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ECOPHYSIOLOGICAL AND GRAVIMETRIC STUDIES ON IVY (*HEDERA HELIX* L.) LEAVES FROM DIFFERENT HABITATS

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ABSTRACT
This paper aim was to analyze ivy leaves behavior on various environments. This species is evergreen, common in numerous habitats, growing on trees or on soil. Therefore, Hedera became a widely used species in air and urban environment quality studies. Assessments on ivy leaves are not expensive and they can be done rapidly. For this study, four data sets were used. The samples were collected from a beech forest, at 250 m asl. The first set was collected from trees and the second set was represented by leaves grown on top of the soil. The third data set was collected from the surface of trees grown in Cathedral Park, Timisoara and the fourth data set was obtained from an intense circulated boulevard in Timisoara. The samples were dried in an oven and then incinerated. The analyzed indices were: leaf dry weight, leaf ash content, tissue mineral deposition, leaf organic matter and leaf organic content. Statistical analysis conducted to numerous variations between the study samples. After the completion of the analysis of variance, the values were found to be heterogeneous. Significant differences between data sets were found.
KEY WORDS: *organic content, leaf features, evergreen species, bioindicator, urban habitat*

INTRODUCTION

Hedera helix L., commonly known as ivy, is an evergreen (i.e. foliar material can be sampled throughout the year), perennial plant, native in the Northern Hemisphere zones, North America, Western, Southern and Central Europe, and Asia (Al-Snafi, 2018). The genus Hedera L., which belongs to the family Araliaceae Juss., has twelve species (McAllister & Marshall, 2017) common to the vegetation of the Europe and Asian continents. Of these, the species *H. helix* L. has an extensive European-Mediterranean area of distribution. Species and cultivars of the genus Hedera differ between them by a host of morphological and biological characteristics. The diversity across their growth pattern, size, shape, and coloration of the leaf lamina plays the greatest role in ornamental gardening, but also for the ability to tolerate really intense insolation (Khailenko et al. 2021).

This species leaves were widely used for the treatment of chronic inflammatory bronchitis and productive cough (Cwientzek et al. 2011; Stauss-Grabo et al. 2011). Moreover, studies confirmed the antifungal, anti-inflammatory, animicrobial, antioxidative, antitumor and spasmolytic activities of *H. helix* leaves extracts (Trute et al. 1997; Mendel et al. 2011; Greunke et al. 2015).

The biologically active compounds which offer the medical benefits of *H. helix* are triterpene saponins (Fazio et al. 2009; Stauss-Grabo et al. 2011; Greunke et al. 2015;). α-hederin in particular is one of the triterpene saponins that mostly offer all effects of *H. helix* and leaf has β2-adrenergic activity (Sieben et al. 2009; Stauss-Grabo et al. 2011).

Ivy leaves showed to be a suitable bioindicator for urban PM and metal pollution assessments. It is an evergreen plant widely available in Romania, as well as in most Europe, and offers a great potential for air pollution biomonitoring with a high temporal- and spatial- resolution. Time-integrative monitoring is of particular interest as most PM related- health impacts are also due to long-term exposure (Castanheiro et al. 2016).

The cultivation of ivy as an ornamental plant dates back about 150 years (Khailenko et al. 2021). At present, ten species introduced into the culture have more than two thousand varieties, most of which belong to the species *H. helix* L. (*H. helix* L., *H. rhombea* Hort.)

Urban habitats frequently present altered abiotic and biotic conditions, including elevated levels for artificial light (Russ et al. 2015), drier soils and higher temperatures (Kuttler, 2008), but also a greater ecosystem fragmentation in a matrix of sealed surface (Alberti, 2015). Trace metals that appear due to human activity are of particular interest within airborne particulate matter (PM), given its non-degradability in the environment (Qian et al. 2014). As the main air contaminant, particulate matter (PM) represent a mixture of solids and liquids, comprising heavy metals, black carbon, chemical elements, polycyclic aromatic hydrocarbons and other substances in the air (Bell et al. 2011). Yang et al. (2005) discovered that 772 tons of PM_{10} in Beijing are removed in one year by city plants. In a Flemish research on the chemical composition of PM_{10}, the elements Cr, Cu, Fe, Mn, Pb and Zn, were identified as traffic-related species (Vercauteren et al. 2011). Urban zones are therefore unique, challenging our traditional understanding of how species assemblages may have an influence on stability, ecosystem functioning, and ecosystem service delivery (Kowarik, 2011; Alberti, 2015; Datcu et al, 2017; Datcu et al, 2018; Ianovici et al, 2020).

