sciendo

Environmental & Socio-economic Studies

environ ses

DOI:10.2478/environ-2025-0008

Environ. Socio.-econ. Stud., **2025, 13, 2: 13-20**

Original article

Invertebrate higher taxa diversity in managed and unmanaged green spaces in the urban environment of Metropolis GZM (Poland)

Aleksandra Poźniak[1,2], Wiktoria Kowolik[1,2], Anna Hibszer[1,2], Jakub Linnert[,2], Natalia Linnert[1,2], Michał Olesiński[1,2], Łukasz Depa[1] *

[1]University of Silesia in Katowice, Faculty of Natural Sciences, Institute of Biology, Biotechnology and Environmental Protection, Bankowa Str 9, 40-007, Katowice
[2]Students' Scientific Association "Faunatycy", University of Silesia in Katowice, Bankowa Str 9, 40-007, Katowice
*E–mail address (*corresponding author): lukasz.depa@us.edu.pl*
ORCID iD: Aleksandra Poźniak: https://orcid.org/0009-0006-4724-6384; Wiktoria Kowolik: https://orcid.org/0009-0001-4767-4120; Anna Hibszer: https://orcid.org/0009-0000-4011-0026; Jakub Linnert: https://orcid.org/0009-0009-6876-8933; Natalia Linnert: https://orcid.org/0009-0006-4140-1881; Michał Olesiński: https://orcid.org/0009-0006-5248-9524; Łukasz Depa: https://orcid.org/0000-0003-4204-5568

ABSTRACT

The issue of urban biodiversity is an extensively studied subject due to the tremendous loss of biological diversity worldwide. Increasing urbanisation affects local habitats through various mechanisms and has become a point of interest in urban planning and biodiversity conservation. It seems that the preservation of green spaces in cities may at least slow the process ofthe loss of biological diversity. Here, we present the results of our study aiming at finding differences in the diversity of high-level invertebrate taxa (HTA) in various types of urban green spaces in the cities of heavily industrially transformed municipalities of Metropolis GZM in southern Poland. Invertebrate diversity was recorded through pitfall trapping in flower beds, lawns, woodland parks, unmanaged shrubbery and unmanaged lawns in vacant lots with abandoned management. The results indicate a relatively uniform diversity of studied habitats, with significant differences between managed and unmanaged lawns, the latter being significantly more diverse. Results indicate that the reduction of mowing and cutting of urban lawns may increase local diversity and serve as a more economical contribution to creating urban meadows.

KEY WORDS: sustainability, environmental degradation, urban ecology, fauna, Insecta, Mollusca, Gastropoda, Arachnida

ARTICLE HISTORY: received 1 April 2025; received in revised form 3 June 2025; accepted 6 June 2025

1. Introduction

Maintenance and recovery of biodiversity in areas transformed by human activity is an ongoing goal of conservation biology and sustainable development. The importance of urban areas is increasing as they continue to rise worldwide (Güneralp & Seto, 2013; Barrico & Castro, 2016; Fenoglio et al., 2021). The process of urbanization comprises not only the significant transformation of existing natural habitats but also their destruction, leading to the creation of human-made, artificially planned and managed greenery. This leads to a general decrease in animal species diversity in cities (Shochat et al., 2010). Fauna of cities is additionally impacted by the effect of urban heat islands, pollution of the environment, reduced resources, and migration barriers for species attempting to settle in high buildings and streets (FENOGLIO ET AL., 2021). Managed urban greenery does not provide sufficient resources for many species, as it is artificially sown or planted with poorly selected and non-indigenous plant species. This further limits access to appropriate food plants for many herbivorous animals, which managed to settle and utilise urban habitats. Management practices (e.g. mowing, cutting) only worsen the habitat heterogeneity (FRANCOEUR ET AL., 2021; WINKLER ET AL., 2024).

