

### **E. Pastures and lands covered with weeds:**

E. 5.21 – forest edge biotopes;

E 2.13 – abandoned pasture and hay meadows.

### **F. Shrubs:**

F 3.11 – Central European shrub thickets.

### **G. Forest-covered lands:**

G 1.8– acidophilic oak forests;

G 1.4115 – Eastern Carpathian wetland alders;

G 1.82 – beech and oak forests;

G 1.22 – mixed oak-elm-ash forests;

G 1.61 – Central European acidophilic beech forests;

G1.A3 – hornbeam forests;

G 1.63 – Central European neutrophilic beech forests;

G 1.A – meso-eutrophic forests with oak, hornbeam, ash and linden

G 5.81 – felling areas.

### **J. Anthropogenically modified habitats:**

J.1. – residential biotopes;

J.4.1. – mainline biotopes (forest plantation belts along the highways).

*Polygonatum multiflorum* (L.) All. – is a perennial herb 30-60 cm tall. A horizontal rhizome is located in the soil. On the rhizome, there are strip scars from underdeveloped scaly leaves and round scars from dead stems. The stem is bare, rounded, the leaves are oblong or elliptical, slightly narrowed at the base, bare, with short petioles, green above and grayish-green below, 10 - 11 cm long and 4 - 4.5 cm wide. Pedicels in sheaths of leaves with three to five flowers, bare, perianth white, narrowed above the throat, slightly expanded at the top, with six green tips, bent at the ends, which are short-hairy above on the inner side. The fruit is a bluish black berry with a diameter of about 1 cm. It blooms in May-June for a month. It is found in shady mixed forests, shrubs in the temperate zone, the lower and middle mountain belts of Europe, the Caucasus, Asia

Minor and Front Asia, the Himalayas and East Asia. In Ukraine, it is found in the Carpathians, in Polissia, in the Forest Steppe, occasionally in the Steppe and the Crimean Mountains (Smirnova & Toropova, 1974). This species has valuable pharmaceutical and decorative properties (Minarchenko et al., 2005) (Fig. 1).



Fig. 1. *Polygonatum multiflorum* (L.) All.

The basis of phenological observations is the registration of successive phases of development and growth of plants, which are distinguished by clearly expressed morphological changes during the year (Berko, 1976).

The study of the age structure was carried out using generally accepted methods that characterize the heterogeneity of individuals in ontogenesis (Rabotnov, 1950).

The age structure was distinguished according to the scheme of T. A. Rabotnov, modified by O. V. Smirnova and others. (Rabotnov, 1950). The generally accepted indices of the age structure were used:

- pregenerative period: p – seedlings, j – juvenile, im – immature, v – virginal;
- generative period: g1 – young generative, g2 – middle-generative, g3 – old generative;
- postgenerative period: ss – subsenile, s – senile.

For an integral assessment of the age status of cenopopulations according to the methodology of I.M. Kovalenko, recovery and aging indices were calculated. In addition, the general age index was applied in the form of the ratio of the aging index to the population recovery index (Kovalenko, 2005).

For a comparative assessment of the level of generativity of individuals in populations, the index of generativity of populations is used, which characterizes the share of plants in a generative state in the population (Kovalenko, 2005; Riznychuk et al., 2019).

Classification of populations was carried out according to Rabotnov (1950), Smirnova & Toropova (1974).

### 3. RESULTS AND DISCUSSION

The conducted studies indicate that according to the age structure of the *Polygonatum multiflorum* (L.) All. in the studied biotopes of Precarpathia, they mostly belong to the normal type. Self-maintenance of coenopopulations occurs in a combined way as a result of generative and vegetative reproduction, the intensity of which depends on local edaphic and coenotic conditions. Cenopopulations of the invasive type were found in some localities.

For coenopopulations of *Polygonatum multiflorum* (L.) All. the minimum percentage of individuals at the pregenerative stages of development was found in coenopopulations of anthropogenically modified biotopes: residential and mainline (Fig. 2).