The transfer of metals to the biosphere (Kocić et al. 2014) as constituents of particulate matter is one of the most complex part from the air pollution problem. Moreover, socio-economic circumstances and human decisions act as further selection and facilitation filters for community structure and biodiversity in various emerging ecosystems, giving the possibility for novel species to form assemblages (Kowarik, 2011; Swan et al. 2011). Also, the functional composition of species assemblages may have shifted due to modified biotic and abiotic conditions (Williams et al. 2009; Kowarik, 2011), leading to short-lived and non-native plant species and to the dominance of seed producing (Concepcion et al. 2015; Williams et al. 2015; Ianovici, 2020).

The aim of this study was to evaluate the behavior of a known bioindicator in urban, urban green and green areas, using some gravimetric and ecophysiological indices for leaves tests.

MATERIALS AND METHODS

The biological material to be assessed was represented by leaves belonging to *Hedera helix*. For this study, four data sets were used, each represented by 25 leaves. The samples from the first and the second data sets were collected from a beech forest, from Hunedoara County, situated on 250 m asl. in October 2020. The first set (data set I) was collected from trees and the second set (data set II) was represented by leaves grown on top of the soil. The third sample set (data set III) was collected from the surface of trees grown in Cathedral Park, Timisoara and the fourth sample set (data set IV) was obtained from an intense circulated boulevard in Timisoara. The last sets were collected in May 2021 and can be considered young. The leaves were intact and healthy.

An analytical balance (Kern model) with the precision of 0.0001 g was utilized for all mass measurements. All the samples were dried in an oven (Sauter model) at 100 °C for 2 hours and weighed, resulting leaf dry weight (LDW). Dried probes were incinerated to ash in a furnace (Nabertherm model) at 500 °C for 2 h. After the completion of the cooling process, the mass of the leaf ash content (LAC) was determined. Leaf ash content is the inorganic residue left after burning the organic matter and represents the mineral content of leaves (Ianovici, 2016; Ianovici et al, 2017). Using this parameter, some indices were calculated, as follows: TMD – Tissues mineral deposition (Eq. 1), LOM – Leaf organic matter (Eq. 2), LOC – Leaf organic content (Eq. 3)

$$TMD = \left(\frac{LAC}{LDW}\right) * 1000 \quad (1)$$

$$LOM = LDW - LAC \quad (2)$$

$$LOC = \frac{(100 * LOM)}{LDW} \quad (3)$$

Statistical processing was realized using Microsoft Office Excel 2016 and PAST Software 3.20 (Hammer et al. 2001). ANOVA test was accomplished. Probability (p) values less than 0.05 were considered significant.

RESULTS AND DISCUSSIONS

Table 1 presents the minimal and maximal values of the analyzed indices for *Hedera helix* leaves from four different sites.

LDW presented the lowest value for the probes from data set II and the biggest between the probes of the fourth data set (Table 1). LAC presented the lowest value for a probe from data set IV and the highest for a probe from the second data set. TMD presented the lowest and the maximum values for probes from data set II. LOM had the minimum between the probes of the second data set and maximum between the probes of the fourth set. LOC presented both, the minimum and the maximum for probes belonging to data set II.

LDW presented the biggest mean for the probes from the data set IV and the lowest values for the probes from the second data set (Fig. 1).

LAC presented the biggest mean for the probes belonging to the first data set analyzed and the lowest mean value for the third data set (Fig. 2).

TABLE 1. Minimal and maximal values obtained for the analyzed indices

Data set	Value	LDW (g)	LAC (g)	TMD (‰)	OM (g)	OC (%)
I	min	0.0208	0.0019	91.3461	0.0189	80.9434
	max	0.1024	0.0192	190.5660	0.0832	90.8653
II	min	0.0170	0.0017	38.6363	0.0128	75.2941
	max	0.0973	0.0100	247.0588	0.0873	96.1263
III	min	0.0181	0.0012	62.1259	0.0169	89.7226
	max	0.1069	0.0092	102.7732	0.0977	93.7864
IV	min	0.0204	0.0010	49.0196	0.0194	87.8620
	max	0.1536	0.0146	121.3793	0.1390	95.0980