The area of Metropolis GZM (Górnośląsko-Zagłębiowska Metropolia) in the region of Upper Silesia in southern Poland is one of the most heavily transformed regions of Europe. Since the 19th century, this region has been a place of constant deforestation and mining due to its rich ore deposits and coal fields. Exploitation of these resources has resulted in heavy industrialisation, landscape transformation and urbanisation (PANCEWICZ ET AL., 2022). This region consists of many contiguous cities, which nowhave a surface of 2554 km^2 and are inhabited by more than 2.2 million people. Large green spaces cover industrially transformed post-mining locations within city centres and are often subject to intense management practices, except for vacant and abandoned lots (parcels), which are mostly unmanaged and undergoing spontaneous succession (DUŚ, 2013). Such lots with unmanaged green spaces seem to be a much better habitat for invertebrates due to more fecund vegetation, providing more protection against environmental factors, hiding places and more variable nutritional resources (PERRY ET AL., 2021). In some cases, such environments may resemble urban meadows – the increasingly suggested type of urban habitat for keeping species diversity in urban zones (ROBINSON & LUNDHOLM, 2012). Due to the expected high number of collected specimens and moderate availability of specialised taxonomists, we decided to apply a higher taxa approach (HTA) (SOUZA DE OLIVEIRA ET AL., 2020) to evaluate terrestrial invertebrate diversity in the environments of green spaces of GZM. The aim of the study was to as certain if managed and unmanaged greenery in cities of GZM differ in terms of their biodiversity at the level of higher invertebrate taxa and verify if reducing management positively affects the invertebrate diversity in urban areas.

2. Materials and methods

Study plots were assigned in five cities belonging to the Metropolis GZM (Górnośląsko-Zagłębiowska Metropolia) in the Silesian voivodeship in southern Poland: Bytom (50.345912, 18.930496), Katowice (50.267897, 19.014329), Chorzów (50.294898, 18.955337), Sosnowiec (50.283022, 19.105599) and Tychy (50.128347, 18.982288). All of the study plots were located in the proximity of the central and most densely built-up parts of the cities (following www.geoportal.gov.pl). In each of the cities, five types of green spaces/environments were chosen for study:

1. lawn – usually regularly mown a few times during vegetational season, not irrigated;
2. flower bed – regularly managed area planted with ornamental, usually herbaceous plants each year, but sometimes also with perennial woody plants, occasionally irrigated;
3. park – typical city park, with usually relatively young trees aged 30–70 years, with regularly mown and raked ground cover, not irrigated;
4. unmanaged shrubs – an unmanaged (abandoned or neglected) area of a vacant lot that was once inhabited but is now overgrown by shrubs and small trees, not irrigated;
5. unmanaged lawn – the lawn where the practice of mowing has been neglected or abandoned, often consisting of herbaceous perennials and very small shrubs and seedlings, not irrigated; study sites of this type of habitat did not comprise purposely established flower meadows or urban meadows, only urban lawns with abandoned management.

We were unable to assign the flora of study plots to any defined phytosociological taxa, as they represented either human-composed sets of species or were under intense succession with significant influence of invasive plant species such as *Solidago Canadensis* and *Reynoutria* spp. Only the flora of mown lawns was similar to the *Lolio-Polygonetum* plant association.

A total of 25 plots were assigned to the study (5 cities x 5 study plots; 5 plots of each vegetation type). Pitfall traps (also called Barber traps) of 6 cm in diameter were used with a mixture of a 30% water solution of ethylene glycol, 10% glycerol, and a drop of scentless detergent to collect invertebrates (about 80 ml of solution per pitfall trap). This solution had a neutral odour, and was chosen so that it did not bait any particular group of animals. They were set four times for seven days, on the following dates: 2026 May 2024, 17-23 June, 22-28 July and 26 August – 1 September 2024 (a total collection period of 28 days). The pitfall traps were placed in the ground, with an opening at the soil level,and a single pitfall trap per study plot. A total of 100 pitfall traps were sited, but six pitfall traps were destroyed or unintentionally removed during the study, so the results are presented for 94 traps. This method of collection was chosen because it was a single uniform method applicable to all our studied habitats. Moericke traps, e.g. were not applicable on lawns, while an entomological sweep net would be difficult to use in parks with scarce vegetation. Additionally, pitfall traps were least susceptible to destruction and could also collect animals strongly connected with the studied environment, with a low possibility of catching accidental species.

The collected specimens were removed from traps in the laboratory, determined to a higher taxonomic rank, and preserved in 70% ethanol for further analysis. Material (collected specimens) is deposited in the zoological collection of the Institute of Biology, Biotechnology and Environmental Protection of the University of Silesia in Katowice.