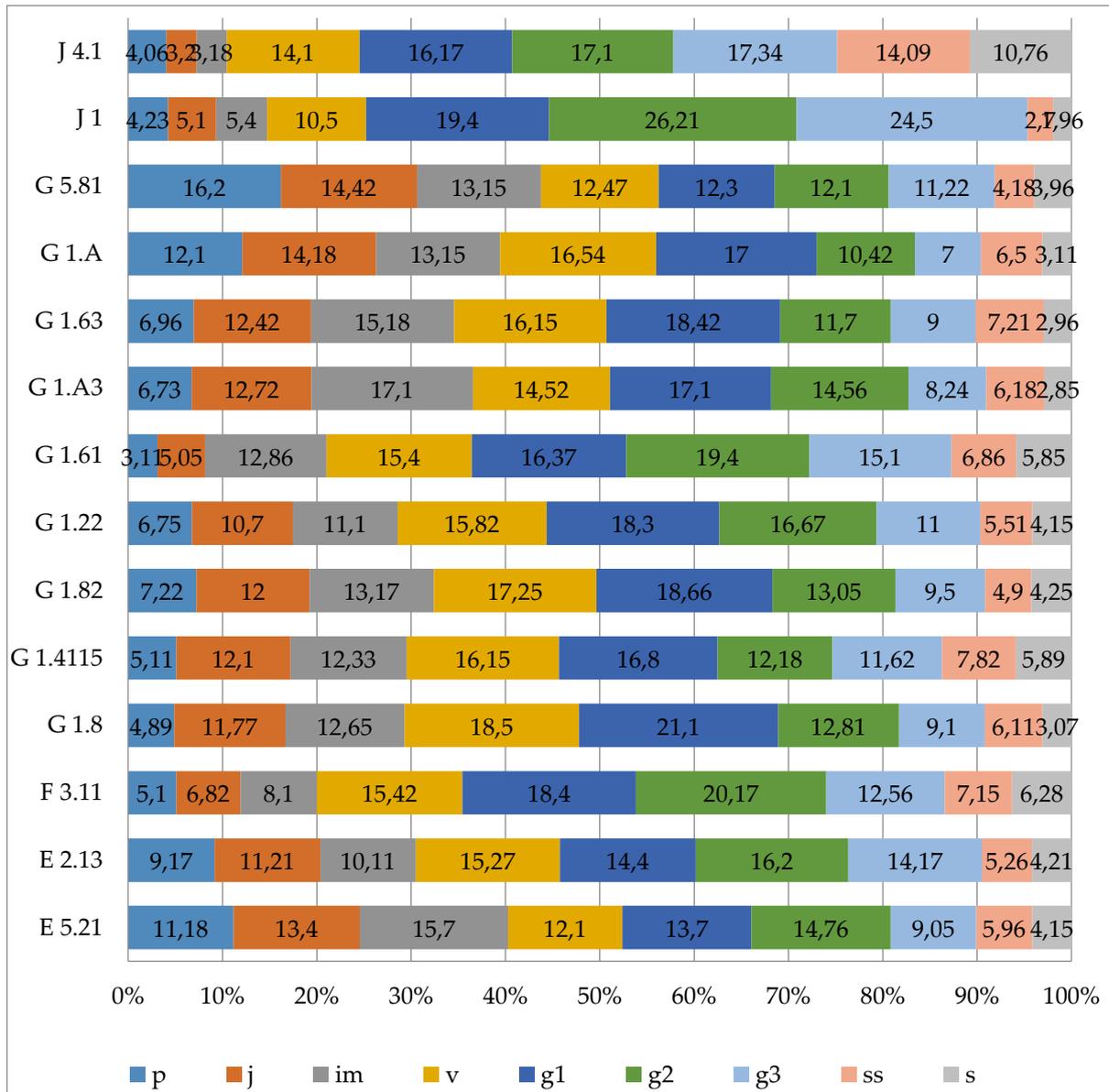


Fig. 2. Spectrum of age states of coenopopulations of *Polygonatum multiflorum* (L.) All. in the biotopes of Precarpathian region.

