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BIO-INDICATION PERSPECTIVE OF *CHELIDONIUM MAJUS* L. IN THE CONDITIONS OF THE URBAN TERRITORY

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The expediency of conducting morphometric analysis of herbaceous plants in order to find out their bioindicative potential and assess the ecological state of the urbanized ecosystems environment is substantiated. The morphological parameters of the growth and development of *Chelidonium majus* L. in the conditions of the urban environment are studied. Species reproductive, assimilation, storage and habitual sphere are investigated. The species population vitality indices of generative organs, photosynthetic, root, habitual indices are explored. The medicinal and decorative properties of *Chelidonium majus*, its distribution width, natural ecological and biological features are analyzed. The vitality of *Chelidonium majus* population in the city functional zones is determined according to the proposed rating scale. The most significant suppression of the *Chelidonium majus* growth processes in the zone of transport routes of the Ivano-Frankivsk urban ecosystem is established. The population of the species shows high vitality in the complex landscaping area (I class of vitality), above average vitality in the housing area (II class of vitality), low vitality in the transport area (V class of vitality). The species is characterized by significant ecological plasticity under the influence of anthropogenic loading, as it directs energy resources to the development of the stem mass and the growth of the above-ground part of the plant, revealing at the same time the K-type of life strategy. At the same time, the reproductive and photosynthetic sphere of the species shows relative stability in the conditions of the urban ecosystem. An exception is *Chelidonium majus* individuals in the transport zone of the city, where a high level of anthropogenic pollution strongly suppresses almost all areas of the plant, including the development of leaves and vegetative organs. *Chelidonium majus* is recommended for use in biomonitoring studies of the ecological state of urban areas, and the stem sphere of the species is the most informative parameter of the species vitality. *Key words: Chelidonium majus* L., urban territory, anthropogenic pollution, biological indication, morphological parameters.

Біоіндикаційна перспективність чистотілу звичайного в умовах міської території. Глібовицька Н.І.
Обгрунтовано доцільність проведення морфометричного аналізу трав'янистих рослин з метою з'ясування їх біоіндикаційної перспективності та оцінки екологічного стану навколишнього середовища урбанізованих екосистем. Досліджено морфологічні параметри росту та розвитку чистотілу в умовах міського середовища. Досліджено репродуктивну, асиміляційну, запасаючу та габітуальну сфери виду. Розраховано індекси життєвості популяції чистотілу звичайного: генеративних органів, фотосинтетичний, кореневий, габітуальний індекси. Проаналізовано лікувальні, декоративні властивості чистотілу звичайного, його широту розповсюдження, природні екологічні та біологічні особливості. Визначено життєвість популяції чистотілу звичайного у функціональних зонах міста відповідно до запропонованої оцінювальної шкали. Встановлено найсуттєвіше пригнічення ростових процесів у зоні транспортних шляхів Івано-Франківської урбоекосистеми. Популяція виду проявляє високу життєвість у зоні комплексного озеленення (I клас життєвості), життєвість вище середньої − у зоні житлової забудови (II клас життєвості), низьку життєвість у зоні транспортних шляхів (V клас життєвості). Вид характеризується значною екологічною пластичністю під впливом антропогенного навантаження, оскільки направляє енергетичні ресурси на розвиток стеблової маси та ріст надземної частини рослини, виявляючи при цьому К-тип життєвої стратегії. При цьому репродуктивна та фотосинтетична сфера виду проявляє відносну стабільність в умовах міської екосистеми. Виняток становлять особини чистотілу в умовах транспортної зони міста, де високий рівень антропогенного забруднення сильно пригнічує практично усі сфери рослини, у тому числі розвиток листків та вегетативних органів. Чистотіл звичайний рекомендований до використання у біомоніторингових дослідженнях екологічного стану міських територій, а стеблова сфера виду є найінформативнішим параметром життєвості виду. *Ключові слова: Chelidonium majus* L., міська територія, антропогенне забруднення, біологічна індикація, морфологічні показники.

Formulation of the problem. One of the most common objects of phytomonitoring of urban areas are herbaceous plants, which are widely distributed in urban phytocenoses. Changes in their morphological parameters of growth and development serve as reliable indicators of the urbanized environment individual ecotopes ecological condition. *Chelidonium majus* is a valuable medicinal, vitamin and decorative plant, distributed almost throughout the territory of Ukraine. However, the bioindicative role of *Chelidonium majus* is poorly studied, there are only some fragmentary data on the reduction of the pollen grains quality of the species under conditions of anthropogenic stress influence. The study of the morphological indicators of the species biomass allows to evaluate both the vitality and the phytoindicative suitability of *Chelidonium majus* in the conditions of urban ecosystems.