Collected specimens of invertebrates were counted and identified to the higher taxonomical ranks of phylum (type), class (e.g. Araneae, Diplopoda), or order (within Insecta). The taxa were then assigned to functional groups (organisms that perform similar tasks in the environment) based on literature data (e.g., STORK, 1987, MARASAS ET AL., 2001, KWON ET AL., 2013) and general characteristics of groups available in taxonomic and faunistic literature. The analysis comprised a sum of the collected specimens per study plot throughout the whole study period. For analysis, we used a sum of specimens of each recorded taxon. Because different feeding strategies provide different ecosystem services, taxa were grouped according to their feeding modes and requirements into omnivores, detritivores, carnivores, phloem feeders, foliage feeders (foliophages), and pollinators. Some of the taxa were simultaneously assigned to a few groups.

Statistical analysis comprised diversity coefficients and evenness (Simpson's, Shannon's, Brillouin's) for each type of studied green space were calculated using MVSP software (Kovach Computing Services). To compare the similarities between the studied habitats, we applied cluster analysis with the UPGMA method based on Simpson's coefficient and Principal Component Analysis for determining taxa distribution by MVSP. Statistical analyses comprised Welch's T-test performed by STATISTICA ver.13.3 package by StatSoft, Inc.

3. Results

During the study, a total of 4282 specimens of invertebrates were collected, representing a total of 24 higher taxa (Table 1). The most abundant were representatives of Collembola – 1452 specimens, followed by Hemiptera – 814 specimens, and Diptera – 356 specimens. The least abundant were Trichoptera and Mantodea, represented only by single specimens.

The number of recorded taxa per sample ranged between 2 and 14, with a mean of 7.94. The number per study plot ranged from 6 to 16, with a mean of 9.64. The mean number of recorded taxa per studied habitat was highest in unmanaged shrubs, with a mean value of 12.4 and lowest in lawns, 10.4 (Fig. 1). However, the difference between them was not statistically significant (Welch's T-test $T = -1.4825$, $df = 5.8595$, $p = 0.1899$).

The species diversity coefficients of the studied types of habitatare presented in Table 2. In general, the highest values of diversity were found in unmanaged lawns, while the lowest was in managed lawns. There was a statistically significant difference between the values of the diversity coefficient for lawns and unmanaged lawns (Welch's T-test $T = -3.034$, $df = 18$, $p < 0.01$) and flower beds and unmanaged lawns ($T = -2.662$, $df = 18$, $p < 0.05$).

Similar differences were also found with evenness indices, with unmanaged lawn having the highest values (Fig. 2), with statistically significant differences between lawns and flower beds (Welch's T-test: $T = -3.51$, $df = 28$, $p < 0.005$ and $T = -2.317$, $df = 28$, $p < 0.05$, respectively).

Cluster analysis based on the Simpson's coefficients of the recorded fauna revealed the presence of two types of habitat: one rich in woody plants (unmanaged shrubs and park) and the second based on herbaceous plants (unmanaged lawn, lawn and flower bed) (Fig. 3). Principal Component Analysis (PCA) allowed us to identify taxa connected with the two types of studied habitats (Fig. 4). Within the environments of managed urban greenery (flower beds, parks and lawns), we could observe several dominant orders of insects (Hymenoptera, Hemiptera, Diptera, Coleoptera, Collembola) but also arachnids (Araneae, Acari). The unmanaged greenery was represented by the presence of isopods and snails (Isopoda, Gastropoda).

Table 1. Total number of recorded taxa and specimens in the studied environments

Taxa	Specimens in the studied environment					Total
	Flower bed	Lawn	Park	Unmanaged shrubs	Unmanaged lawn	
Gastropoda	26	1	6	108	17	158
Nematoda	0	0	1	1	0	2
Oligochaeta	2	0	0	0	6	8
Isopoda	20	3	3	288	8	322
Acari	32	116	52	16	45	261
Opilliones	4	1	23	5	4	37
Araneae	24	23	21	39	72	179
Pseudoscorpiones	0	1	1	0	0	2
Diplopoda	2	0	0	0	2	4
Chilopoda	1	0	0	1	0	2
Collembola	355	193	577	96	231	1452
Coleoptera	42	43	29	39	65	218
Dermaptera	1	4	13	8	6	32
Diptera	60	81	87	49	79	356
Hymenoptera	97	51	37	99	63	347
Hemiptera	48	573	47	66	80	814
Lepidoptera	1	0	0	4	0	5
Psocoptera	4	6	5	6	3	24
Blattodea	2	4	0	0	0	6
Orthoptera	1	4	0	0	6	11
Thysanoptera	6	6	1	17	8	38
Siphonaptera	0	0	0	1	1	2
Trichoptera	1	0	0	0	0	1
Mantodea	0	0	0	0	1	1
Total no. of specimens	729	1110	903	843	697	4282
Total no of taxa	20	16	15	17	18	

