NAT. CROAT. | VOL. 32 | No 1 | 159-175 | ZAGREB | June 30, 2023

original scientific paper / izvorni znanstveni rad
DOI 10.20302/NC.2023.32.11

VASCULAR FLORA OF TUŠKANAC FOREST PARK (ZAGREB, CROATIA)

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Essert, S., Koštro, A. & Hruševar, D.: Vascular flora of Tuškanac Forest Park (Zagreb, Croatia). Nat. Croat., Vol. 32, No. 1., 159-175, Zagreb, 2023.

Tuškanac Forest Park has been floristically studied over the past 15 years, but most extensively and systematically during the year 2021. Tuškanac Forest Park is a natural treasure in the center of Zagreb City. This oblong 150-year-old stand of oak, common beech, and hornbeam is a natural extension of the vegetation of Mount Medvednica and descends almost to Zagreb's main street (Ilica). A total of 173 vascular plant taxa were recorded (62 families and 131 genera). The largest part of the flora consists of Angiospermae (163 taxa; 94.2 %), followed by Monilophyta (6 taxa; 3.5%) and Gymnospermae (4 taxa; 2.3%). Rosaceae is the richest family with 14 taxa (8.1%), followed by Asteraceae *sensu lato* (13 taxa; 7.5%), Poaceae (11 taxa; 6.4%), Lamiaceae (9 taxa; 5.2%) and Fabaceae (8 taxa; 4.6%). The highest percentage of recorded plants are hemicryptophytes (41.0%) and phanerophytes (27.7%). The analysis of chorotypes shows that the Eurasian floral elements dominate (50.9%), followed by European (18.5%) and Mediterranean elements (8.1%). Urbanophobic (45.3%) significantly outnumber urbanophilic taxa (8.7%). A "close to nature" environmental condition is additionally confirmed by the low values calculated for Indicators of anthropogenisation and by the low share of alien flora (27 taxa; 15.6%). The following invasive alien taxa grow in the study site: *Ailanthus altissima*, *Duchesnea indica*, *Erigeron annuus*, *Parthenocissus quinquefolia*, *Phytolacca americana*, *Robinia pseudoacacia* and *Veronica persica*. According to IUCN categories, only two taxa belong to threatened categories: *Taxus baccata* and *Lilium martagon* are vulnerable (VU) and both taxa are strictly protected in Croatia.

Key words: biodiversity, floral elements, life forms, indices of urbanity and anthropogenic changes, urban flora

Essert, S., Koštro, A. & Hruševar, D.: Vaskularna flora park šume Tuškanac (Zagreb, Croatia). Nat. Croat., Vol. 32, No. 1., 159-175, Zagreb, 2023.

Floristično istraživanje Park šume Tuškanac provodi se posljednjih 15 godina, a najobuhvatnije i najsustavnije istraživanje provedeno je tijekom 2021. godine. Park šuma Tuškanac prirodno je blago u samom centru Zagreba. Ova 150 godina stara sastojina hrasta, bukve i običnog graba predstavlja prirodni produžetak vegetacije Medvednice i spušta se gotovo do središnje zagrebačke ulice (Ilice). Ukupno je zabilježeno 173 svojti vaskularnih biljaka (62 porodice i 131 rod). Najveći dio flore čine kritosjemenjače (Angiospermae) sa 163 svojte (94,2 %), a slijede ih papratnjače (Monilophyta) sa 6 svojti (3,5 %) i golosjemenjače (Gymnosperme) s 4 svojte (2,3 %). Porodica ruža (Rosaceae) vrstama je najbogatija (14 svojti, 8,1 %), a potom slijede glavočike (Asteraceae *sensu lato*) s 13 svojti (7,5 %), trave (Poaceae) s 11 svojti (6,4 %), usnače (Lamiaceae) s 9 svojti (5,2 %) te mahunarke (Fabaceae) s 8 svojti (4,6 %). Prema životnom obliku najveći postotak zabilježenih biljaka pripada hemikriptofitima (41,0 %), a za njima slijede fanerofiti (27,7 %). Analiza flornih elemenata ukazuje na dominaciju euroazijskog flornog elementa (50,9 %), a slijede biljke europskog (18,5 %) i mediteranskog (8,1 %) flornog elementa. Udio urbanofobnih svojti (45,3 %) značajno premašuje udio urbanofilnih svojti (8,7 %). Doprirodno stanje okoliša je dodatno potvrđeno izračunatim vrijednostima indikatora antropogenizacije i podu-

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prijeto niskim udjelom alohtone flore (27 svojti, 15,6 %). Invazivne vrste zabilježene na području istraživanja su sljedeće: žljezdasti pajasen (*Ailanthus altissima*), indijska jagodnjača (*Duchesnea indica*), jednogodišnja hudoljetnica (*Erigeron annuus*), petolisna lozika (*Parthenocissus quinquefolia*), američki kermes (*Phytolacca americana*), obični bagrem (*Robinia pseudoacacia*) i perzijska čestoslavica (*Veronica persica*). Prema IUCN-ovoj kategorizaciji samo dvije svojte pripadaju u neku od kategorija ugroženosti: šumska tisa (*Taxus baccata*) i zlatni ljiljan (*Lilium martagon*) su ranjive svojte (VU) i obje su strogo zaštićene vrste hrvatske flore.

Ključne riječi: biološka raznolikost, florni elementi, indeksi urbanizacije i antropogenizacije, urbana flora, životni oblici

INTRODUCTION

The Zagreb is the capital and the largest city of the Republic of Croatia, occupying an area of 641.32 km^2. According to Šiško & Polančec (2020), 75.1% of the city consists of green areas. Although this percentage is high, it should be considered that the differences in percentages by city districts are significant and vary from 92.5% on the outskirts of the city (Brezovica) to a deficient 3.6% in the city district of Trešnjevka-North. The city's green areas include 22 forest parks (FP). Forest parks are different in both sizes and distances from each other. They can be found on the western borders of Zagreb (Susedgrad FP) to the eastern edges (Lisičine FP) over a length of approximately 20 km and the north-south direction over a width of almost 9 km. Because they are mostly natural old forests integrated into the urban structure of the city, they have an extremely important ecological role (anti-erosional, hydrological, microclimatic, environmental, ecological corridors, etc.), but they also have invaluable social, recreational, and educational functions (Matić & Anić, 2010).