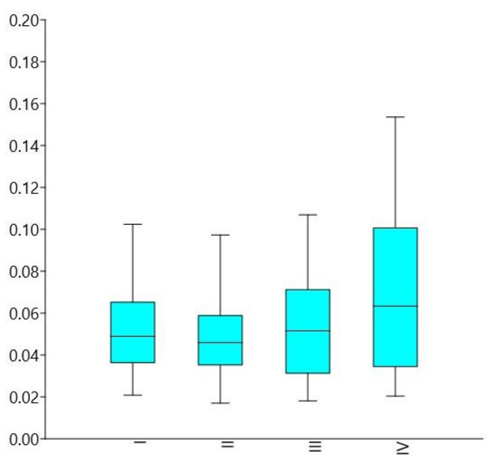

FIG 1. LDW (g) values for all data sets analyzed (box plots with mean ± SE)

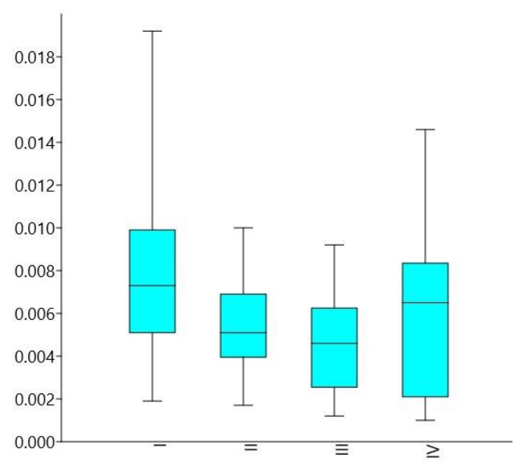

FIG 2. LAC (g) values for all data sets analyzed (box plots with mean ± SE)

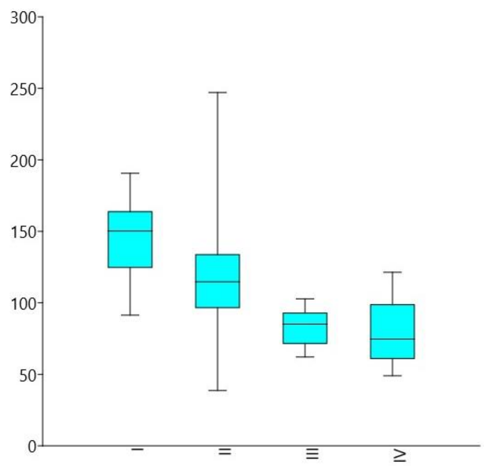

FIG 3. TDM (‰) values for all data sets analyzed (box plots with mean ± SE)

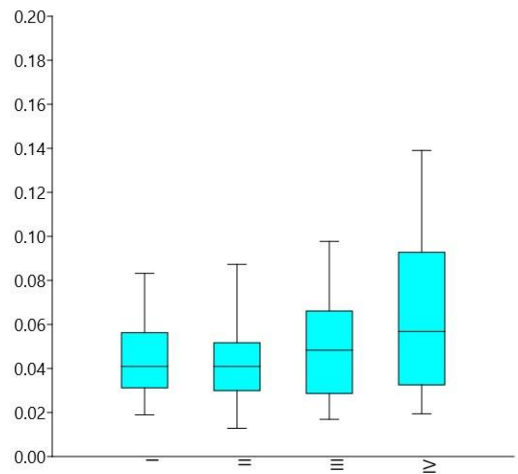

FIG 4. LOM (g) values for all data sets analyzed (box plots with mean ± SE)

TDM had the highest mean values for the probes belonging to data set I and the lowest mean values for data set 4 (Fig. 3).

LOM had the highest mean value for the probes belonging to the fourth data set and the lowest mean values for the probes from the second data set (Fig. 4).

LOC had the highest mean value for the probes belonging to the data set IV and the lowest mean value for the probes from the first data set analyzed (Fig. 5).

Table 2 presents the results obtained after the completion of ANOVA test.