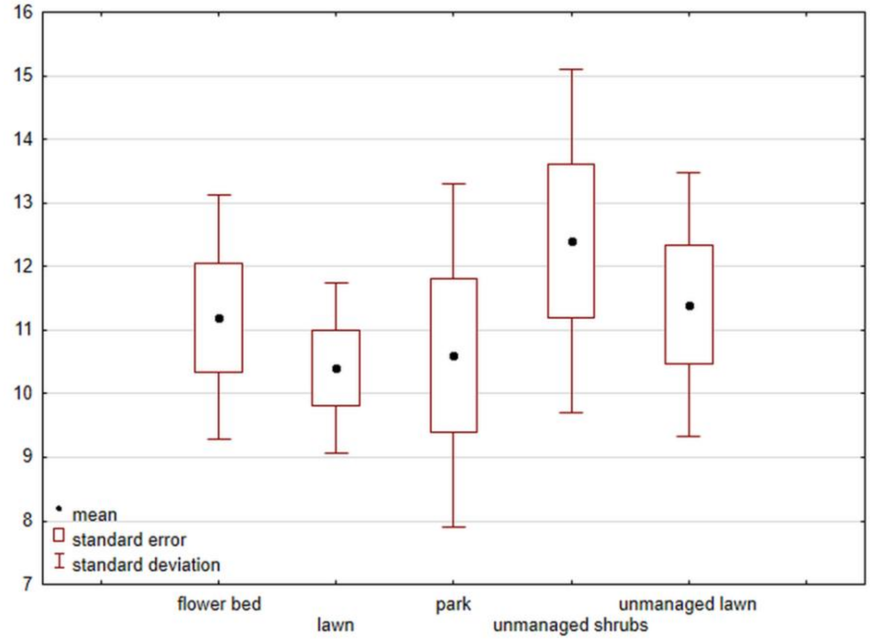

Fig. 1. Mean number of recorded taxa per studied type of environment

Table 2. Mean values of species diversity coefficients in the studied environments

Studied environments	Simspon's		Shannon's		Brillouin's	
	coefficient	evenness	coefficient	evenness	coefficient	evenness
Flower bed	0.709	0.795	1.611	0.722	1.413	0.716
Lawn	0.630	0.709	1.427	0.648	1.312	0.641
Park	0.687	0.778	1.582	0.728	1.409	0.724
Unmanaged shrubs	0.665	0.734	1.597	0.672	1.464	0.664
Unmanaged lawn	0.793	0.885	1.839	0.813	1.677	0.811

