Urban forest oases and their ecological importance: A study on the biodiversity of the entomological fauna in the Regional Park of Groane

Francesco Patriarca[1], Augusto Loni[2], Silvia Baldo[3], Alessia Cacace[3], Daniela Lupi [1]
1 University of Milan, Defens, Via Giovanni Celoria, 2, 20133, Milano, Italy
2 Department of Agriculture, Food and Environment, Via del Borghetto, 80, 56124 Pisa, Italy
3 LIPU, Oasi, Via Don Orione 43, 20811 Cesano Maderno, Italy

Abstract
This study investigates the entomological diversity in an urban forested area. Despite the urbanized surroundings, the park, known as "Oasi LIPU," remains crucial for a variety of plant and animal species. In six sampling sites, pitfall traps were employed to monitor ground-dwelling insects, supplemented by visual observation. The app iNaturalist was used for a complete assessment. Statistical analyses, including CAP and Permanova, reveal distinct differences among the sampling sites. Nevertheless, biodiversity indices confirm the disturbance in the area. Regardless of these perturbations, the study highlights the key role of urban forested areas in conserving biodiversity, especially in protecting species listed as Vulnerable on the IUCN Red List of Italy.

Key words: monitoring, biodiversity index, wooden areas, ground beetles, rove beetles

Introduction
Anthropic activities have severely affected biodiversity, especially in developed countries with high population densities and fragmented landscapes (Rands et al., 2010). In Europe, deciduous forests were originally the most prevalent habitat (Wermelinger, 2021). Today, we face fragmented landscapes, where initiatives to create complex ecological networks are crucial to support the EU Habitat Directive and the Natura 2000 network (Muys et al., 2022). However, European forests and woods remain crucial for sustaining soil fauna, harbouring numerous species of microorganisms, fungi, annelids, nematodes, and arthropods (Muys et al., 2022). In densely urbanised areas, woods can play a vital role in the safeguards of biodiversity and help preserve from further losses (Lupi et al., 2023). This study aims to improve the knowledge of entomological biodiversity inhabiting forest wood inside the Regional Park of Groane, known as "Oasi Lipu," positioned close to urbanised areas.

Material and Method
Insect biodiversity was inspected, primarily focusing on Coleoptera collected in pitfall traps, implemented by regular visual observations of insects on vegetation and the information acquired from iNaturalist (a citizen science platform for naturalists).

Study area
The study was conducted in the Groane Regional Park (25 km north-west of Milan, Italy), specifically in the "Oasi LIPU di Cesano Maderno", a natural park under regional law. It covers about 100 hectares of woodland, heathland and wetlands close to a heavily urbanised and industrialised area (Ballabio, 2011). Soil-dwelling insects' diversity was investigated in six sampling sites (a, b, c, d, e, f) within the wooded area of the Oasis. The chosen sampling zones highlight a diverse array of ecological characteristics, ranging from wooded areas populated by Robinia trees to humid and stagnant regions, further distinguished by the presence of artificial ponds.

Sampling and identification.
Soil-dwelling insects were monitored using pitfall traps (Ø: 60 mm, 100 ml) baited with 50 ml of white wine vinegar supplemented with 15 g of salt and covered with a tile to limit rainwater ingress and allow access to specimens. Three traps at a distance of 3-10 m (Hohbein et al., 2018) were placed at each site and were checked and emptied twice a month with an interval of 7-10 days. In total, 126 samples were collected (3 traps per 6 sites per 7 surveys) during the whole collection period from May to September 2022. At each sampling event, traps were emptied and bait replaced. Trap contents were transferred in vials with ethanol 70% (*v*/*v*) and stored in a freezer until classification. Furthermore, insect biodiversity was inspected by regular visual observations on vegetation with the help of iNaturalist app. Various keys were employed for insect classification to identify all collected specimens, and specialists were consulted when needed. All iNaturalist data underwent thorough verification, and any incorrect or unclear identifications were excluded.