Data on vascular flora for the urban areas of the City of Zagreb are more or less dispersed in literature (Mitić *et al.*, 2007; Hudina *et al.*, 2012; Alegro *et al.*, 2013; Vuković *et al.*, 2013; Čičmir & Boršić, 2016; Budisavljević *et al.*, 2017 & Justić *et al.*, 2020) and so far, only two forest parks have been botanically investigated in the city area, i.e. the forest parks Dotrščina (Budisavljević *et al.*, 2017) and Jelenovac (Justić *et al.*, 2020). We here present a floristic study of Tuškanac Forest Park, which forms the eastern edge of the city center forest park complex. Although the researched area is a highly visited location, this paper presents the first collected and published results.

STUDY AREA

Tuškanac Forest Park (hereafter Tuškanac) is an oblong area of 21.76 ha that stretches from the Tuškanac public garage (350 m from Zagreb's main street Ilica), along Tuškanac Street and across Dubravka Road, all the way to the Cmrok Meadow in the north (Fig. 1). According to Šegota & Filipčić (2003), who followed Köppen's climate types, Zagreb is included into an area with amoderately warm humid climate with warm summers, where the average air temperature of the hottest month is lower than 22°C (Cfb climate). The mean annual temperature in Zagreb is 11.7 °C and average annual precipitation is 885 mm (Nožinić *et al.*, 2022). The climate diagram for Zagreb is shown in Fig. 2. The study area is located at an altitude of 150–200 m a. s. l. Landscape of the Park is mostly natural, being covered by climazonal hornbeam and sessile oak forest [*Epimedio-Carpinetum betuli* (Horvat 1938) Borhidi 1963], typical vegetation for the colline belt of Central Croatia during and after the Little Ice Age (Hruševar *et al.*, 2020). The largest part of the studied area includes a 150-year-old mixed stand of sessile oak,

beech, and hornbeam with admixed trees of acacia, linden, chestnut, wild cherry, ash, and maple alongside some planted American pine and common spruce trees. In one part of the park, there are a childrens' playground and several small meadows (Anić & Oršanić, 2010; Gašparović & Mrđa, 2010).

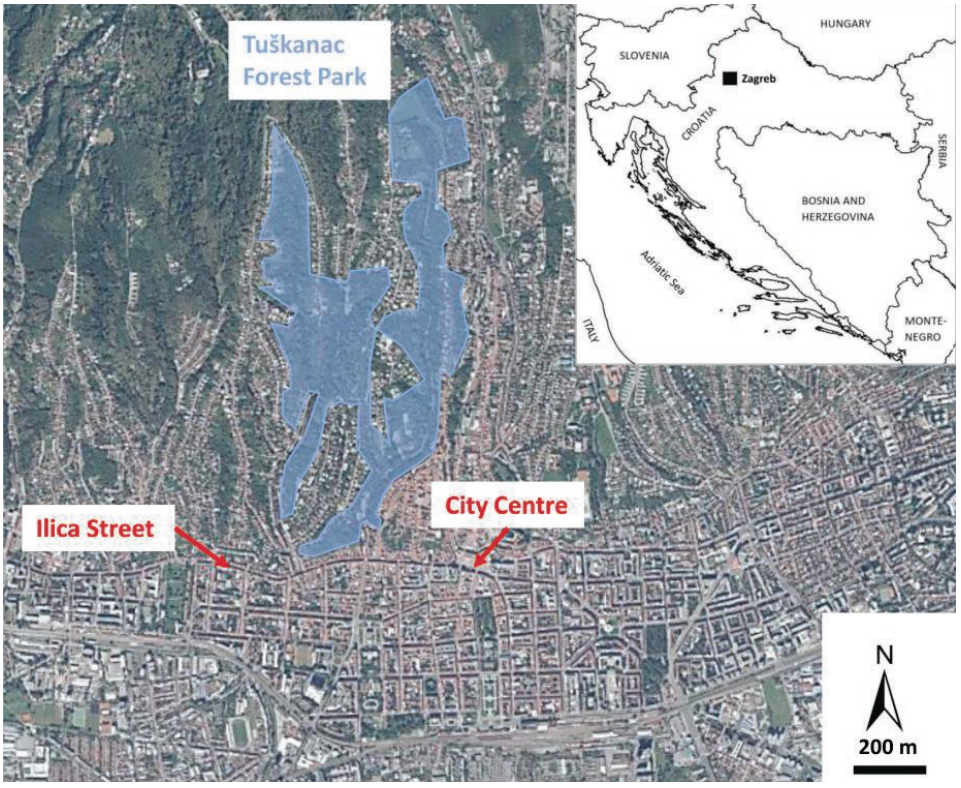

Fig. 1. Position of Forest Park Tuškanac, City of Zagreb

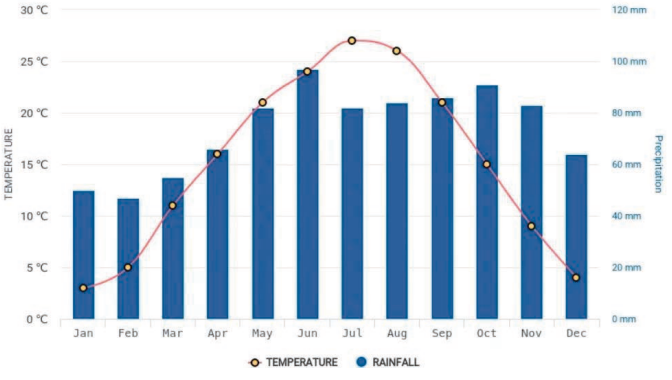

Fig. 2. Climate diagram (mean annual temperature and average precipitation) for Zagreb in the period 1861-2018. (https://cdn.hikb.at)

MATERIALS AND METHODS

The flora of Tuškanac was occasionally investigated during the last 15 years, but the most extensive approach was carried out during the year 2021. Private gardens were not investigated because we were interested in the flora composition of the area set aside for public use. Native and alien taxa are shown in Appendix 1. Additionally, the cultivated plants of the Tuškanac public area were noticed, but have been excluded from the floristic analysis (App. 2).

The following pertinent literature was considered in the present research: Nikolić (2020), Nikolić & Kovačić (2008), Rothmaler (1995), Franjić & Škvorc (2010, 2014), and Godet (2000). Nomenclature follow *Flora Croatica Database* (Nikolić, 2021).