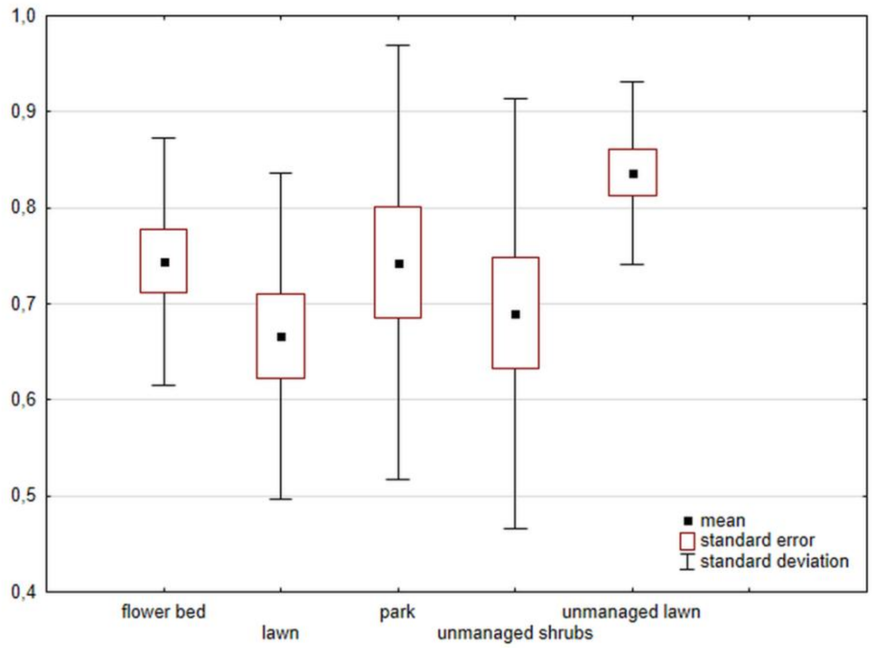

Fig. 2. Mean values of evenness indices in the studied types of environment

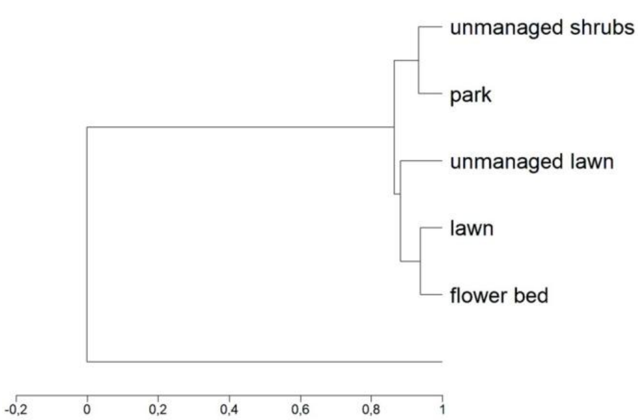

Fig. 3. Results of cluster analysis of invertebrate fauna in the studied types of environments based on Simpson's coefficient with the UPGM method

The differences in management practices or their absence are markedby the composition of invertebrate functional groups in the studied environments (Fig. 5). The abundance of pollinators in the flower bed is comparable with that in unmanaged greenery and higher than in lawns and parks. The lawn is especially rich in phloem-feeding insects, mainly Hemiptera (aphids and true bugs). Also, the abundance of particular functional groups was more evenly distributed in unmanaged greenery than in managed greenery, where one of the groups always dominated, e.g. detritivores in flower beds and parks and phloem feeders in lawns.

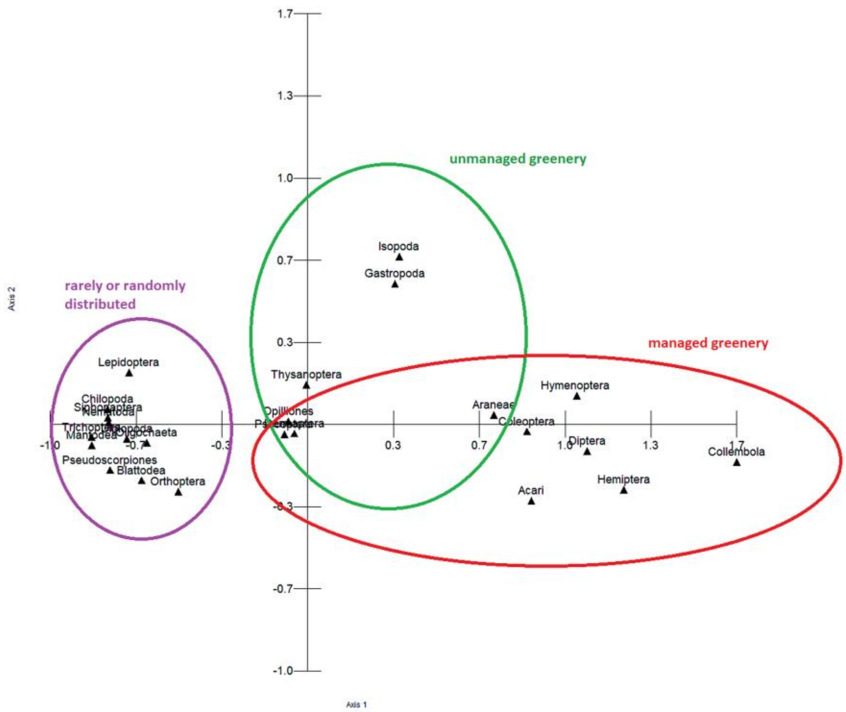

Fig. 4. PCA analysis of taxa recorded in the studied types of environments. Red and green circles indicate groups of species particularly abundant in two types of urban greenery; purple circles mark species of very low abundance, occurring accidentally or rarely in a few samples

