



Alien species in the urban flora of Ivano-Frankivsk: taxonomic composition, life forms, and ecological groups

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Abstract

This study provides a comprehensive ecological assessment of the alien plant component of the urban flora of Ivano-Frankivsk, Ukraine. A checklist of alien species was compiled and analysed by family and genus, with species further categorised as casual, naturalised, or invasive following international terminology in invasion biology (sensu Pyšek et al., 2004).

The alien fraction comprises 202 species belonging to 143 genera and 48 families, with *Asteraceae* (21.8%), *Brassicaceae* (10.0%), and *Poaceae* (8.4%) being the most represented families. The genera *Amaranthus* and *Vicia* exhibited the highest species richness. Growth-form analysis revealed a predominance of annual herbaceous plants, while Raunkiaer's life-form classification indicated a prevalence of therophytes and hemicryptophytes.

Ecological grouping demonstrated the dominance of heliophytes, xeromesophytes, and mesotrophs, consistent with the adaptation of alien species to urban environmental conditions. These findings provide a structural and ecological characterisation of the alien flora of Ivano-Frankivsk and establish a basis for biodiversity monitoring, conservation planning, and ecological management of urban ecosystems.

Keywords: alien species, systematic analysis, life form, bioecological assessment, urban flora, biodiversity, Ivano-Frankivsk.

1. Introduction

The study of processes underlying the anthropogenic spread of plants has attracted scientific interest for more than a century, and attention to this issue continues to increase steadily. A general trend in the contemporary development of synanthropic floras is the growing contribution of alien species to their composition. These species warrant particular attention, as some of them, following naturalization, may become permanent components of regional floras. This process is of both scientific and practical interest, since the majority of alien plant species are agricultural weeds or possess toxic properties (Melnik 2009).

Alien species are an integral component of urban ecosystems, which highlights the relevance of studying them to forecast future changes in their composition, dynamics, and development. In urbanized environments, the process of alien species invasion may sometimes reach a critical scale. Consequently, in recent years, increasing scientific attention has been devoted to the study of urban alien floras in medium-sized and large cities (Zvyagintseva 2013). The city of Ivano-Frankivsk is particularly representative in this regard. The historical development of the city as a commercial and cultural centre, together with intensive agriculture and horticulture, has been among the key factors facilitating the introduction and establishment of alien species.

The study of alien plants within specific regions makes it possible to promptly detect the occurrence of potentially harmful species, implement appropriate measures for their eradication, and limit their further spread (Sytschak 2012).

Review of Previous Research. The large body of scientific literature on the topic demonstrates its significance and relevance in contemporary research (Volodymyrets et al. 2022). Khlystun (2006) investigated the alien flora of the city of Chernivtsi. She recorded 104 alien species and conducted a comprehensive analysis of the city's alien flora. Studies conducted in the city of Lviv are presented in the works of Chuba and Mamchur (2018). B. Prots (2013) describes alien plant species of the Carpathian region of Ukraine and considers the following species to be the most harmful in Zakarpattia: *Acer negundo* L., *Ambrosia artemisiifolia* L., *Echinocystis lobata* (Michx.) Torr. & A. Gray, *Fraxinus pennsylvanica* Marschall, *Helianthus tuberosus* L., *Heracleum sosnowskyi* Manden., *Impatiens glandulifera* Royle, *Reynoutria japonica* Houtt., *Reynoutria × bohemica* Chrtek & Chrtková, *Robinia pseudoacacia* L., *Solidago canadensis* L., and *Solidago gigantea* Aiton. Information on the distribution of certain alien species of the family Brassicaceae in Western Ukraine can be found in the works of A. P. Ilyinska (2009). Sytschak (2012) investigated alien plants in Ivano-Frankivsk Oblast. The results of her study provide information on new localities of 71 alien species belonging to 23 families. Until recently, the urban flora of Ivano-Frankivsk had not been the subject of dedicated studies, with only fragmentary information available from works focusing on broader regions. Only recently did we publish the first analysis of the alien component of the city's flora, addressing primary distribution areas, pathways of introduction, and the degree of species naturalization (Prokopiv and Mylenka 2026). In the present study, we extend this approach by focusing on the ecological characteristics of the alien flora, including its taxonomic composition, life forms, and ecological groups.