The taxonomic analysis follows Nikolić (2013), life forms Raunkiaer (1934), chorological classification Horvatić (1963) and Horvatić *et al.* (1967-1968), origin and chronoelement (type and time of immigration) Medvecká *et al.* (2012). Alien species were evaluated by considering Boršić *et al.* (2008) and were additionally compared with the List of Invasive Alien Species of Union concern (Anonymous, 2019).

The degree of anthropogenic transformation and the main trends in the process of invasion follows Jackowiak (1990, 2006):

- total anthropogenisation (IAn_t), the proportion of alien plants in total flora
- permanent anthropogenisation (IAn_p), the proportion between naturalized alien and total flora with excluded diaphytes
- total archaeophytisation (IAr_t), the proportion of archaeophytes in total flora
- permanent archaeophytisation (IAr_p), proportion between archaeophytes and total flora with excluded diaphytes
- total kenophytisation (IKn_t), the proportion of neophytes among total flora
- permanent kenophytisation (IKn_p), the proportion between neophytes and total flora with excluded diaphytes
- modernisation (IM), the proportion of neophytes in naturalized alien flora
- fluctuation (IF), the proportion of diaphytes in total flora

The influence of man on site conditions follows Landolt *et al.* (2010), as was the case with values used for life forms and choroelements.

The exception among life forms means that nanophanerophytes and phanerophytes are united in a single category for easier comparison with other areas of Central Croatia. Among choroelements alien taxa have been included in the category cultivated and adventitious plants, as proposed by Horvatić (1963) and Horvatić *et al.* (1967-1968). This can cause misunderstandings considering that cultivated alien plants were included in floral analysis, however only native (spontaneous) and naturalized (archeophytes and neophytes/kenophytes) or casual alien taxa (diaphytes) were of interest to us (App. 1). Nevertheless, the list of cultivated plants is also attached to this article because some of the planted ornamental taxa may pose a threat to natural flora and vegetation in the future (App. 2). Among chronoelements an exception is made for alien plants with European origins, treated here as native (eg. *Cyclamen purpurascens* Mill. and *Melissa officinalis* L.). The standards in terminology of type and time of immigration of plants are based on Mitić *et al.* (2008) and modified for Indices of anthropogenisation according to Kornaś (1981) and Mirek (1981).

Data on IUCN categories were based on Nikolić & Topić (2005) and legal protection in Croatia on Anonymous (2016).

RESULTS AND DISCUSSION

In all, 173 taxa were found and were classified in 131 genera and 62 families (App. 1). The plants in cultivation are shown in Appendix 2. Since ornamental taxa sometimes become casual or even naturalized, with the possibility of invasive spread, we decided to present them in the same way as taxa from Appendix 1, even though they were excluded from floristic analysis.

The largest part of the flora consists of Angiospermae (163 taxa; 94.2%). Among angiosperms, the most numerous were eudicotyledons (132 taxa; 76.3%), while Lilianae (30 taxa; 17.3%) and Magnolianae (1 taxon; 0.6%) were represented with significantly lower proportions. Phylum Monilophyta with 6 taxa (3.5%) surpasses Gymnospermae (4 taxa; 2.3%). A more extensive presentation of species, genera and family numbers and percentages within higher taxonomic categories is shown in Tab. 1.

Tab. 1. Higher taxonomic representation of vascular flora in the Tuškanac Forest Park area

TAXONIMIC ANALYSIS	MONILOPHYTA	SPERMATOPHYTA			
		GYMNOSPERMAE	ANGIOSPERMAE		
		Pinidae	Magnolianae	Lilianae	Eudicotyledones
Taxa	6 (3.5 %)	4 (2.3 %)	1 (0.6 %)	30 (17.3 %)	132 (76.3 %)
Genus	5 (3.8 %)	3 (2.3 %)	1 (0.8 %)	22 (16.8 %)	100 (76.3 %)
Family	4 (6.5 %)	2 (3.2 %)	1 (1.6 %)	9 (14.5 %)	46 (74.2 %)

The richest family is Rosaceae (14 taxa; 8.1%), followed by Asteraceae (Asteroideae and Cichorioideae; 13 taxa; 7.5%), Poaceae (11 taxa; 6.4%), Lamiaceae (9 taxa; 5.2%) and Fabaceae (8 taxa; 4.6%) (Fig. 3). The other families comprise less than 4% of the total flora. Compared to Jelenovac Forest Park which is in the immediate vicinity and has similar characteristics (Justić *et al.*, 2020), it can be noted that the four most numerous families of the two parks correspond, but in Jelenovac there are more species in the Asteraceae family than in Rosaceae. The high representation of species from the rose family is partly the result of the horticultural value of some of the noticed native and alien taxa.

Concerning the life forms (Fig. 4) hemicryptophytes prevail (71 taxa; 41.0%), followed by phanerophytes (including nanophanerophytes) (48 taxa; 27.7%), geophytes (29 taxa; 16.8%), therophytes (19 taxa; 11.0%) and chamaephytes (6 taxa; 3.5%). The high percentage of hemicryptophytes and the low representation of chamaephytes are expected considering that the researched area is in a temperate climate zone (see e.g., Raunkiaer, 1934, Horvat, 1949, Leuschner & Ellenberg, 2017). The high percentage of phanerophytes is typical for areas dominated by forest communities, while a certain number of casual non-native plants is another reason for the high percentage of woody species in the studied area. Geophytes refer mostly to early blooming spring plants, as the dense shade of a closed forest canopy hinders growth in the herb layer during summer (Leuschner & Ellenberg, 2017).

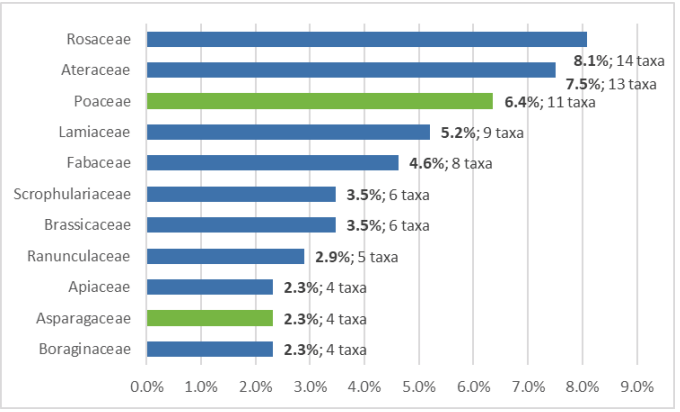

Fig. 3. Representation of the most common families (with percentage higher than 2%) in the Tuškanac Forest Park area. Blue columns indicate Eudicetyledones and green columns indicate Lilianae.