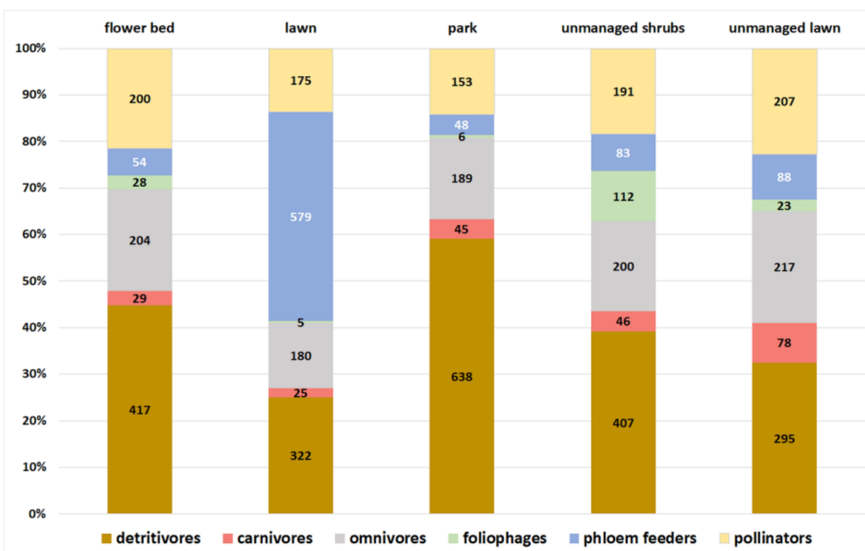

Fig. 5. Share of functional groups of invertebrates recorded in the studied types of environments (number indicates the total number of specimens belonging to a particular group in a particular type of environment)

4. Discussion and conclusions

The results indicated that there was no clear difference between invertebrate fauna in habitats belonging to managed and unmanaged urban greenery. The taxonomic composition of fauna in both types of habitats is relatively uniform, with representatives of all major groups of invertebrates. However, the following differences are yet observable:

First of all, the general composition of urban fauna indicates a lack of taxa related to water. The applied methods focused on terrestrial invertebrates, yet many flying insects were caught by pitfall traps, e.g. Hymenoptera, Diptera, and Hemiptera. No representatives of water-dependent insects from orders: Odonata, Ephemeroptera, Plecoptera and only a single specimen of Trichoptera were recorded (Table 1). Furthermore, taxa preferring at least partially or temporarily humid habitats such as Gastropoda and Isopoda, were noted from unmanaged habitats, with plant growth unlimited by pruning or mowing, thus better at retaining moisture near the ground through decreased insolation of the soil. Management activity decreases the cover of the soil and exposes it to sunlight, promoting evaporation (Trémeau et al., 2024). The observed pattern of occurrence of these two taxa was similar in domestic gardens along a rural-urban gradient in Basel, Switzerland (Braschler et al., 2020).

The type of vegetation affects the faunistic composition of invertebrate fauna, as indicated by cluster analysis (Fig. 3), which clustered habitats overgrown by woody plants (parks and unmanaged shrubs) separately from open habitats (managed and unmanaged lawns and flower beds). This is also supported by the presence of carnivores, which in unmanaged greenery and parks were more abundant than in lawns and flowerbeds (Fig. 5), with woody vegetation probably increasing habitat heterogeneity, beneficial for predators (Thomson & Hoffmann, 2013; Frey et al., 2018). However, other studies suggest that general landscape properties rather than garden characteristics influence urban biodiversity (Braschler et al., 2020). Our results are relatively uniform and, apart from mown and unmanaged lawns, indicate that the studied habitats provide similar living conditions for invertebrates, as shown by thesimilarity of recorded fauna.