Ivano-Frankivsk, with an area of 83.7 km², is a major administrative, economic, and cultural centre of the Prykarpattia region, as well as an important transport hub with well-developed road and railway connections to other regions of Ukraine. The city is located within the Bystrytsia depression, at the confluence of the Bystrytsia Nadvirińska and Bystrytsia Solotvynska rivers. The population is approximately 250,000 inhabitants (Ivano-Frankivsk Regional State Administration 2025). Intensive expansion of residential development, infrastructural modernization, and increasing economic activity in the city are transforming landscape structures and creating numerous anthropogenic niches that facilitate the establishment of alien species. The presence of a large number of parks and squares in Ivano-Frankivsk (including Shevchenko Park of Culture and Recreation, Park of Internationalist Warriors, Park Molodizhnyi, Memorial Square, Glory Square, and Railway Station Square) increases the risk of local colonization by alien plants. This situation requires systematic monitoring and the implementation of preventive measures in urban greening practices.

Knowledge of the bioecological characteristics of alien species is essential for reducing their negative impact on plant diversity and for developing effective systems for controlling their spread (Maltseva 2016). In summary, the present study aimed to investigate the taxonomic structure and analyze the bioecological characteristics of the alien fraction of the urban flora of Ivano-Frankivsk.

2. Materials and methods

The study focused on the alien component of the urban flora of Ivano-Frankivsk, Ukraine. Field surveys were conducted by the author between 2020 and 2024 using both transect walks and observations at fixed sites.

Field surveys. The research was conducted over four consecutive growing seasons, with 4–5 field visits during each of the spring, summer, and autumn periods. Sampling routes covered a wide range of urban habitats, including central districts, residential areas, industrial zones, transportation corridors (roads and railways), recreational areas (parks and squares), as well as waste accumulation sites (landfills and informal dumps). This spatial coverage ensured adequate representation of the urban flora, encompassing sites with varying degrees of anthropogenic transformation—from intensively built-up areas to semi-natural green spaces.

Criteria for alien species. Alien species were defined as plants not native to the region, introduced intentionally or unintentionally by humans, and capable of independent reproduction and spread. According to the international framework (Pyšek et al., 2004), species were classified into three categories: *casual*, *naturalised*, and *invasive*. Based on the time of introduction, alien species were further divided into *archaeophytes* and *neophytes*. A detailed analysis of primary ranges, introduction history, and naturalisation status is provided in a previous study (Prokopiv & Mylenka, 2026).

Taxonomic and ecological treatment. Species names and authorship follow the Plants of the World Online database (POWO 2023), while family circumscription is based on the APG IV classification (Angiosperm Phylogeny Group 2016). Life-form analysis of the alien flora was conducted according to the classification of plant life forms based on the position of renewal buds above the soil surface, combined with the system of morphological plant types applied in recent studies (Maltseva, 2016). Ecological profiling of species according to their responses to light availability, moisture regime, and soil fertility was performed following the classification of ecological groups in the modern interpretation of Dvirna (2019).

Data sources. The checklist of alien species was compiled using the author's field records, published literature, and herbarium specimens from the Vasyl Stefanyk Carpathian National University and the Institute of Ecology of the Carpathians. Specimens collected during fieldwork are deposited in the herbarium of Vasyl Stefanyk Carpathian National University.

3. Results and discussion

Based on a synthesis of published data, herbarium collections, and our own investigations conducted during 2020–2024, we determined that the alien component of the urban flora of Ivano-Frankivsk comprises 202 species of vascular plants belonging to 143 genera and 48 families. On average, 4.2 species occur per family. Half of the families (50.0%) in the studied flora are monotypic. A high proportion of monotypic families is a characteristic feature of alien and synanthropic floras (Protopopova 1991). The taxonomic proportions for the study area are as follows: 1: 3: 4.2; the generic coefficient is 3.0.

The three leading families in the taxonomic spectrum comprise 81 species, accounting for 40% of the total number of alien plants (Table 1). The families *Asteraceae*, *Brassicaceae*, and *Poaceae* are globally widespread. The highest species richness is recorded in *Asteraceae* (44 species, or 21.8%), whose representatives are well adapted to diverse environmental conditions and possess several advanced traits. The leading position of this family is characteristic of the Holarctic region in general. A prominent role is also played by *Brassicaceae* (20 species, or 10.0%), whose representatives are widely distributed in the Mediterranean and Irano-Turanian regions. The third position is occupied by *Poaceae* (17 species, or 8.4%). In general, such a distribution of the three dominant families is also typical of the alien fraction of the flora of Ukraine as a whole (Protopopova 1991).