Relevance of research. Indicators of plant growth and development are among the most informative in biomonitoring studies of the environmental condition. Morphological analysis of *Chelidonium majus* biomass allows to identify the most sensitive biomarkers to anthropogenic stress and their subsequent application in phytomonitoring practice.

The connection of the author's work with important scientific and practical tasks. *Chelidonium majus* is a synanthropic species that is undemanding to the conditions of its existence, which is easily transported over considerable distances and is characterized by a significant development of its own population in our country and throughout the world. Studying the reactions of plants at the organismal level to different levels of anthropogenic pressure in the urban environment will allow us to determine the phytoindicative potential of the species.

Analysis of recent research and publications. *Chelidonium majus* is a self-pollinating plant whose distribution area covers central, eastern, northern Europe, western and central Asia, as well as North America. The species grows in deciduous, mixed forests of Ukraine, in Polissia, in the steppe and forest-steppe, in the Carpathians. Stocks of *Chelidonium majus* raw materials in Ukraine make it possible to annually harvest dozens of tons of grass for various household and medical needs. *Chelidonium majus* is a mesophyte, a moisture-loving and shade-tolerant plant, it can grow on any type of soil, but it prefers soils with a high content of nitrogen and organic substances [15]. The oncoprotective [2, 11, 12, 14, 18, 19], anti-inflammatory, antioxidant [5], disinfectant [3, 6, 7, 20], antifungal, anthelmintic [9], antiviral effect [10] of the plant is known due to the rich chemical composition of its organs and tissues. However, there is very little scientific information regarding the specific use of the species in biological monitoring of urban areas. In the literature, information on the reproductive sphere reactions of *Chelidonium majus* to man-made loading is partially analyzed [16, 17]. The inhibitory effect of heavy metals, in particular, cadmium, copper, zinc, on root growth and seed germination of *Chelidonium majus* has also been established [4].

Highlighting previously unsolved parts of the general problem to which this article is devoted. A considerable number of scientific publications are devoted to the unique healing properties of *Chelidonium majus*, which is widely used in the treatment and prevention of many diseases. The biological and ecological features of the species are widely covered in the scientific literature, but there are practically no publications on the possible use of the plant for phytoindicative purposes. Therefore, an urgent task is to study the morphological parameters of plant vitality under the influence of anthropogenic loading.

Novelty. It is advisable to use the analyzed morphological indicators of growth and development of *Chelidonium majus* in bioindicative practice when assessing the ecological state of the environment in urban areas. The wide distribution and ecological plasticity of the plant indicates the convenience, accessibility and simplicity of the species as an object of biomonitoring studies.

Methodological or general scientific significance. The morphological parameters of *Chelidonium majus* vitality are analyzed in the conditions of the Ivano-Frankivsk region ecotopes with different functional purposes. The reproductive, assimilation, storage and habitual spheres of the plant are studied.

Presentation of the main material. The research is conducted in the conditions of the complex landscaping area, housing area and transport area of Ivano-Frankivsk city. Demyaniv Laz – a tract on the city outskirts – is chosen as the background ecologically clean territory. In each area, 15 adult individuals of *Chelidonium majus* are selected at the flowering stage for the purpose of further morphological analysis [13]. To generalize the data, we use the previously proposed assessment scale of the plant vitality (Table 1).

To identify *Chelidonium majus* vitality in the city functional areas the following morphology parameters, that form the four spheres of the plant, are analyzed:

– assimilation sphere: leaves and stems mass of the one plant, photosynthetic index (the ratio of leaf mass to the whole plant mass), stem index (the ratio of stem mass to the whole plant mass);

– reproductive sphere: generative organs mass of one plant, generative organs index (the ratio of generative organs mass to the whole plant mass);

– storage sphere: root mass, root index (the ratio of root mass to the whole plant mass);

– habitual sphere: the total mass of the plant, the aboveground part mass, the ratio of the underground part mass to the aboveground part mass of the plant.

In the conditions of the city of Ivano-Frankivsk, there is a decrease in the mass of vegetative and generative organs of *Chelidonium majus* compared to background indicators (Fig. 1).