The spectrum of age states of these cenopopulations has a pronounced centered character with a peak at the middle-generative stage (26.21% and 17.1%, respectively, in residential and mainline biotopes) and old generative stage (24.5% and 17.34%, respectively). A characteristic feature of coenopopulations of residential biotopes is also a low proportion of individuals of postgenerative period (senile and subsenile). This pattern is due to the artificial adjustment of the age structure due to the mechanical removal of individuals for decorative purposes (Riznychuk, 2007).

Normal full-fledged members of the coenopopulation with a maximum in pregenerative groups of individuals, mainly juvenile, immature and virginal, which determines the left-sided spectrum of the age structure, are formed in most forest biotopes (meso-eutrophic forests with oak, hornbeam, ash and linden; Central European acidophilic beech forests; hornbeam forests; mixed oak-elm-ash forests; beech and oak forests and Eastern Carpathian wetland alders). This pattern is most pronounced for cenopulations developing on felling areas in all studied landscape-geographic units, and the investigated cenopulations are invasive in nature.

An exception among forest biotopes are cenopulations formed in the acidophilic beech forests of the Precarpathian region. The spectrum of age states has a centered character with a predominance of generative individuals.

The right-hand spectrum of age states, in which early- and middle-aged individuals predominate (respectively, 18.4% and 20.17%), form cenopulations in biotopes confined to Central European shrub thickets.

In the spectrum of age states of coenopulations of *Polygonatum multiflorum* (L.) All. in forest edge biotopes, the share of individuals in pregenerative (p, j, im, v) and generative (g1, g2, g3) states is almost the same and varies within 11–16%. And the share of sub-senile and senile (postgenerative period) individuals in the sum is 10.11%, which is one of the lowest indicators among the studied cenopulations.

A similar trend in the formation of the spectrum of age states was also established for the coenopulations of abandoned pastures and hay meadows.

Ontogenetic indices were calculated for the integral assessment of the age status of the studied cenopulations (Kovalenko, 2005) (Tab. 1).

Tab. 1

*Ontogenetic indexes of coenopulations of Polygonatum multiflorum* (L.) All. in the biotopes of Precarpathian region

<b>Indexes Types of biotopes</b>	<b>Recovery index, %</b>	<b>Aging index, %</b>	<b>Generativity index, %</b>	<b>Age index, %</b>
Forest edge biotopes	52,38	19,16	37,51	0,37
Abandoned pasture and hay meadows	45,76	23,64	44,77	0,52
Central European shrub thickets	35,44	25,99	51,13	0,73
Acidophilic oak forests	47,81	18,29	43,01	0,38
Eastern Carpathian wetland alders	45,69	25,33	40,6	0,55
Beech and oak forests	49,64	16,65	48,96	0,34
Mixed oak-elm-ash forests	44,37	20,66	50,79	0,47
Central European acidophilic beech forests	21,02	27,81	50,87	1,32
Hornbeam forests	51,07	17,27	39,90	0,34
Central European neutrophilic beech forests	50,71	19,17	39,12	0,38
Meso-eutrophic forests with oak, hornbeam, ash and linden	55,62	16,61	34,42	0,30
Felling areas	56,24	19,36	35,62	0,34
Residential biotopes	25,23	29,16	70,1	1,15
Mainline biotopes	24,57	42,19	50,61	1,72

The highest indices of recovery (Irec.  $\geq$  50%) were found for coenopulations of *Polygonatum multiflorum* (L.) All., formed in biotopes of beech and oak forests (Irec.  $\approx$  50%), Central European neutrophilic beech forests (Irec. = 50.71%), hornbeam forests (Irec. = 51.07%), forest edge biotopes (Irec. = 52.38%), meso-eutrophic forests with oak, hornbeam, ash and linden (Irec. = 55.62%), as well as in felling areas, where the analyzed indicator reaches the maximum value - 56.24%. The

lowest indices of age (0.34–0.38%) and aging are also observed in a similar range of biotopes. The last indicator for these biotopes varies in the range of 16.61–19.36%, which indicates the presence of favorable conditions for the development and high reproductive potential of *Polygonatum multiflorum* (L.) All. coenopopulations.