Thirty-six families comprise 56 species, representing 27,7% of their total number, and are represented by 1–3 species each.

Table 1. Spectrum of leading families in the alien fraction of the urban flora of Ivano-Frankivsk

№	Family	Number of species (% of total)	Number of genera (% of total)
1.	<i>Asteraceae</i>	44 (21,8)	28 (19,6)
2.	<i>Brassicaceae</i>	20 (10,0)	14 (9,8)
3.	<i>Poaceae</i>	17 (8,4)	10 (7,0)
4.	<i>Amaranthaceae</i>	15 (7,4)	6 (4,2)
5.	<i>Fabaceae</i>	13 (6,4)	9 (6,3)
6.	<i>Lamiaceae</i>	9 (4,4)	7 (4,9)
7.	<i>Apiaceae</i>	7 (3,4)	6 (4,2)
8.	<i>Boraginaceae</i>	5 (2,5)	5 (3,4)
9.	<i>Caryophyllaceae</i>	4 (2,0)	4 (2,8)
10.	<i>Malvaceae</i>	4 (2,0)	3 (2,1)
11.	<i>Polygonaceae</i>	4 (2,0)	2 (1,4)
12.	<i>Rosaceae</i>	4 (2,0)	3 (2,1)
	Total	146 (72,3)	97 (67,8)

In the generic spectrum, the leading genera are *Amaranthus* L. and *Vicia* L. (5 species each), followed by *Atriplex* L. and *Lepidium* L. (4 species each). The genera *Artemisia* L., *Euphorbia* L., *Lamium* L., *Oxalis* L., *Setaria* P. Beauv., *Sonchus* L., *Reynoutria* Houtt., *Veronica* L., and *Xanthium* L. are represented by 3 species each. The remaining 131 genera include 1–2 species.

In the life-form spectrum according to Raunkiaer's classification, therophytes dominate, comprising 130 species (64%) (Fig. 1). At the same time, this group is heterogeneous in terms of naturalization status: it includes casual species (e.g., *Setaria italica* (L.) P. Beauv., *Amaranthus caudatus* L., *Artemisia annua* L.), naturalized species (*Euphorbia peplus* L., *Vicia villosa* Roth, *Papaver rhoeas* L., *Hyoscyamus niger* L.), as well as invasive species (*Galinsoga parviflora* Cav., *Erigeron annuus* (L.) Desf., *Impatiens parviflora* DC., *Echinocystis lobata* (Michx.) Torr. & A.Gray). The second-largest group is hemicryptophytes, with 46 species (23% of the total), including *Euphorbia helioscopia* L., *Lathyrus tuberosus* L., *Lamium album* L., and *Phlox paniculata* L. Phanerophytes account for 9% of the total number of species. Among them, invasive species include *Acer negundo* L., *Robinia pseudoacacia* L., *Juglans regia* L., and *Quercus rubra* L. An increased proportion of therophytes and a reduced role of chamaephytes and cryptophytes are characteristic features of urban floras in general (Moysiyenko 1999; Melnik 2001).