The most significant suppression of *Chelidonium majus* development processes is recorded in the city's transport area, in particular – a 5-fold decrease in stem mass compared to the background value. The biomass of flowers and leaves is lower than the corresponding

Table 1

The scale for Chelidonium majus vitality assessing in urban areas conditions

Deviation from control, %	The class of vitality	Category of stability
1-10	1	high
11-20	2	above average
21-30	3	average
31-50	4	below average
>50	5	low

values in control individuals by 3.4 and 2.1 times. The total mass and the mass of the aboveground part of the plants in the transport zone of the urban system are 3.2 and 3.4 times lower than in the background area. A significant decrease in *Chelidonium majus* biomass is not found in the complex landscaping area, the greatest suppression of root mass is recorded in the housing area. In the conditions of the Ivano-Frankivsk city, the mass of individual structures of complex landscaping area increases in the following series of morphological indicators: flower mass → root mass → leaf mass → stem mass → aboveground part mass → total plant mass.

In the conditions of Ivano-Frankivsk urban system, there is an increase in the biomass indices of *Chelidonium majus* plants in the following order: index of generative organs → root index → photosynthetic index → habitual index → stem index (Table 2).

Thus, the species directs energy resources mainly to the development of above-ground mass, in particular stem mass.

The deviation from the control of the vitality indicators of *Chelidonium majus* individuals in the conditions of Ivano-Frankivsk city indicates that the population of the species is characterized by high vitality in the area of complex landscaping (I vitality class), above average vitality in the housing area (II vitality class), low vitality vitality in the transport area (V class of vitality) (Table 3).

The reduction of *Chelidonium majus* individual parts biomass to the background values in the conditions of functional areas of the city takes place in the following series: mass of leaves → mass of flowers → total mass of the plant = mass of the aerial part → mass of the root → mass of the stem.

The main conclusions. *Chelidonium majus* reacts sensitively to the anthropogenic loading of the urban ecosystem by reducing the vegetative and generative organs biomass. The most intense suppression of the growth and development processes is observed in the conditions of transport area of the city. The species exhibits a K-type life strategy, directing metabolic resources to the growth of the vegetative sphere, in particular stem

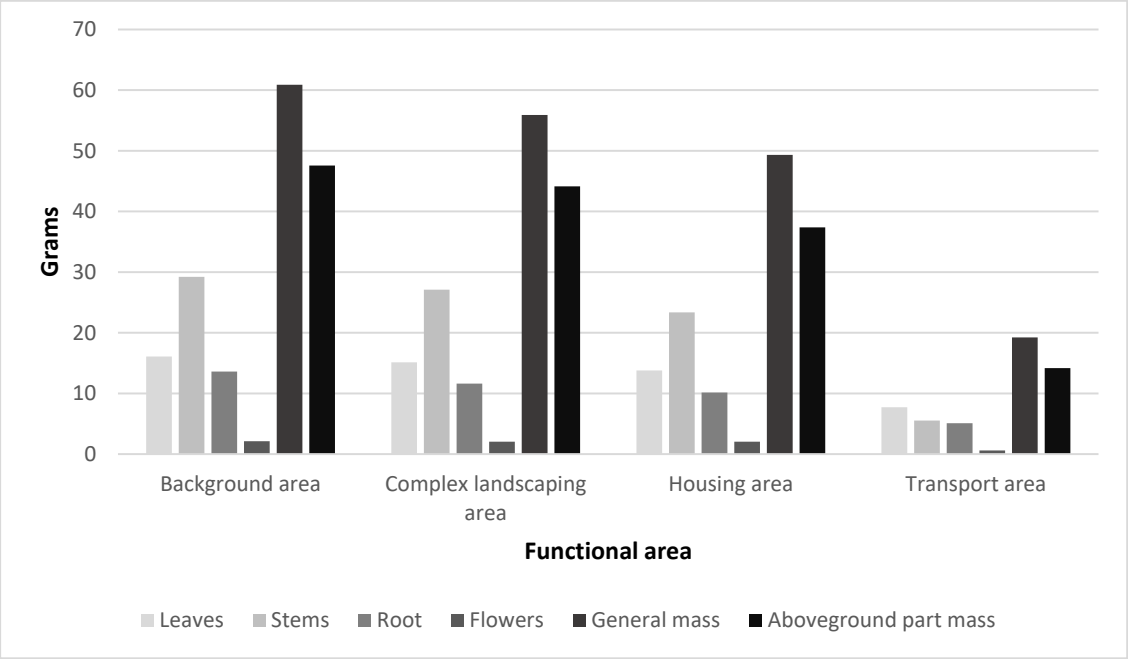

Figure 1. The structure of Chelidonium majus biomass in Ivano-Frankivsk functional areas

Table 2

Chelidonium majus biomass indexes in Ivano-Frankivsk city functional areas

Functional area	Assimilation sphere		Storage area	Habitual sphere	Reproductive sphere
	Photosynthetic index	Stem index	Root index	Habitual index	Generative organs index
Background area	0,27	0,47	0,45	0,31	0,43
Complex landscaping area	0,27	0,48	0,21	0,28	0,05
Housing area	0,29	0,46	0,21	0,27	0,04
Transport area	0,38	0,29	0,28	0,40	0,03