Data Analysis
Data were analysed using Statistical Multivariate Analysis. Samples were organised in a raw data matrix reporting an array of rows (beetle species) and columns (all the trap samples). To reduce the right-skewed distribution of the species assemblage and to down-weight the most abundant species, the raw data were log-e transformed (Clarke and Warwick, 2001). Differences or similarities in insect assemblages between sites were visualised using Canonical Analysis of Principal Components (CAP). The axes that best discriminate the 'a priori' groups of site samples were first identified. On this two-dimensional ordination, the vectors of the beetle species variables were overlaid. The vectors of the beetle species variables were superimposed on this two-dimensional ordination. Permanova Analysis was then used to find significant differences in the sites. A two- factor design was applied to the "site" fixed design adopting a "sequential" sum of squares of type I. Sørensen's index was then used to examine similarities between the sites. Biodiversity indices (Margalef, Shannon-Wiener, Evenness and Simpson indices) were then calculated using the six different sites as variables.

Results and discussion

The checklist included 198 species. Two Odonata, *Sympetrum sanguineum* (Müller, 1764) and *Sympetrum depressiusculum* (Sélys, 1841), are categorised respectively as Vulnerable (C1) and Vulnerable (A2C+3C+4C), according to the IUCN Red List of Italy, while other 39 species were included in the IUCN Red List of Italy, as Least Concern.

Pitfall traps allowed to collect 211 specimens belonging to 20 distinct species of Coleoptera. *Ocypus olens* (Müller, 1764), *Abax continuus* (Ganglbauer, 1891), and *Nebria brevicollis* (Fabricius, 1792), resulted as dominant species accounting for 60% of the collection.

The CAP analysis, based on the "Site" factor, clearly distinguishes site "*c*" from others along the first axes. The substantial canonical correlations of $\delta_1 = 0.7$ and $\delta_2 = 0.5$ affirm a strong association between multivariate data and the hypothesis of group differences (Fig. 1).

Pseudoophonus rufipes (De Geer, 1774) is the species correlated with site *c* and *d*, while *Platynus assimilis* (Paykull, 1790)*, Carabus coriaceus* (Linnaeus, 1758) and *Notiophilus rufipes* (Curtis, 1829) resulted correlated with site *d*. *Ocypus olens* (Müller, 1764) is positively correlated with site *e*. Permanova results well matched with the graphical representation, showing significant differences from site *b* vs *c* (p 0.002), *b* vs *d* (p 0.005), *c* vs *d* (p 0.005), *c* vs *e* (p 0.005), *c* vs *f* (p 0.01), *d* vs *e* (p 0.001), *d* vs *f* (p 0.006).

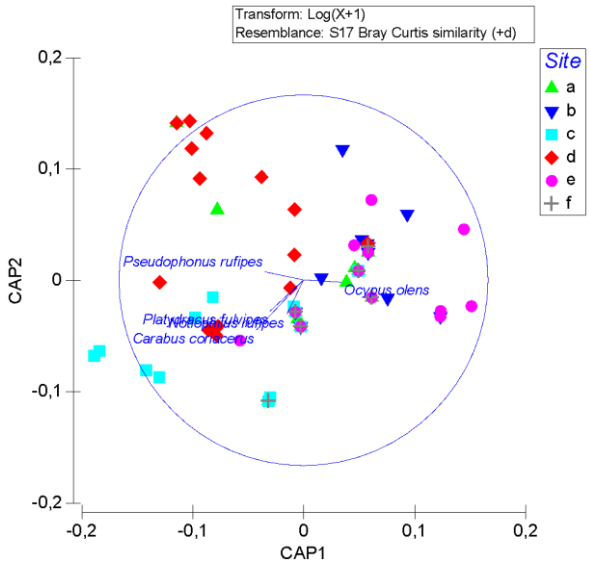

Fig. 1. Differences among localities according to PCO ordination on data of trap samples (blue arrows represent the overlaying of vectors of the species variables).

In the matrix in Fig. 2 the sites with the highest similarity are respectively *a* and *f*, *e* and *b*, with a value of about 0.7. These sites are followed by *d* and *b*, *d* and *c*, *e* and *c*, and *f* and *e* also show a similarity with a value around 0.5. The largest distances are between sites *f* and *d*, and *c* and *b*, with a value of 0.3.