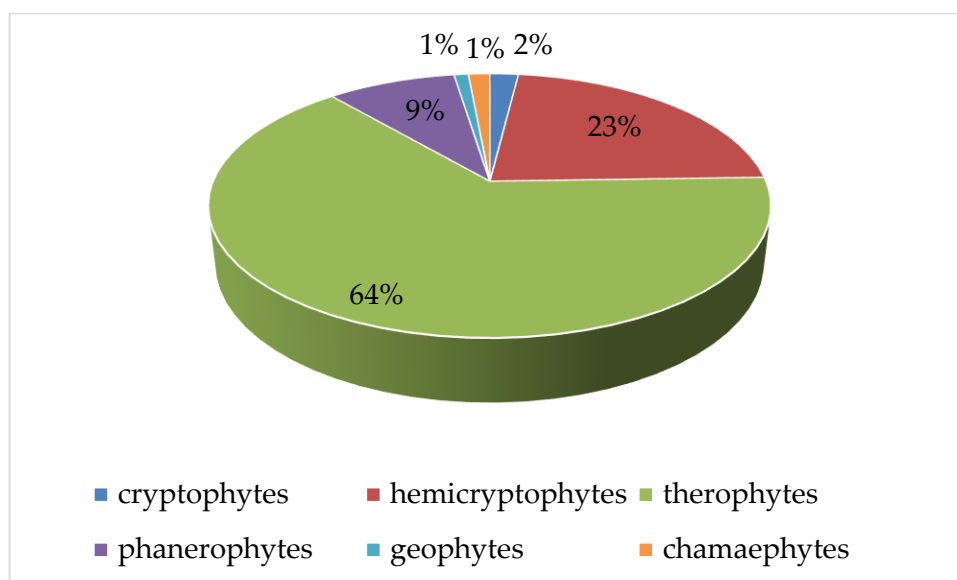


Fig. 1. Life-form spectrum of the alien urban flora of Ivano-Frankivsk

Growth-form analysis according to the classification of I.G. Serebryakov (1962) showed that the alien flora is predominantly composed of herbaceous plants — 182 species (90,1%), with the majority represented by annuals (105 species) (Table 2). The second largest group consists of perennial herbaceous polycarpic species (51 species). The third group includes biennial and perennial monocarpic species. The number of woody plants in the studied flora is relatively small — 20 species. The ratio of woody to herbaceous plants is 1:9.

Table 2. Growth-form analysis of the alien urban flora of Ivano-Frankivsk

Biomorph		Number of species	% of total
Lianas		4	2,0
Herbaceous polycarpics		51	25,2
Woody plants	Trees	10	5,0
	Shrubs	6	3,0
Herbaceous monocarpics	Annuals	105	52,0
	Perennials or biennials	26	12,8

In the vegetation-type spectrum, summer-green plants dominate, comprising 177 species (87,6%) (Fig. 2). Examples include *Amaranthus albus* L., *Galinsoga parviflora* Cav., *Lonicera tatarica* L., and *Spergula arvensis* L. The second-largest group consists of species with spring-summer-green vegetation, represented by 16 species (7,9%). Most of these species belong to the family Brassicaceae, which is characterized by a short life cycle (*Brassica rapa* L., *Erysimum cheiranthoides* L., *Lunaria annua* L., *Thlaspi arvense* L.). Species with winter-green and spring-summer-autumn-green vegetation types each account for 4 species. The spring-green vegetation type is represented by a single species (0,5%) (Fig. 2).