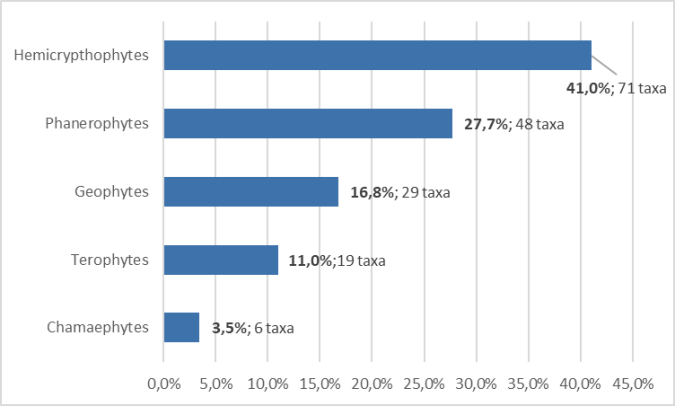

Fig. 4. Life-form spectrum of the flora of Tuškanac Forest Park.

Chorological analysis revealed that the Eurasian element dominates with 50.9% of the total determined flora (88 taxa; see Fig. 5). It is followed by the European element (32 taxa; 18.5%), Mediterranean element (14 taxa; 8.1%), cultivated and adventitious plants (11 taxa; 6.4%), Southern-East-European element (7 taxa; 4.0%) and widespread or cosmopolitan plants (7 taxa; 4.0%). Other groups (Illyrian-Balkan, South-European, Atlantic, East-European-Pontic, Central-European and Circumholarctic elements) make up less than 10% of total recorded flora. The high percentage of the Eurasian element is as expected due to the geographical location of Zagreb, but is partly a result of a modern approach, based on the indicator values presented in Landolt *et al.* (2010). For instance, a large number of taxa that Horvatić *et al.* (1967–1968) considered cosmopolitan are treated here as Eurasian or Mediterranean, just as the Central European element is here mostly replaced with the European. Another ambiguity that needs to be clarified concerns the cultivated taxa, planted for ornamental purposes due to their horticultural value. Despite the fact that they were excluded from flora analysis, a re-

latively high percentage of cultivated and adventitious plants refers here to alien flora, casual aliens or invasive neophytes. This is consequence of human disturbance, i.e. use of the area as a recreational zone and the horticultural activities that were carried out in the past or are still being carried out in some parts of the surveyed public area. By comparing these results with those for Jelenovac (Justić *et al.*, 2020) it can be noted that the Eurasian element prevails in both areas. However, in Jelenovac almost a quarter of taxa belong to widespread plants, which is much higher than in Tuškanac. Unlike Tuškanac, Jelenovac has more grassy areas, so it is assumed that this could be one of the reasons, in addition to the different approach to the treatment of chorology discussed earlier. Additionally, the lower percentage of cultivated and adventitious plants in Tuškanac is caused by the fact that taxa planted for ornamental purposes, like *Sequoiadendron giganteum* (Lindl.) J.Buchholz, *Calocedrus decurrens* (Torr.) Florin, *Platanus* x *acerifolia* (Aiton) Willd., *Lonicera fragrantissima* Lindl. & Paxton, *Prunus laurocerasus* L., etc. (see Appendix 2), whose viable seeds or their generative or generative or vegetative propagation was not observed at the study site in the last 15 years, were excluded from floristic analysis.

Majority of taxa belong to native flora (146 taxa; 84.4%). Among the alien flora archaeophytes (14 taxa; 8.1%) surpasses neophytes (7 taxa; 4.0%), and diaphytes count the smallest number of species (6 taxa; 3.5%) (Fig. 6). Only few plants successfully "escape" from yards and gardens and most often belong to trees (*Aesculus hippocastanum* L., *Ficus carica* L., *Gleditsia triacanthos* L., *Prunus cerasifera* Ehrh.), while shrubs and herbs were represented with only one taxon (*Mahonia aquifolium* (Pursh) Nutt. and *Brunnera macrophylla* (Adams) I.M.Johnst., respectively). The research showed that all seven neophytes are also invasive: *Ailanthus altissima* (Mill.) Swingle, *Duchesnea indica* (Andrews) Teschem., *Erigeron annuus* (L.) Desf, *Parthenocissus quinquefolia* (L.) Planch., *Phytolacca americana* L., *Robinia pseudoacacia* L. and *Veronica persica* Poir. Invasive taxa were observed mostly along forest edges, where natural vegetation has been thinned or removed for some reason, proving again that healthy and vital climazonal plant communities are the best protection against invasive species. This is in accordance with the fact that number of invasive plants increased with habitat diversity (Nikolić *et al.*, 2013), so their relatively low number on study site is partly a result of the stabile uni-