SØRENSEN INDEX	a					
a	1	b				
b	0.35	1	c			
c	0.38	0.31	1	d		
d	0.47	0.50	0.52	1	e	
e	0.43	0.70	0.50	0.47	1	f
f	0.72	0.43	0.46	0.28	0.55	1

Fig. 2. Differences among localities according to Sørensen's index on data of trap samples.

In Tab. 2, all sites show low values of the Margalef index (Magurran, 1988), with site *b* standing out with a value of 2.4. On the other hand, site *f* has the lowest value, only 1.1, indicating a lower species diversity. This difference is also confirmed by the Shannon-Wiener index, where site *f* has the lowest value (1.0). Sites *d* and *e*, on the other hand, stand out for greater equal distribution of species, with an Evenness score of 0.9, indicating a uniform distribution of species. The Simpson index shows good values in all sites.

Tab. 2. Biodiversity indices for the six different sampling sites in the "Oasi" on data of trap samples.

SITES	BIODIVERSITY INDICES			
	D	H'	λ	S

a	1.8	1.6	0.8	0.2
b	2.4	1.5	0.7	0.3
c	2.1	1.6	0.7	0.2
d	2.3	2.0	0.9	0.1
e	1.9	1.8	0.9	0.2
f	1.1	1.0	0.7	0.4

Conclusions

The CAP analysis and Sørensen's index both confirmed significant differences between sampling sites, providing robust evidence of distinct ecological areas in the oasis. The biodiversity indices clearly indicate that the environment is disturbed (Hussain et al., 2012), despite some sites exhibiting higher species richness and equal distribution values (as seen in sites *d* and *e*). The lower diversity and even distribution observed in the other sites suggests a level of disturbance in the ecosystem analysed (Magurran, 1988).

Anyway, despite the surrounding urban development, these oases still play a crucial role as vital refuges, supporting a wide range of plant and animal species, including those classified as Vulnerable or Least Concern by the IUCN Red List of Italy. This underlines the importance of preserving these wooded areas, even within urban contexts, as they may still be home to protected species.

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References

Ballabio, E. 2011. Relazione Naturalistica Oasi LIPU Cesano Maderno. URL https://www.oasicesanomaderno.it/. Accessed 15 June 2023.

Clarke, K. and Warwick, R. M. 2001. Change in Marine Communities: An Approach to Statistical Analysis and Interpretation. Primer-E Ltd: Plymouth, UK.

Hohbein, R. R. and Conway, C. J. 2018. Pitfall traps: A review of methods for estimating arthropod abundance. Wildlife Society Bulletin. 42: 597-606.

Hussain, N., Ali, A. and Lazem, L. F. 2012. Ecological indices of key biological groups in Southern Iraqi marshland during 2005-2007. Mesopotamian Journal of Marine Sciences. 27 (2): 112-125.

Lupi, D., Zanetti, A., Triberti, P., Facchini, S., Rigato, F., Jucker, C., Malabusini, S., Savoldelli, S., Cortesi, P. and Loni, A. 2023. Insect Biodiversity in a Prealpine Suburban Hilly Area in Italy. Insects, 14 (9): 727.

Magurran, A. E. 1988. Ecological diversity and its measurement. In: Chapman and Management. Academic Press, London: pp 61-80.

Muys, B., Angelstam, P., Bauhus, J., Bouriaud, L., Jactel, H., Kraigher, H., Müller, J., Pettorelli, N., Pötzelsberger, E., Primmer, E., Svoboda, M., Thorsen, B. J. and Van Meerbeek, K. 2022. Forest Biodiversity in Europe. European Forest Institute.

Rands, M. R. W., Adams, W. M., Bennun, L., Butchart, S. H. M., Clements, A., Coomes, D., Entwistle, A., Hodge, I., Kapos, V., Scharlemann, J. P. W., Sutherland, W. J. and Vira, B. 2010. Biodiversity Conservation: Challenges Beyond 2010. Science, 329: 1298-1303.
Wermelinger, B. 2021. Forest Insects in Europe: Diversity, Functions, and Importance. Taylor & Francis Group, LLC.