The observed difference between flower beds, managed and unmanaged lawns regarding species diversity and evenness (Fig. 2) indicates how important the avoidance of management practices may be to preserve urban invertebrate diversity. The practice of mowing, performed several times during the season, poses a significant danger to local urban invertebrate fauna. It usually tends to maintain short-cut grass and is performed regardless of the flowering period of plants. This practice differs from extensive, traditional cutting of meadows, usually performed once or twice a year for hay. Intense mowing or cutting of an urban lawn causes a decrease in the presence of flowering stems and increases insolation, which, in conditions of urban heat islands, causes almost permanent drying of lawns (Wright et al., 2003). These factors are important in influencing the invertebrate fauna of such habitats (Norton et al., 2019). In unmanaged habitats, where the vegetation was less disturbed, we observed the distribution pattern of invertebrates closer to natural and evenness indices, higher than in managed habitats. While the number of taxa present in these habitats was not significantly higher, their distribution pattern was statistically significantly different. These habitatsmay be regarded as a form of spontaneous vegetation, which has also been found to have higher invertebrate richness and abundance (Robinson & Lundholm, 2012) and also more evenly abundant functional groups of invertebrates (Fig. 5).

A significant number of Hemipterans arefoundin the lawns studied. This insect order comprises many plant sap-sucking families (planthoppers, aphids, scale insects, psyllids, and many true bugs) which exploit the phloem of plants (phloem feeders, Fig. 5), especially those that are in worse physiological condition, e.g. cities (Luniak, 2008). Their vast amount within lawns marks the worse condition of the plants, resulting from mowing and dehydration stress. On the contrary, the high number of snails and slugs (Gastropoda) in unmanaged shrubs is in line withso far reported data concerning urban zones (Čiliak et al., 2024).

Our results clearly indicate that, especially in the case of urban lawns, intense management does not allow the occurrence of high biological diversity. This observation may be followed by a second one, that avoiding management of established urban lawns may easily lead to their transformation into urban meadows without the necessity of additional expenditures, being some of the factors preventing from setting urban meadows (Hoyle et al., 2017). While some studies have indicated that mowing decreases soil contamination from human activity (Manninen et al., 2010), our results indicate that an unmanaged grassland is a favourable habitat for more taxa than a mown one. In the case of pollinators, it has been documented that urban meadows based on special seed mixes consisting of indigenous plant species may serve as an additional resource (Heiniger et al., 2023). Our results strongly support the results of Chollet et al. (2018) that the reduction of management practices, especially the mowing frequency of urban lawns, positively contributes to biological diversity and asustainable urban environment.

References

Barrico L., Castro P. 2016. Urban Biodiversity and Cities' Sustainable Development. [in:] Castro P., Azeiteiro U., Bacelar-Nicolau P., Leal Filho W., Azul A. (eds), *Biodiversity*