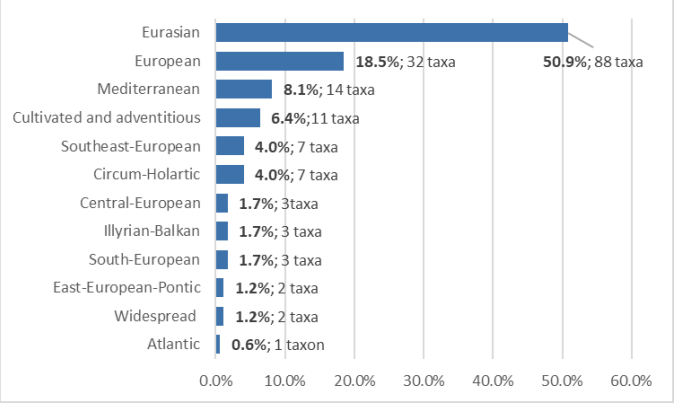

Fig. 5. Chorological spectrum of the flora of Tuškanac Forest Park

form climazonal vegetation of Tuškanac. The species *Ailanthus altissima* is on the European list of alien invasive species (Anonymous, 2019) and it invades various areas in southern Europe (e.g., Iamonico, 2022) so we believe that it represents the greatest threat to the flora of the researched area. It is a very resistant, fast-spreading, and fast-growing woody species (Hruševar & Posavec-Vukelić, 2008) that, in addition to having an allelopathic effect, also forms dense assemblages and therefore often successfully completely suppresses the indigenous flora (Nikolić *et al.*, 2014). In future, attention should also be given to some taxa from App. 2. and their ability to become naturalized or even invasive in the flora of Croatia. For instance, *Buddleja davidii* Franch., *Catalpa bignonioides* Walter, *Paulownia tomentosa* (Thunb.) Steud., *Philadelphus coronarius* L., *Pinus strobus* L., *P.* x *acerifolia*, *P. laurocerasus*, *Symphoricarpos albus* (L.) S.F.Blake and *Thuja orientalis* L. are considered invasive aliens in the City of Ljubljana (Strugulc-Krajček *et al.*, 2016). Additional caution is needed in monitoring the populations of diaphytes because they all, except *B. macrophylla* and *F. carica*, are also invasive in the neighboring Slovenia, in area with similar climatic and vegetation features (Strugulc-Krajček *et al.*, 2016).

Analysis of indicators of anthropogenisation (IA) (Tab. 2) and its comparison with other study sites (Alegro *et al.*, 2013, Hruševar *et al.*, 2018) indicate much lower IA values for Tuškanac than are calculated for other areas of continental Croatia. An exception is observed in the Indicator of modernisation (IM) with a higher value than calculated for the seminatural area of Hrvatsko zagorje (Hruševar *et al.*, 2018) and Indicator of fluctuation changes (IF), with a value higher than found in other study sites of Central Croatia (Alegro *et al.*, 2013, Hruševar *et al.*, 2018). The former is due the relatively high share of neophytes among the naturalised alien taxa, and the latter is due to the relatively high share of diaphytes in analysed flora. Nevertheless, the very low values calculated for Indicator of total and permanent anthropisation (IAn_t, IAn_p), Indicator of total and permanent archeophytisation (IAr_t; IAr_p), Indicator of total and permanent kenophytisation (IKn_t; IKN_p) speak in favour to "close to nature" site condition.

Influence of man on site conditions revealed that urbanoneutral plants dominated with 45.9% (79 taxa; see Fig. 7). They are followed by moderately urbanophobic (47

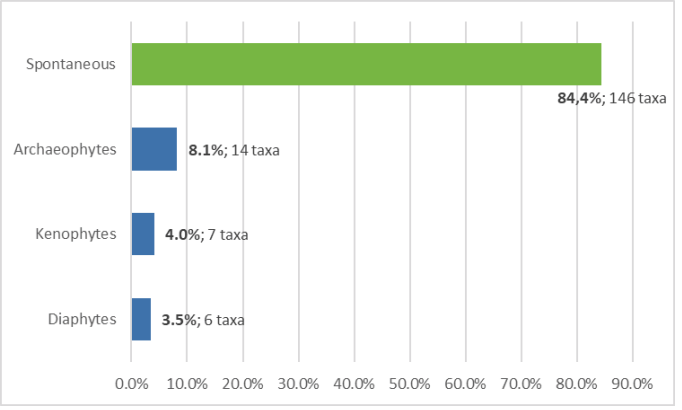

Fig. 6. Origin and chronoelement of the flora of Tuškanac Forest Park. Green column indicates native taxa and blue columns indicate alien taxa.

Tab. 2. Indicators of anthropogenisation for Tuškanac and its comparison with other floristic study sitea from Central Croatia (data were taken from Alegro *et al.*, 2013; Hruševar *et al.*, 2018)

Anthropogenisation level	Tuškanac	Hrvatsko zagorje	Zagreb - Savica	Zagreb -Jarun
Indicator of total anthropisation (IAn_t)	15.6	16.5	27.8	25.4
Indicator of permanent anthropisation (IAn_p)	12.6	14.9	26.8	24.2
Indicator of total archeophytisation (IAr_t)	8.1	10.0	16.7	13.9
Indicator of permanent archeophytisation (IAr_p)	8.4	10.2	16.9	14.2
Indicator of total kenophytisation (IKn_t)	4.0	4.6	9.7	9.9
Indicator of permanent kenophytisation (IKn_p)	4.2	4.7	9.9	10.1
Indicator of modernisation (IM)	33.3	31.6	36.8	41.6
Indicator of fluctuation change (IF)	3.5	1.9	1.4	1.6

taxa; 27.3%), strictly urbanophobous (31 taxa; 18.0%), moderately urbanophilic (12%; 7.0%) and strictly urbanophilic (3 taxa; 1.7%). In terms of percentages, urbanophobic plants (45.3%) significantly exceed the urbanophilic (8.7%), meaning that taxa that most often grow in natural habitats are more than five times as common in Tuškanac than plants that are often present in human-impacted or extensively managed vegetation. Although these values can be used as a simplified hemeroby index (Landolt *et al.*, 2010) this is not often the case in analysis of Croatian flora, making it possible to compare our results only with provincial areas outside of Zagreb (Hruševar *et al.*, 2018). The flora of Tuškanac shows a greater tendency to be "close to nature" vegetation than seminatural area of the planned Hrvatsko zagorje Regional Park (Hruševar *et al.*, 2018), which additionally supports values given by IA analysis.