Table 3

Chelidonium majus vitality deviation from the control in Ivano-Frankivsk city

Vitality parameter	Deviation from control, %		
	Complex landscaping area	Housing area	Transport area
Leaves mass	6	15	53
Stem mass	9	21	81
Root mass	14	29	61
Flowers mass	3	6	72
Total weight	10	21	68
The mass of the aboveground part	9	19	70
Average value	9	19	68
Vitality class	I	II	V

and habitual mass. The stem mass is the most informative phytoindicative parameter of *Chelidonium majus*, while the plants leaves mass is the most stable indicator parameter under the urbotechnogenic impact.

Prospects for the use of research results. The relative stability of leaf biomass and reproductive organs mass of *Chelidonium majus* in the conditions of the urban environment indicates a significant adaptive potential of the species, capable of maintaining functional capacity in stressful conditions of existence. It is expedient to use *Chelidonium majus* in monitoring studies of the urban environment ecological state.

References

1. Aditya D. Patil, Parth S. Aphale, Dharmendra B. Sharma, Ramesh R. Bhonde.Can homeopathic medicine *Chelidonium majus* serve a dual role of an anti-obesity and anti-diabetic agent? *Medical Hypotheses*. 2022. No 159. 110749 p. https://doi.org/10.1016/j.mehy.2021.110749.
2. Ali Parsania, Mohammad Hassan Pouriayevali, Masoud Parsania, Mahdi Ghorbani. *Chelidonium majus* L. alkaloid extract enhances TRAIL-induced apoptosis in HeLa cell line through death receptors 4 and 5 upregulation. *Gene Reports*. 2021. No. 25. 101311 p. https://doi.org/10.1016/j.genrep.2021.101311.
3. Ciorîță A., Suciu M., Macavei S., Kacso I., Lung I., Soran M-L., Pârvu M. Green Synthesis of Ag-MnO2 Nanoparticles using *Chelidonium majus* and *Vinca minor* Extracts and Their In Vitro Cytotoxicity. *Molecules*. 2020. No. 25(4). 819 p. https://doi.org/10.3390/molecules25040819
4. Doycheva, Iva V. The Effect of Some Heavy Metals (Cd, Cu, Pb, Zn) and Substrates on *Chelidonium majus* L. Seed Germination and Seedling Growth. *Ecologia Balkanica*. 2021. No. 13(2). P. 115–124.
5. Fabriki-Ourang S., Shahabzadeh H. The effect of abiotic elicitors on antioxidants and phytochemical traits of celandine (*Chelidonium majus*) under drought stress. *Iranian Journal of Field Crop Science*. 2019. No. 50(1). P. 139–150. doi: 10.22059/ijfcs.2018.250266.654435
6. Krizhanovska V., Sile I., Kronberga A., Nakurte I., Mezaka I., Dambrova M., Pugovics O., Grinberga S. The Cultivation of *Chelidonium majus* L. Increased the Total Alkaloid Content and Cytotoxic Activity Compared with Those of Wild-Grown Plants. *Plants*. 2021. No. 10(9). 1971 p. https://doi.org/10.3390/plants10091971
7. Krzyżek P., Junka A., Słupski W., Dołowacka-Jóźwiak A., Płachno B.J., Sobiecka A., Matkowski A., Chodaczek G., Płusa T., Gościniak G., Zielińska S. Antibiofilm and Antimicrobial-Enhancing Activity of *Chelidonium majus* and *Corydalis cheilanthifolia* Extracts against Multidrug-Resistant *Helicobacter pylori*. *Pathogens*. 2021. No. 10(8). 1033 p. https://doi.org/10.3390/pathogens10081033
8. Mahdi Yahyazadeh, Rieke Meinen, Robert Hänsch, Sara Abouzeid, Dirk Selmar. Impact of drought and salt stress on the biosynthesis of alkaloids in *Chelidonium majus* L. *Phytochemistry*. 2018. No. 152. P. 204–212. https://doi.org/10.1016/j.phytochem.2018.05.007.
9. Myriam Esteban-Ballesteros, Jaime Sanchis, Camino Gutiérrez-Corbo, Rafael Balaña-Fouce, Francisco A. Rojo-Vázquez, Camino González-Lanza, María Martínez-Valladares. In vitro anthelmintic activity and safety of different plant species against the ovine gastrointestinal nematode *Teladorsagia circumcincta*. *Research in Veterinary Science*. 2019. No. 123. P. 153–158. https://doi.org/10.1016/j.rvsc.2019.01.004.
10. Nawrot J., Wilk-Jędrusik M., Nawrot S., Nawrot K., Wilk B., Dawid-Pać R., Urbańska M., Micek I., Nowak G., Gornowicz-Porowska J. Milky Sap of Greater Celandine (*Chelidonium majus* L.) and Anti-Viral Properties. *International Journal of Environmental Research and Public Health*. 2020. No. 17(5). 1540 p. https://doi.org/10.3390/ijerph17051540
11. Petruczynik A., Tuzimski T., Plech T., Misiurek J., Szalast K., Szymczak G. Comparison of Anticancer Activity and HPLC-DAD Determination of Selected Isoquinoline Alkaloids from *Thalictrum foetidum*, *Berberis* sp. and *Chelidonium majus* Extracts. *Molecules*. 2019. No. 24(19). 3417 p. https://doi.org/10.3390/molecules24193417
12. Popenda Łukasz. Protoberberine Compounds Extracted From *Chelidonium majus* L. As Novel Natural Photosensitizers for Cancer Therapy. *Phytomedicine*. 2019. No. 64. 152919 p. doi: 10.1016/j.phymed.2019.152919
13. Rudenko S. S., Kostyshyn S. S., Morozova T. V. General ecology. Practical course: teaching study guide for students of higher education. *Part 2. Natural terrestrial ecosystems*. Chernivtsi, 2008. 320 p.