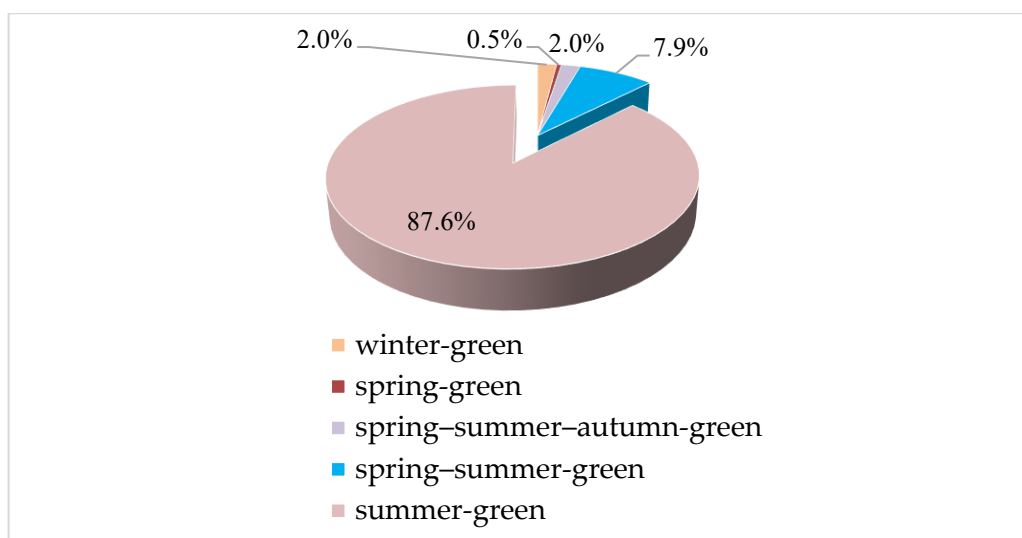


Fig. 2. Vegetation-type spectrum of the alien urban flora of Ivano-Frankivsk

An important biomorphological characteristic reflecting the ecological conditions under which the flora develops is the type of aerial shoot structure. In the studied alien fraction of the flora, non-rosette species dominate, comprising 139 species (69%) (Fig. 3). Examples include *Agrostemma githago* L., *Atriplex tatarica* L., *Trifolium hybridum* L., and *Leonurus cardiaca* L.

The second largest group consists of semi-rosette plants — 48 species (24%). Representative examples include *Bromus tectorum* L., *Avena sativa* L., *Hordeum vulgare* L., *Aethusa cynapium* L., and *Artemisia annua* L. The least numerous group comprises rosette plants, with 15 species (7%), including *Cichorium intybus* L., *Onopordum acanthium* L., *Sonchus arvensis* L., and *Diploaxis tenuifolia* (L.) DC.

The predominance of non-rosette and semi-rosette species in the alien flora is associated with the similarity between the ecological conditions in their primary ranges and those at their sites of introduction.

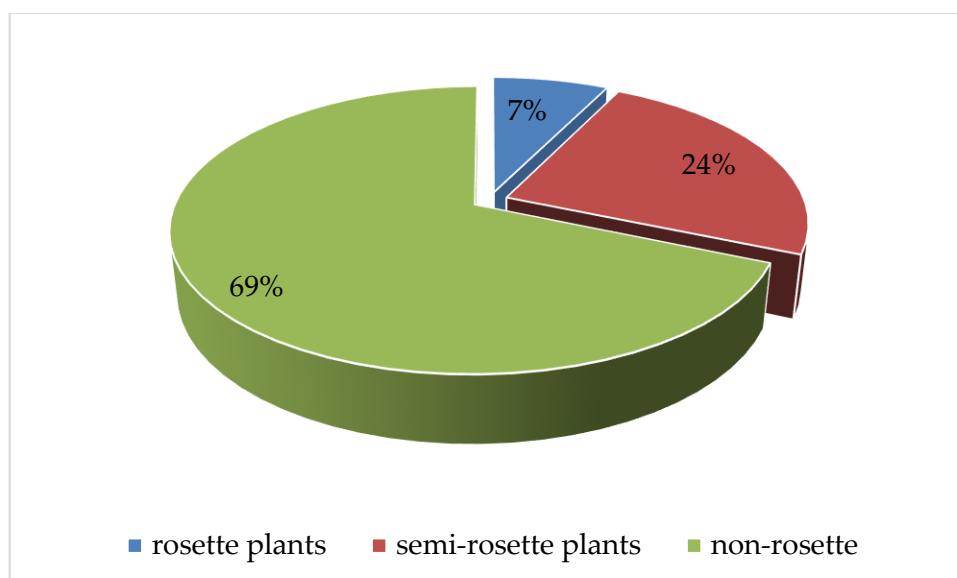


Fig. 3. Aboveground shoot types of alien species in the urban flora of Ivano-Frankivsk

The characteristics of the root system most clearly reflect hydrological conditions and substrate properties, including the degree of anthropogenic transformation, which is expressed in the proportion of species with different root-system morphologies. In the studied alien flora, species

with a taproot system clearly dominate, accounting for 81%. Examples include *Acer negundo* L., *Cotinus coggygria* Scop., *Orlaya grandiflora* (L.) Hoffm., *Matricaria chamomilla* L., *Brassica napus* L., and others. Species with a fibrous root system are much less common (14%), represented by *Bromus arvensis* L., *Panicum miliaceum* L., *Digitaria sanguinalis* (L.) Scop., *Hordeum murinum* L., among others. The least numerous group consists of species with a mixed taproot–fibrous root system (5%) (Fig. 4).