Out of a total of 173 recorded taxa, *Taxus baccata* L. and *Lilium martagon* L. are classified, according to the IUCN classification, as Vulnerable (VU) species, and are the only plants listed in any threatened category. *Ruscus hypoglossum* L. and *Cyclamen purpurascens* are Near Threatened (NT), and *Galanthus nivalis* L. and *Poa annua* L. have the Least Concern (LC) status. In the researched area, many young yew trees were observed in

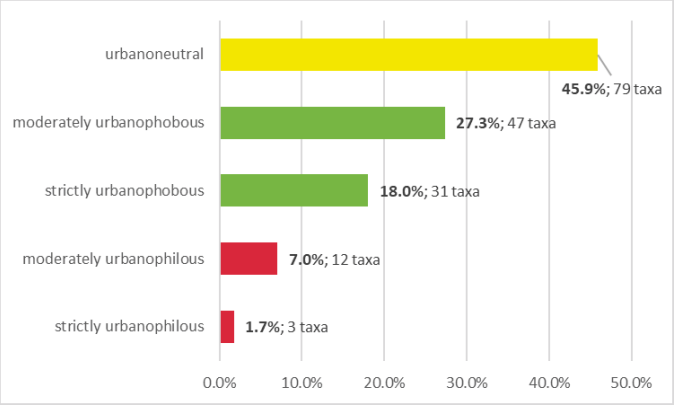

Fig. 7. Levels of urbanity of the flora of Tuškanac Forest Park. Blue column indicates indifferent taxa, green columns indicate close to nature taxa and red columns indicates hemerobic plants.

several locations within the forest. We believe that the observed trees were not deliberately planted, but since they are very common in the surrounding gardens, it is assumed that birds have dispersed them throughout the forest. Just one plant individuum of *L. martagon* species was observed at the northern end of Dubravka Road. *T. baccata* and *L. martagon* are the only taxa from the studied area that has legal protection in Croatia (Anonymous, 2016).

CONCLUSION

This floristic research shows that Tuškanac Forest Park has a valuable botanical richness and a "close to nature" environmental condition. Considering the constant increase in Zagreb's population and the expansion of urban parts of the city, we believe that monitoring the urban flora is extremely important. We hope that results present here will reach the wider population of the capital city and encourage it to value and preserve its urban green zones even more. Floristic research is the first step towards getting to know the biodiversity of the forest park and a good basis for the later production of brochures and booklets, which should also familiarize the wider population of the city with the plant richness of these green oases. Education of the local population is certainly a good path towards permanent and high-quality protection of these invaluable forests.

ACKNOWLEDGEMENTS

We would like to express our gratitude to the unknown reviewers for their constructive advice that improved the clarity and readability of the manuscript.

Received September 19, 2022

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Appendix 1. The list of vascular plant taxa recorded in Tuškanac Forest Park and included in floristic analysis.

Life-forms: G-geophytes, P-phanerophytes, Ch-chamaephytes, H-hemicrypthophytes, T- terophytes;

Chorotypes: 1) Mediterranean, 2) Illyrian-Balkan, 3) South-European, 4) Atlantic, 5) East-European-Pontic, 6) Southeast-European, 7) Central-European, 8) European, 9) Eurasian, 10) Circum-Holarctic, 11) Widespread or Cosmopolitan plants, 12) Cultivated and adventitious plants;

Origin and chronoelements: sp – spontaneous/native, ar – archeophytes, df – diaphytes/casual alien, kn – kenophytes/neophytes, kn+ – invasive neophytes (taxa on Croatian preliminary list), kn++ – invasive neophytes (taxa also on EU IAS list), E – Europe, As – Asia, Af – Africa, N Am – North America

Levels of urbanity: 1 – strictly urbanophobic, 2 – moderately urbanophobic, 3 – urbanoneutral, 4 – moderately urbanophilic, 5 – strictly urbanophilic

IUCN status: LC – least concern, NT – near threatened, VU – vulnerable.

Protection status: strictly protected (S4)

FAMILY	TAXON	LIFE FORM	CHORO-TYPE	URB. INFL.	CHRONO. ORIGIN	GEO. ORIGIN	IUCN
MONILOPHYTA (PTERIDOPHYTA)							
Aspleniaceae	*Asplenium trichomanes* L.	H	11	1	sp		
	Asplenium scolopendrium L.	H	9	2	sp		
Dryopteridaceae	*Dryopteris filix-mas* (L.) Schott	H	10	3	sp		
	Polystichum aculeatum (L.) Roth	H	9	1	sp		
Equisetaceae	*Equisetum arvense* L.	G	10	3	sp		
Woodsiaceae	*Athyrium filix-femina* (L.) Roth	H	9	1	sp		
SPERMATOPHYTA - GYMNOSPERMAE							
Pinaceae	*Picea abies* (L.) H. Karst.	P	8	2	sp		
	Pinus nigra J. F. Arnold	P	2	2	sp		
	Pinus sylvestris L.	P	10	1	sp		
Taxaceae	*Taxus baccata* L.	P	9	3	sp		VU, S4

FAMILY	TAXON	LIFE FORM	CHORO-TYPE	URB. INFL.	CHRONO. ORIGIN	GEO. ORIGIN	IUCN
SPERMATOPHYTA - ANGIOSPERMAE							
MAGNOLIANAE							
Aristolochiaceae	*Asarum europaeum* L.	H	9	1	sp		
LILIANAE							
Amaryllidaceae	*Allium ursinum* L.	G	9	2	sp		
	Galanthus nivalis L.	G	3	3	sp		LC
Araceae	*Arum maculatum* L.	G	8	2	sp		
Asparagaceae	*Polygonatum multiflorum* (L.) All.	G	9	1	sp		
	Polygonatum odoratum (Mill.) Druce	G	9	1	sp		
	Ruscus aculeatus L.	Ch	1	1	sp		
	Ruscus hypoglossum L.	Ch	1	1	sp		
Cyperaceae	*Carex digitata* L.	H	9	2	sp		
	Carex divulsa Stokes	H	1	3	sp		
	Carex sylvatica Huds.	H	9	3	sp		
Dioscoreaceae	*Tamus communis* L.	G	1	1	sp		
Iridaceae	*Crocus purpureus* Weston	G	3	?	sp		
	Crocus vernus (L.) Hill	G	8	2	sp		
Juncaceae	*Luzula campestris* (L.) DC.	H	9	2	sp		
	Luzula sylvatica (Huds.) Gaudin	H	8	1	sp		
Liliaceae	*Erythronium dens-canis* L.	G	9	1	sp		
	Gagea lutea (L.) Ker Gawl.	G	9	2	sp		
	Lilium martagon L.	G	9	1	sp		VU
Poaceae	*Anthoxanthum odoratum* L.	H	9	3	sp		
	Brachypodium sylvaticum (Huds.) P. Beauv.	H	9	3	sp		
	Bromus hordeaceus L.	T	9	4	sp		
	Dactylis glomerata L.	H	9	3	sp		
	Digitaria sanguinalis (L.) Scop.	T	9	5	ar	E, As, Af	
	Hordeum murinum L.	T	1	4	ar	E, As	
	Lolium perenne L.	H	9	3	sp		
	Melica ciliata L.	H	9	2	sp		
	Milium effusum L.	G	10	1	sp		
	Poa annua L.	T	9	3	sp		LC
	Poa trivialis L.	H	9	2	sp		
EUDICOTYLEDONES							
Aceraceae	*Acer campestre* L.	P	9	1	sp		
	Acer platanoides L.	P	7	3	sp		
	Acer pseudoplatanus L.	P	8	3	sp		
Apiaceae	*Aegopodium podagraria* L.	H	9	3	sp		
	Hacquetia epipactis (Scop.) DC.	H	6	1	sp		
	Heracleum sphondylium L.	H	8	3	sp		
	Sanicula europaea L.	H	9	1	sp		
Apocynaceae	*Vinca minor* L.	Ch	9	3	sp		
Araliaceae	*Hedera helix* L.	P	8	3	sp		
Asteraceae	*Achillea millefolium* L.	H	9	3	sp		
	Arctium lappa L.	H	9	3	ar	E As	
	Bellis perennis L.	H	9	3	sp		