Cenopopulations of *Polygonatum multiflorum* (L.) in the following biotopes are characterized by a rather high reproductive potential: Eastern Carpathian wetland alders ( $I_{rec.} = 45.69\%$ ;  $I_{aging} = 25.33\%$ ;  $I_{age} = 0.55$ ), pasture and hay meadows ( $I_{rec.} = 45.76\%$ ;  $I_{aging} = 23.64\%$ ;  $I_{age} = 0.52$ ), acidophilic oak forests ( $I_{rec.} = 47.81\%$ ;  $I_{aging} = 18.29\%$ ;  $I_{age} = 0.38$ ) and mixed oak-ash forests ( $I_{rec.} = 44.37\%$ ;  $I_{aging} = 20.66\%$ ;  $I_{age} = 0.47$ ). A significant decrease in the recovery index and an increase in the aging and age indices are observed in anthropogenic biotopes. So, for the coenopopulations of *Polygonatum multiflorum* (L.) All. of the mainline biotope, their values are, respectively, 24.57%, 42.19% and 1.72%. This indicates the presence of conditions that do not correspond to the cenopopulation optimum and the threat of further development of cenopopulations within these biotopes.

Cenopopulations of acidophilic beech forests require special attention, for which a low recovery index (21.02%) and a high aging index (27.81%) against a high generativity index (50.87%) were determined. The index of generativity is one of the highest among all studied coenopopulations of *Polygonatum multiflorum* (L.) All. Such a state of the cenopopulation may be a consequence of natural cyclical changes or indicate its regression. Therefore, a promising direction for further research is the monitoring of the state of the coenopopulations of *Polygonatum multiflorum* (L.) All. in the beech forests of the Precarpathian region.

#### 4. CONCLUSIONS

1. According to the age structure the cenopopulations of the genus *Polygonatum* Mill. species are full members in the investigated biotopes of Precarpathian region. They mostly belong to the normal type, less often to the invasive type. The spectra of their age states and reproductive potential are determined by a set of biotope conditions and have species specificity.

2. For coenopopulations of *Polygonatum multiflorum* (L.) All. a centered spectrum of age states was found in the conditions of the residential and mainline biotopes; the left-side - in most wooded lands and in felling areas; the right side - in shrub thickets. In the coenopopulations of forest edge and pasture biotopes, the proportion of individuals of the pregenerative and generative periods is almost the same. The highest recovery indices are found in felling areas (36.24%) and meso-eutrophic forests with oak, hornbeam, ash and linden (55.62 %) biotopes. The lowest recovery indices were found in the biotopes of Central European acidophilic beech forests (21.02%) and anthropogenic biotopes: residential (25.30%) and mainline (24.57%).

3. The most informative markers of the age structure, which indicate the ecological status of coenopopulations in the conditions of specific biotopes and the degree of tension of environmental factors, are the nature of the spectrum of age states and the value of the recovery index. Left-sided spectra of age states in combination with high recovery indices indicate the presence of favorable conditions and a high reproduction potential of cenopopulations.

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Для популяційних досліджень визначення вікового стану має більше значення, ніж визначення календарного віку. Проведені дослідження вказують, що за віковою структурою ценопопуляції *Polygonatum multiflorum* (L.) All. у досліджених біотопах Передкарпаття переважно належать до нормального типу. Самопідтримання ценопопуляцій відбувається комбінованим способом внаслідок генеративного та вегетативного розмноження, інтенсивність якого залежить від локальних едафічних і ценотичних умов. Спектри їх вікових станів і репродуктивний потенціал визначаються сукупністю біотопічних умов і мають видову специфіку. Характер спектру вікових станів і величина індексу відновлення є найбільш інформативними індикаційними маркерами. Лівосторонні спектри у поєднанні з високими індексами відновлення вказують на наявність сприятливих умов та високий потенціал відтворення ценопопуляцій. Найбільш сприятливими для реалізації потенціалу відтворення більшості ценопопуляцій досліджених видів є біотопи лісових зрубів; найменш сприятливими – примагістральні біотопи.

**Ключові слова:** вікова структура, індекс відновлення, *Polygonatum multiflorum* (L.) All., Передкарпаття.