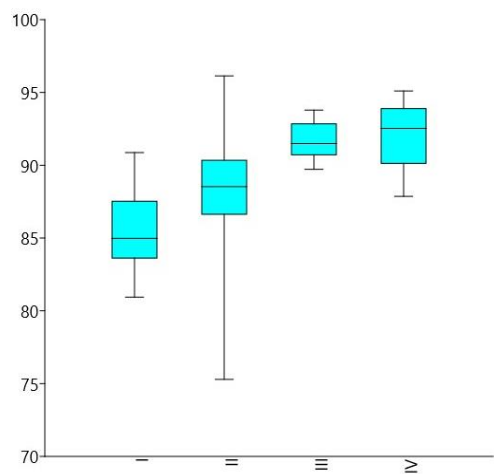

FIG. 5. LOC (%) values for all data sets analyzed (box plots with mean ± SE)

TABLE 2. Analysis of variance between the analyzed data sets for LDW, LAC, TMD, OM and OC on *H. helix*

Parameter	Levene's test	Welch F test		
		F	df	p
LDW (g)	0.000709	2.131	52.32	0.1074
LAC (g)	0.008196	5.112	51.92	0.003567
TMD (‰)	0.01116	46.84	49.6	1.67E-14
OM (g)	0.000562	2.731	52.18	0.05307
OC (%)	0.01116	46.84	49.6	1.67E-14

All data were heterogeneous. In this case we applied F Welch test. The values of LAC (p = 0.003567), TMD (p = 1.67E-14) and LOC (p = 1.67E-14) were significantly different for the studied sets. LDW (p=0.1074) and OM (p=0.05307) did not presented significant variations. For the samples collected from the soil surface (data set II), leaf dry weight and organic matter presented the lowest means, although these parameters did not presented a p lower than 0.05. Also, the samples collected during the spring (data sets III and IV) did not present high ash content values, probably because they were young.

Urban trees and herbs has been ordinarily documented to influence positively the problem of atmospheric pollution through PM accumulation (Janhäll, 2015; Weber et al. 2014). Plants are known to filter air pollutants including NO_x, CO_2 and SO_2 (Yang et al. 2005; Ottelé et al. 2010) and there are numerous species which provide additional ecosystem services such as biodiversity, urban heat island mitigation and improved aesthetics (Abhijith et al. 2017; Weber et al. 2014).

Ivy is a species widely found in urban ecosystems, with morphological particularities that allow rapid assessments. The micro-morphological features of plant leaves, with irregular structure, promote the accumulation of different atmospheric particulates on their surface (Grote et al. 2016; Weerakkody et al. 2018).

Leaves dust depositions are principally influenced by specific leaf structure, plant species, the type of plant, atmospheric conditions (Litschke and Kuttler, 2008; Mo et al., 2015; Chen et al. 2017). Also, the tolerance to pollution in plants depend on the biochemical indices like total chlorophyll content, relative water content, abcisic acid content, leaf extract pH (ascorbic acid content total chlorophyll, relative water content and leaf extract pH (Agarwal, 2017).

In the case of *Hedera*, differences between the analyzed indices appeared for tissue mineral deposition, ash content and organic content. Thus, leaves accumulated different types of compounds depending on the zone. Further studies are necessary to observe possible bioindicator and bioaccumulation potentials on ivy leaves.

CONCLUSIONS

The study purpose was to analyze ivy leaves behavior regarding ecophysiological and gravimetrical traits. The species presented variations for some indices, when the plants grown in different environments. The data were heterogeneous and significant differences appeared in the case of leaf ash content, tissue mineral deposition and organic content. For the samples collected from the soil surface, leaf dry weight and organic matter presented the lowest means. Also, the samples collected during the spring did not present high ash content values.