FAMILY	TAXON	LIFE FORM	CHORO-TYPE	URB. INFL.	CHRONO. ORIGIN	GEO. ORIGIN	IUCN
Asteraceae	*Centaurea jacea* L.	H	8	3	sp		
	Erigeron annuus (L.) Desf.	H	12	3	kn+	N Am	
Berberidaceae	*Berberis vulgaris* L.	P	8	3	sp		
	Epimedium alpinum L.	G	3	3	sp		
	Mahonia aquifolium (Pursh.) Nutt.	P	12	3	df	N Am	
Boraginaceae	*Brunnera macrophylla* (Adams) I.M.Johnst.	G	12	3	df	E As	
	Pulmonaria officinalis L.	H	2	1	sp		
	Symphytum officinale L. ssp. *officinale*	H	9	3	sp		
	Symphytum tuberosum L. ssp. *angustifolium* (A.Kern.) Nyman	G	6	2	sp		
Brassicaceae	*Alliaria petiolata* (M. Bieb.) Cavara et Grande	H	9	3	sp		
	Capsella bursa-pastoris (L.) Medik.	H	9	3	ar	E	
	Cardamine bulbifera (L.) Crantz	G	8	2	sp		
	Cardamine enneaphyllos (L.) Crantz	G	6	1	sp		
	Cardamine hirsuta L.	T	9	4	ar	E As	
	Rorippa sylvestris (L.) Besser	H	8	3	sp		
Campanulaceae	*Campanula patula* L.	H	8	3	sp		
	Campanula trachelium L.	H	9	2	sp		
Caprifoliaceae	*Lonicera caprifolium* L.	P	6	2	sp		
	Sambucus nigra L.	P	8	3	sp		
	Viburnum lantana L.	P	9	2	sp		
Caryophyllaceae	*Stellaria holostea* L.	Ch	9	1	sp		
	Stellaria media (L.) Vill.	T	9	4	sp		
Celastraceae	*Euonymus europaeus* L.	P	9	2	sp		
Cichoriaceae	*Aposeris foetida* (L.) Less.	H	6	2	sp		
	Crepis vesicaria L.	T	1	3	sp		
	Hieracium murorum L.	H	9	3	sp		
	Lactuca serriola L.	H	9	4	ar	E, As, Af	
	Lapsana communis L.	H	9	3	sp		
	Mycelis muralis (L.) Dumort.	H	9	3	sp		
	Sonchus asper (L.) Hill	T	9	3	ar	E, As, Af	
	Taraxacum officinale F. H. Wigg.	H	9	3	sp		
Clusiaceae	*Hypericum montanum* L.	H	8	2	sp		
Cornaceae	*Cornus sanguinea* L.	P	8	4	sp		
Corylaceae	*Carpinus betulus* L.	P	9	2	sp		
	Corylus avellana L.	P	8	3	sp		
Euphorbiaceae	*Euphorbia dulcis* L.	G	5	1	sp		
Fabaceae	*Gleditsia triacanthos* L.	P	12	4	df	N Am	
	Laburnum anagyroides Medik.	P	6	2	sp		
	Lathyrus vernus (L.) Bernh.	G	9	1	sp		
	Medicago lupulina L.	T	9	3	sp		
	Robinia pseudoacacia L.	P	12	3	kn+	N Am	
	Trifolium pratense L.	H	9	3	sp		
Fabaceae	*Trifolium repens* L.	H	9	4	sp		
	Vicia sativa L.	T	1	4	ar	E, As, Af	

FAMILY	TAXON	LIFE FORM	CHORO-TYPE	URB. INFL.	CHRONO. ORIGIN	GEO. ORIGIN	IUCN
Fagaceae	*Castanea sativa* Mill.	P	1	2	ar	E, As	
	Fagus sylvatica L.	P	8	1	sp		
	Quercus petraea (Matt.) Liebl.	P	8	1	sp		
Fumariaceae	*Corydalis bulbosa* (L.) DC.	G	8	3	sp		
	Corydalis solida (L.) Clairv.	G	8	2	sp		
Geraniaceae	*Geranium phaeum* L.	H	8	2	sp		
	Geranium robertianum L.	T	10	3	sp		
	Geranium rotundifolium L.	T	1	5	sp		
Hippocastanaceae	*Aesculus hippocastanum* L.	P	12	3	df	E	
Juglandaceae	*Juglans regia* L.	P	1	2	ar		
Lamiaceae	*Ajuga reptans* L.	H	9	3	sp		
	Glechoma hederacea L.	H	9	3	sp		
	Lamium galeobdolon (L.) Crantz	Ch	5	2	sp		
	Lamium maculatum (L.) L.	H	8	3	sp		
	Lamium orvala L.	H	2	1	sp		
	Lamium purpureum L.	T	1	4	ar	E, As, Af	
	Melissa officinalis L.	H	1	3	sp		
	Prunella vulgaris L.	H	10	3	sp		
	Stachys sylvatica L.	H	9	3	sp		
Loranthaceae	*Loranthus europaeus* Jacq.	P	9	3	sp		
Moraceae	*Ficus carica* L.	P	1	3	df	As	
Oleaceae	*Fraxinus excelsior* L.	P	8	2	sp		
	Fraxinus ornus L.	P	9	2	sp		
	Ligustrum vulgare L.	P	9	2	sp		
Onagraceae	*Circaea lutetiana* L.	G	9	3	sp		
Oxalidaceae	*Oxalis acetosella* L.	G	9	1	sp		
Papaveraceae	*Chelidonium majus* L.	H	9	3	ar	E, As	
Phytolaccaceae	*Phytolacca americana* L.	H	12	3	kn+	N Am	
Plantaginaceae	*Plantago lanceolata* L.	H	9	3	sp		
	Plantago major L.	H	9	3	sp		
	Plantago media L.	H	7	3	sp		
Polygonaceae	*Polygonum aviculare* L.	T	9	3	sp		
	Polygonum persicaria L.	T	11	3	sp		
	Rumex sanguineus L.	H	9	2	sp		
Primulaceae	*Cyclamen purpurascens* Mill.	G	6	2	sp		NT
	Lysimachia nummularia L.	H	8	2	sp		
	Primula vulgaris Huds.	H	9	3	sp		
Ranunculaceae	*Anemone nemorosa* L.	G	8	2	sp		
	Clematis vitalba L.	P	8	2	sp		
	Ranunculus bulbosus L.	H	9	3	sp		
	Ranunculus ficaria L.	G	8	2	sp		
	Ranunculus lanuginosus L.	H	8	1	sp		
Rosaceae	*Agrimonia eupatoria* L.	H	9	2	sp		
	Crataegus monogyna Jacq.	P	9	2	sp		
	Duchesnea indica (Andrews) Focke	H	12	3	kn+	As	
	Geum urbanum L.	H	9	3	sp		
	Potentilla micrantha DC.	H	9	3	sp		