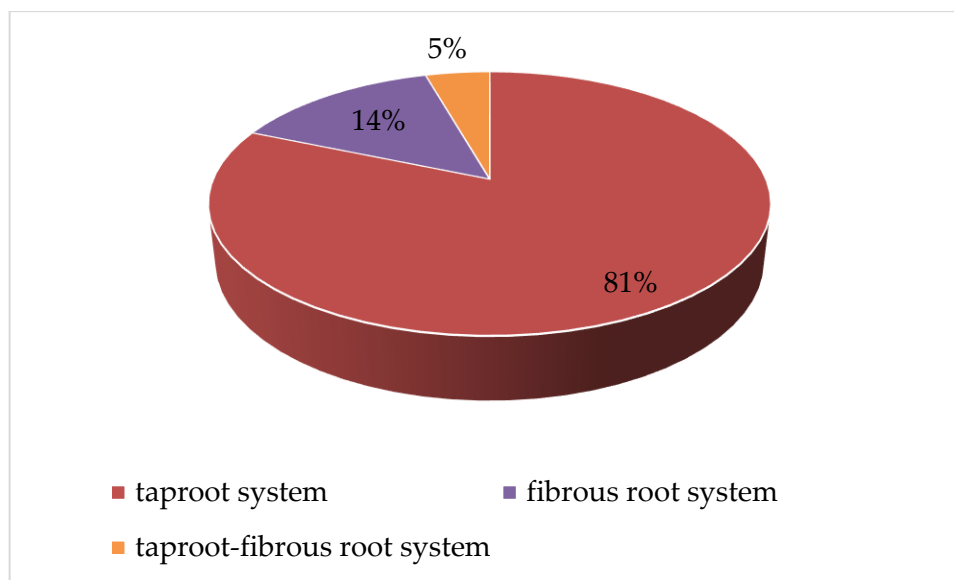


Fig. 4. Root-system spectrum of the alien urban flora of Ivano-Frankivsk

The interaction of plant organisms with the environment is commonly characterized by the response of species to specific environmental conditions, expressed as ecological factors. We conducted an ecological analysis of the alien fraction of the flora of Ivano-Frankivsk based on three ecological factors: light, moisture, and soil fertility (Table 3).

The results showed that, in terms of adaptation to light, heliophytes predominate, comprising 134 species (66%). These are plants of open habitats such as meadows, slopes, and roadsides along railways and highways. Examples include *Echinochloa crus-galli* (L.) P. Beauv., *Amaranthus albus* L., *Artemisia annua* L., and *Calendula officinalis* L. The second-largest group consists of sciophyte–heliophyte species, represented by 52 species (26%). These taxa exhibit broad ecological plasticity and are adapted to semi-open ecotopes, e.g., *Hemerocallis fulva* (L.) L., *Anethum graveolens* L., *Conium maculatum* L., and *Galinsoga parviflora* Cav. The least numerous group comprises helio-sciophytes, with 16 species (8%), including *Acer negundo* L., *Orlaya grandiflora* (L.) Hoffm., *Impatiens parviflora* DC., and *Lonicera tatarica* L. (Table 3).

Among hygromorphs in the studied flora, xeromesophytes dominate, accounting for 85 species (42%), such as *Bromus tectorum* L., *Cenchrus americanus* (L.) Morrone, *Amaranthus caudatus* L., and *Asclepias syriaca* L. The second and third positions are occupied by mesophytes (68 species, 34%) and mesoxerophytes (23 species, 11%). Typical mesophytes include *Conium maculatum* L., *Helianthus tuberosus* L., *Brassica napus* L., and *Saponaria officinalis* L. Mesoxerophytes are represented by *Atriplex sagittata* Borkh., *Elaeagnus angustifolia* L., *Lathyrus tuberosus* L., and *Marrubium vulgare* L. The remaining ecological groups are less numerous, comprising 2–7 species each (Table 3).

Table 3. Ecological spectrum of the alien urban flora of Ivano-Frankivsk

Ecological groups	Number of species	% of total
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Ecological spectrum according to light requirements:		
Heliophytes	134	66
Heliosciophytes	16	8
Scieliophytes	52	26
Ecological spectrum according to moisture requirements		
Xerophytes	7	3
Subxerophytes	2	1
Xeromesophytes	85	42
Mesoxerophytes	23	11
Submesophytes	8	4
Mesophytes	68	34
Hygromesophytes	5	3
Hygrophytes	4	2
Ecological spectrum according to soil fertility		
Mesotrophs	118	58
Eutrophs	81	40
Oligotrophs	3	2

Plant–environment interactions are commonly characterized through the reaction norm of species to specific ecological factors. We conducted an ecological analysis of the alien fraction of the flora of Ivano-Frankivsk based on three ecological factors: light, moisture, and soil fertility (Table 3).