14. Sadra Hesami, Shahabeddin Safi, Kambiz Larijani, Hassanali Naghdi Badi, Vahid Abdossi, Milad Hadidi, Synthesis and characterization of chitosan nanoparticles loaded with greater celandine (*Chelidonium majus* L.) essential oil as an anticancer agent on MCF-7 cell line. *International Journal of Biological Macromolecules*. 2022. No. 194. P. 974–981. https://doi.org/10.1016/j.ijbiomac.2021.11.155.
15. Sathasivam R., Yeo H.J., Park C.H., Choi M., Kwon H., Sim J.E., Park S.U., Kim J.K. Molecular Characterization, Expression Analysis of Carotenoid, Xanthophyll, Apocarotenoid Pathway Genes, and Carotenoid and Xanthophyll Accumulation in *Chelidonium majus* L. *Plants*. 2021. No. 10(8). 1753 p. https://doi.org/10.3390/plants10081753
16. Samatadze T.E., Yurkevich O.Y., Hazieva F.M., Konyaeva E.A., Morozov A.I., Zoshchuk S.A., Amosova A.V., Muravenko O.V. Agro-Morphological, Microanatomical and Molecular Cytogenetic Characterization of the Medicinal Plant *Chelidonium majus* L. *Plants*. 2020. No. 9(10). 1396 p. https://doi.org/10.3390/plants9101396
17. Víctor N. Suárez-Santiago, M. Carmen Fernández-Fernández, Miguel A. Pérez-Gutiérrez, Samira Ben-Menni Schuler, Maria J. Salinas-Bonillo, Ana T. Romero-García, Morphological and ultrastructural diversity and character evolution of the pollen in the tribe Chelidonieae (Papaveraceae). *Review of Palaeobotany and Palynology*. 2018. No 258. P. 83–97. https://doi.org/10.1016/j.revpalbo.2018.07.004.
18. Wang X., Decker C.C., Zechner L. In vitro wound healing of tumor cells: inhibition of cell migration by selected cytotoxic alkaloids. *BMC Pharmacol Toxicol*. 2019. No. 20. 4 p. https://doi.org/10.1186/s40360-018-0284-4
19. Warowicka A., Qasem B., Dera-Szymanowska A., Wołuń-Cholewa M., Florczak P., Horst N., Napierała M., Szymanowski K., Popenda Ł., Bartkowiak G., Florek E., Goździcka-Józefiak A., Młynarz P. Effect of Protoberberine-Rich Fraction of Chelidonium majus L. on Endometriosis Regression. *Pharmaceutics*. 2021. No. 13(7). 931 p. https://doi.org/10.3390/pharmaceutics13070931\
20. Zielińska S., Matkowski A., Dydak K., Czerwińska M.E., Dziągwa-Becker M., Kucharski M., Wójciak M., Sowa I., Plińska S., Fijałkowski K., Ciecholewska-Juśko D., Broda M., Gorczyca D., Junka A. Bacterial Nanocellulose Fortified with Antimicrobial and Anti-Inflammatory Natural Products from Chelidonium majus Plant Cell Cultures. *Materials*. 2022. No. 15(1). 16 p. https://doi.org/10.3390/ma15010016