FAMILY	TAXON	LIFE FORM	CHORO-TYPE	URB. INFL.	CHRONO. ORIGIN	GEO. ORIGIN	IUCN
Rosaceae	*Potentilla reptans* L.	H	9	3	sp		
	Potentilla sterilis (L.) Garcke	H	4	3	sp		
	Prunus avium (L.) L.	P	9	3	sp		
	Prunus cerasifera Ehrh.	P	9	3	df	E, As	
	Prunus domestica L.	P	9	4	ar	E, As	
	Prunus padus L.	P	9	1	sp		
	Rosa canina L.	P	9	2	sp		
	Rosa pendulina L.	P	8	1	sp		
	Rubus idaeus L.	P	9	3	sp		
	Rubus spp.						
Rubiaceae	*Galium aparine* L.	T	9	3	sp		
	Galium odoratum (L.) Scop.	G	9	1	sp		
Salicaceae	*Populus alba* L.	P	9	3	sp		
	Populus nigra L.	P	9	2	sp		
	Salix alba L.	P	9	3	sp		
Scrophulariaceae	*Lathraea squamaria* L.	G	9	1	sp		
	Melampyrum pratense L.	T	9	2	sp		
	Scrophularia nodosa L.	H	10	2	sp		
	Veronica chamaedrys L.	Ch	9	3	sp		
	Veronica hederifolia L.	T	9	3	sp		
	Veronica persica Poir.	T	12	4	kn+	As	
Simaroubaceae	*Ailanthus altissima* (Mill.) Swingle	P	12	5	kn++	As	
Saxifragaceae	*Chrysosplenium alternifolium* L.	H	9	2	sp		
Tiliaceae	*Tilia cordata* Mill.	P	8	2	sp		
	Tilia platyphyllos Scop.	P	8	2	sp		
Ulmaceae	*Ulmus glabra* Huds.	P	8	2	sp		
	Ulmus minor Mill.	P	1	2	sp		
Urticaceae	Urtica dioica L.	H	9	3	sp		
Violaceae	*Viola alba* Besser	H	7	2	sp		
	Viola odorata L.	H	9	3	ar	E, As, Af	
Vitaceae	*Parthenocissus quinquefolia* (L.) Planchon	P	12	3	kn+	N Am	

Appendix 2. The list of cultivated vascular plant taxa recorded in Tuškanac Forest Park but excluded from floristic analysis

Life-forms: P-phanerophytes;

Chorotypes: 12) Cultivated and adventitious plants;

Origin and chronoelements: cul – cultivated, E – Europe, As – Asia, Af – Africa, N Am – North America, hybrid

Levels of urbanity: 1 – strictly urbanophobous, 2 – moderately urbanophobous, 3 – urbanoneutral, 4 – moderately urbanophilous, 5 – strictly urbanophilos

FAMILY	TAXON	LIFE FORM	CHORO-TYPE	URB. INFL.	CHRONO. ORIGIN	GEO. ORIGIN
SPERMATOPHYTA - GYMNOSPERMAE						
Cupressaceae	*Calocedrus decurrens* (Torr.) Florin	P	12	?	cul	N Am
	Sequoiadendron giganteum (Lindl.) J. Buchholz	P	12	?	cul	N Am
	Thuja orientalis L.	P	12	5	cul	As
Pinaceae	*Pinus strobus* L.	P	12	2	cul	N Am
SPERMATOPHYTA - ANGIOSPERMAE						
EUDICOTYLEDONES						
Bignoniaceae	*Catalpa bignonioides* Walter	P	12	5	cul	N Am
Buddlejaceae	*Buddleja davidii* Franch.	P	12	3	cul	As
Caprifoliaceae	*Lonicera fragrantissima* Lindl. et Paxton	P	12	?	cul	As
	Symphoricarpos albus (L.) S. F. Blake	P	12	?	cul	N Am
Hippocastanaceae	*Aesculus* × *carnea* Zeyh.	P	12	?	cul	hybrid
Hydrangeaceae	*Philadelphus coronarius* L.	P	12	4	cul	E, As
Oleaceae	*Forsythia suspensa* (Thunb.) Vahl	P	12	5	cul	As
	Jasminum nudiflorum Lindl.	P	12	4	cul	As
Platanaceae	*Platanus* x *acerifolia* (Aiton) Willd.	P	12	5	cul	hybrid
Rosaceae	*Chaenomeles japonica* (Thunb.) Spach	P	12	5	cul	As
	Prunus laurocerasus L.	P	12	3	cul	E, As
Scrophulariaceae	*Paulownia tomentosa* (Thunb.) Siebold et Zucc.	P	12	3	cul	E, As