REFERENCES

- Abhijith K., Kumar P., Gallagher J., McNabola A., Baldauf R., Pilla F., Broderick B., Di Sabatino S., Pulvirenti B. 2017. Air pollution abatement performances of green infrastructure in open road and built-up street canyon environments—A review. *Atmos. Environ*. 162: 71–86.
- Agarwal A. 2017. Evaluation of indoor plants for their pollution tolerance ability. *Research & Reviews: Journal of Ecology and Environmental Sciences*, 5(2): 21-25.
- Alberti M. 2015. Eco-evolutionary dynamics in an urbanizing planet. *Trends Ecol.Evol.* 30: 114–126.
- Al-Snafi A.E. 2018. Pharmacological and therapeutic activities of *Hedera helix*-A review. *Iosr J. Pharm.* 8: 41–53.
- Bell L.M., Morgenstern R. Harrington. W. 2011. Quantifying the human health benefits of air pollution policies: review of recent studies and new directions in accountability research. *Environ. Sci. Policy* 14: 357–368.
- Castanheiro A., Samson R., DeWael K. 2016. Magnetic- and particle-based techniques to investigate metal deposition on urban green. *Science of the Total Environment* 571: 594–602.
- Chen L., Liu C., Zhang L., Zou R., Zhang Z. 2017. Variation in tree species ability to capture and retain airborne fine particulate matter (PM2.5). *Sci. Rep.* 7: 3206.
- Concepcion E.D., Moretti M., Altermatt F., Nobis M.P., Obrist M.K. 2015. Impacts of urbanisation on biodiversity: the role of species mobility. degree of specialization and spatial scale. *Oikos* 124: 1571–1582.
- Cwientzek U., Ottillinger B., Arenberger P. 2011. Acute bronchitis therapy with ivy leaves extracts in a two-arm study. A double-blind. randomised study vs. another ivy leaves extract. *Phytomedicine* 18: 1105–1109.
- Datcu A.-D., Sala F., Ianovici N. 2017. Studies regarding some morphometric and biomass allocation parameters in the urban habitat on *Plantago major*. *Research Journal of Agricultural Science*. 49 (4): 96-102
- Datcu A.D., Tanase R.M., Ianovici N. 2018. Biomass Allocation Parameters in *Taraxacum officinale*. *Proceedings OF THE INTERNATIONAL CONFERENCE ON LIFE SCIENCES*, 411-417
- Fazio S., Pouso J., Dolinsky D., Fernandez A., Hernandez M. 2009. Tolerance. safety and efficacy of *Hedera helix* L. extract in inflammatory bronchial diseases underclinical practice conditions: A prospective. open. multicentre postmarketing study in 9657 patients. *Phytomedicine* 16: 17–24.
- Greunke C., Hage-Hülsmann A., Sorkalla T., Keksel N., Felix H. 2015. Pulmonary pharmacology & therapeutics a systematic study on the influence of the main ingredients of an ivy leaves dry extract on the b 2 -adrenergic responsiveness of human airway smooth muscle cells. *Pulm. Pharmacol. Ther.* 31: 92–98.
- Grote R., Samson R., Alonso R., Amorim J.H., Carinanos P., Churkina G., Fares S., Thiec D. Le, Niinemets Ü., Mikkelsen T.N., Paoletti E., Tiwary A., Calfapietra C. 2016. Functional traits of urban trees: air pollution mitigation potential. *Front. Ecol. Environ.* 14: 543–550. https://doi.org/10.1002/fee.1426.
- Hammer Ø., Harper D.A.T., Ryan P.D. 2001. PAST: Paleontological Satistics software package for education and data analysis. *Paleontologica Electronica* 4(1): 1-9.
- Ianovici N, Batalu A., Hriscu D., Datcu AD. 2020. Phytomonitoring study on intra urban variations of leaves of some evergreen and deciduous trees. *Ecological Indicators*. DOI:10.1016/j.ecolind.2020.106313
- Ianovici N. 2016. *Taraxacum officinale* (Asteraceae) in the urban environment: seasonal fluctuations of plant traits and their relationship with meteorological factors. *Acta Agrobot.* 69 (3): 1677.
- Ianovici N. 2020. The influence of meteorological factors on the dynamic of *Ambrosia artemisiifolia* pollen in an invaded area. *Not Bot Horti Agrobo*. DOI:10.15835/nbha48211862
- Ianovici N., Latis AA, Radac AI. 2017. Foliar traits of *Juglans regia*, *Aesculus hippocastanum* and *Tilia platyphyllos* in urban habitat. *Romanian Biotechnological Letters*. 22 (2):12400-12408
- Janhäll S. 2015. Review on urban vegetation and particle air pollution –deposition and dispersion. *Atmos Environ*. 105: 130–137.
- Khailenko E.V., Plugatar S.A., Zylova V.K. 2021. Preservation of biodiversity of the genus Hedera L. in the Nikita botanical garden. *IOP Conf. Series: Earth and Environmental Science* 677: 052090.