With respect to substrate trophicity, three ecological groups are distinguished: eutrophs, mesotrophs, and oligotrophs. Trophic status is defined by the synecological optimum associated with a particular level of soil nutrient availability. Our study revealed that mesotrophs dominate, comprising 118 species (58% of the total). Examples include *Amaranthus albus* L., *Orlaya grandiflora* (L.) Hoffm., *Coreopsis grandiflora* Hogg ex Sweet, *Lactuca serriola* L., and *Erigeron annuus* (L.) Desf. These species have moderate nutrient requirements and are capable of growing on soils with a relatively wide range of nutrient availability.

The second largest group consists of eutrophs — 81 species (40%), which develop normally on nutrient-rich soils. Representative examples include *Onopordum acanthium* L., *Rudbeckia laciniata* L., *Sonchus asper* (L.) Hill, and *Impatiens parviflora* DC. The least numerous group comprises oligotrophs, with 3 species (2%) (Table 3).

4. Conclusions

Alien species in the urban flora of Ivano-Frankivsk demonstrate considerable taxonomic and ecological diversity, reflecting general patterns characteristic of urban floras. The leading families (Asteraceae, Brassicaceae, and Poaceae) and certain genera (*Amaranthus*, *Vicia*) are well represented in the alien flora, indicating their considerable capacity for naturalisation and establishment in urban habitats. An important feature of the species composition is the substantial proportion of monotypic families and genera, highlighting the specificity of introduction processes and the formation of the urban flora.

Life-form analysis revealed a high proportion of therophytes (64% of the total number of species) and herbaceous monocarpic plants (64.8%). The most frequent traits included summer-green vegetation, taproot systems, and non-rosette aerial shoots. Ecological grouping further indicated the dominance of heliophytes, xeromesophytes, and mesotrophs, consistent with the adaptation of alien species to the stressful conditions of urban environments. The prevalence of annual herbaceous plants highlights their competitive ability in dynamic urban ecosystems.

Overall, the results not only characterise the structural and ecological features of alien species in the city but also provide insights into the processes of alien species establishment and spread within urban landscapes. These findings provide a basis for biodiversity monitoring, conservation measures, and the development of ecological management strategies for urban areas.

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Research involving human participants and/or animals. Not applicable.

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Наталія Прокопів, Мирослава Миленка. Чужорідні види в урбанофлорі Івано-Франківська: таксономічний склад, життєві форми та екологічний аналіз. Журнал Прикарпатського національного університету імені Василя Стефаника. Біологія 13. 52-61.

Анотація

У дослідженні здійснено комплексну еколого-біологічну оцінку адвентивного компоненту урбанофлори Івано-Франківська (Україна). Складено конспект адвентивних видів та проведено їхню таксономічну класифікацію за родинами й родами; види віднесено до випадкових, натуралізованих та інвазійних відповідно до міжнародної термінології інвазійної біології (*sensu* Pyšek et al., 2004).

Адвентивна фракція включає 202 види, що належать до 143 родів і 48 родин, серед яких найбільш представленими є *Asteraceae* (21,8%), *Brassicaceae* (10%) та *Poaceae* (8,4%). Найбільше видове багатство виявлено у родах *Amaranthus* та *Vicia*. Аналіз форм росту показав переважання однорічних трав'янистих рослин, тоді як класифікація життєвих форм за Раункієром засвідчила домінування терофітів та гемікриптофітів.

Екологічне групування виявило перевагу геліофітів, ксеромезофітів та мезотрофів, що відображає адаптацію адвентивних видів до умов міського середовища. Отримані результати забезпечують структурну та екологічну характеристику адвентивної флори Івано-Франківська й створюють основу для моніторингу біорізноманіття, планування заходів зі збереження та розробки стратегій екологічного менеджменту міських екосистем.

Ключові слова: чужорідні види, систематичний аналіз, життєва форма, біоекологічна оцінка, урбанофлора, біорізноманіття, Івано-Франківськ.