and Education for Sustainable Development. World Sustainability Series, Springer, Cham: 29–42.
Braschler B., Gilgado J.D., Zwahlen V., Rusterholz H.-P., Buchholz S., Baur B. 2020. Ground-dwelling invertebrate diversity in domestic gardens along a rural-urban gradient: landscape characteristics are more important than garden characteristics. *PloS ONE*, 15, 10: e0240061.
Chollet S., Brabant Ch., Tessier S., Jung V. 2018. From urban lawns to urban meadows: reduction of mowing frequency increases plant taxonomic, functional and phylogenetic diversity. *Landscape Urban Planning*, 180: 121–124.
Čiliak M., Čejka T., Tej B., Oboňa J., Manko P. 2024. Species richness patterns and community structure of land snail communities along an urban-rural gradient in river floodplains. *Urban Ecosystems*, 27: 953–963.
Duś E. 2013. Allotment gardens and spatial development – two case studies from the Katowice conurbation, Poland. *Environmental & Socio-economic Studies*, 1, 4: 41–51.
Fenoglio M.S., Calviño A., González E., Salvo A., Videla M. 2021. Urbanisation drivers and underlying mechanisms of terrestrial insect diversity loss in cities. *Ecological Entomology*, 46, 4: 757–771.
Francoeur X.W., Dagenais D., Paquette A., Dupras J., Messier C. 2021. Complexifying the urban lawn improves heat mitigation and arthropod biodiversity. *Urban Forestry & Urban Greening*, 60: 127007.
Frey D., Vega K., Zellweger F., Ghazoul J., Hansen D., Moretti M. 2018. Predation risk shaped by habitat and landscape complexity in urban environments. *Journal of Applied Ecology*, 55, 5: 2343–2353.
Güneralp B., Seto K.C. 2013. Futures of global urban expansion: uncertainties and implications for biodiversity conservation. *Environmental Research Letters*, 8: 014025.
Heiniger C., Rochefort S., Prunier P. 2023. Floral resources used by bees in urban areas: the case of Geneva, Switzerland. *Frontiers in Ecology and Evolution*, 11: 1199438.
Hoyle H., Jorgensen A., Warren P., Dunnett N., Evans K. 2017. "Not in their front yard" The opportunities and challenges of introducing perennial urban meadows: a local authority stakeholder perspective. *Urban Forestry and Urban Greening*, 25: 139–149.
Kwon T.-S., Park Y.K., Lim J.-H., Ryou S.H., Lee C.M. 2013. Change of arthropod abundance in burned forests: different patterns according to functional groups. *Journal of Asia-Pacific Entomology*, 16: 321–328.
Luniak M. 2008. Fauna of the Big City—Estimating Species Richness and Abundance in Warsaw Poland. [in:] Marzluff J.M., Shulenberger E., Endlicher W., Alberti M., Bradley G., Ryan C., Simon U., Zum Brunnen C. (eds.), *Urban Ecology*. Springer US: Boston, MA, USA: 349–354.
Manninen S., Forss S., Venn S. 2010. Management mitigates the impact of urbanization on meadow vegetation. *Urban Ecosystems*, 13: 461–481.
Marasas M.E., Sarandón S.J., Cicchino A.C. 2001. Changes in soil arthropod functional group in a wheat crop under conventional and no tillage systems in Argentina. *Applied Soil Ecology*, 18: 61–68.
Norton B.A., Bending G.D, Clark R., Corstanje R., Dunnett N., Evans K.L., Graufius D.R., Gravestock E., Grice S.M., Harris J.A., Hilton S., Hoyle H., Lim E., Mercer T.G., Pawlett M., Pescott O.L., Richards J.P., Southon G.E., Warren P.H. 2019. Urban meadows as an alternative to short mown grassland: effects of composition and height on biodiversity. *Ecological Applications*, 29, 6: e01946.
Pancewicz A., Janikowska W., Tadla N., Wawrzonowska K. 2022. Revitalization of Degraded Areas and Facilities in the Cities of Core of the Metropolis GZM. *Architecture, Civil Engineering, Environment*, 15, 39–52.
Perry K.I., Hoekstra N.C., Culman S.W., Gardiner M.M. 2021. Vacant lot soil degradation and mowing frequency shape communities of belowground invertebrates and urban spontaneous vegetation. *Urban Ecosystems*, 24: 737–752.
Robinson S.L., Lundholm J.T. 2012. Ecosystem services provided by urban spontaneous vegetation. *Urban Ecosystems*, 15: 545–557.
Shochat E., Lerman S.B., Anderies J.M., Warren P.S., Faeth S.H., Nilon C.H. 2010. Invasion, competition, and biodiversity loss in urban ecosystems. *Bioscience*, 60, 3: 199–208.
Souza de Oliveira Jr. S., Ortega J.C.G., dos Santos Ribas L.G., Guimarães Lopes V., Bini L.M. 2020. Higher taxa are sufficient to represent biodiversity patterns. *Ecological Indicators*, 111: 105994.
Stork N.E. 1987. Guild structure of arthropods from Bornean rainforest trees. *Ecological Entomology*, 12: 69-80.
Thomson L.J., Hoffmann A.A. 2013. Spatial scale of benefits from adjacent woody vegetation on natural enemies within vineyards. *Biological Control*, 64, 1: 57–65.
Trémeau J., Olascoaga B., Backman L., Karvinen E., Vekuri H., Kulmala L. 2024. Lawns and meadows in urban green space – a comparison from perspectives of greenhouse gases, drought resilience and plant functional types. *Biogeosciences*, 21: 949–972.
Winkler J., Pasternak G., Sas W., Hurajová E., Koda E., Vaverková M.D. 2024. Nature-Based Management of Lawns—Enhancing Biodiversity in Urban Green Infrastructure. *Applied Sciences*, 14: 1705.
Wright D.A., Frost J.P., Patterson D.C., Kilpatrick D.J. 2003. The influence of weight of ryegrass per unit area and treatment at and after mowing on rate of drying. *Grass and Forage Science*, 52, 1: 86–98.