- Kocić K., Spasić T., Urošević M.A., Tomašević M. 2014. Trees as natural barriers against heavy metal pollution and their role in the protection of cultural heritage. *J. Cult. Herit.* 15: 227–233.
- Kowarik I. 2011. Novel urban ecosystems. biodiversity. and conservation. *Environ. Pollut.* 159: 1974–1983.
- Kuttler W. 2008. The urban climate – basic and applied aspects. In: Marzluff J.M., Shulenberger E., Endlicher W., Alberti M., Bradley G., Ryan C., Simon U., ZumBrunnen C. (Eds.). Urban ecology. An international perspective on the interaction between humans and nature. Springer. New York. pp. 233–248.
- Litschke T., Kuttler W. 2008. On the reduction of urban particle concentration by vegetation a review. *Meteorol. Z.* 17: 229–240..
- McAllister H.A., Marshall R.H. 2017. Hedera: the complete guide. London. The Royal Horticultural Society. p. 401
- Mendel M., Chłopecka M., Dziekan N., Wiechetek M. 2011. The effect of the whole extract of common ivy (*Hedera helix*) leaves and selected active substances on the motoric activity of rat isolated stomach strips. *J. Ethnopharmacol.* 134: 796–802. https://doi.org/10.1016/j.jep.2011.01.036
- Mo L., Ma Z., Xu Y., Sun F., Lun X., Liu X., Chen J., Yu X. 2015. Assessing the capacity of plant species to accumulate particulate matter in Beijing, China. *PLoS One* 10: 0140664.
- Ottelé M., van Bohemen H.D., Fraaij A.L. 2010. Quantifying the deposition of particulate matter on climber vegetation on living walls. *Ecol. Eng.* 36: 154–162.
- Qian P., Zhou L., Zheng X., Dong Y.,Wang Y. 2014. Magnetic properties of airborne particulate matter in Shanghai during dust storm events and the implications for heavy metal contaminant sources. *Environ. Earth Sci.* 72: 4167–4178. http://dx.doi.org/10. 1007/s12665-014-3313-7
- Russ A., Ruger A., Klenke R. 2015. Seize the night: European Blackbirds (Turdus merula) extend their foraging activity under artificial illumination. *J. Ornithol.* 156: 123–131. http://dx.doi.org/10.1007/s10336-014-1105-1
- Sieben A., Prenner L., Sorkalla T., Wolf A., Jakobs D., Runkel F., Häberlein H. 2009. α-Hederin. but not hederacoside c and hederagenin from Hedera helix. affects thebinding behavior. Dynamics. and regulation of β2-adrenergic receptors. *Biochemistry* 48: 3477–3482. https://doi.org/10.1021/bi802036b
- Stauss-Grabo M., Atiye S., Warnke A., Wedemeyer R.S., Donath F., Blume H.H. 2011. Observational study on the tolerability and safety of film-coated tablets containing ivy extract (Prospan® Cough Tablets) in the treatment of colds accompanied by coughing. *Phytomedicine* 18: 433–436. https://doi.org/10.1016/J.PHYMED.2010.11.009
- Swan C.M., Pickett S.T.A., Slavecz K., Warren P., Willey K.T. 2011. Biodiversity and community composition in urban ecosystems: coupled human, spatial and metacommunity processes. In: Niemelä. J. (Ed.). Handbook of Urban Ecology. Oxford University Press. Oxford. 392 pp.
- Trute A., Gross J., Mutschler E., Nahrstedt A. 1997. In vitro antispasmodic compounds of the dry extract obtained from *Hedera helix. Planta Med.* 63:125–129.
- Vercauteren J., Matheeussen C., Wauters E., Roekens E., et al. 2011. Chemkar PM10: an extensive look at the local differences in chemical composition of PM10 in Flanders. Belgium. *Atmos. Environ.* 45: 108–116.
- Weber F., Kowarik I., Säumel I. 2014. Herbaceous plants as filters: immobilization of particulates along urban street corridors. *Environmental pollution* (Barking, Essex : 1987) 186: 234–240.
- Weerakkody U., Dover J.W., Mitchell P., Reiling K. 2018. Evaluating the impact of individual leaf traits on atmospheric particulate matter accumulation using natural and synthetic leaves. Urban For. *Urban Green.* 30: 98–107. https://doi.org/10.1016/ j.ufug.2018.01.001.
- Williams N.S.G., Hahs A.K., Vesk P.A. 2015. Urbanisation. Plant traits and the composition of urban floras. *Perspect. Plant Ecol. Evol. Syst.* 17: 78–86. http://dx.doi.org/10.1016/j.ppees.2014.10.002
- Williams N.S.G., Schwartz M.W., Vesk P.A., McCarthy M.A., Hahs A.K., Clemants S.E., Corlett R.T., Duncan R.P., Norton B.A., Thompson K., McDonnell M.J. 2009.A conceptual framework for predicting the effects of urban environments on floras. *J. Ecol.* 97: 4–9. http://dx.doi.org/10.1111/j.1365-2745.2008.01460.x
- Yang J., McBride J., Zhou J., Sun Z. 2005. The urban forest in Beijing and its role in air pollution reduction. Urban For. *Urban Green.* 3: 65–78.